

3.0 Watershed Inventory

3.1 Water Quality Data

An important aspect of the watershed planning process is to examine current water quality data as well as historic data to understand the issues present in the watershed. The historic data, some of which has been collected since as early as 1989, though only data collected since 2000 will be presented in this WMP, will provide a baseline in which to compare the data collected by the LaGrange County SWCD in 2011. The historical data of consequence was combined with the watershed assessment that was done as part of this project to characterize water quality problems and their sources and tie them to stakeholder concerns. The following sections will provide a detailed description of all water quality data that has been collected in the watershed from 2000 through 2011.

3.1.1 Water Quality Parameters

Water quality analysis of adjacent subwatersheds within the St. Joseph River Watershed (HUC 04050001) has historically shown that certain water quality pollutants are prevalent in the water system. For this reason, particular parameters were chosen to be examined as part of the Pigeon River-Pigeon Creek project. Those parameters are dissolved oxygen (DO), temperature, *E. coli*, turbidity, total dissolved solids (TDS), total suspended solids (TSS), total phosphorus, nitrate, biological oxygen demand (BOD), and pH. The LaGrange County SWCD is also interested in determining the Qualitative Habitat Evaluation Index (QHEI) and the macro-invertebrate Index of Biotic Integrity (mIBI). Provided below is a description of why each of those parameters are important to the quality of water. Please note the standard or target provided in the description of each parameter below is the standard that was chosen by the Pigeon River Watershed steering committee to use for the purposes of determining loads and necessary reductions.

Dissolved Oxygen

Dissolved oxygen (DO) is the measure of oxygen in the water available for uptake by aquatic life. Typically, streams with a DO level greater than 8 mg/L are considered very healthy and streams with DO levels less than 2 mg/L are very unhealthy as there is not enough oxygen to supply to aquatic life. DO is affected by many factors including: temperature - the warmer the water the harder it is for oxygen to dissolve; flow - more oxygen can enter a stream where the water is moving faster and turning more; and aquatic plants - an influx of plant growth will use more oxygen than normal which does not leave enough available DO for other aquatic life, however photosynthesis will add oxygen to the water during the day. Thus, DO levels may change frequently when there is excessive aquatic plant growth. Excessive amounts of suspended or dissolved solids will decrease the amount of DO in the water. The state of Indiana has set a standard of an average of at least 5 mg/L /day but not less than 4 mg/L of DO for warm water streams. The US EPA recommends that DO not exceed 9 mg/L so as to avoid super-saturation of DO.

Temperature

Temperature can affect many aspects of the health of the water system. Water temperature is a controlling factor for aquatic organisms. If there are too many swings in water temperature, metabolic activities of aquatic organisms may slow, speed up, or even stop. Many things can affect water temperature including stream canopy, dams, and industrial discharges. The state of Indiana has set a standard for water temperature depending on if the waterbody is a cold or warm water system. Michigan has a state standard maximum of between 40 and 85 degrees Fahrenheit for cold water streams, depending on the month that sampling has taken place.

Escherichia coli

E. coli is a bacteria found in all warm-blooded animal and human waste. *E. coli* testing is used as an indicator of fecal contamination in the water. While not all *E. coli* is harmful, there are certain strains that can cause serious illness in humans. *E. coli* may be present in the surface water system due to faulty septic systems, CSO overflows, wildlife (particularly geese) and from contaminated stormwater runoff from animal feeding operations. Due to the serious health risks from fecal contamination of waterways, the state of Indiana has developed the full body contact standard of 235 cfu/100 ml for any one water sample and 125 cfu/100 ml as a geometric mean for five (5) equally spaced samples taken over a 30 day period.

Turbidity

Turbidity is the measure of the cloudiness of the water which may be caused by sediment, urban runoff, resurfaced sediment from the stream bottom, or an overgrowth of aquatic plants or animals. High levels of turbidity can block out essential sunlight for submerged plants and animals and may raise water temperatures, which then can decrease DO. Sediment in the water causing it to be turbid can clog fish gills and smother nests when it settles, thus effecting the overall health of the aquatic biota. Turbid water may be caused from farm field erosion, feedlot or urban stormwater runoff, eroding stream banks, and/or excessive aquatic plant growth, including excessive algae growth. The US EPA recommends that the turbidity in the water measure less than 10.4 NTUs.

Total Dissolved Solids

TDS's are solid particles within the water system that can flow through a 2 micrometer sieve. TDS is typically related to aesthetic value of drinking water but can be used as an indicator of other pollutants, such as magnesium, sodium, and sulfates. When TDS is measured the sum of cations and anions is determined. However, the type of dissolved ion cannot be determined from the TDS analysis. For this reason, TDS is measured to provide a general measure of water quality. Both Indiana and Michigan have set a standard of less than 750 mg/L of TDS to represent good water quality.

Total Suspended Solids

The amount of Total Suspended Solids (TSS) in the water system is typically due to stream bank erosion or runoff from agricultural fields and will have the same type of deleterious effect on water quality as mentioned above under turbidity. The US EPA recommends a target of less than 25 mg/L of TSS to maintain a healthy aquatic ecosystem. The Pigeon River steering committee has decided to use the US EPA recommendation as it set to be more stringent than the IDEM or MI DEQ targets or standards.

Phosphorus

Phosphorus is an essential nutrient for aquatic plants however, too much phosphorus can create an over growth of plants and algae which can lower the DO in a water system and decrease the amount of light that penetrates the surface thus killing other aquatic life that depends on these for survival. Some types of aquatic plants that thrive when phosphorus levels are high, such as blue-green algae, are toxic. Humans and animals can be effected by blue-green algae and associated toxins by ingesting the algae, inhaling it's toxins or by dermal contact with the algae and/or it's toxins. Excessive amounts of phosphorus have also been found in ground water thus increasing the bacteria growth in underground water systems. Phosphorus can reach surface and ground water through fertilizer runoff from row crop fields, barnyard runoff from animal feeding operations, faulty septic systems, and the disposal of cleaning supplies containing phosphorus in landfills or down the drain. The state of Indiana has set a target of 0.3 mg/L of phosphorus in a water sample for listing a stream segment as impaired.

Nitrate

Nitrates can have the same effect on the water system as phosphorus, only to a much lesser degree. Nitrates can be found at levels up to 30mg/L in some waters before detrimental effects on aquatic life occur. However, due to the fact that infants who consume water with nitrate levels exceeding the US EPA MCL of 10 mg/L can become ill, nitrates in drinking water should be of particular concern to people who use wells as their drinking water source. The most common sources of nitrates in the project area are from fertilizer runoff from row crop fields, naturally leaching from worked agricultural land, faulty septic systems, and sewage. The Pigeon River steering committee is using the US EPA reference level for nitrates in the water system, which is set at 1.5 mg/L.

Biological Oxygen Demand

BOD is used as a general measure of the amount of organic pollution present within the water system. BOD analysis will provide the amount of pollution that is consumed by microbes within the water system by determining the amount of dissolved oxygen consumed by microbes over a five day period. BOD measuring greater than 50% indicates a higher amount of pollution in the water sample.

pH

pH is the measure of a substance's acidity or alkalinity and is an important factor in the health of a water system as if a stream is too acidic or basic it will affect the aquatic organisms' biological functions. A healthy stream typically has a pH between 6 and 9, depending on soil type and substances that come from dissolved bedrock. The pH can also change the water's chemistry. For example, a higher pH means that a smaller amount of ammonia in the water may make it harmful to aquatic organisms and a lower pH may increase the amount of metal present in the water. For these reasons, the state of Indiana has set a standard for pH of between 6 and 9.

Macroinvertebrate Index of Biotic Integrity

The Macroinvertebrate Index of Biotic Integrity (mIBI) is used as an indicator of water quality. Macroinvertebrates are collected from the water system and classified down to the genus level. The number and type of macroinvertebrates found show the overall health of the water as some macroinvertebrates can only survive when little to no contaminants are present. The Pigeon River steering committee set a target of the index ranking to be greater than 35, which is based on the IDEM reference level.

Qualitative Habitat Evaluation Index

The Qualitative Habitat Evaluation Index is another method used to determine the quality of a waterway. Various aspects of aquatic habitat are evaluated including in-stream habitat and the surrounding landuse, to determine the waterway's ability to support aquatic life such as fish and macroinvertebrates. A score greater than 61 is considered to be a stream that fully supports aquatic life, and a score between 51 and 61 is considered a stream that partially supports aquatic life.

3.1.2 Water Quality Targets

For the purpose of interpreting inventory data and defining problems, target values were identified for water quality parameters of concern (Table 17).

Table 17: Water Quality Targets

Parameter	Target	Source
Dissolved Oxygen	> 6 mg/L and not > 9 mg/L	327 IAC 2-1-6/US EPA recommendation
Temperature	40-85 degrees F	MI – R.323.1075
<i>Escherichia coli</i>	< 235 CFU/100 ml per single sample and < 125 CFU/100 ml per the geometric mean of 5 equally spaced samples over a 30 day period	327 IAC 2-1.5-8
Turbidity	< 10.4 NTU	US EPA recommendation (2000)
Total Dissolved Solids	< 750 mg/L	MI – R.323.1051 / 327 IAC 2-1-6
Total Suspended Solids	< 25 mg/L	US EPA recommendation
Total Phosphorus	< 0.3 mg/L	IDEM 303d listing criteria
Nitrate	< 1.5 mg/L	US EPA reference level (2000)
Nitrate-Nitrite	< 1.5 mg/L	Dodds et al. (1998)
TKN	<0.076 mg/L	Dodds et al. (1998)
Biological Oxygen Demand	< 50%	Hoosier Riverwatch Protocol
pH	> 6 or < 9	327 IAC 2-1-6
macroinvertebrate Index of Biotic Integrity (mIBI)	>23 points / >36 points	Hoosier Riverwatch Protocol / IDEM (2008)
Qualitative Habitat Evaluation Index (QHEI)	> 51 pts	IDEM (2008)
Index of Biotic Integrity (IBI) (fish)	≥ 36 points	IDEM (2006)

3.2 Water Quality Sampling Efforts

A variety of water quality assessment projects have been completed within the Pigeon River/Pigeon Creek and its tributaries. These include the Indiana and Michigan Integrated Reports, the Indiana TMDL Report, the Michigan Department of Environmental Quality’s Surface Water Protection Report, the Steuben County SWCD’s water quality monitoring program, and LaGrange County SWCD’s water quality monitoring program as part of this project. A summary of each study’s methodology and general results are discussed below. Subsequent sections detail specific study information as it relates to each subwatershed. Figure 14 displays all the historic sampling locations in the project area.

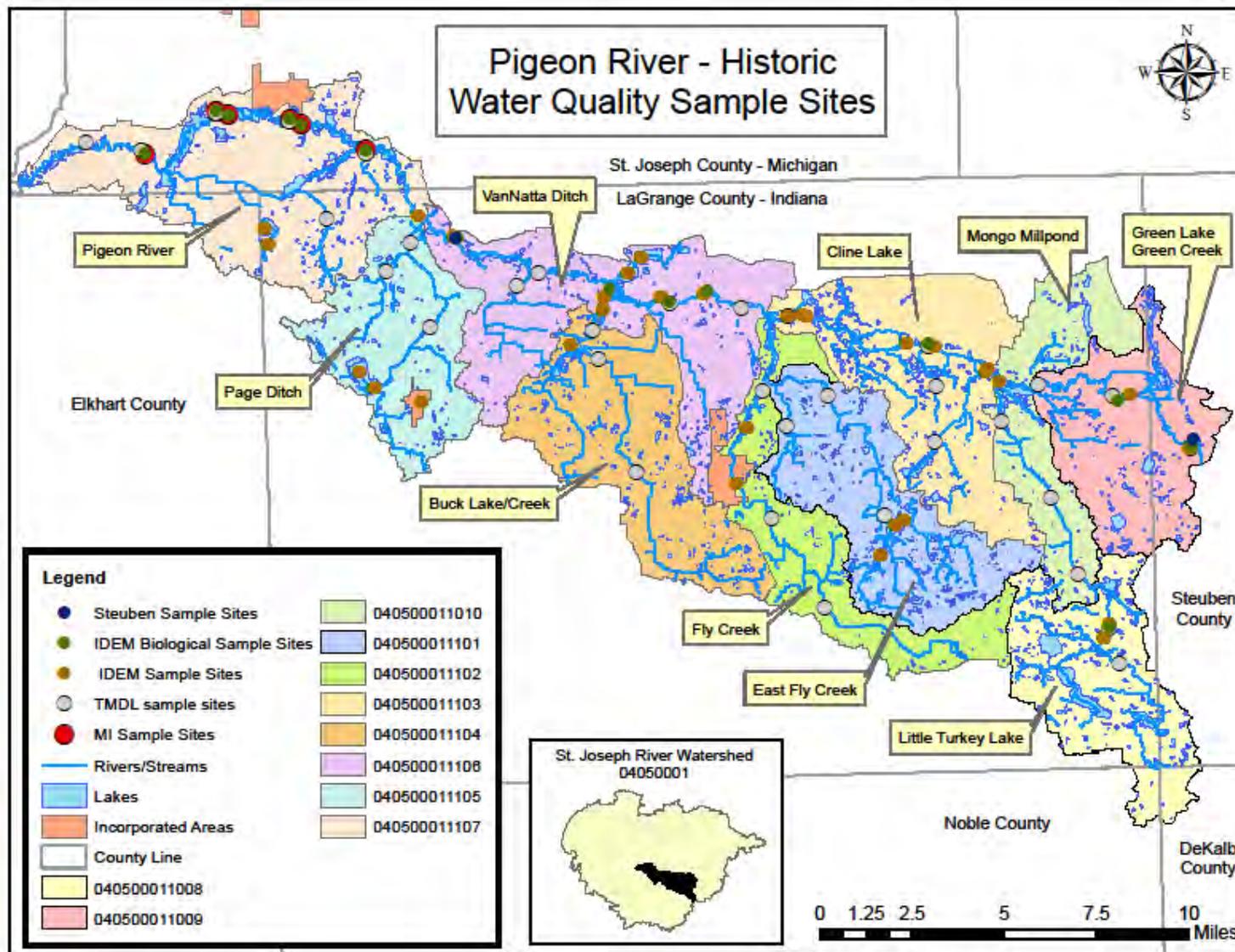


Figure 14: Pigeon River-Pigeon Creek Historic Sampling Locations

3.2.1 Integrated Water Quality Assessment (305(b) Report)

Each state is required to perform water quality analysis of its surface waters and report their findings to EPA in a report called the “Integrated Report” (IR) on a biannual basis, as mandated by the CWA§305(b). Prior to compiling the IR, a list of water bodies that do not meet state standards is developed as mandated by the CWA§303(d). This has become commonly known as the 303(d) list. IDEM’s 2010 IR has not yet been approved for release by EPA. However, the Pigeon River is on the 2008 IDEM 303(d) list of impaired waters for dissolved oxygen, *E. coli*, impaired biotic community, mercury and PCBs in fish tissue, phosphorus, and ammonia.

Michigan lists the Pigeon River as being impaired for mercury and PCBs in fish tissue and PCBs in the water table in the 2010 MI Department of Environmental Quality (DEQ) IR. A full list of those waters impaired, as designated by the State, can be found in Table 18.

As part of the IDEM monitoring process, water samples are analyzed for numerous substances. Those relevant to this WMP include: nitrogen, pH, phosphorous, DO, turbidity, QHEI, and mIBI. IDEM has been collecting data since 1989, however only data collected since 2000 was analyzed and sorted for the purpose of this project.

Michigan uses a similar monitoring protocol as Indiana, however, the MI DEQ tested for different parameters; mostly heavy metals. The only data collected by the MI DEQ assessments program relevant to this WMP were collected in 2000 at three sites, and 2005 at one site within the Pigeon River subwatershed. For the purposes of this WMP, analysis of MI DEQ water quality data will only include total suspended solids, nitrate-nitrite, TKN, nitrite, ortho-phosphate, and total phosphorus.

Table 18: Waterbodies Listed in the Indiana and/or Michigan Integrated Report

14-DIGIT HUC	COUNTY	ASSESSMENT UNIT ID	ASSESSMENT UNIT NAME	CAUSE OF IMPAIRMENT
INDIANA				
4050001110110	LAGRANGE	INJ01BB_T1007	Turkey Creek - Unnamed Tributary	DISSOLVED OXYGEN
4050001110110	LAGRANGE	INJ01BB_T1007	Turkey Creek - Unnamed Tributary	E. COLI
4050001110120	LAGRANGE	INJ01BC_T1298	PIGEON CREEK	E. COLI
4050001120010	LAGRANGE	INJ01C1_03	Pigeon River (Downstream of Ontario Millpond)	E. COLI
4050001120020	LAGRANGE	INJ01C2_00	FLY CREEK-HEADWATERS (LAGRANGE)	E. COLI
4050001120050	LAGRANGE	INJ01C5_01	Pigeon River	E. COLI

14-DIGIT HUC	COUNTY	ASSESSMENT UNIT ID	ASSESSMENT UNIT NAME	CAUSE OF IMPAIRMENT
4050001120060	LAGRANGE	INJ01C6_01	PIGEON RIVER (UPSTREAM OF SCOTT IN)	PCBs in Fish Tissue
4050001120060	LAGRANGE	INJ01C6_02	Pigeon River (Downstream of Scott, IN)	E. COLI
4050001120060	LAGRANGE	INJ01C6_02	PIGEON RIVER (DOWNSTREAM OF SCOTT, IN)	PCBs in Fish Tissue
4050001120060	LAGRANGE	INJ01C6_T1001	VAN NATTA DITCH	PCBs in Fish Tissue
4050001120060	LAGRANGE	INJ01C6_T1001A	VAN NATTA DITCH - UNNAMED TRIBUTARY	PCBs in Fish Tissue
4050001110110	LAGRANGE CO	INJ01P1093_00	LAKE OF THE WOODS	IMPAIRED BIOTIC COMMUNITIES
4050001110110	LAGRANGE CO	INJ01P1093_00	LAKE OF THE WOODS	Mercury in Fish Tissue
4050001110110	LAGRANGE CO	INJ01P1098_00	PRETTY LAKE	Mercury in Fish Tissue
4050001110110	LAGRANGE CO	INJ01P1101_00	Little Turkey Lake	PHOSPHORUS
4050001120030	LAGRANGE CO	INJ01P1132_00	ROYER LAKE	IMPAIRED BIOTIC COMMUNITIES
4050001120030	LAGRANGE CO	INJ01P1133_00	FISH LAKE	IMPAIRED BIOTIC COMMUNITIES
4050001120030	LAGRANGE CO	INJ01P1133_00	FISH LAKE	Mercury in Fish Tissue
4050001120050	LAGRANGE CO	INJ01P1157_00	NORTH TWIN LAKE	IMPAIRED BIOTIC COMMUNITIES
4050001110080	ST. JOSEPH CO	INJ01B8_T1027	PIGEON CREEK	IMPAIRED BIOTIC COMMUNITIES
MICHIGAN	COUNTY	STREAM MILES	ASSESSMENT UNIT NAME	CAUSE OF IMPAIRMENT
4050001110701	ST. JOSEPH CO	32.543073 Miles	PIGEON RIVER	Mercury in Fish Tissue
4050001110701	ST. JOSEPH CO	32.543073 Miles	PIGEON RIVER	PCBs in Fish Tissue
4050001110701	ST. JOSEPH CO	32.543073 Miles	PIGEON River	PCBs in Water Table

3.2.2 Total Maximum Daily Load Report

Once a waterbody is listed as impaired on the 303(d) list, the State is required to write a Total Maximum Daily Load (TMDL) report for the waterbody that is impaired. A TMDL outlines the

maximum amount of the parameter causing the impairment that can be present in the waterbody before it affects the integrity of the water resource. A TMDL also provides potential sources of the impairment and ways to address the problems. All contributing sources of the pollutants (point and nonpoint sources) are identified and are allocated a portion of the allowable load. The waterbody usually requires a reduction in pollution discharge in order to help solve the problem. Natural background sources, seasonal variations and a margin of safety are all taken into account in the allocations. TMDLs must clearly identify the links between the waterbody use impairment, the causes of impairment, and the pollutant load reductions needed to meet the applicable water quality standards. A TMDL is currently being developed by IDEM for the Pigeon Creek and Pigeon River watersheds in Indiana for *E. coli*.

A comprehensive survey of the Pigeon River and Pigeon Creek watersheds was conducted by Indiana Department of Environmental Management (IDEM) in 2010. The TMDL development process includes water chemistry data collection and analysis, and collection of data to determine an Index of Biotic Integrity (IBI) for fish, as well as rank aquatic habitat using the Qualitative Habitat Evaluation Index (QHEI). A stream's IBI score represents the degree to which a body of water is capable of supporting a "well-balanced aquatic community." This is further defined as "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)]. A stream segment is non-supporting for Aquatic Life Use (ALUS) when the monitored fish community receives an Index of Biotic Integrity (IBI) score of less than 35 which is considered "Poor" or "Very Poor". Table 19 below, modified from a table developed by Karr et al. 1986, shows how streams and rivers in Indiana are ranked using the IBI ranking system for fish.

Water quality samples are taken using a randomized grab sample and analyzed by IDEM before the development of the TMDL begins. Nutrient samples were collected three times during the summer of 2010, and IBI and QHEI samples were collected once during the summer of 2010 at certain sample sites. Samples were taken at 60 locations total within the Pigeon Creek and Pigeon River watersheds, with 34 of those sites located within this project area. Samples were analyzed for *E. coli*, nitrate-nitrite, TKN, total nitrogen, total phosphorus, total suspended solids, fish IBI and habitat.

After examining the results of the survey it was determined that the primary cause of impairment was *Escherichia coli* bacteria (*E. coli*) and nutrients. Pollution sources in the watersheds include non-point sources (e.g. row crop agriculture and pastures), urban and rural runoff, land application of manure, and point sources (e.g. straight pipe dischargers), septic systems, and combined sewer overflow outlets (in Steuben County only; not in this project area).

Table 19: IDEM IBI Ranking System

Total IBI Score	Integrity Class	Attributes
53-60	Excellent	Comparable to “least impacted” conditions, exceptional assemblage of species.
45-52	Good	Decreased species richness (intolerant species in particular), sensitive species present.
35-44	Fair	Intolerant and sensitive species absent, skewed trophic structure.
23-34	Poor	Top carnivores and many expected species absent or rare, omnivores and tolerant species dominant.
12-22	Very Poor	Few species and individuals present, tolerant species dominant, diseased fish frequent.
<12	No Fish	No fish captured during sampling.

