5.0 Part III; Watershed Inventory

Part three of the watershed inventory describes data collected and observations made during the watershed planning process, including information from a watershed windshield survey and key recommendations, as well as a detailed analysis of stakeholder concerns.

5.1 Watershed Inventory Summary

In addition to a detailed analysis of existing GIS and water quality data, a watershed-wide windshield survey and five (5) individual landowner site visits were conducted in early April of 2013. The windshield survey was conducted by traveling most of the roads within the watershed and recording observations using GPS. Data recorded included potential BMP location and details, cropping practices and landuse, pasture and confinement operations, and any other relevant information.

Landowner site visits included a discussion of the watershed planning process, resource concerns, evaluation property, and a discussion about implementing recommended BMPs. Several potential projects were identified on private ground, and are detailed along with other site-specific BMPs in Section 9.2. Section 9.1 details basin-wide BMPs.

The detailed watershed inventory yielded the following watershed-wide observations and key recommendations for addressing water quality issues:

1. Wetlands are critical features within the watershed, especially where field and pasture areas drain. These wetlands have been impacted, and may no longer be efficient at treating runoff. In many cases, field tiles bypass these wetlands and drain directly to ditches and streams. Recommendations include:
    - Restoration of wetlands adjacent to crop fields and pastures will increase sediment storage and nutrient uptake.
2. Many crop fields drain to a central depressional zone within the field where tile drains runoff under existing wetlands and into streams. Tile discharges observed after a rain event showed very turbid water, indicating that much of the eroded sediment may also be transported through these tiles and directly into nearby waterways. Recommendations include:
    - Installing tile restrictor plates or blind inlets at tile riser locations in depressional areas or at field edges where tile systems direct runoff around wetlands. This will force runoff to exit the system at a slower rate, allowing eroded sediment to drop out and remain in the field. Secondary benefits will include a reduced flood pulse as water is stored in the fields for a longer period.
3. Pasture operations are somewhat limited within the watershed and, for the most part, are in good condition without evidence of overgrazing. Pasture operations that have been overgrazed or too densely stocked may be contributing to high levels of bacteria and nutrients in streams. Recommendations include:
    - Focusing pasture improvement practices and landowner outreach to these high-impact pasture operations. BMPs should include stream fencing and buffer zones, rotational grazing, and alternative water systems and on-site runoff control/detention.

4. There is only a handful of permitted Concentrated Animal Feeding Operations (CAFO) within the watershed, and these operations were observed to be utilizing best practices with respect to waste management. There are, however, numerous small livestock feeding operations within the basin that are not permitted, and are not managing onsite waste control. Many of these sites have small, bare feed areas and barns, located on the top of a hill, or a side slope, where pollution is running off the site directly into a stream or ditch. Recommendations that focus on reducing or minimizing runoff and treating contaminants include:
    - Gutter systems on farm buildings and barn areas, water diversions around feed areas, detention basins, and small treatment ponds/wetlands.
5. Flat, productive fields within the watershed are difficult to drain, resulting in the construction of ditches and channelized streams to move more water faster. The challenge is to maintain productivity and drainage while reducing nutrient loss and the impacts of flooding. Recommendations include:
    - Installing two-stage ditches in headwater areas where streams have been channelized, providing additional capacity for floodwaters and increase nutrient removal.
    - Install water control structures at the outlets of small drainage ditches to temporarily store runoff.
6. Certain tillable sections of the watershed are on very long, steep slopes. Although crop residue is maintained on these fields, sheet and rill erosion is still occurring. Recommendations include:
    - Installing terrace systems on HEL fields, focusing on fields with the longest slopes.
7. Several areas surrounding lakes in the watershed are not currently serviced by a wastewater treatment plant. These areas are generally much older developments, likely on septic systems. It is possible these older developments are contributing contamination through failing septic systems. Recommendations include:
    - Conducting outreach on septic system maintenance to areas not served by a treatment plant.
    - Certify septic pumpers to inspect septic tanks.
    - Recommend homeowners get their septic tanks pumped and inspected every 3 years.
    - Septic pumpers file an inspection report with the County Health Department.
    - Define a “sensitive area” boundary in the watershed close to creeks and waterways. Base boundary on soil types and slopes – where seepage from a drain field could reasonably be expected to reach a watercourse before being adequately treated.

5.2 Analysis of Stakeholder Concerns

This section, as described in section 2.3, provides a condensed list of stakeholder concerns gathered during public and one-on-one meetings. These concerns may or may not be supported by data, and may not be quantifiable, but are important to the relevance of the watershed plan.

An effort was made to “poll” watershed stakeholders for the purposes of identifying concerns. Stakeholder input was solicited by conducting surveys at scheduled public meetings, speaking directly with watershed landowners and SWCD board members. Overall, stakeholder concerns identified at public meetings can be focused on water quality, while individual landowners expressed concerns with

flooding and drainage. Practices implemented to reduce flooding and improve drainage can also improve water quality. An example would be the two-stage ditch; a BMP that reduces local flooding by maintaining or improving drainage, while improving water quality by filtering pollution. Table 39 lists the most important stakeholder concerns relevant to the watershed plan. During the first public meeting, a handout was provided to participants listing problems and concerns from the previous plan. Participants were then asked to list whether or not these were still a concern or not. The results or votes were then tallied; a total of 135 votes were received indicating the 2006 plan concerns were still valid and 53 total votes indicating the concerns were no longer valid. For example, concerns related to dying lakes and property values, both concerns in 2006, are no longer concerns today.

Concerns are listed in order from most to least important and are based on number of votes as detailed in Section 2.3. In order to improve implementation efficiency and reduce complexity, only those concerns that received seven or more votes are included. Also, some concerns were deliberately left out due their relevance to this plan and their ability to be addressed such as property values and overextending campgrounds. Several of the concerns listed in Table 39 include a lumping of issues identified by stakeholders. For example, any lake-specific concerns with respect to bacteria or the Angola WWTP were lumped into bacteria and concerns with drainage and wetlands, as well as wildlife, were lumped into degraded wetlands and ecological habitat. Concerns related to nonpoint source pollution, road and farm runoff were lumped into urban and rural runoff. Finally, concerns related to environmental stewardship, outreach and cooperation are not listed in Table 39 as they received only a few votes and are solutions rather than problems; outreach is listed as an implementation strategy and stewardship and cooperation is already being promoted in the watershed.

Table 39 – Primary Stakeholder Concerns

Concern	Supported by Data (yes/no)	Notes/Analysis
1. Bacteria	yes	Bacteria concentrations in watershed lakes and streams continue to be a major concern. Exceedences in water quality standards are numerous and a TMDL plan was completed in 2012 for bacteria.
2. Water Pollution