3.2.3 Fish Consumption Advisory (FCA)

The Indiana Department of Environmental Management, the Indiana Department of Natural Resources and the Indiana Department of Health have worked together since 1972 on a collaborative effort to compile the Indiana Fish consumption advisory. The Michigan Department of Community Health (MDCH) is responsible for the Michigan Fish Consumption Advisory. The advisories are mostly based on fish tissue samples. It is important to note that a fish advisory for a body of water does not mean that the water is unsafe for other recreational activities.

The state of Indiana has assigned one of five groups to fish that are on the fish consumption advisory. Those groups are listed in Table 20.

Table 20: Indiana Fish Consumption Advisory Groups

Advisory Groups of the Indiana Fish Consumption Advisory	
Group 1	Unrestricted consumption. One meal per day for women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15.
Group 2	Limit to one meal per week for adults. One meal per month for women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15.
Group 3	Limit to one meal per month for adults. Women who are pregnant or breast-feeding, women who plan to have children, and children under the age of 15 DO NOT EAT.
Group 4	Limit to one meal every 2 months for adults. Women who are pregnant or breast-feeding, women who plan to have children, and children under the age of 15 DO NOT EAT.
Group 5	No consumption (DO NOT EAT).

Common carp is on the fish consumption advisory for all water bodies within Indiana. Depending on the size of the fish, it is either placed in the group 3, 4, or 5 advisory group. Visit, www.in.gov/isdh/files/2010_FCA.pdf for more information. The Michigan Fish Consumption Advisory for the Pigeon River notes consumption warnings for smallmouth bass and suckers. More information can be found at, www.michigan.gov/fishandgameadvisory. FCA's for specific waterbodies are discussed in section 3.3 under the respective subwatershed.

3.2.4 Michigan Biosurveys

The Surface Water Assessment Section, Water Bureau, MI DEQ, conducted qualitative biological surveys and collected water and sediment samples in 2000 and 2005 to assess point and non-point source pollution throughout the upper St. Joseph River watershed. Both chemical and biological integrity data was collected.

Biological communities respond to the cumulative effects of multiple environmental stressors, so this monitoring component is an important tool for water quality evaluation. Good water quality is indicated if the diversity of macroinvertebrates and fish is high, and poor water quality is generally indicated by low biota diversity and/or abundance.

The surveys were conducted according to the guidelines of Great Lakes Environmental Assessments Section (GLEAS) Procedure #51 (MDEQ, 1997). The macroinvertebrate communities were scored with metrics that rate waterbodies from excellent (+5 to +9) to poor (-5 to -9). However, ratings ranging from +4 to -4 are considered acceptable ratings. Those ratings that are in the negative, but have not reached -5, are indicative of waterbodies that are strongly tending toward poor quality, while those with positive ratings, but have not reached a

rating of +5 are indicative of only a slight impairment. Stream habitat was qualitatively evaluated using a scoring system that ranged in value from 0 to 135.

Only the portion of the Pigeon River subwatershed located in Michigan was involved in the Michigan Biosurvey project and will be discussed under the respective subwatershed in Section 3 of this WMP.

3.2.5 Steuben County SWCD Water Quality Monitoring Program

The Steuben County SWCD has collected and analyzed water quality samples throughout the county on a limited basis since 1996. Testing was done using both the Hoosier Riverwatch protocol and professional laboratories. Steuben County SWCD tested for several parameters relevant to the work being conducted for this project including, *E. coli*, total phosphorus, TSS, dissolved oxygen, pH, temperature, and specific conductance. One sample site that Steuben County SWCD has been collecting data at since 2007 is located within this project area, in the Green Lake/Green Creek subwatershed.

3.2.6 LaGrange County SWCD Water Quality Monitoring Program

The LaGrange County SWCD began water sampling at 60 sites throughout the Pigeon River watershed project area in November, 2010. Grab samples were collected once monthly and were taken back to the SWCD's approved laboratory for analysis. A flow meter was also used in the field. Parameters analyzed include pH, temperature, dissolved oxygen, total dissolved solids, turbidity, *E. coli*, nitrates, total phosphorus, and total suspended solids. Flow was also measured at a minimum of one site in each subwatershed to aid in load calculations. Water quality monitoring by the LaGrange County SWCD will continue as long as funds are available to support the task.

3.3 Water Quality Data Analysis at the Subwatershed Level

An analysis of historical data was performed breaking the data down to the subwatershed level. The following sections describe the results of each of the water quality studies mentioned in section 3.2 at the subwatershed level. Please note that sample sites identified on the map are only numbered if those particular sample sites are discussed in the narrative.

3.3.1 Green Lake/Green Creek Subwatershed

There are fifteen total water quality sampling sites located within the Green Lake/Green Creek subwatershed, as can be seen in Figure 15. Three sites were used by IDEM for the 303(d) list; three sites were used by IDEM for the TMDL report; two sites were used by IDEM to collect biological data; one site was used by Steuben County SWCD for their water quality monitoring program, and five sample sites were used by LaGrange County SWCD to collect water quality data for the purposes of this WMP project.

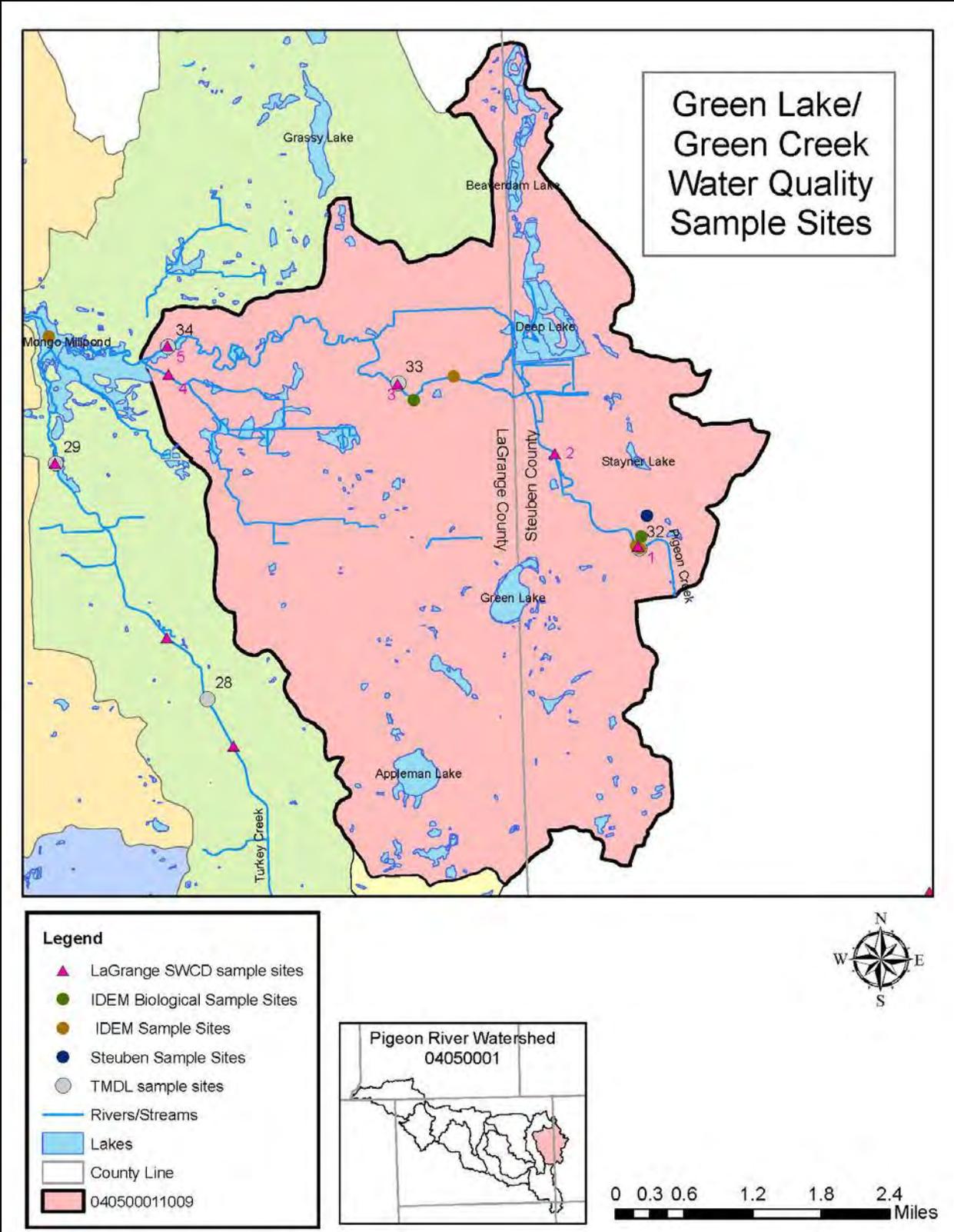


Figure 15: Green Lake/Green Creek Water Quality Sample Sites

IDEM Integrated Report Water Quality Assessment

IDEM collected water samples for analysis weekly in June, July, and September in 2000 and monthly from June through October in 2010. As can be seen in Table 21, nearly every parameter exceeded the set target during the testing cycles. Of particular note is that *E. coli* exceeded the state standard of 235 cfu/100ml 40% of the time and it exceeded the geometric mean standard of 125 CFU/100 ml, and TKN exceeded the target of 0.076mg/L 37% of the time.

Table 21: Green Lake/Green Creek: IDEM 303(d) List Monitoring Data Analysis

Green Lake/Green Creek			
Parameter	Mean	Unit	# Does Not Meet Target
Ammonia	0.395	mg/L	3/26
Total Kjeldahl Nitrogen	0.567	mg/L	11/30
Nitrate-Nitrite	0.636	mg/L	3/28
Suspended Solids, Total	5.333	mg/L	0/3
Dissolved Solids, Total	227.167	mg/L	0/12
Turbidity	7.065	NTU	3/17
Phosphorus, Total	0.116	mg/L	3/28
Dissolved Oxygen	6.406	mg/L	6/53
pH	7.615	SU	0/33
<i>E. coli</i>	(geo mean) 244.94	CFU/100 ml	1/1

IDEM TMDL Study

Three sample sites were selected and analyzed by IDEM for the Pigeon Creek and Pigeon River TMDL. Each site was sampled in June, July and September, 2010. As can be seen in Table 22, nitrate-nitrite exceeded the target level of 1.5 mg/L in 11% of the samples, and dissolved oxygen exceeded the Indiana state standard in 11% of the samples. It should also be noted that IBI and QHEI was determined for this subwatershed, and the resulting scores indicate a healthy aquatic ecosystem.

Table 22: Green Lake/Green Creek: IDEM TMDL Study Data Analysis

Green Lake/Green Creek			
Parameter	Mean	Unit	# Does Not Meet Target
Total Kjeldahl Nitrogen	0.939	mg/L	0/9
Nitrate-Nitrite	1.11	mg/L	1/9
Suspended Solids, Total	2.000	mg/L	0/9
Phosphorus, Total	0.020	mg/L	0/9
Dissolved Oxygen (site 25)	7.540	mg/L	2/18
pH (site 25)	7.950	SU	0/18
IBI - Site 32/33/34	50/48/56		
QHEI - Site 32/33/34	Good/Good/Good to Excellent		

Steuben County Water Quality Monitoring Program

As part of the Steuben County SWCD's ongoing water quality monitoring program, water quality data was collected ten times during the recreational season between 2007 and 2010 at one location in the Green Creek/Green Lake subwatershed. As can be seen in Table 23, both TSS and D.O. exceeded the target level in 10% of the samples, and *E. coli* exceeded the state standard in 20% of the samples.

Table 23: Green Lake/Green Creek: Steuben County SWCD Water Quality Data Analysis

Green Lake/Green Creek - Pigeon Creek			
Parameter	Mean	Unit	# Does Not Meet Target
Suspended Solids, Total	8.080	mg/L	1/10
Phosphorus, Total	0.037	mg/L	0/10
Dissolved Oxygen	8.063	mg/L	1/10
pH	7.809	SU	0/10
<i>E. coli</i>	204.000	CFU/100 ml	2/10

LaGrange County SWCD Water Quality Monitoring Program

LaGrange County SWCD sampled water quality monthly at five sites within Green Lake/Green Creek subwatershed from November 2010 through August 2011. As can be seen in Table 24, temperature, D.O, TDS, turbidity, *E. coli*, nitrates, total phosphorus and TSS all exceeded the target levels. However, special consideration should be given to temperature, D.O. and nitrates, as they all exceed target levels nearly 50% of the time and are all closely related. It is also important to note that temperature exceeded the maximum of 85 degrees Fahrenheit in 50% of the samples analyzed. The SWCD also sampled the macroinvertebrate community located at each of the five sample sites located in Green Lake/Green Creek. Sites 1, 2, 3, and 5 all scored high enough to indicate an excellent aquatic ecosystem. Site 4 also scored high indicating a good aquatic ecosystem.

Table 24: Green Lake/Green Creek: LaGrange County Water Quality Data Analysis

Green Lake/Green Creek			
Parameter	Mean	Unit	% that does not meet target
pH	7.7	SU	0.0%
Temp	10.9	Celsius	50.0%
D.O.	9.3	mg/L	52.0%
Total Dissolved Solids	444.5	mg/L	6.0%
Turbidity	5.5	NTU	10.0%
E. coli	211.0	CFU/100 ml	32.0%
Nitrate	2.0	mg/L	46.0%
Phosphorus, Total	0.2	mg/L	8.0%
Total Suspended Solids	8.0	mg/l	4.0%
Macroinvertebrates	43	River Watch	0.0%
Habitat	87	River Watch	0.0%

3.3.2 Little Turkey Lake Subwatershed

There are ten total water quality sampling sites located within the Little Turkey Lake/Turkey Creek subwatershed, as can be seen in Figure 16. Two sites were used by IDEM for the 303(d) list; two sites were used by IDEM for the TMDL report; one site was used by IDEM to collect biological data, and five sample sites were used by LaGrange County SWCD to collect water quality data for the purposes of this WMP project.

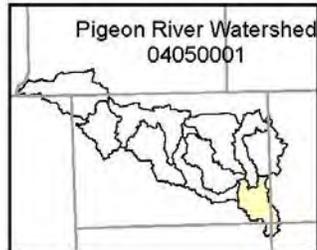
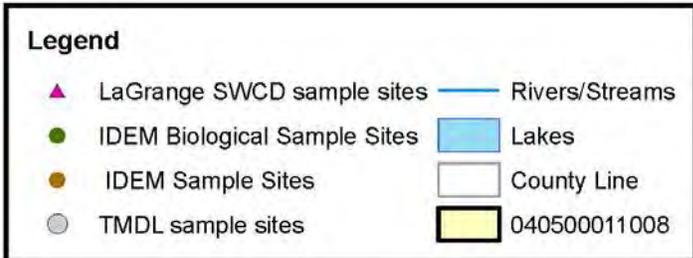


Figure 16: Little Turkey Lake/Turkey Creek Water Quality Sample Sites

IDEM Integrated Report Water Quality Assessment

IDEM collected water samples for analysis in Little Turkey Lake/Turkey Creek subwatershed in 2005 and 2010. As can be seen in Table 25, TKN exceeded the target level of 0.076 mg/L in 33% of the samples, TSS exceeded the target of 25 mg/L in 50% of the samples, and *E. coli* exceeded the geometric mean state standard of 125 cfu/100ml.

Table 25: Little Turkey Lake/Turkey Creek: IDEM 303(d) Monitoring Data Analysis

Little Turkey Lake			
Parameter	Mean	Unit	# Does Not Meet Target
Ammonia	0.048	mg/L	0/5
Total Kjeldahl Nitrogen	0.367	mg/L	2/6
Nitrate-Nitrite	0.267	mg/L	0/6
Suspended Solids, Total	4.333	mg/L	0/3
Turbidity	5.799	NTU	0/18
Phosphorus, Total	0.085	mg/L	0/6
Dissolved Oxygen	6.160	mg/L	6/18
pH	7.873	SU	0/18
<i>E. coli</i>	(geo mean) 155.38	CFU/100 ml	1/1

IDEM TMDL Study

Two sample sites within Little Turkey Lake/Turkey Creek subwatershed were selected and analyzed by IDEM for the Pigeon Creek and Pigeon River TMDL. Each site was sampled in June, July and September, 2010. As can be seen in Table 26, TKN exceeded the target level of 0.076 mg/L in 50% of the samples, nitrate-nitrite exceeded the target level of 1.5 mg/L in 33% of the samples, TSS exceeded the target level of 25 mg/L in one sample, and dissolved oxygen exceeded the Indiana state standard in 50% of the samples. It should be noted that the high level of D.O. in the water column may be directly related to the high level of nitrogen found in the water column. IBI and QHEI were determined for Little Turkey Lake/Turkey Creek and the scores indicate a very poor aquatic ecosystem.

Table 26: Little Turkey Lake/Turkey Creek: IDEM TMDL Study Data Analysis

Little Turkey Lake (Sites 25 and 26)			
Parameter	Mean	Unit	# Does Not Meet Target
Total Kjeldahl Nitrogen	0.558	mg/L	3/6
Nitrate-Nitrite	2.432	mg/L	2/6
Suspended Solids, Total	10.333	mg/L	1/6
Phosphorus, Total	0.085	mg/L	0/6
Dissolved Oxygen	7.700	mg/L	6/12
pH	7.850	SU	0/12
Site 25-IBI	12		
Site 25-QHEI	Very Poor		

Fish Consumption Advisory

Little Turkey Lake, Lake of the Woods and McClish Lake, located in the Little Turkey Lake/Turkey Creek subwatershed, are listed on the Fish Consumption Advisory for Black Crappie and Bluegill, both of which are a Group 1 advisory. Lake of the Woods, also located in the Little Turkey Lake/Turkey Creek subwatershed, is also listed for Bluegill, which is a Group 1 advisory.

LaGrange County SWCD Water Quality Monitoring Program

LaGrange County SWCD sampled water quality monthly at five sites within Little Turkey Lake/Turkey Creek subwatershed from November 2010 through August 2011. As can be seen in Table 27, all parameters exceeded the target levels at some point during the sampling cycle. However, it should be noted that pH and D.O. exceeded the target levels in at least 60% of the samples, nitrate exceeded the target level 43% of the time, and *E. coli* and total phosphorus exceeded the target levels in at least 20% of the samples. The SWCD also sampled the macroinvertebrate community located at each of the five sample sites located in Little Turkey Lake/Turkey Creek. Sites 11, 12, 13, and 15 all scored high enough to indicate an excellent aquatic ecosystem. Site 14 also scored high indicating a good aquatic ecosystem.

Table 27: Little Turkey Lake/Turkey Creek: LaGrange County Water Quality Data Analysis

Little Turkey Lake			
Parameter	Mean	Unit	% that does not meet target
pH	8.3	SU	60.0%
Temp	11.7	Celsius	40.0%
D.O.	9.6	mg/L	68.0%
Total Dissolved Solids	342.1	mg/L	2.0%
Turbidity	5.3	NTU	8.0%
E. coli	276.0	CFU/100 ml	22.0%
Nitrate	1.5	mg/L	43.0%
Phosphorus, Total	0.2	mg/L	20.0%
Total Suspended Solids	10.0	mg/L	8.0%
Macroinvertebrates	31	River Watch	0.0%
Habitat	82	River Watch	0.0%

3.3.3 Mongo Millpond Subwatershed

There are ten total water quality sampling sites located within the Mongo Millpond subwatershed, as can be seen in Figure 17. Two sites were used by IDEM for the 303(d) list; two sites were used by IDEM to collect biological data; three sites were used by IDEM for the TMDL report, and five sample sites were used by LaGrange County SWCD to collect water quality data for the purposes of this WMP project.

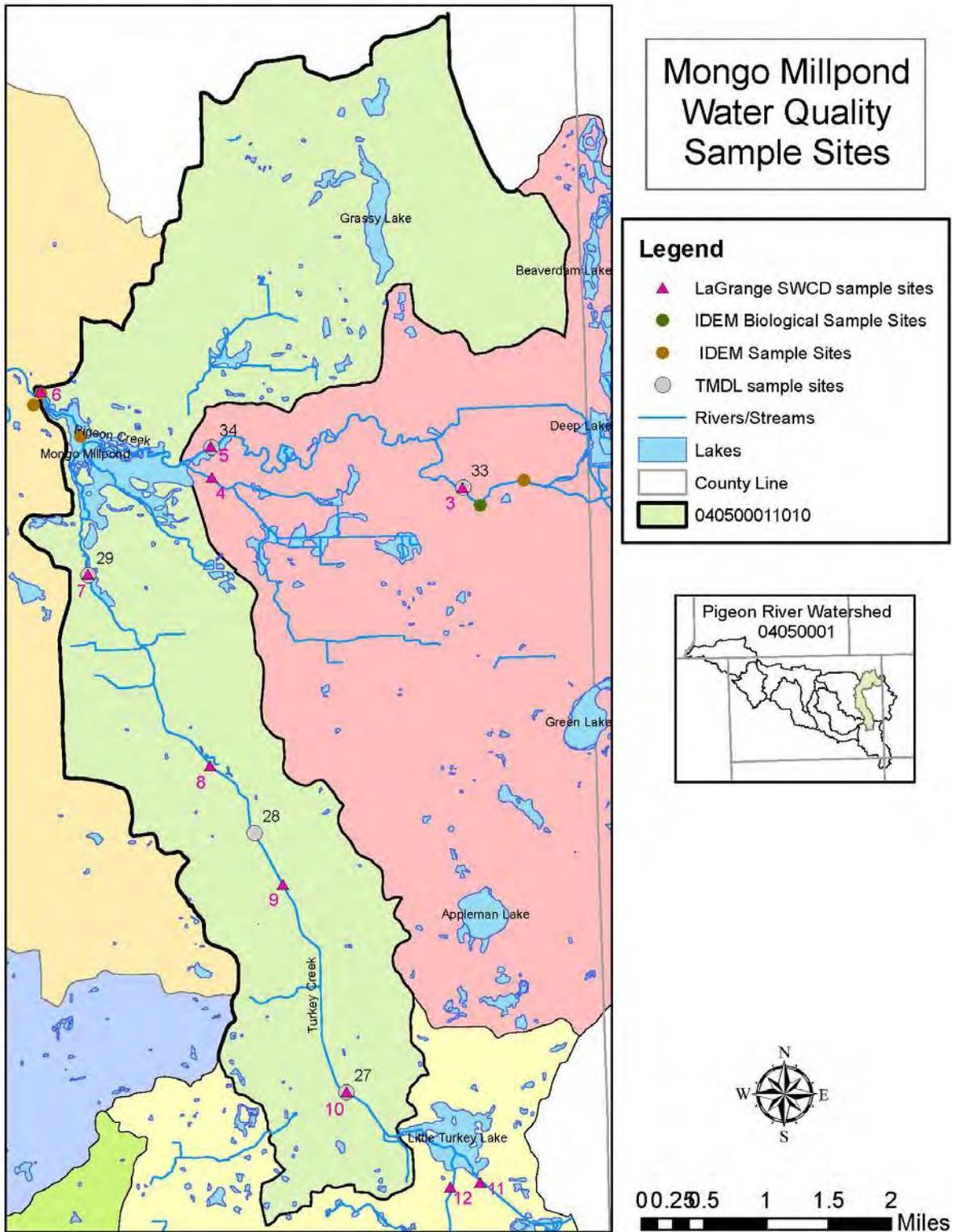


Figure 17: Mongo Millpond Water Quality Sample Sites

IDEM Integrated Report Water Quality Assessment

IDEM collected water samples for analysis in Mongo Millpond subwatershed in 2000. Samples were taken from Mongo Millpond and the Pigeon River. The sample analysis is presented in separate tables below as the hydrology of the millpond and river are very different. Table 28 shows the data analysis for the Mongo Millpond and as can be seen in the table, nitrogen levels exceeded the target levels and turbidity exceeded the target level of 10.4 NTU in 13% of the samples.

Table 28: Mongo Millpond: IDEM 303(d) Monitoring Data Analysis

Mongo Millpond - Mongo Millpond			
Parameter	Mean	Unit	# Does Not Meet Target
Total Kjeldahl Nitrogen	0.537	mg/L	1/2
Nitrate-Nitrite	2.597	mg/L	1/1
Turbidity	5.689	NTU	2/15
Phosphorus, Total	0.044	mg/L	0/1
Dissolved Oxygen	7.979	mg/L	0/17

Table 29 below shows the data analysis of the Pigeon River sampling site located within the Mongo Millpond subwatershed. As can be seen in the table, turbidity exceeded the target levels in one sample. Five *E.coli* samples were collected spaced evenly within a 30 day period to determine the geometric mean.

Table 29: Mongo Millpond-Pigeon River: IDEM 303(d) Monitoring Data Analysis

Mongo Millpond - Pigeon River			
Parameter	Mean	Unit	# Does Not Meet Target
Turbidity	4.980	NTU	1/5
Dissolved Oxygen	7.979	mg/L	0/17
pH	7.740	SU	0/5
<i>E. coli</i>	(geo. Mean) 159.57	CFU/100 ml	1/1

IDEM TMDL Study

Three sample sites within Mongo Millpond subwatershed were selected and analyzed by IDEM for the Pigeon Creek and Pigeon River TMDL. Each site was sampled in June, July and September, 2010. As can be seen in Table 30, nitrate-nitrite and D.O. were the only two parameters that exceeded the target level. Nitrate-nitrite and D.O. exceeded the target levels each twice. Therefore, it is reasonable to suspect that the spikes in D.O. may be due to the spikes in nitrogen levels which can increase algae production and increase dissolved oxygen in the water column. It should also be noted that biological data was collected at two sites in Mongo Millpond. The IBI and QHEI scores indicate a healthy aquatic ecosystem in the Mongo Millpond subwatershed.

Table 30: Mongo Millpond: IDEM TMDL Study Data Analysis

Mongo Millpond (Sites 27, 28, and 29)			
Parameter	Mean	Unit	# Does Not Meet Target
Total Kjeldahl Nitrogen	0.939	mg/L	0/9
Nitrate-Nitrite	3.272	mg/L	2/9
Suspended Solids, Total	2.000	mg/L	0/9
Phosphorus, Total	0.020	mg/L	0/9
Dissolved Oxygen	7.580	mg/L	2/18
pH	7.950	SU	0/18
IBI - Site 28/29	52/54		
QHEI - Site 28/29	Good/Good to Excellent		

LaGrange County SWCD Water Quality Monitoring Program

LaGrange County SWCD sampled water quality monthly at five sites within Mongo Millpond subwatershed from November 2010 through August 2011. As can be seen in Table 31, all parameters exceeded the target levels at some point during the sampling cycle except for pH which never exceeded the target level. However, it should be noted temperature and nitrate exceeded the target levels set by this project in 50% and 56%, respectively, of the samples. D.O. exceeded target levels in 62% of the samples, and total phosphorus and *E. coli* exceeded the targets levels in at least 10% of the samples. The SWCD also sampled the macroinvertebrate community located at each of the five sample sites located in the Mongo Millpond subwatershed. All five sites scored high enough to indicate an excellent aquatic ecosystem.

Table 31: Mongo Millpond: LaGrange County Water Quality Data Analysis

Mongo Millpond			
Parameter	Mean	Unit	% that does not meet target
pH	8.1	SU	0.0%
Temp	11.4	Celsius	50.0%
D.O.	9.5	mg/L	64.0%
Total Dissolved Solids	386.8	mg/L	2.0%
Turbidity	4.7	NTU	2.0%
E. coli	147.0	CFU/100 ml	16.0%
Nitrate	1.7	mg/L	56.0%
Phosphorus, Total	0.2	mg/L	10.0%
Total Suspended Solids	8.0	mg/L	2.0%
Macroinvertebrates	41	River Watch	0.0%
Habitat	88	River Watch	0.0%

3.3.4 Cline Lake Subwatershed

There are sixteen total water quality sampling sites located within the Cline Lake subwatershed, as can be seen in Figure 18. Six sites were used by IDEM for the 303(d) list; four sites were used by IDEM for the TMDL report, of which three were used to collect biological data, and six sample sites were used by LaGrange County SWCD to collect water quality data for the purposes of this WMP project.

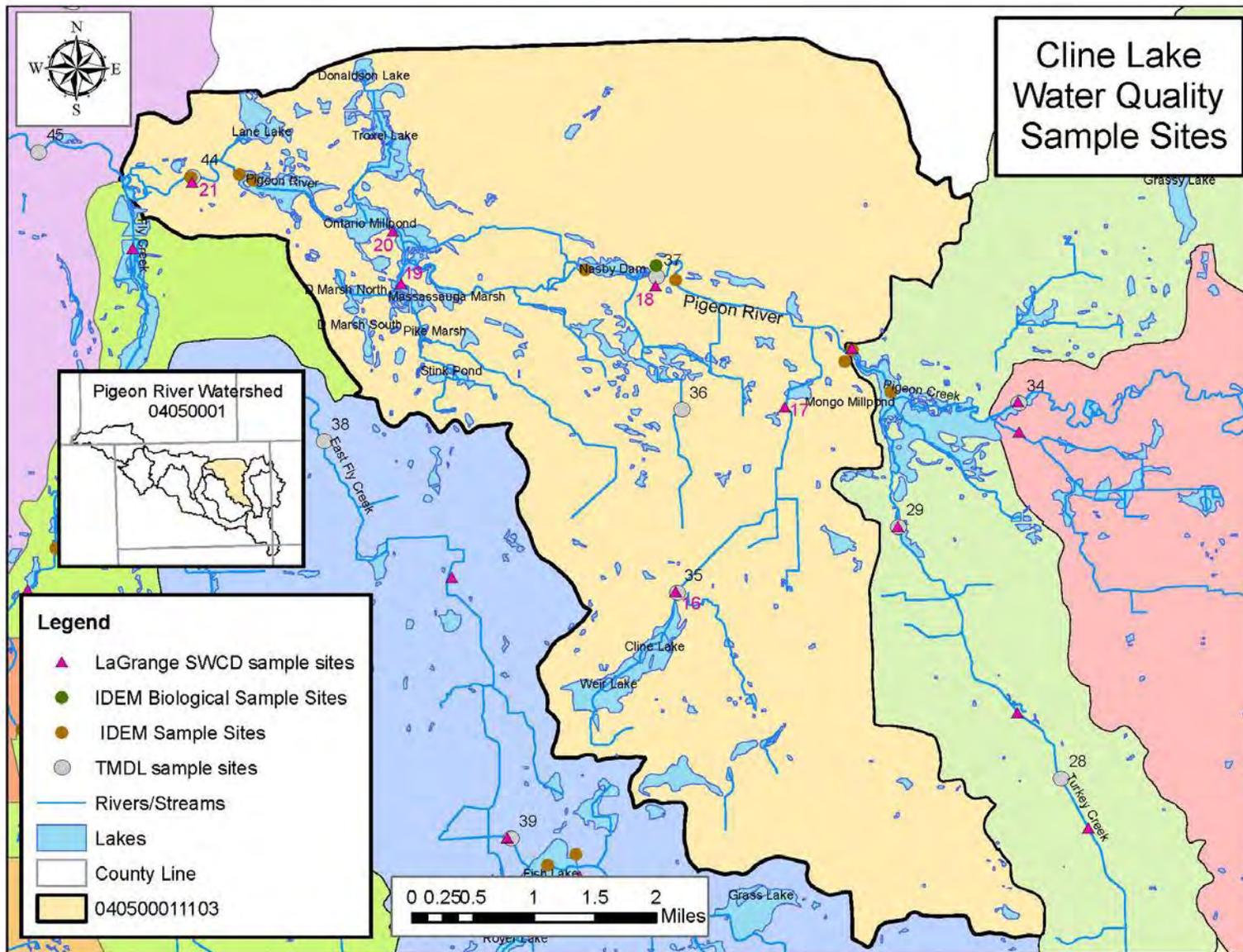


Figure 18: Cline Lake Subwatershed Water Quality Sample Sites

IDEM Integrated Report Water Quality Assessment

IDEM collected water samples for analysis in Cline Lake subwatershed in 2000 and 2005. Samples were taken from Nasby and Ontario Millponds and the Pigeon River. The sample analysis is presented in separate tables below as the hydrology of the millpond and river are very different. Table 32 shows the data analysis for the Nasby and Ontario Millponds and as can be seen in the table, nitrate-nitrite exceeded the target level in 100% of the samples. Samples were collected in July 2000 from each pond once for most parameters. Two samples from each pond were collected for analysis of TKN and three samples were collected from Nasby Dam and four samples from Ontario Millpond for analysis of DO.

Table 32: Cline Lake – Nasby and Ontario Millponds: IDEM 303(d) Monitoring Data Analysis

Cline Lake - Nasby and Ontario Millponds			
Parameter	Mean	Unit	# Does Not Meet Target
Ammonia	0.107	mg/L	0/2
Total Kjeldahl Nitrogen	0.335	mg/L	2/4
Nitrate-Nitrite	2.404	mg/L	2/2
Phosphorus, Total	0.066	mg/L	0/5
Dissolved Oxygen	7.271	mg/L	0/7
pH	8.000	SU	0/2

Table 33 below shows the data analysis of the Pigeon River sampling site located within the Cline Lake subwatershed. As can be seen in the table, TKN exceeded the target level in one sample, turbidity exceeded the target level in two samples, and *E. coli* exceeded geometric mean state standard of 125 cfu/100ml.

Table 33: Cline Lake-Pigeon River: IDEM 303(d) Monitoring Data Analysis

Cline Lake - Pigeon River			
Parameter	Mean	Unit	# Does Not Meet Target
Ammonia	0.000	mg/L	0/2
Total Kjeldahl Nitrogen	0.333	mg/L	1/3
Nitrate-Nitrite	0.823	mg/L	0/3
Suspended Solids, Total	0.000	mg/L	0/3
Dissolved Solids, Total	383.333	mg/L	0/3
Turbidity	5.689	NTU	2/15
Phosphorus, Total	0.070	mg/L	0/3
Dissolved Oxygen	7.979	mg/L	0/17
pH	7.837	SU	0/17
<i>E. coli</i>	(geo mean) 173.94	CFU/100 ml	1/1

IDEM TMDL Study

Four sample sites within Cline Lake subwatershed were selected and analyzed by IDEM for the Pigeon Creek and Pigeon River TMDL. Each site was sampled in June, July and September, 2010. As can be seen in Table 34, nitrate-nitrite and D.O. were the only two parameters that exceeded the target level. Nitrate-nitrite and D.O. exceeded the target levels each once. TKN exceeded the target level of 0.076 mg/L in 82% of the samples and TSS exceeded the target level of 25 mg/L in 27% of the samples. It should also be noted that biological data was collected at three sites in Cline Lake. The IBI and QHEI for site 35, a headwater stream, indicate a healthy aquatic ecosystem. However, downstream at sites 37 and 44, both located on the main stem of the Pigeon River, the IBI and QHEI scores indicate a very poor aquatic ecosystem.

Table 34: Cline Lake: IDEM TMDL Study Data Analysis

Cline Lake (Sites 35, 36, 37, and 44)			
Parameter	Mean	Unit	# Does Not Meet Target
Total Kjeldahl Nitrogen	0.787	mg/L	9/11
Nitrate-Nitrite	1.147	mg/L	1/11
Suspended Solids, Total	12.636	mg/L	3/11
Phosphorus, Total	0.031	mg/L	0/11
Dissolved Oxygen	7.500	mg/L	1/23
pH	7.670	SU	0/3
IBI - Site 35/37/44	54/12/34		
QHEI - Site 35/37/44	Good to Excellent/Very Poor/ Poor		

LaGrange County SWCD Water Quality Monitoring Program

LaGrange County SWCD sampled water quality monthly at six sites within Cline Lake subwatershed from November 2010 through August 2011. As can be seen in Table 35, all parameters did not meet the target levels at some point during the sampling cycle except for TSS which never exceeded the target level. D.O. did not meet target levels 64% of the time, with 7% of those that did not meet the target level falling below 4 mg/L and all other samples measuring above 9 mg/L. It should also be noted that E. coli exceeded the state standard of 235 cfu/100 ml in 20% of the samples and nitrates exceeded the target level of 1.5 mg/L in 46% of the samples. The SWCD also sampled the macroinvertebrate community located at each of the six sample sites located in the Cline Lake subwatershed. All six sites scored high enough to indicate an excellent aquatic ecosystem.

Table 35: Cline Lake: LaGrange County Water Quality Data Analysis

Cline Lake			
Parameter	Mean	Unit	% that does not meet target
pH	8.5	SU	14.0%
Temp	11.7	Celsius	37.0%
D.O.	10.0	mg/L	64.0%
Total Dissolved Solids	391.6	mg/L	2.0%
Turbidity	5.1	NTU	3.0%
E. coli	140.0	CFU/100 ml	20.0%
Nitrate	1.8	mg/L	46.0%
Phosphorus, Total	0.2	mg/L	8.0%
Total Suspended Solids	7.0	mg/L	0.0%
Macroinvertebrates	41	River Watch	0.0%
Habitat	84	River Watch	0.0%

3.3.5 East Fly Creek Subwatershed

There are thirteen total water quality sampling sites located within the East Fly Creek subwatershed, as can be seen in Figure 19. Three sites were used by IDEM for the 303(d) list; three sites were used by IDEM for the TMDL report, of which two were used to collect biological data, and seven sample sites were used by LaGrange County SWCD to collect water quality data for the purposes of this WMP project.

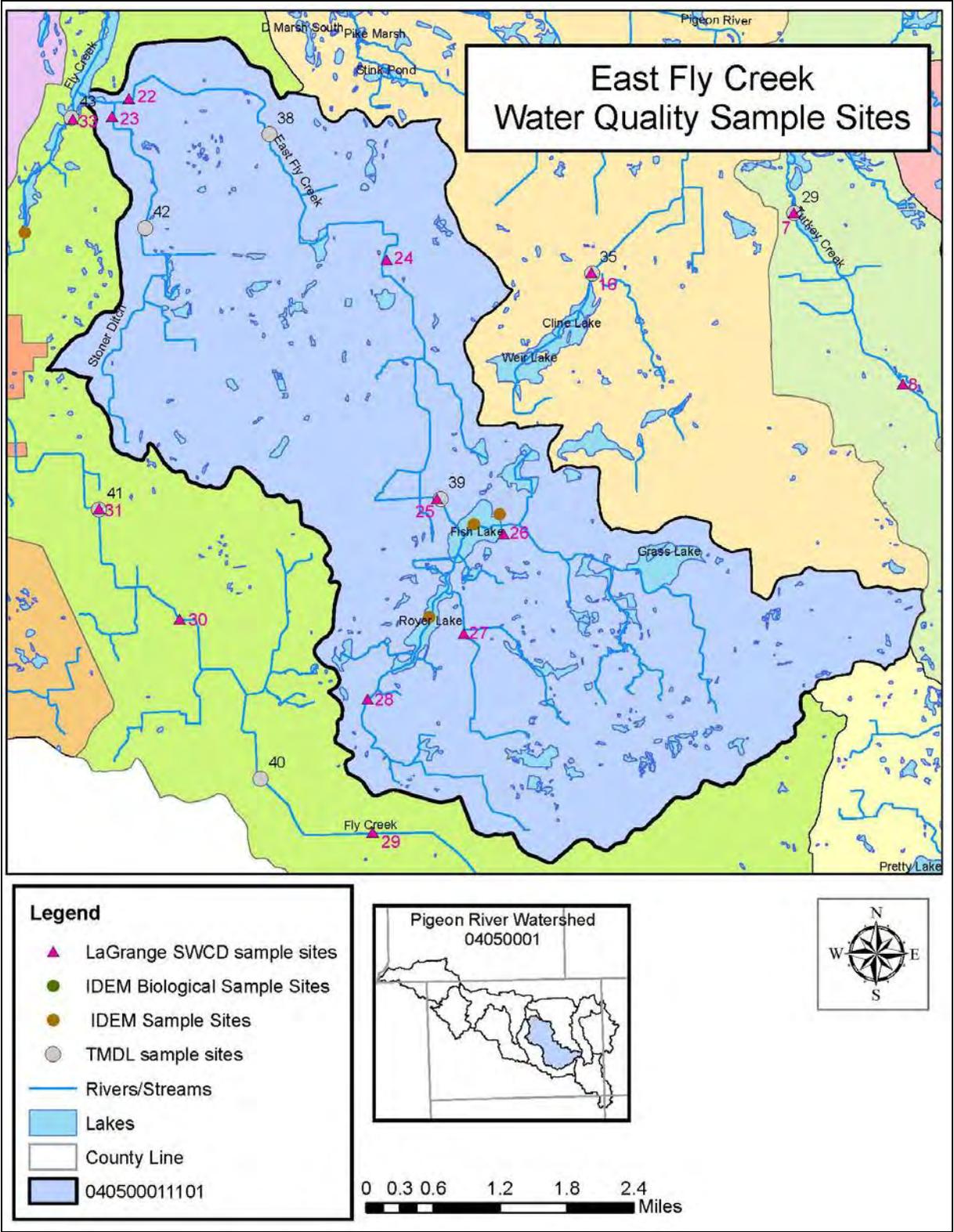


Figure 19: East Fly Creek Water Quality Sample Sites

IDEM Integrated Report Water Quality Assessment

IDEM collected water samples for analysis in East Fly Creek subwatershed in 2000. As can be seen in Table 36, TKN, and turbidity exceeded the target levels once during the sampling cycle.

Table 36: East Fly Creek: IDEM 303(d) Monitoring Data Analysis

East Fly Creek			
Parameter	Mean	Unit	# Does Not Meet Target
<i>E. coli</i>	(geo mean) 41.84	mg/L	0/1
Total Kjeldahl Nitrogen	1.074	mg/L	1/2
Turbidity	4.980	mg/L	1/5
Dissolved Oxygen	6.674	mg/L	0/9
pH	7.767	SU	0/6

IDEM TMDL Study

Four sample sites within East Fly Creek subwatershed were selected and analyzed by IDEM for the Pigeon Creek and Pigeon River TMDL. One of the four sites was taken from the Fish and Royer Lake WWTP outfall. The results of the analysis are separated into two different tables below, one for the stream sample sites, and one for the WWTP outfall site. The stream sample sites were sampled in June, July and September, 2010 and the WWTP was tested once in September, 2010. As can be seen in Table 37, nitrate-nitrite, TKN, and TSS all exceeded the target levels. Nitrate-nitrite exceeded the target level of 1.5 mg/L in 33% of the samples, TKN exceeded the target level of 0.076 mg/L in 67% of the samples and TSS exceeded the target level of 25 mg/L in 11% of the samples. It should also be noted that biological data was collected at two sites in East Fly Creek subwatershed. The IBI and QHEI for site 39, located on the main channel of East Fly Creek, indicate a healthy aquatic ecosystem. However, site 42, a headwater stream to Pigeon River had lower IBI and QHEI scores which indicate a very poor aquatic ecosystem.

Table 37: East Fly Creek: IDEM TMDL Study Data Analysis

East Fly Creek (Sites 38, 39, and 42)			
Parameter	Mean	Unit	# Does Not Meet Target
Total Kjeldahl Nitrogen	0.827	mg/L	6/9
Nitrate-Nitrite	1.544	mg/L	3/9
Suspended Solids, Total	6.667	mg/L	1/9
Phosphorus, Total	0.052	mg/L	0/9
Dissolved Oxygen	6.680	mg/L	0/18
pH	7.870	SU	0/18
IBI - Site 39/42	48/12		
QHEI - Site 39/42	Good/Very Poor		

Table 38 shows the results of the data analysis for the Fish and Royer Lake WWTP outfall. TKN and nitrate-nitrite each exceeded the target levels during the sampling cycle. This indicates that the WWTP is not completely eliminating the release of nitrogen into the stream. According to the US EPA, the WWTP had one violation of nitrogen in January, 2011. This violation has since been resolved. The violation reported by the US EPA does not coincide with the excessive nitrate-nitrite levels observed during the TMDL water quality analysis as that sample was taken in September of 2010.

Table 38: East Fly Creek-Fish and Royer Lake WWTP Outfall: IDEM TMDL Study Data Analysis

East Fly Creek (Fish and Royer Lake WWTP outfall)			
Parameter	Mean	Unit	# Does Not Meet Target
Total Kjeldahl Nitrogen	0.800	mg/L	1/1
Nitrate-Nitrite	20.400	mg/L	1/1
Suspended Solids, Total	0.000	mg/L	0/1
Phosphorus, Total	0.000	mg/L	0/1
Dissolved Oxygen	8.450	mg/L	0/1
pH	7.540	SU	0/1

Fish Consumption Advisory

Fish Lake, located within the East Fly Creek subwatershed, is listed on the 2010 Fish Consumption Advisory for Golden Redhorse and White Sucker. Both are Group 1 advisories.

LaGrange County SWCD Water Quality Monitoring Program

LaGrange County SWCD sampled water quality monthly at seven sites within East Fly Creek subwatershed from November 2010 through August 2011. As can be seen in Table 39, all parameters did not meet the target levels at some point during the sampling cycle except for TDS which never exceeded the target level. D.O. did not meet target levels 72% of the time, with 5% of those that did not meet the target level falling below 4 mg/L and all other samples measuring above 9 mg/L. It should also be noted that E. coli exceeded the state standard of

235 cfu/100 ml in 45% of the samples, total phosphorus exceeded the target level of 0.3 mg/L in 24% of the samples, and nitrates exceeded the target level of 1.5 mg/L in 91% of the samples. The high nitrates are due to direct animal access, lack of filter strips or streambank buffering, barnyards with direct runoff into ditches, and to a lesser extent field tiling and faulty or improperly installed septic systems. It would not be unreasonable to assume the high levels of D.O. are associated to the high levels of nutrients found in the water column as high levels of nutrients can contribute to excessive algae growth (observed at many sites) which will produce a lot of dissolved oxygen. The SWCD also sampled the macroinvertebrate community located at each of the seven sample sites located in the East Fly Creek subwatershed. Six of the sites scored high enough to indicate an excellent aquatic ecosystem and one site, located at the headwaters, scored only enough to indicate a fair aquatic ecosystem.

Table 39: East Fly Creek: LaGrange County Water Quality Data Analysis

East Fly Creek			
Parameter	Mean	Unit	% that does not meet target
pH	8.6	SU	16.0%
Temp	11.1	Celsius	30.0%
D.O.	10.4	mg/L	72.0%
Total Dissolved Solids	386.2	mg/L	0.0%
Turbidity	6.1	NTU	12.0%
E. coli	617.0	CFU/100 ml	45.0%
Nitrate	3.5	mg/L	91.0%
Phosphorus, Total	0.5	mg/L	24.0%
Total Suspended Solids	10.0	mg/L	6.0%
Macroinvertebrates	36	River Watch	0.0%
Habitat	86	River Watch	0.0%

3.3.6 Fly Creek Subwatershed

There are eleven total water quality sampling sites located within the Fly Creek subwatershed, as can be seen in Figure 20. Two sites were used by IDEM for the 303(d) list; three sites were used by IDEM for the TMDL report, of which two were used to collect biological data, and six sample sites were used by LaGrange County SWCD to collect water quality data for the purposes of this WMP project.

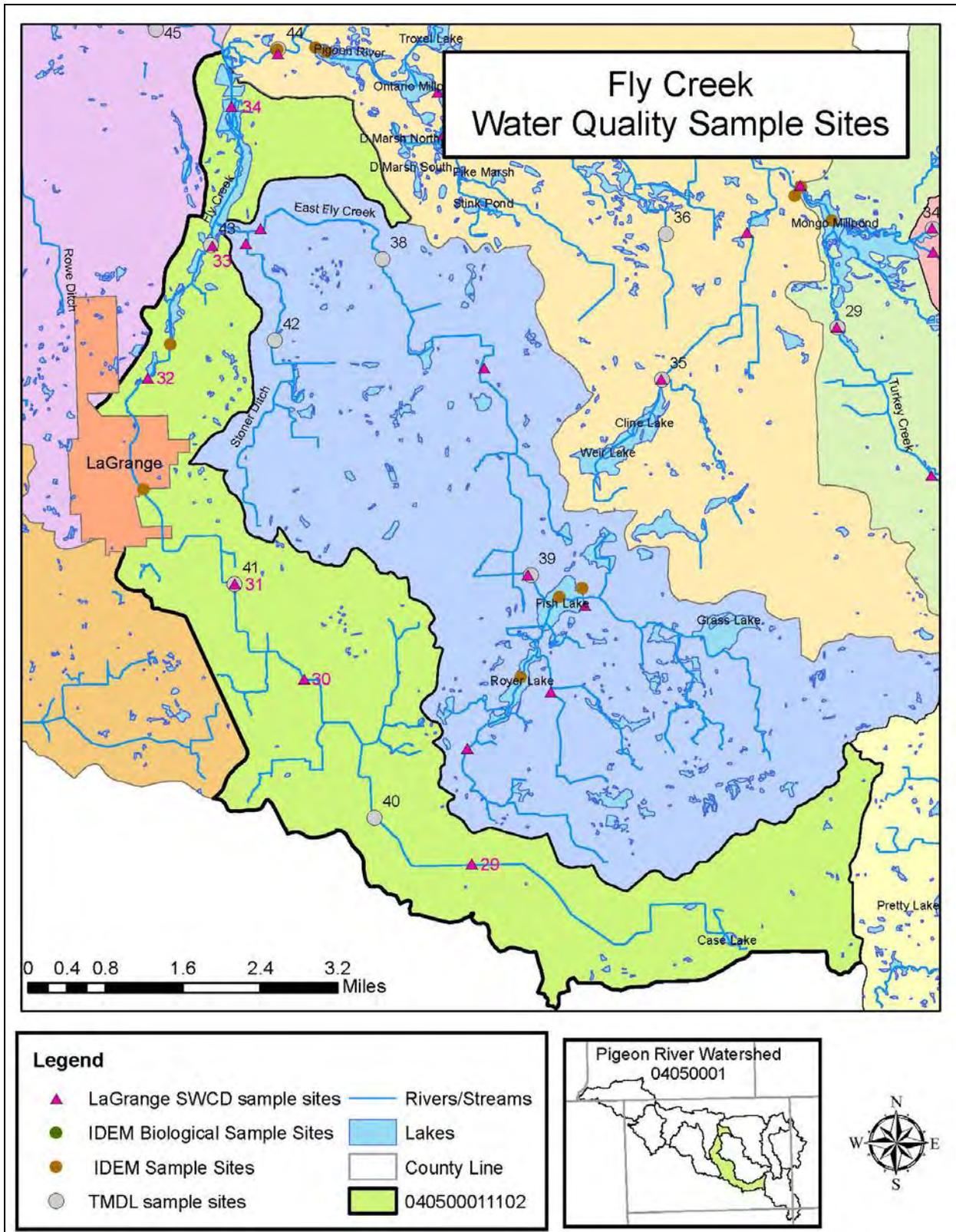


Figure 20: Fly Creek Water Quality Sample Sites

IDEM Integrated Report Water Quality Assessment

IDEM collected water samples for analysis in East Fly Creek subwatershed in 2000. As can be seen in Table 40, *E. coli*, D.O, and turbidity exceeded the target levels during the sampling cycle. Of particular note is that D.O. exceeded the target of 9 mg/L in 90% of the samples. *E. coli* did not exceed the geometric mean standard of 125 cfu/100ml. However, IDEM's Consolidated Assessment and Listing Methodology would consider this subwatershed impaired since *E.coli* samples collected in late June and July, 2000 resulted in very high readings averaging 1,370 cfu/100ml exceeding 576 cfu/100ml for a single sample.

Table 40: Fly Creek: IDEM 303(d) Monitoring Data Analysis

Fly Creek			
Parameter	Mean	Unit	# Does Not Meet Target
Turbidity	14.259	NTU	2/10
Dissolved Oxygen	10.346	mg/L	9/10
pH	7.932	SU	0/10
<i>E. coli</i>	(geo mean) 50.45	CFU/100 ml	0/1

IDEM TMDL Study

Three sample sites within Fly Creek subwatershed were selected and analyzed by IDEM for the Pigeon Creek and Pigeon River TMDL. The sites were sampled in June, July and September, 2010. As can be seen in Table 41, nitrate-nitrite, TKN, and D.O. were the only parameters that exceeded the target levels. TKN exceeded the target level of 0.076 mg/L in 11% of the samples, nitrate-nitrite exceeded the target level of 1.5 mg/L in 100% of the samples, and D.O. exceeded the target level of < 9mg/L in one sample. It should also be noted that biological data was collected at one site in Fly Creek subwatershed. The IBI and QHEI scores for site 43, located on the main channel of Fly Creek, indicate a poor to very poor aquatic ecosystem.

Table 41: Fly Creek: IDEM TMDL Study Data Analysis

Fly Creek (Sites 40, 41, and 43)			
Parameter	Mean	Unit	# Does Not Meet Target
Total Kjeldahl Nitrogen	0.079	mg/L	1/9
Nitrate-Nitrite	2.322	mg/L	9/9
Suspended Solids, Total	2.444	mg/L	0/9
Phosphorus, Total	0.011	mg/L	0/9
Dissolved Oxygen	7.460	mg/L	1/18
pH	7.790	SU	0/18
IBI - Site 43	26		
QHEI - Site 43	Very Poor to Poor		

LaGrange County SWCD Water Quality Monitoring Program

LaGrange County SWCD sampled water quality monthly at six sites within Fly Creek subwatershed from November 2010 through August 2011. As can be seen in Table 42, all parameters did not meet the target levels at some point during the sampling cycle except for TDS which never exceeded the target level. D.O. did not meet target levels 73% of the time, with 1% of those that did not meet the target level falling below 4 mg/L and all other samples measuring above 9 mg/L. It should also be noted that *E. coli* exceeded the state standard of 235 cfu/100 ml in 58% of the samples, total phosphorus exceeded the target level of 0.3 mg/L in 17% of the samples, and nitrates exceeded the target level of 1.5 mg/L in 100% of the samples. The high nitrates are due to direct animal access, lack of filter strips or streambank buffering, barnyards with direct runoff into ditches, and to a lesser extent field tiling and faulty or improperly installed septic systems. It would not be unreasonable to assume the high levels of D.O. are associated with the high levels of nutrients found in the water column as high levels of nutrients can contribute to excessive algae growth which will produce a lot of dissolved oxygen. The SWCD also sampled the macroinvertebrate community located at each of the six sample sites located in the Fly Creek subwatershed. All six of the sites scored high enough to indicate an excellent aquatic ecosystem.

Table 42: Fly Creek: LaGrange County Water Quality Data Analysis

Fly Creek			
Parameter	Mean	Unit	% that does not meet target
pH	8.5	SU	12.0%
Temp	10.5	Celsius	27.0%
D.O.	10.7	mg/L	73.0%
Total Dissolved Solids	437.8	mg/L	0.0%
Turbidity	6.2	NTU	13.0%
<i>E. coli</i>	1020.0	CFU/100 ml	58.0%
Nitrate	3.5	mg/L	100.0%
Phosphorus, Total	0.2	mg/L	17.0%
Total Suspended Solids	10.0	mg/L	33.0%
Macroinvertebrates	29	River Watch	0.0%
Habitat	81	River Watch	0.0%

3.3.7 Buck Lake/Buck Creek Subwatershed

There are twelve total water quality sampling sites located within the Buck Lake/Buck Creek subwatershed, as can be seen in Figure 21. One site was used by IDEM for the 303(d) list; three sites were used by IDEM for the TMDL report, of which one was used to collect biological data, and eight sample sites were used by LaGrange County SWCD to collect water quality data for the purposes of this WMP project.

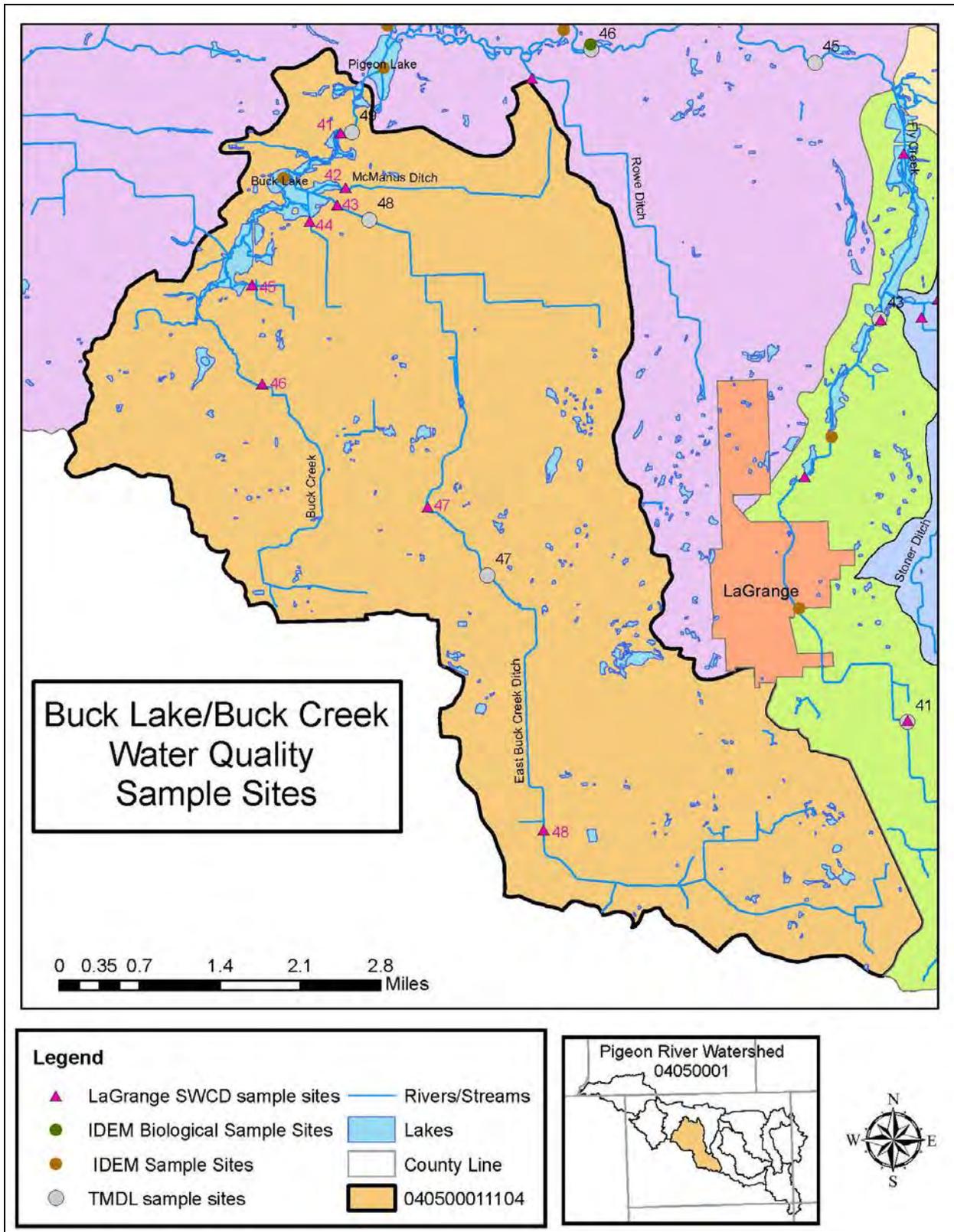


Figure 21: Buck Lake/Buck Creek Water Quality Sample Sites

IDEM Integrated Report Water Quality Assessment

IDEM collected water samples for analysis in Buck Lake/Buck Creek subwatershed in 2000. As can be seen in Table 43, TKN, nitrate-nitrite, and D.O. did not meet target levels during the sampling cycle. TKN and nitrate-nitrite exceeded the target levels in 100% of the samples, and D. O. did not meet target levels in 71% of the samples with 43% of that falling below 4 mg/L. Excessive nutrient loading from livestock related issues is the likely cause for observed algal growth at most of the sample sites. The excessive algal growth is the most reasonable cause of low D.O. readings.

Table 43: Buck Lake/Buck Creek: IDEM 303(d) Monitoring Data Analysis

Buck Lake/Buck Creek			
Parameter	Mean	Unit	# Does Not Meet Target
Ammonia	0.084	mg/L	0/2
Total Kjeldahl Nitrogen	1.194	mg/L	2/2
Nitrate-Nitrite	2.636	mg/L	2/2
Phosphorus, Total	0.065	mg/L	0/2
Dissolved Oxygen	6.829	mg/L	5/7
pH	8.025	SU	0/2

IDEM TMDL Study

Three sample sites within Buck Lake/Buck Creek subwatershed were selected and analyzed by IDEM for the Pigeon Creek and Pigeon River TMDL. The sites were sampled in June, July and September, 2010. As can be seen in Table 44, nitrate-nitrite, TKN, and D.O. were the only parameters that exceeded the target levels. TKN exceeded the target level of 0.076 mg/L in 100% of the samples, nitrate-nitrite exceeded the target level of 1.5 mg/L in 67% of the samples, and D.O. exceeded the target level of < 9mg/L in 33% of the samples. It should also be noted that biological data was collected at one site in Buck Lake/Buck Creek subwatershed. The IBI and QHEI scores for this site located on the main channel of Buck Creek indicate an excellent aquatic ecosystem.

Table 44: Buck Lake/Buck Creek: IDEM TMDL Study Data Analysis

Buck Lake - Buck Creek (Sites 47, 48, and 49)			
Parameter	Mean	Unit	# Does Not Meet Target
Total Kjeldahl Nitrogen	0.831	mg/L	9/9
Nitrate-Nitrite	2.312	mg/L	6/9
Suspended Solids, Total	2.778	mg/L	0/9
Phosphorus, Total	0.032	mg/L	0/9
Dissolved Oxygen	7.950	mg/L	5/15
pH	8.010	SU	0/15
IBI - Site 49	60		
QHEI - Site 49	Excellent		

LaGrange County SWCD Water Quality Monitoring Program

LaGrange County SWCD sampled water quality monthly at eight sites within Buck Lake/Buck Creek subwatershed from November 2010 through August 2011. As can be seen in Table 45, all parameters did not meet the target levels at some point during the sampling cycle. D.O. did not meet target levels 76% of the time, with all of those that did not meet the target level exceeding 9 mg/L. It should also be noted that *E. coli* exceeded the state standard of 235 cfu/100 ml in 64% of the samples, total phosphorus exceeded the target level of 0.3 mg/L in 40% of the samples, and nitrates exceeded the target level of 1.5 mg/L in 67% of the samples. It would not be unreasonable to assume the high levels of D.O. are associated with the high levels of nutrients found in the water column as high levels of nutrients can contribute to excessive algae growth which will produce a lot of dissolved oxygen initially, but can cause D.O. depletion as excessive algae die and decompose. The SWCD also sampled the macroinvertebrate community located at each of the eight sample sites located in the Buck Lake/Buck Creek subwatershed. Six sites scored high enough to indicate an excellent aquatic ecosystem, while site 44, a small headwater stream leading into Buck Lake scored only to be in poor aquatic health, and site 46, another headwater stream on the western edge of the subwatershed leading into Buck Lake scored to be in fair aquatic health.

Table 45: Buck Lake/Buck Creek: LaGrange County Water Quality Data Analysis

Buck Lake - Buck Creek			
Parameter	Mean	Unit	% that does not meet target
pH	8.3	SU	6.0%
Temp	11.3	Celsius	23.0%
D.O.	10.3	mg/L	76.0%
Total Dissolved Solids	439.3	mg/L	3.0%
Turbidity	9.9	NTU	27.0%
E. coli	1039.0	CFU/100 ml	64.0%
Nitrate	3.0	mg/L	67.0%
Phosphorus, Total	0.4	mg/L	40.0%
Total Suspended Solids	16.0	mg/L	12.0%
Macroinvertebrates	33	River Watch	12.5%
Habitat	79	River Watch	12.5%

3.3.8 VanNatta Ditch Subwatershed

There are twenty-two total water quality sampling sites located within the VanNatta Ditch subwatershed, as can be seen in Figure 22. Eight sites were used by IDEM for the 303(d) list; four sites were used by IDEM for the TMDL report, IDEM also collected biological data at four sites for use in developing the TMDL report, and six sample sites were used by LaGrange County SWCD to collect water quality data for the purposes of this WMP project.

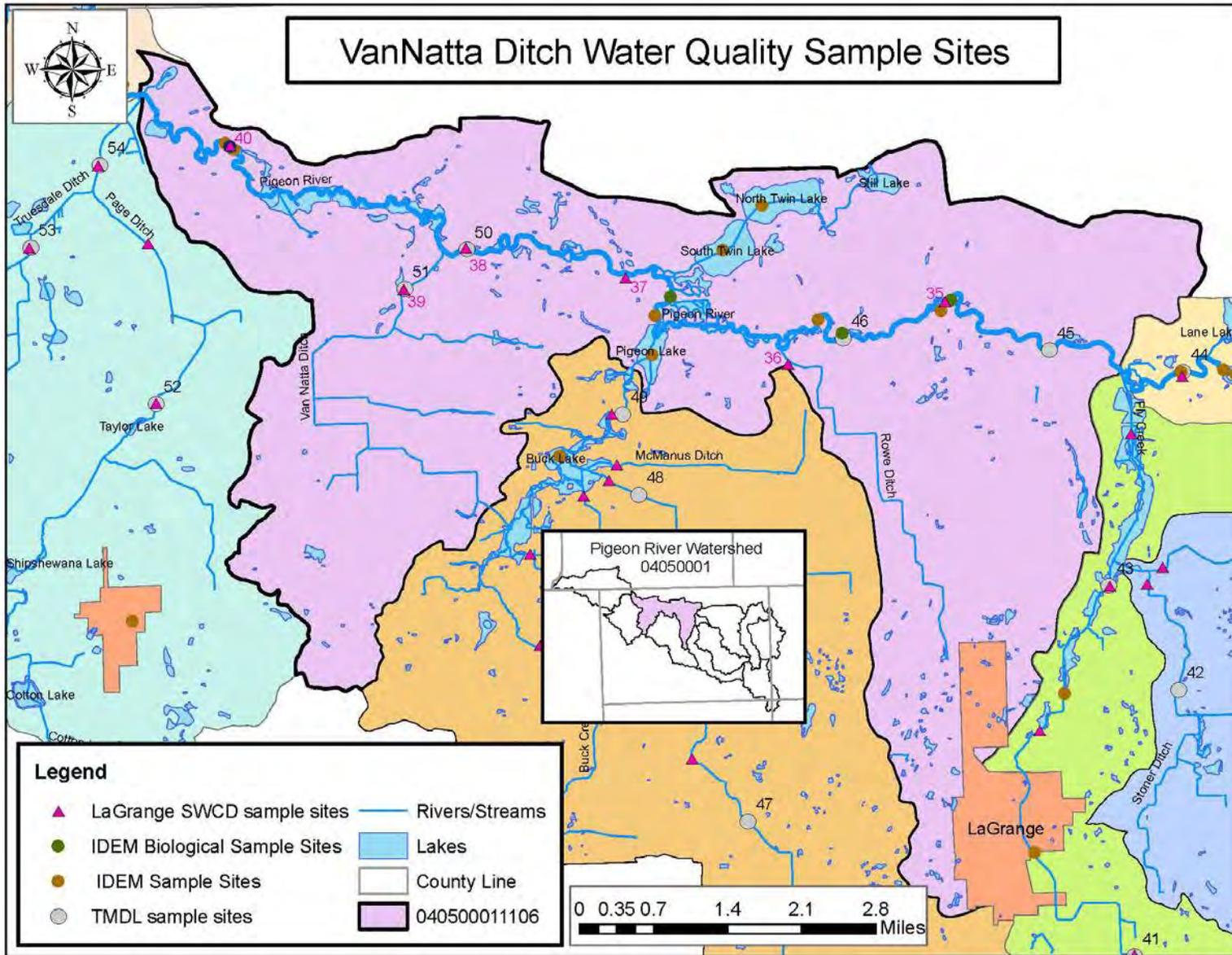


Figure 22: VanNatta Ditch Water Quality Sample Sites

IDEM Integrated Report Water Quality Assessment

IDEM has been collecting water samples for analysis in VanNatta Ditch subwatershed at least monthly since 2000. Data is available to the public from June 2000 through November 2010. As can be seen in Table 46, nearly all parameters did not meet the target levels at some point during the sampling cycle, except for TDS which never exceeded the target level. It should be noted that TKN exceeded the target level of 0.076 mg/L in 85% of the samples, nitrate-nitrite exceeded the target level of 1.5 mg/L in 40% of the samples, and D.O. did not meet target levels during the sampling cycle in 46% of the samples, with only 6% of that falling below 4 mg/L and 40% measuring greater than 9 mg/L. Algal growth was observed at sampling sites with low D.O. readings due to algal decomposition.

Table 46: VanNatta Ditch: IDEM 303(d) Monitoring Data Analysis

VanNatta Ditch			
Parameter	Mean	Unit	# Does Not Meet Target
Ammonia	0.036	mg/L	4/144
Total Kjeldahl Nitrogen	0.698	mg/L	139/147
Nitrate-Nitrite	1.529	mg/L	59/147
Suspended Solids, Total	3.785	mg/L	1/130
Dissolved Solids, Total	379.567	mg/L	0/141
Turbidity	7.641	NTU	24/160
Phosphorus, Total	0.030	mg/L	0/106
Dissolved Oxygen	8.558	mg/L	94/206
pH	8.075	SU	1/302
<i>E. coli</i>	94.125	CFU/100 ml	1/20

IDEM TMDL Study

Four sample sites within VanNatta Ditch subwatershed were selected and analyzed by IDEM for the Pigeon Creek and Pigeon River TMDL. The sites were sampled in June, July and September, 2010. As can be seen in Table 47, TKN is the only parameter that did not meet the target level. TKN exceeded the target level of 0.076 mg/L in 75% of the samples. It should also be noted that biological data was collected at four sites in VanNatta Ditch subwatershed. The IBI scores indicated a fair to good representation of fish in the ecosystem. The QHEI scores for this subwatershed indicate a fair to poor aquatic habitat.

Table 47: VanNatta Ditch: IDEM TMDL Study Data Analysis

VanNatta Ditch (Sites 45, 46, 50, and 51)			
Parameter	Mean	Unit	# Does Not Meet Target
Total Kjeldahl Nitrogen	0.543	mg/L	9/12
Nitrate-Nitrite	1.069	mg/L	0/12
Suspended Solids, Total	8.833	mg/L	0/12
Phosphorus, Total	0.039	mg/L	0/12
Dissolved Oxygen	7.240	mg/L	0/22
pH	7.950	SU	0/22
IBI - Site 46/50/51	40/42/38		
QHEI - Site 46/50/51	Fair/Fair/Fair to Poor		

LaGrange County SWCD Water Quality Monitoring Program

LaGrange County SWCD sampled water quality monthly at six sites within VanNatta Ditch subwatershed from November 2010 through August 2011. As can be seen in Table 48, only TDS and TSS did not exceed target levels during the sampling cycle. Nitrate exceeded the target level of 1.5 mg/L in 48% of the samples, and total phosphorus exceeded the target level of 0.3 mg/L in 10% of the samples. D.O. did not meet target levels 55% of the time, with all of those that did not meet the target level exceeding 9 mg/L. It should also be noted that *E. coli* exceeded the state standard of 235 cfu/100 ml in 64% of the samples. It would not be unreasonable to assume the high levels of D.O. are associated to the high levels of nutrients found in the water table as high levels of nutrients can contribute to excessive algae growth which will produce a lot of dissolved oxygen initially, but can cause D.O. depletion as excessive algae die and decompose. The SWCD also sampled the macroinvertebrate community located at each of the six sample sites located in the VanNatta Ditch subwatershed. All six sites mIBI scores were high enough to indicate an excellent aquatic ecosystem.

Table 48: VanNatta Ditch: LaGrange County Water Quality Data Analysis

VanNatta Ditch			
Parameter	Mean	Unit	% that does not meet target
pH	7.8	SU	3.0%
Temp	11.0	Celsius	28.0%
D.O.	9.9	mg/L	55.0%
Total Dissolved Solids	393.9	mg/L	0.0%
Turbidity	5.6	NTU	5.0%
<i>E. coli</i>	187.0	CFU/100 ml	27.0%
Nitrate	1.7	mg/L	48.0%
Phosphorus, Total	0.2	mg/L	10.0%
Total Suspended Solids	8.0	mg/L	0.0%
Macroinvertebrates	44	River Watch	0.0%
Habitat	87	River Watch	0.0%

3.3.9 Page Ditch Subwatershed

There are thirteen total water quality sampling sites located within the Page Ditch subwatershed, as can be seen in Figure 23. Three sites were used by IDEM for the 303(d) list; three sites were used by IDEM for the TMDL report, IDEM also collected biological data at two sites for use in developing the TMDL report, and seven sample sites were used by LaGrange County SWCD to collect water quality data for the purposes of this WMP project.

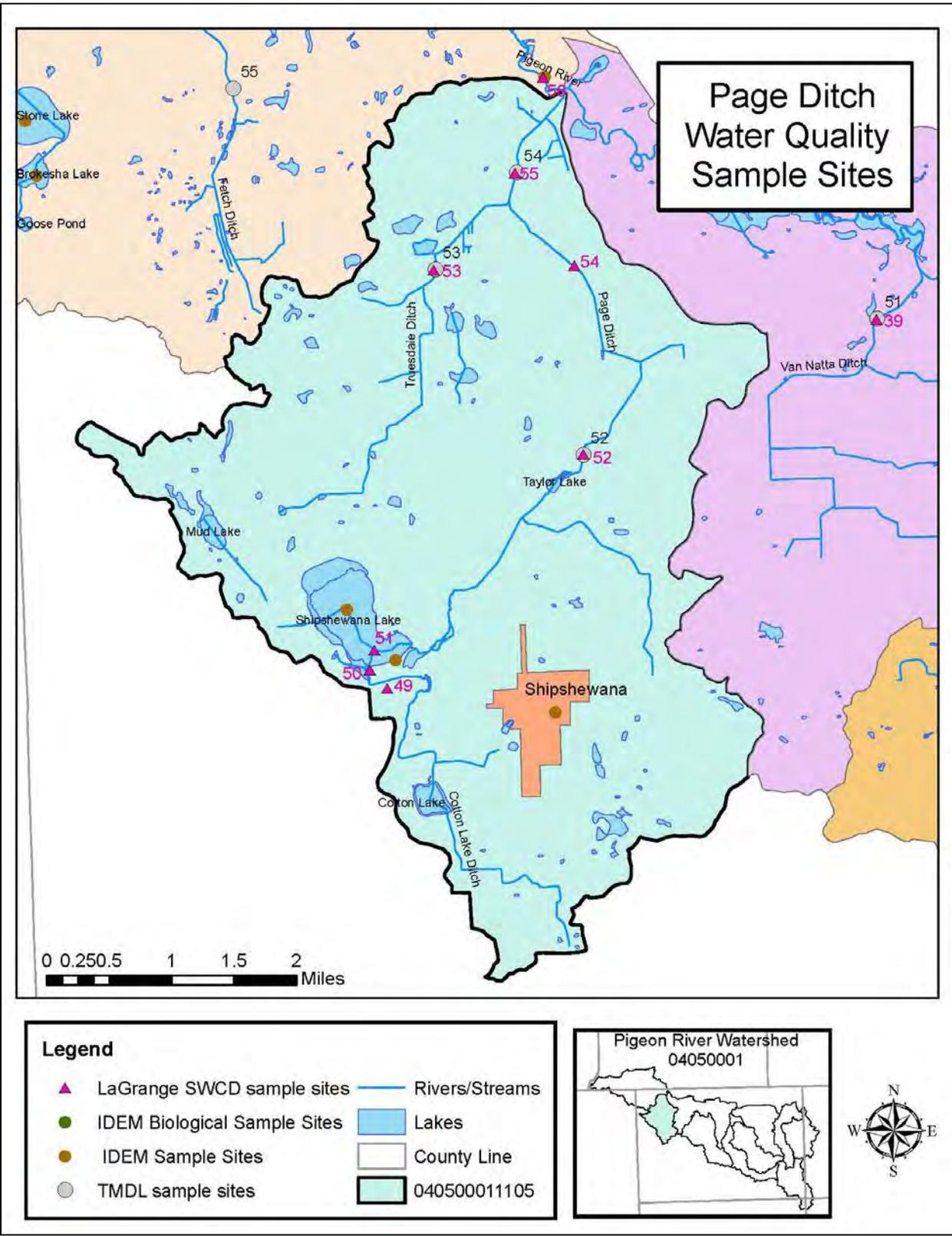


Figure 23: Page Ditch Water Quality Sample Sites

IDEM Integrated Report Water Quality Assessment

IDEM collected water samples for analysis from three sites in Page Ditch subwatershed in 2000. As can be seen in Table 49, turbidity, D.O, and pH did not meet their respective target. Turbidity exceeded the target level of 10.4 mg/L in 24% of the samples, D.O. did not meet the target level in 70% of the samples with 7% of those samples measuring below 4 mg/L and 63% of those samples measured over 9 mg/L, and pH exceeded the state standard in 22% of the samples.

Table 49: Page Ditch: IDEM 303(d) Monitoring Data Analysis

Page Ditch			
Parameter	Mean	Unit	# Does Not Meet Target
Ammonia	0.051	mg/L	0/2
Turbidity	6.061	NTU	5/21
Phosphorus, Total	0.130	mg/L	0/2
Dissolved Oxygen	9.015	mg/L	19/27
pH	8.352	SU	5/23
<i>E. coli</i>	2.6	CFU/100 ml	0/1

IDEM TMDL Study

Three sample sites within Page Ditch subwatershed were selected and analyzed by IDEM for the Pigeon Creek and Pigeon River TMDL. The sites were sampled in June, July and September, 2010. As can be seen in Table 50, TKN, nitrate-nitrite, TSS, and total phosphorus all exceeded target levels. TKN exceeded target levels in 100% of the samples, nitrate-nitrite exceeded the target level of 1.5 mg/L in 78% of the samples, TSS exceeded the target level of 25 mg/L in 44% of the samples, and total phosphorus exceeded the target level of 0.3 mg/L in 33% of the samples. It should also be noted that biological data was collected at two sites in Page Ditch subwatershed. Site 53, a headwater stream had an IBI score indicative of an excellent macroinvertebrate community while site 54 scored much lower indicating a poor macroinvertebrate community. The same pattern was seen with the QHEI scores where site 53 scored high enough to be considered an excellent aquatic habitat, and site 54 scored much lower indicating a poor aquatic ecosystem. Several differences help explain such a wide gap in scores between sites. Site 53 has many wetland areas adjacent to the ditch system and fewer livestock influences while site 54 has fewer wetland buffers allowing greater livestock influences. In addition site 54 is directly influenced by the town of Shipshewana and a much higher rural population.

Table 50: Page Ditch: IDEM TMDL Study Data Analysis

Page Ditch (Sites 52, 53, and 54)			
Parameter	Mean	Unit	# Does Not Meet Target
Total Kjeldahl Nitrogen	1.978	mg/L	9/9
Nitrate-Nitrite	2.344	mg/L	7/9
Suspended Solids, Total	69.667	mg/L	4/9
Phosphorus, Total	0.241	mg/L	3/9
Dissolved Oxygen	7.190	mg/L	0/12
pH	7.920	SU	0/12
IBI - Site 53/54	60/32		
QHEI - Site 53/54	Excellent/Poor		

Fish Consumption Advisory

Lake Shipshewana, Truesdale Ditch, Page Ditch, and Cotton Lake Ditch, located in Page Ditch subwatershed, are listed on the 2010 Fish Consumption Advisory specifically for Carp which is a Group 3 advisory.

LaGrange County SWCD Water Quality Monitoring Program

LaGrange County SWCD sampled water quality monthly at seven sites within Page Ditch subwatershed from November 2010 through August 2011. As can be seen in Table 51, all parameters did not meet target levels at least once during the sample cycle. It should be noted that nitrate exceeded the target level of 1.5 mg/L in 78% of the samples, and total phosphorus exceeded the target level of 0.3 mg/L in 70% of the samples. This may account for D.O. not meeting target levels in 61% of the samples with only 1% of those falling below 4 mg/L. *E. coli* exceeded the state standard of 235 cfu/ml in 51% of the samples. Turbidity exceeded the target level of 10.4 NTU in 29% of the samples and TSS exceeded the target level of 25 mg/L in 17% of the samples which indicates there may be some erosion issues, raw sewage entering the water column, livestock access or barnyard runoff in the Page Ditch subwatershed. The SWCD also sampled the macroinvertebrate community at each of the seven sample sites located in the Page Ditch subwatershed. All seven sites mIBI scores were high enough to indicate a good to excellent aquatic ecosystem.

Table 51: Page Ditch: LaGrange County Water Quality Data Analysis

Page Ditch			
Parameter	Mean	Unit	% that does not meet target
pH	8.2	SU	4.0%
Temp	11.7	Celsius	30.0%
D.O.	9.8	mg/L	61.0%
Total Dissolved Solids	379.3	mg/L	1.0%
Turbidity	10.3	NTU	29.0%
E. coli	864.0	CFU/100 ml	51.0%
Nitrate	3.1	mg/L	78.0%
Phosphorus, Total	0.5	mg/L	70.0%
Total Suspended Solids	16.0	mg/L	17.0%
Macroinvertebrates	25	River Watch	0.0%
Habitat	76	River Watch	0.0%

3.3.10 Pigeon River Subwatershed

There are twenty-six total water quality sampling sites located within the Pigeon River subwatershed, as can be seen in Figure 24. Three sites were used by IDEM for the 303(d) list; six sites were used by IDEM for the TMDL report, IDEM also collected biological data at six sites for use in developing the TMDL report, six sites were used by the MI DEQ for the 303(d) list, and five sample sites were used by LaGrange County SWCD to collect water quality data for the purposes of this WMP project.

IDEM Integrated Report Water Quality Assessment

IDEM collected water samples for analysis from three sites in Pigeon River subwatershed in 2000. Two sample sites were located in Brokesha and Stone Lakes and one site was located on the Pigeon River. The lakes were analyzed separately from the river as the two different water sources have very different hydrology. Table 52 shows the analysis of the Pigeon River sample site. As can be seen in the table, turbidity, D.O, and *E. coli* did not meet the target levels. Turbidity exceeded the target level of 10.4 mg/L in one of the samples, D.O. did not meet the target level in 44% of the samples with all of those samples measuring above 9 mg/L. Table 53 shows the data analysis for the lakes. Only TKN exceeded the target level, but it exceeded in 100% of the samples.

Table 52: Pigeon River – Pigeon River: IDEM 303(d) Monitoring Data Analysis

Pigeon River - Pigeon River			
Parameter	Mean	Unit	# Does Not Meet Target
Turbidity	4.430	NTU	1/16
Dissolved Oxygen	8.679	mg/L	7/16
pH	8.045	SU	0/16

Table 53: Pigeon River – Brokesha and Stone Lakes: IDEM 303(d) Monitoring Data Analysis

Pigeon River - Brokesha and Stone Lakes			
Parameter	Mean	Unit	# Does Not Meet Target
Ammonia	0.027	mg/L	0/3
Total Kjeldahl Nitrogen	0.316	mg/L	3/3
Nitrate-Nitrite	0.022	mg/L	0/3
Phosphorus, Total	0.033	mg/L	0/3
Dissolved Oxygen	7.819	mg/L	0/17
pH	6.300	SU	0/4

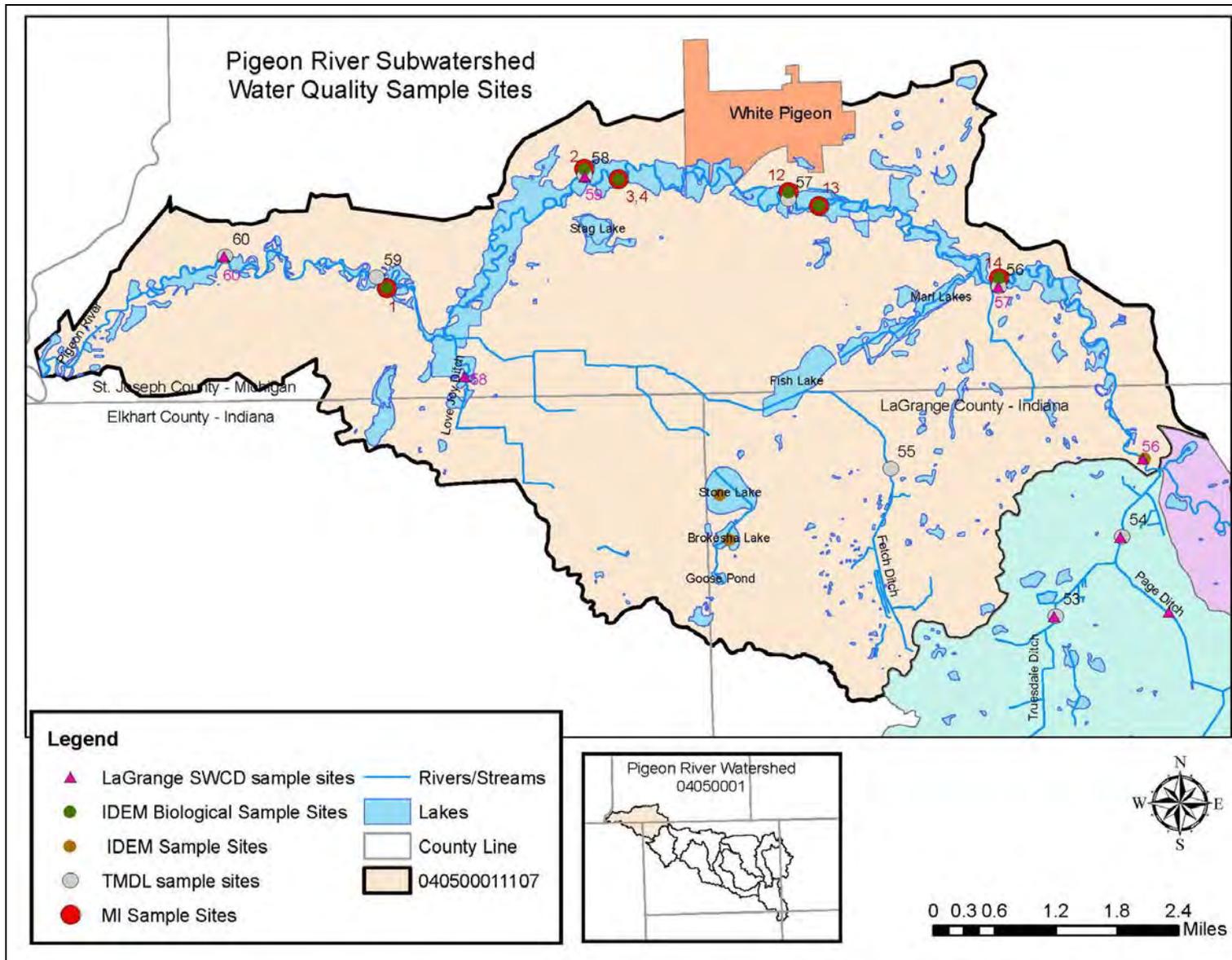


Figure 24: Pigeon River Subwatershed Water Quality Sample Sites

IDEM TMDL Study

Six sample sites within Pigeon River subwatershed were selected and analyzed by IDEM for the Pigeon Creek and Pigeon River TMDL. The sites were sampled in June, July and September, 2010. As can be seen in Table 54, TKN, TSS, and D.O. all exceeded target levels. TKN exceeded target levels in 94% of the samples which can be attributed to traditional farming practices and the ditch system containing many tile outflows. TSS exceeded the target level of 25 mg/L in one of the samples, and D.O. exceeded the target level in 34% of the samples. It should also be noted that biological data was collected at four sites in Pigeon River subwatershed. All four sites are located on the Pigeon River main stem with sites 56 and 57 upstream of White Pigeon and sites 58 and 59 downstream of White Pigeon. The IBI score for site 56 ranked the fish community to be in fair health, and the QHEI score for site 56 ranked the aquatic habitat to be in poor to fair health. The IBI score for sites 57 and 58 were both 22 which indicates a poor fish community and the QHEI score for both sites indicate a very poor aquatic habitat. The IBI score for site 59 was very high indicating an excellent fish community and the QHEI score was also very high indicating an excellent aquatic ecosystem.

Table 54: Pigeon River: IDEM TMDL Study Data Analysis

Pigeon River (Sites 55, 56, 57, 58, 59, and 60)			
Parameter	Mean	Unit	# Does Not Meet Target
Total Kjeldahl Nitrogen	0.816	mg/L	17/18
Nitrate-Nitrite	1.025	mg/L	0/18
Suspended Solids, Total	10.722	mg/L	1/18
Phosphorus, Total	0.040	mg/L	0/18
Dissolved Oxygen	6.810	mg/L	12/35
pH	8.060	SU	0/35
IBI - Site 56/57/58/59	36/22/22/60		
QHEI - Site 56/57/58/59	Poor to Fair/Very Poor/Very Poor/ Excellent		

Michigan Biosurvey

MI DEQ sampled water chemistry at four sites, including sites 4, 12, 13, and 14 in the Pigeon River subwatershed. They also sampled four sites for biological and/or habitat quality at sites 1, 2, 3 and 4 located in the Pigeon River subwatershed. Data was collected once in July 2000 at sites 1, 2, 3, and 4 and once in September, 2005 at sites 12, 13, and 14. As can be seen in Table 55, TKN and nitrate+nitrite exceeded the target levels during the sampling cycle. TKN exceeded the target of 0.076 mg/L in 100% of the samples and nitrate+nitrite exceeded the target level of 1.5 mg/L in 75% of the samples. Biological data was also collected at all six sites in 2005. All six sites scored high enough to indicate an excellent aquatic habitat.

Table 55: Pigeon River subwatershed: MI Biosurvey Data Analysis

Pigeon River			
Parameter	Mean	Unit	# Does Not Meet Target
Total Kjeldahl Nitrogen	0.970	mg/L	4/4
Nitrate-Nitrite	1.660	mg/L	3/4
Nitrite	0.010	mg/L	0/4
Suspended Solids, Total	5.750	mg/L	0/4
Phosphorus, Total	0.046	mg/L	0/4
pH	8.210	SU	0/4
IBI (Site 1)	Excellent		
mIBI (Sites 2/3/4)	Excellent/Excellent/Excellent		
QHEI (Sites 1/2/3/4)	Excellent/Excellent/Excellent/Excellent		

LaGrange County SWCD Water Quality Monitoring Program

LaGrange County SWCD sampled water quality monthly at five sites within Pigeon River subwatershed from November 2010 through August 2011. As can be seen in Table 56, all parameters did not meet target levels at least once during the sample cycle except for TDS which never exceeded the target level. It should be noted that nitrate exceeded the target level of 1.5 mg/L in 52% of the samples, and D.O. exceeded 9mg/l in 44% of the samples. It should also be noted that temperature exceeded the maximum target level in 26% of the samples analyzed. However, when compared to recent water quality analysis in other subwatersheds, Pigeon River subwatershed ranks higher in overall water quality. The SWCD also sampled the macroinvertebrate community located at each of the five sample sites located in the Pigeon River subwatershed. All five sites mIBI scores were high enough to indicate an excellent aquatic ecosystem.

Table 56: Pigeon River: LaGrange County Water Quality Data Analysis

Pigeon River			
Parameter	Mean	Unit	% that does not meet target
pH	8.3	SU	2.0%
Temp	11.5	Celsius	0.0%
D.O.	9.8	mg/L	44.0%
Total Dissolved Solids	360.4	mg/L	0.0%
Turbidity	5.5	NTU	2.0%
E. coli	141.0	CFU/100 ml	20.0%
Nitrate	1.6	mg/L	52.0%
Phosphorus, Total	0.2	mg/L	4.0%
Total Suspended Solids	9.0	mg/L	38.0%
Macroinvertebrates	47	River Watch	0.0%
Habitat	93	River Watch	0.0%

Fish Consumption Advisory

The Pigeon River subwatershed appears on the Michigan Department of Community Health's 2011-2012 Fish Consumption Advisory for mercury and PCBs in Brown Trout and PCBs in Suckers.

3.4 Water Quality Analysis Summary

The water quality in the Pigeon River watershed has been analyzed over the past several decades, though only data collected since 2000 was used for the purposes of this WMP. When historic data is compared to current data collected by this project, there are some apparent persistent problems, and a few new issues. The reasons for why there have been some changes will become apparent after reviewing the landuse in the watershed. Tables 57 and 58 below, show the average water quality for each parameter tested. Those cells that are highlighted in grey represent parameter averages that exceed the target levels, those cells that are blacked out represent parameters that were not tested for the corresponding subwatershed. After reviewing the tables, it is clear that *E. coli* remains a severe impairment to the water resources, especially in Fly Creek subwatershed and nitrogen remains a severe impairment throughout the watershed. The 2011 data collection performed by the LaGrange County SWCD also found that oversaturation of dissolved oxygen is a severe impairment throughout the watershed.

Table 57: Historic Water Quality Analysis Averages

Parameter	Unit	Green Lake	Little Turkey	Mongo Millpond	Cline Lake	Fly Creek	East Fly Creek	VanNatta Ditch	Buck Lake	Page Ditch	Pigeon River
Ammonia	mg/L	0.395	0.048					0.036	0.084	0.051	
Total Kjeldahl Nitrogen	mg/L	0.753	0.463	0.939	0.56	0.079	0.951	0.621	1.013	1.978	0.893
Nitrate-Nitrite	mg/L	0.873	1.350	3.272	0.985	2.322	1.544	1.299	2.474	2.344	1.343
Nitrite	mg/L										0.010
Suspended Solids, Total	mg/L	5.137	7.333	2.0	6.318	2.444	6.667	6.309	2.778	69.667	8.236
Dissolved Solids, Total	mg/L	227.167			383.333			379.567			
Turbidity	NTU		5.799	4.980	5.689	14.259		7.641		6.061	
Phosphorus, Total	mg/L	0.058	0.085	0.020	0.051	0.011	0.052	0.035	0.049	0.186	0.043
pH	SU	7.791	7.862	7.845	7.754	7.861	7.819	8.013	8.018	8.136	8.105
DO	mg/L	7.336	6.93	7.780	7.740	8.903	6.677	7.899	7.390	8.103	7.745
<i>E. coli</i>	CFU/100 ml	224.47	155.38	159.57	173.94	50.45	41.84	94.125		2.6	

Table 58: LaGrange County SWCD's 2011 Water Quality Analysis Averages

Parameter	Unit	Green Lake	Little Turkey	Mongo Millpond	Cline Lake	Fly Creek	East Fly Creek	VanNatta Ditch	Buck Lake	Page Ditch	Pigeon River
Nitrate	mg/L	2.0	1.5	1.7	1.8	3.5	3.5	1.7	3.0	3.1	1.6
Suspended Solids, Total	mg/L	8	10	8	7	10	10	8	16	16	9
Dissolved Solids, Total	mg/L	444.47	342.06	386.78	391.63	437.8	386.21	393.9	439.3	379.3	360.4
Turbidity	NTU	5.5	5.31	4.66	5.12	6.2	6.12	5.6	9.9	10.3	5.5
Phosphorus, Total	mg/L	0.20	0.23	0.23	0.17	0.22	0.47	0.20	0.39	0.45	0.17
pH	SU	7.74	8.3	8.13	8.48	8.5	8.59	7.8	8.3	8.2	8.3
DO	mg/L	9.3	9.58	9.46	9.99	10.7	10.36	9.9	10.3	9.8	9.8
<i>E. coli</i>	CFU/100 ml	211	276	147	140	1020	617	187	1039	864	141

3.5 Landuse Inventory by Subwatershed

This section will provide information that was obtained through windshield and desktop surveys of each subwatershed, as well as information that has been gathered via government agencies (i.e. IDEM and MDEQ) and historic data found through research at the subwatershed level. However it is important to note that there are particular trends that have been found watershed wide as described below.

Pigeon River has a diverse stakeholder community that influences the nonpoint source pollutant dynamics. The Amish community comprises the largest landowner group throughout the majority of the subwatersheds and has the greatest influence on the ditch systems feeding into the main channel of Pigeon River. The Amish community is the fastest growing population throughout the project area and comprises the bulk of livestock influences on the water resources. Many Amish landowners are splitting their properties into smaller holdings to allow for the younger generation to build a home and stay close to the family. For this reason, cropland is decreasing and more small animal feeding operations are being erected throughout the project area.

As determined by the use of the Purdue University L-THIA program, the predominant landuse in the project area is agriculture. This is illustrated in Figure 25 and Table 59, as agriculture encompasses nearly 66% of the total land use in the project area. Landowners using modern farming practices are scattered throughout the project area but primarily have the largest agricultural influences on water quality in the most eastern and western subwatersheds. The landuse inventory conducted as part of this project revealed that in most cases, buffering ditch banks, and livestock exclusion fencing are the major BMP requirements. It is important to note that in this community, practices tend to remain stable with few land-use changes over large time periods (with the exception of the Shipshewana area).

Although there are few urban areas in the project area, it has been found that urban and lake resident stakeholders do have influence on the water system in the project area. Educational outreach is ongoing with groups such as the Steuben and Lagrange County Lake Associations, and working with the growing community of Shipshewana is planned for the future. Working with the built-up communities in the project area will play a major role in reducing NPS from urban and lake resident sources. However, the quickest and most dramatic results in reducing nonpoint source pollutants lie in utilizing BMP installation within the agricultural community. Below is a breakdown of land use gathered in the project area including NPDES permitted facilities, potential pollution sources, and areas of concern which were identified through an extensive watershed survey. Looking at the land use practices and issues at a subwatershed level will help to identify where efforts should be focused to reduce NPS in surface water.

Pigeon River Watershed Land Use

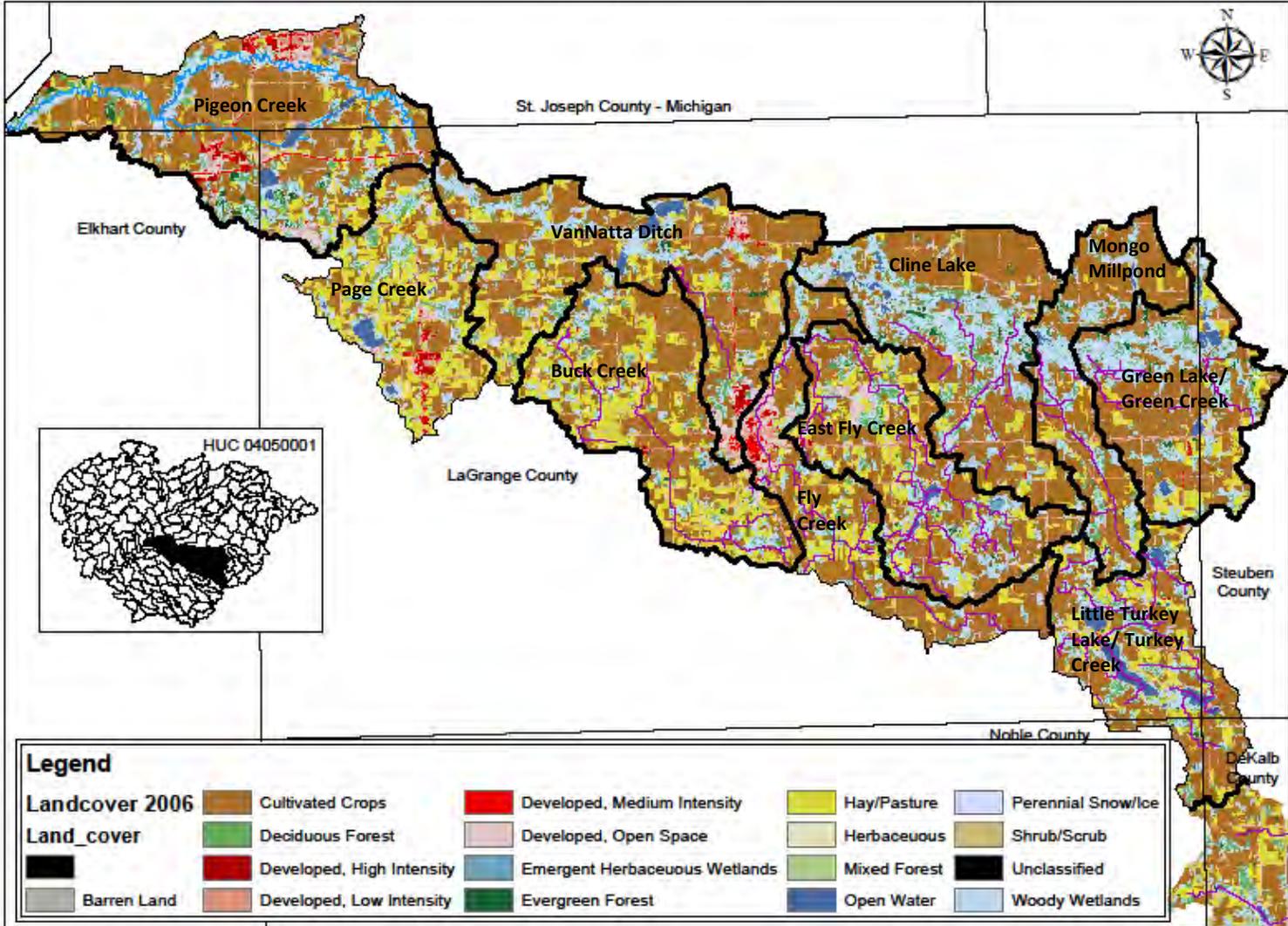


Figure 25: Land Use in the Pigeon River Project Area

Table 59: Land Use in the Pigeon River Project Area

Land use	Total	% of Project Area
Water	26,246.6	16.9%
Developed - High Density (HD)	5062.4	3.3%
Developed - Low Density (LD)	7,197.83	4.6%
Industrial	314.4	0.2%
Cultivated Crops	74,468.6	47.9%
Grass/ Pasture	27,429.3	17.6%
Forest	13,465.4	8.7%
Other	1,358.57	0.9%
Total	155,543	100%

3.5.1 Green Lake Land Use

The Green Lake-Green Creek subwatershed is located on the east edge of the project area in Steuben and LaGrange counties (Figure 26). The watershed is 13,562 acres (5488.35 hectares) in size and contains Green Lake, Deep Lake, and Appleman Lake. The major influence on water quality in Green Lake – Green Creek subwatershed is agriculture as cultivated crops and grass and/or pasture take up approximately 60% of the land (Table 60).

The Pigeon River Fish and Wildlife Area (PRFWA), a major recreational area in the project area, is partially located within the Green Lake-Green Creek subwatershed. Nearly 28% of the subwatershed is covered by surface water. This is likely due to the fact that the PRFWA itself contains 529 acres of lakes and impoundments, and over 17 miles of free flowing river.

Table 60: Green Lake-Green Creek Land Use

	Water	Developed -HD	Developed - LD	Industrial	Cultivated Crops	Grass/ Pasture	Forest	Other	Total
Acres	3766.3	240.9	494	28.7	6382	1688.5	960.1	1.5	13562
%	27.8	1.8	3.6	0.2	47	12.5	7.1	<1	100

Pigeon Creek, located within Green Lake-Green Creek subwatershed, is listed on the 2008 303(d) list of impaired waters for *E. coli* and Impaired Biotic Communities. Pigeon Creek is also listed in the Indiana Fish Consumption Advisory. Figure 27 displays those waterways that are listed as impaired by the state of Indiana.

Green Lake-Green Creek Sub-Watershed



Figure 26: Green Lake-Green Creek Sub-Watershed

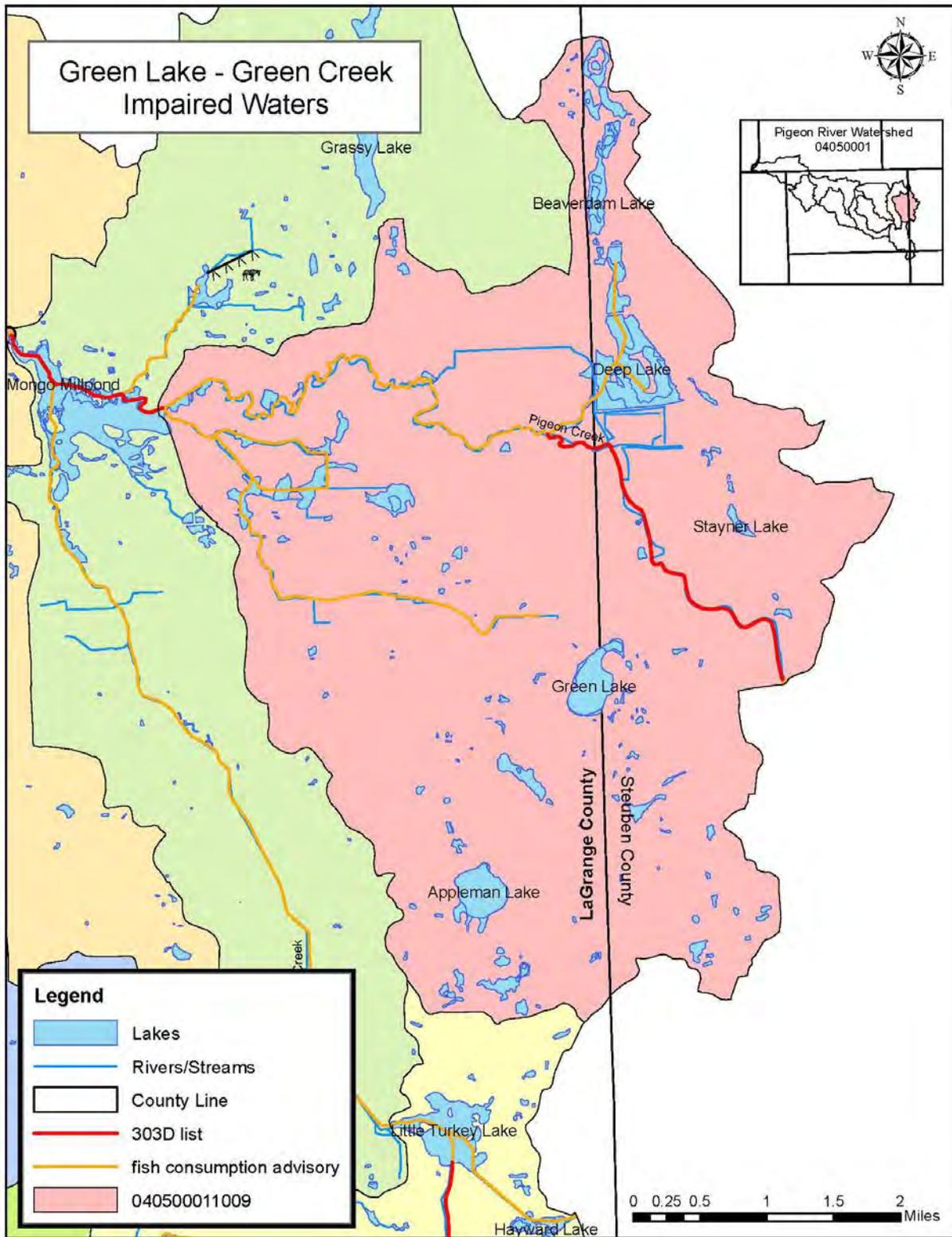


Figure 27: Green Lake – Green Creek Impaired Waters

There is not a National Pollution Discharge Elimination System (NPDES) permitted facility located within this subwatershed. However, there are a few sites located in this subwatershed that may pose a pollution risk to water resources. There is one swine operation that is a registered CFO with the state of Indiana located within the Green Lake – Green Creek subwatershed. There are also two underground storage tanks (USTs) located within this subwatershed. While USTs do not pose an immediate threat to water resources, they do run the risk of leaking if not properly inspected and maintained. Table 61 lists the potential pollution threats in the Green Lake – Green Creek subwatershed. Figure 28 shows the location of the CFO and USTs in the Green Lake – Green Creek subwatershed.

Table 61: Potential Water Quality Pollution Threats in Green Lake-Green Creek

Type of Threat	Potential Contaminant	Number in Watershed
Underground Storage Tank	Oil/Gas	1
Confined Feeding Operations	Manure runoff/sedimentation	1

Windshield (direct observation from the public road system) and desktop (using satellite and aerial photography) surveys revealed that Green Lake is primarily influenced by several lateral ditch systems. There was one site in particular that exhibited a lot of erosion and lack of a vegetative riparian buffer. This site is in need of a filter strip to help prevent NPS from reaching the stream. The remaining portion of the effected ditch system does not have farm fields adjacent to the ditchbank. This site is outlined in Table 62 and labeled in Figure 29. The surveys also revealed the large amount of soil located within Green Lake – Green Creek subwatershed that is ranked as either HEL or PHEL. Special care will need to be taken by landowners who are farming this land. The vast majority of the system flows through wetlands with the main channel and majority of lateral ditches lying within the Pigeon River Fish and Wildlife Area.

Table 62: Little Turkey Lake Windshield Survey Observations

Type of Threat	Potential Contaminant	Number in Watershed
Lack of Riparian Buffer	Sediment, nutrient runoff	1 mile

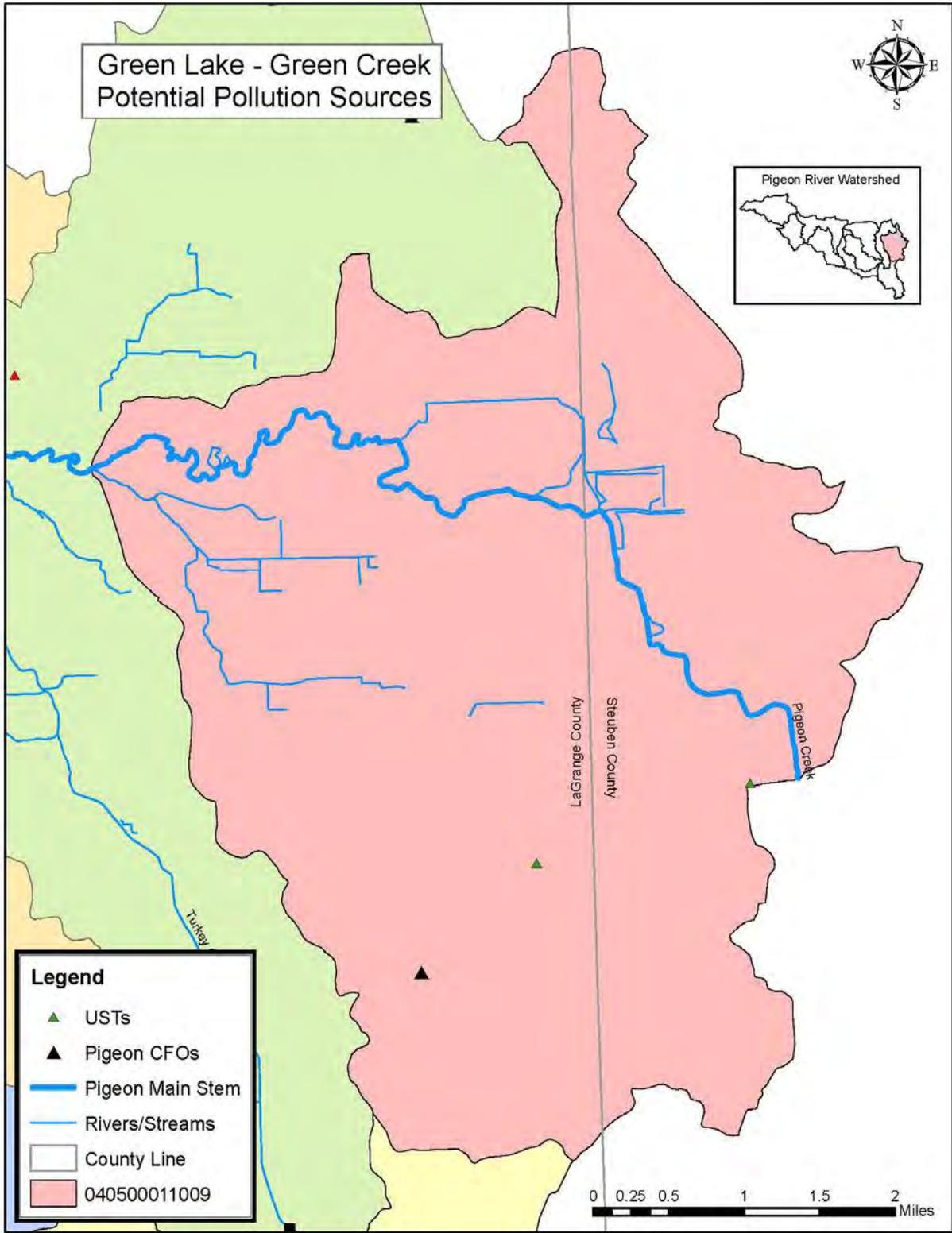


Figure 28: Green Lake-Green Creek Potential Pollution Issues

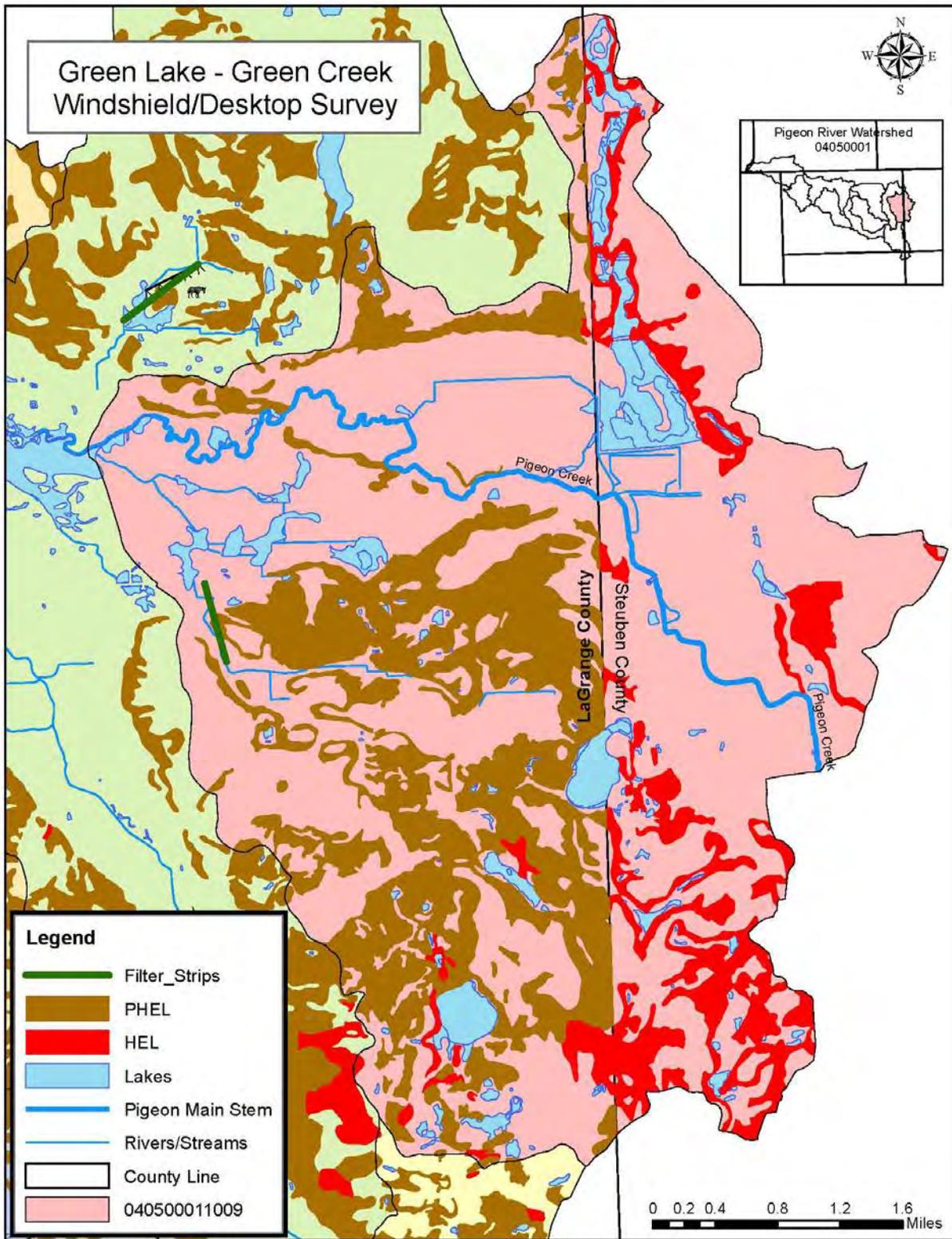


Figure 29: Green Lake – Green Creek Windshield/Desktop Survey Map

3.5.2 Little Turkey Lake Land Use

The Little Turkey Lake subwatershed is the most southeasterly subwatershed in the project area. It is located within DeKalb, Noble, Steuben, and LaGrange counties, with the majority of the watershed in LaGrange County (Figure 30). It is approximately 13,283 acres (5375.44 hectares) in size and contains many lakes including Pretty, Big Long, and Big and Little Turkey Lakes. Major waterways in this subwatershed are Turkey Creek and Maumee Ditch. The predominant land use in the subwatershed is agriculture encompassing nearly 62% of the area. However, due to the large number of large lakes in this subwatershed, 24% of the subwatershed is water. Table 63 is a summary of the land use in the subwatershed.

Table 63: Little Turkey Lake – Turkey Creek Land Use

	Water	Developed - HD	Developed - LD	Industrial	Cultivated Crops	Grass/ Pasture	Forest	Other	Total
Acres	3248.8	313.4	517.9	4.4	5874.5	2343.5	970.3	10.2	13283
%	24.5	2.4	3.9	<1	44.2	17.6	7.3	<1	100

An unnamed tributary to Turkey Creek is listed on Indiana’s 2008, 303(d) list of impaired waters for dissolved oxygen and *E. coli*. Lake of the Woods and McClish Lake are listed for an impaired biotic community (IBC), Lake of the Woods and Pretty Lake are listed for mercury in fish tissue, and Little Turkey Lake is listed for phosphorus. Turkey Creek, Maumee Ditch and three unnamed tributaries are on the Indiana Fish Consumption advisory for black Crappie and Bluegill, both ranked as a Group 1 advisory. These impairments can be seen on Figure 31.

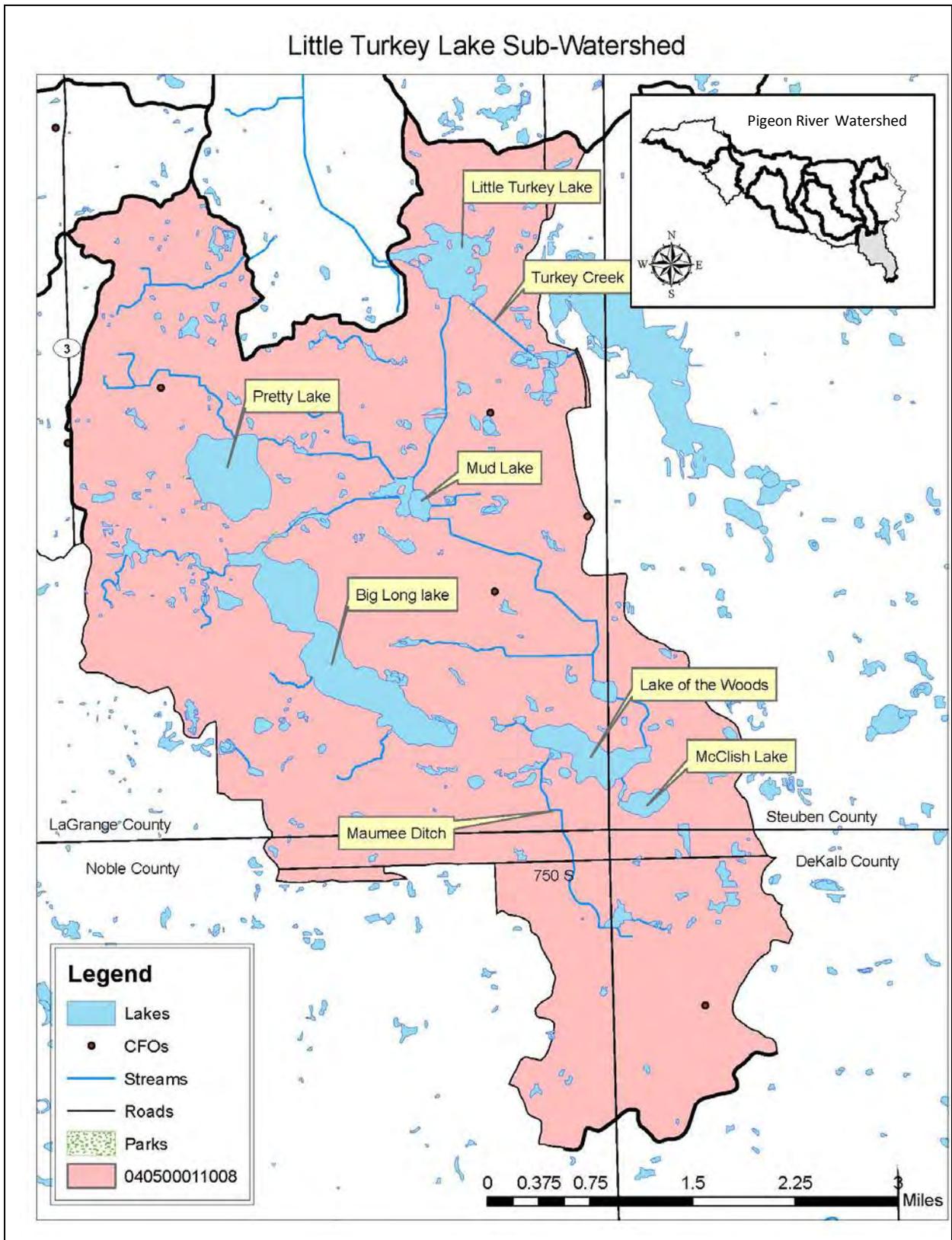


Figure 30: Little Turkey Lake Subwatershed

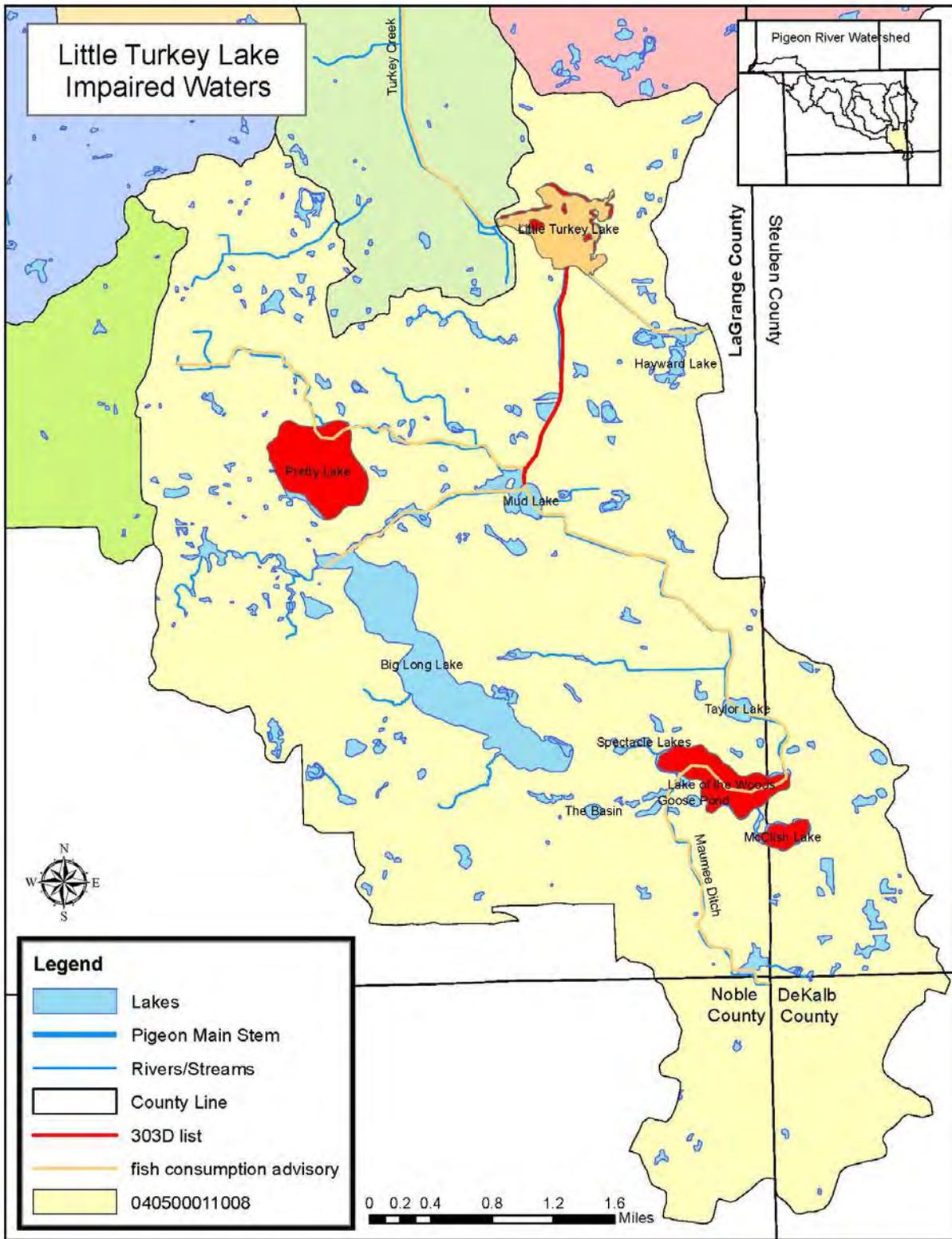


Figure 31: Little Turkey Lake Impaired Waters

Little Turkey Lake is primarily influenced by agricultural fields and several large livestock operations. There are five CFOs located wholly in the subwatershed, and one CFO located on the boundary of the drainage area. This subwatershed has many large and small lakes. The largest and most populated lakes, including Little and Big Turkey Lakes, Lake of the Woods, Pretty Lake and Big Long Lake have a centralized sewer system which is maintained by the LaGrange County Utility District, Region B. Region B has an NPDES permit and has not had any noncompliance events reported within the past decade. However, the Utility Districts discharge point is to Turkey Creek located in the Mongo Millpond subwatershed. It should be noted here that many lake residents use lawn fertilizers to maintain the beautiful turf grass that is prevalent around the larger, more populated lakes. The fertilizer does have the potential to runoff of the property and enter the lake thus increasing the potential for aquatic plant growth, including the harmful blue-green algae.

The Big Long Lake Marina, located in the Little Turkey Lake subwatershed, is a LUST site. The underground storage tank has been closed so no longer poses a threat. However, there are other USTs on this site that are currently monitored by the IDEM UST program. Table 64 shows the potential pollution risks in the Little Turkey Creek subwatershed, and Figure 32 shows the location of the potential pollution risks.

Table 64: Potential Water Quality Pollution Threats in Little Turkey Lake

Type of Threat	Potential Contaminant	Number in Watershed
Leaking Underground Storage Tank	Oil/Gas	1
Confined Feeding Operations	Manure runoff/sedimentation	5

Windshield and desktop surveys revealed that Little Turkey Lake is primarily influenced by agriculture, including many animal feeding operations. Several sites were noted while performing the windshield survey which can be seen in Table 65 and Figure 33. The surveys also revealed the large amount of soil located within Little Turkey Lake subwatershed that is ranked as either HEL or PHEL. Special care will need to be taken by landowners who are farming this land.

Table 65: Little Turkey Lake Windshield Survey Observations

Type of Threat	Potential Contaminant	Number in Watershed
Livestock Access to Ditch	Sediment, Bacteria, Nutrients	2
Need for Exclusion Fencing	Sediment, Bacteria, Nutrients	2000 feet
Lack of Riparian Buffer	Sediment, nutrient runoff	5 miles
Barnyard Runoff	Sediment, Bacteria, Nutrient	1

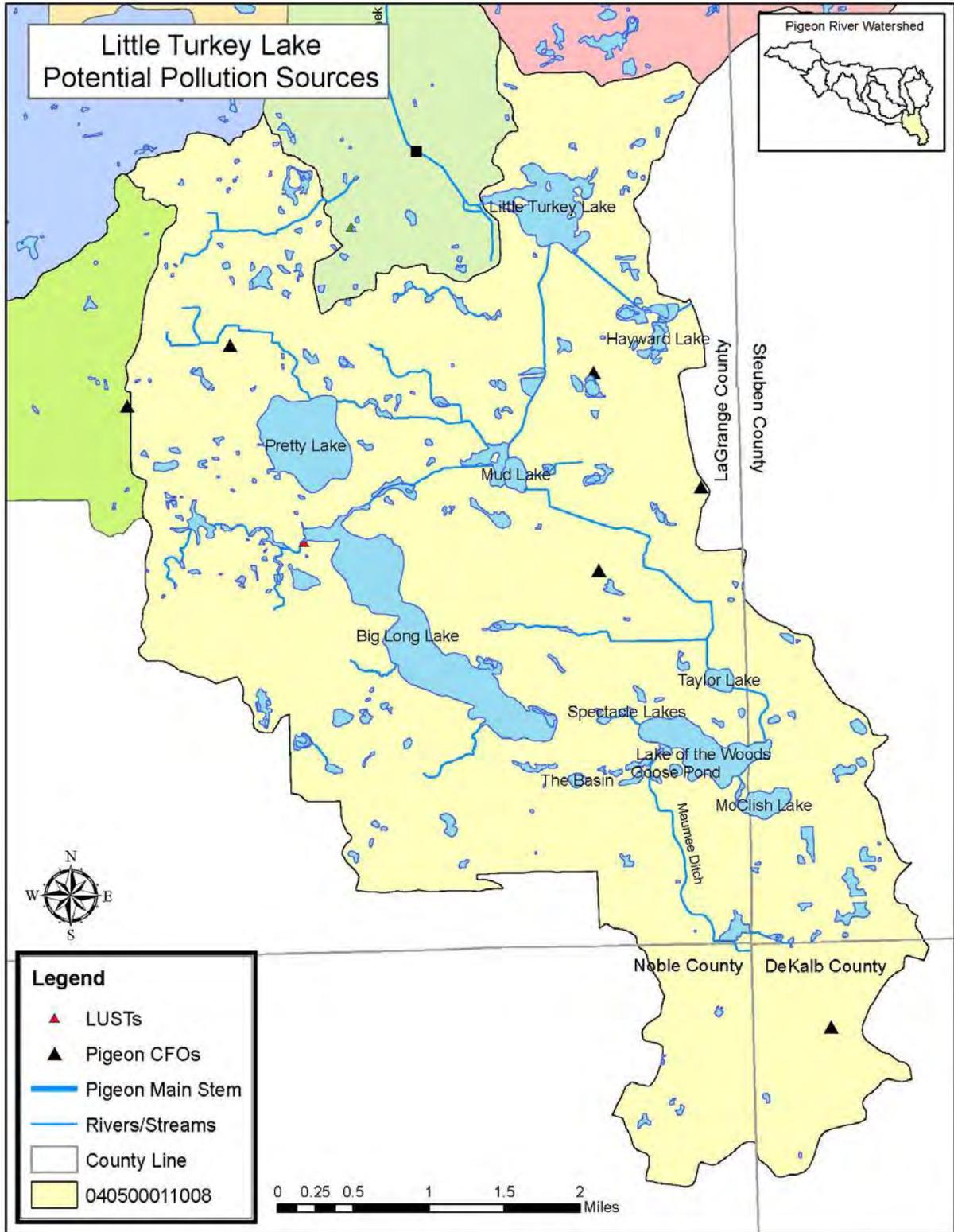


Figure 32: Little Turkey Lake Potential Pollution Issues

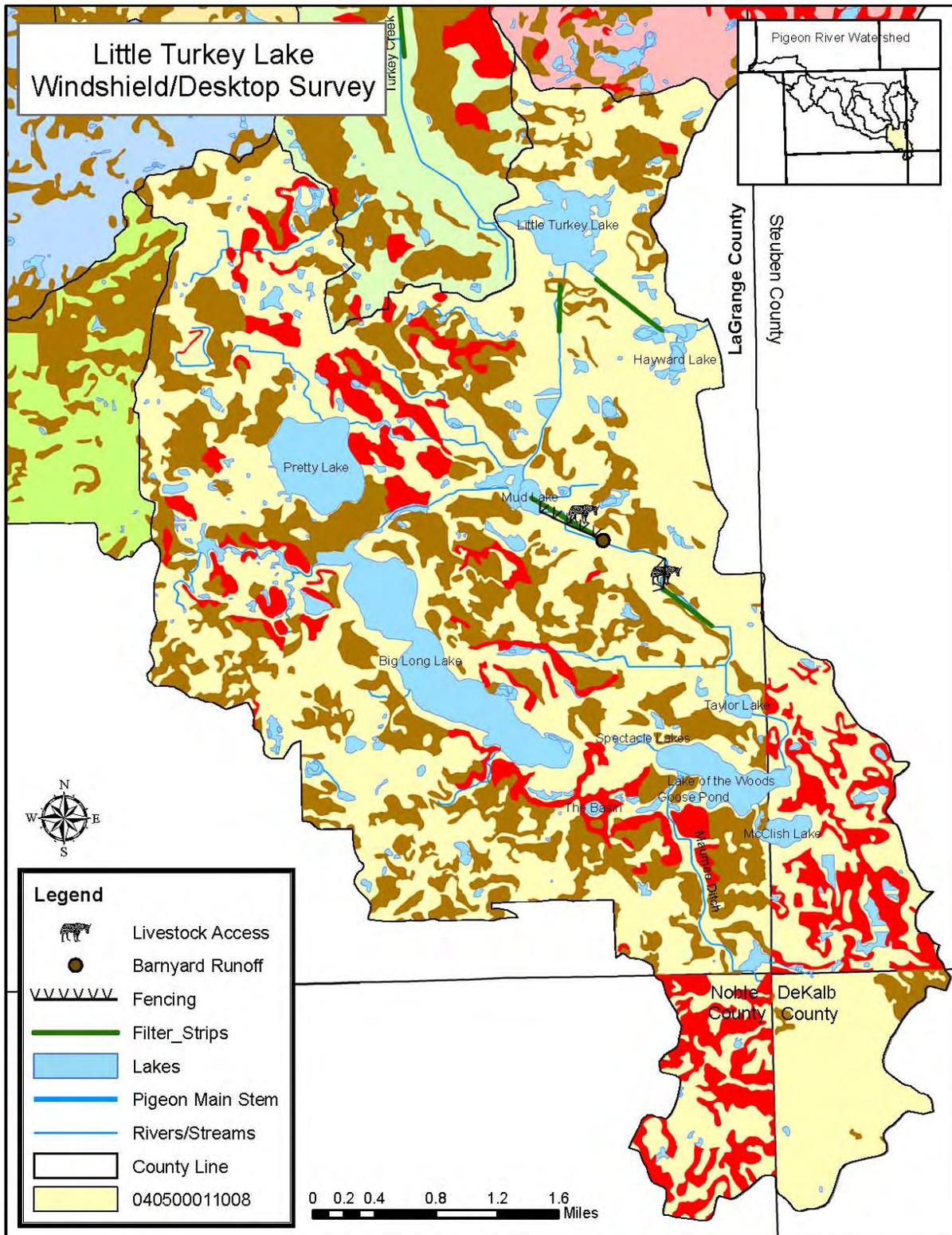


Figure 33: Little Turkey Lake – Turkey Creek Windshield/Desktop Survey

3.5.3 Mongo Millpond-Pigeon Creek Land Use

The Mongo Millpond subwatershed is located entirely in LaGrange County and is just west of Green Lake subwatershed (Figure 34). It is approximately 10,492 acres (4245.96 hectares) in size and contains the Mongo Millpond reservoir. The major waterways located within this subwatershed are the Pigeon and Turkey Creek. The predominant land use in the subwatershed is agriculture, which is nearly 67% of the total land use. The eight acre Turkey Creek Wetland Conservation Area, a part of the Pigeon River Fish and Wildlife Area, is located in the Mongo Millpond subwatershed. Both of these recreational areas are managed by the Fish and Wildlife Department of the IN DNR. Table 66 displays the distribution of land use in the Mongo Millpond subwatershed.

Table 66: Mongo Millpond Land Use

	Water	Developed - HD	Developed - LD	Industrial	Cultivated Crops	Grass/ Pasture	Forest	Other	Total
Acres	2390.9	185.4	288.6	N/A	6146.7	859.9	620.6	0	10492
%	22.8	1.8	2.7	N/A	58.6	8.2	5.9	0	100

The land use with the most influence on water quality in the Mongo Millpond subwatershed is agriculture. But as with the Green Lake subwatershed, Mongo Millpond is also largely composed of water, which takes up nearly 23% of the surface area, due to the 77 acre Millpond and the surrounding wetland areas that are located within the PRFWA which is located within this subwatershed. The small town of Mongo (P=300) is located within the drainage area, but the growth rate is stagnant and urban NPS does not seem to be a major issue within the subwatershed.

Pigeon Creek, located east of the Mongo Millpond, is listed on the Indiana 2008, 303(d) list of impaired waters for *E. coli*. Turkey Creek and an unnamed tributary to Mongo Millpond are listed on the Indiana fish consumption advisory (Figure 35).

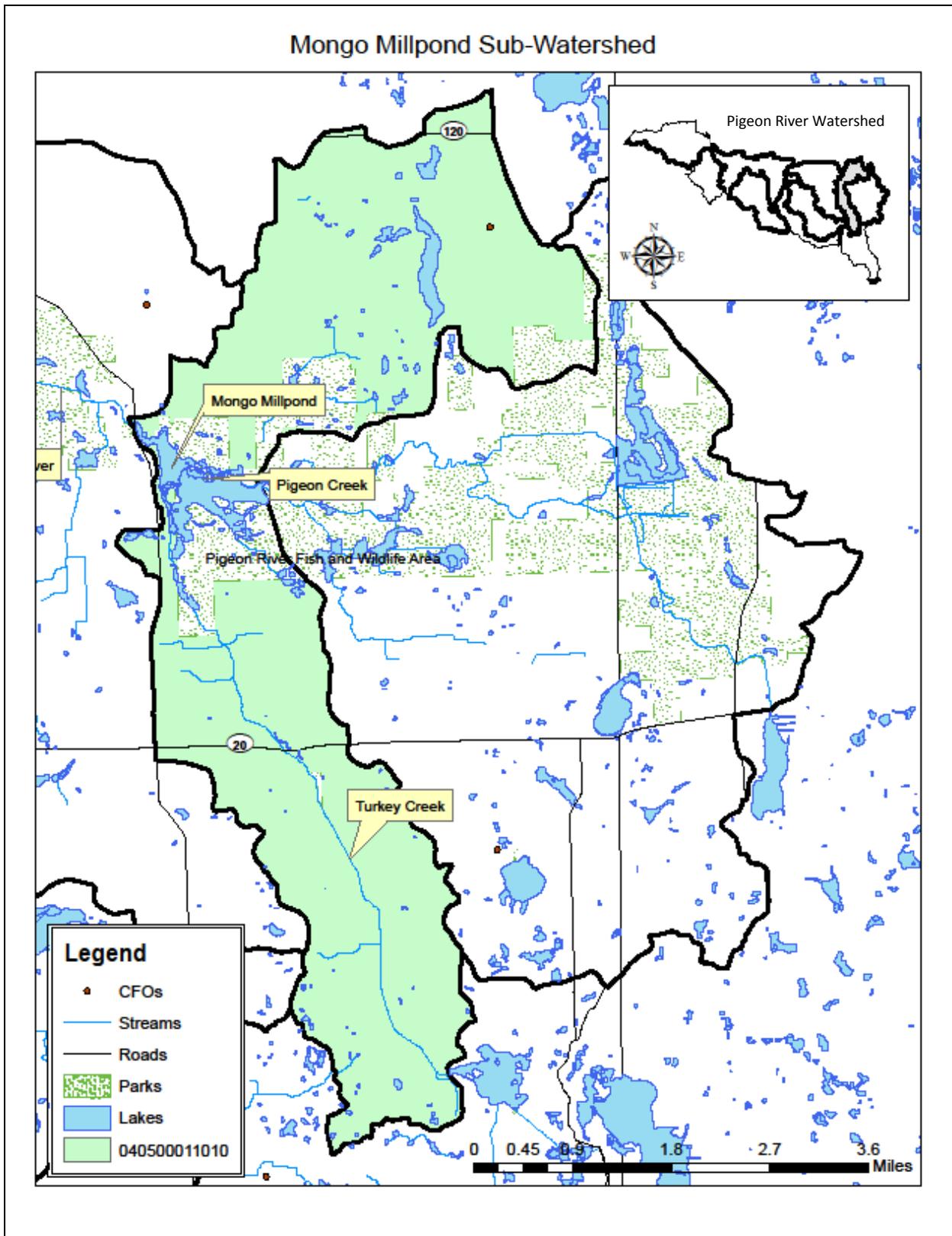


Figure 34: Mongo Millpond Subwatershed

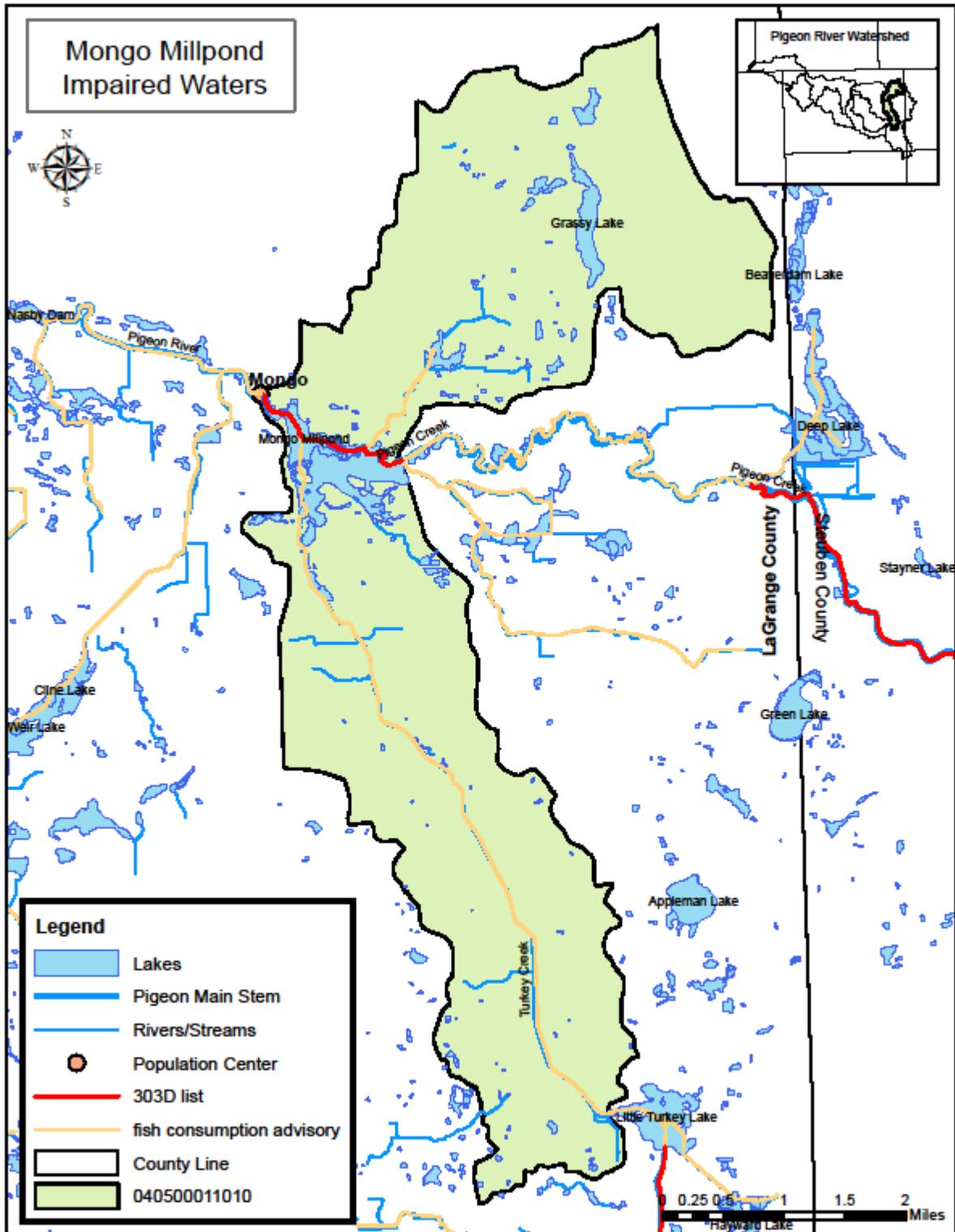


Figure 35: Mongo Millpond Impaired Waters

The LaGrange County Utility District, Region B, which services the built-up lakes located in the Mongo Millpond subwatershed is the only NPDES permitted facility located in the subwatershed. Region B has one Sanitary Sewer Outfall (SSO) which discharges into Turkey Creek and has not reported any overflows within the past decade. While there has not been a reported overflow from Region B in the past ten years, it is important to monitor the discharge point and educate the public on water conservation in their homes to keep from having any unnecessary overflows.

There are two LUST site located within the Mongo Millpond subwatershed; the Pigeon River Fish and Wildlife Area, and the Mongo Country Store. Both LUST sites are located in, or around, the town of Mongo. The PRFWA and Mongo Country Store LUSTs are still active. This means that IDEM is still working with these organizations to remediate the problem by either upgrading the UST or closing it all together.

There is one CFO located in the northeastern portion of the subwatershed. This facility is a dairy operation and is not located near any major waterways and does not seem to pose a significant threat to water quality. Table 67 and Figure 36 display the potential pollution risks in the Mongo Millpond subwatershed and their location, respectively.

Table 67: Potential Water Quality Pollution Threats in Mongo Millpond

Type of Threat	Potential Contaminant	Number in Watershed
Leaking Underground Storage Tank	Oil/Gas	2
Confined Feeding Operations	Manure runoff/sedimentation	1
NPDES Permitted Facility	Nutrients, Bacteria, Sediment	1

The windshield and desktop survey revealed that the Mongo Millpond is primarily influenced by agricultural fields along Pigeon Creek south of the main channel which flows through Pigeon River Fish and Wildlife Area. The north lateral ditch is filtered through a series of wetlands. While the majority of the town of Mongo is located in the Cline Lake subwatershed, it is important to this project as the town of Mongo surrounds the tail-waters and is not on a centralized sewer system. Improperly maintained or faulty septic systems may have some influence on pollutants entering the main river channel. As was mentioned in section 2.6, the LaGrange County Health Department estimates that nearly 75% of installed septic systems are currently failing. However, visual observations of Mongo Millpond revealed one area in particular where livestock have direct access to open water as a drinking water source which can lead to significant sedimentation and high nutrient and *E. coli* levels in the water column. Where the livestock have access to the stream, the bank has become completely denuded of vegetation and is in need of a riparian buffer. The survey also revealed the large amount of soil rated as PHEL. Table 68 and Figure 37 show the results of the windshield and desktop surveys for the Mongo Millpond subwatershed.

Table 68: Mongo Millpond Windshield Survey Observations

Type of Threat	Potential Contaminant	Number in Watershed
Livestock Access to Ditch	Sediment, Bacteria, Nutrients	1
Need for Exclusion Fencing	Sediment, Bacteria, Nutrients	1500 feet
Lack of Riparian Buffer	Sediment, nutrient runoff	3 miles

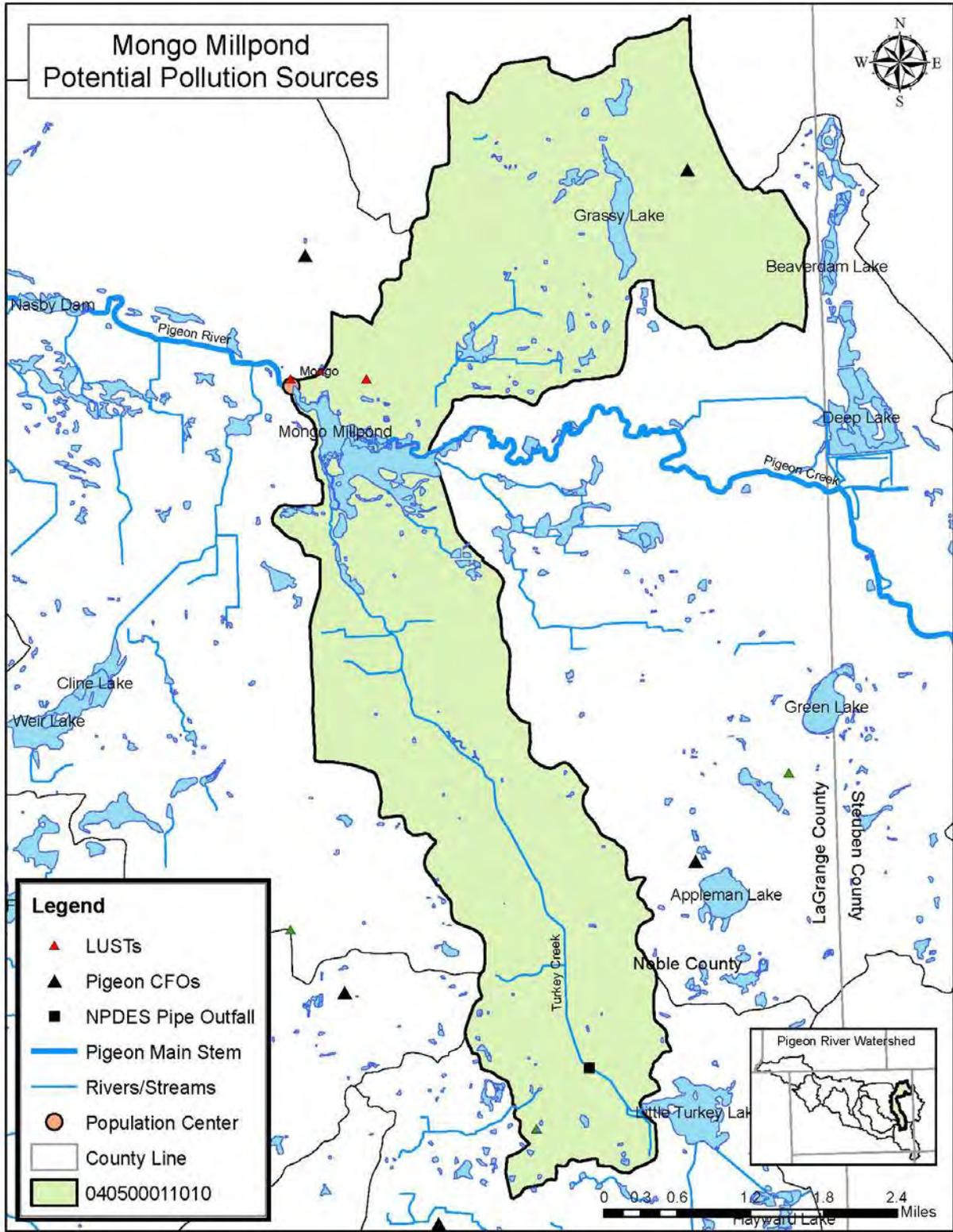


Figure 36: Mongo Millpond Potential Pollution Issues

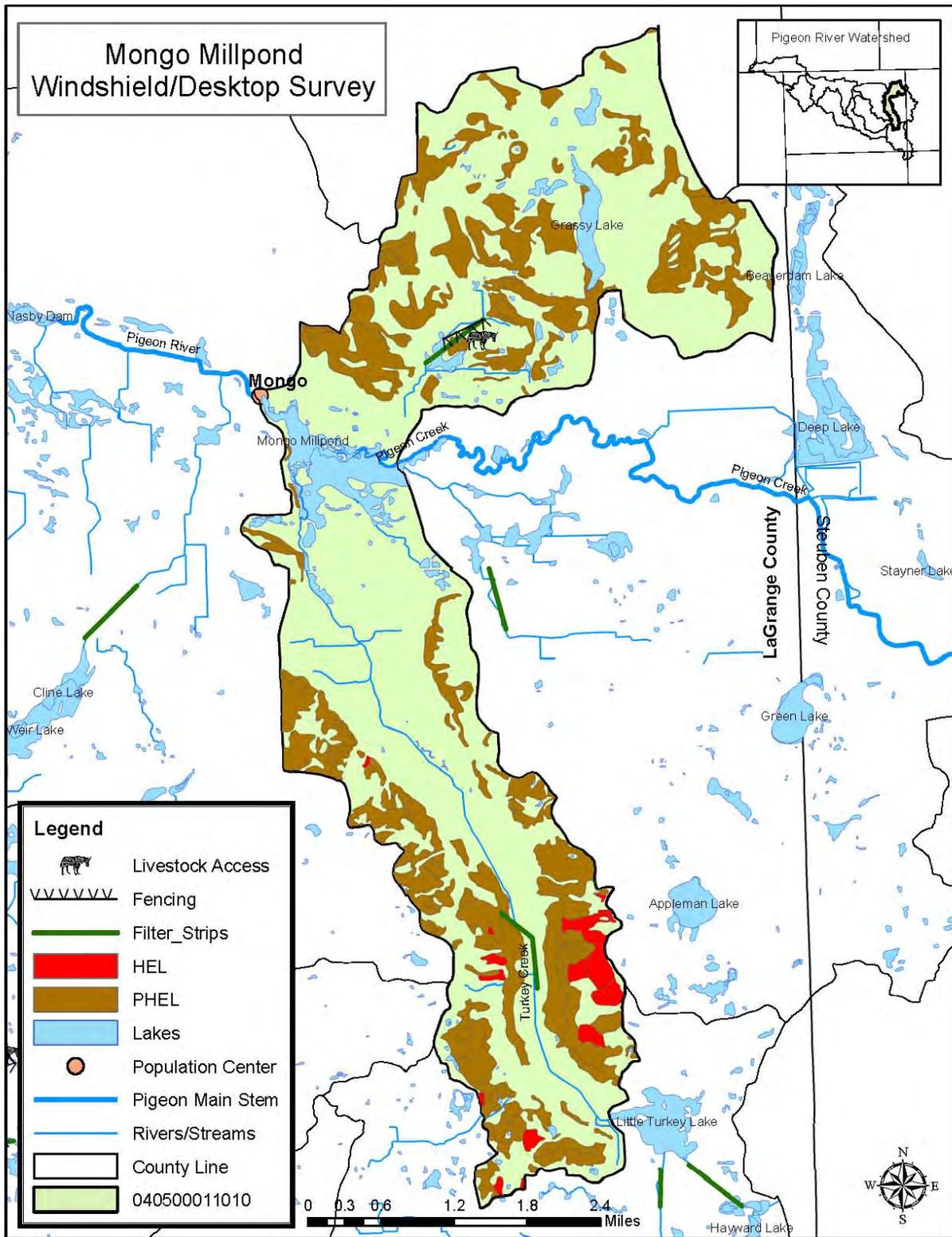


Figure 37: Mongo Millpond Windshield/Desktop Survey Results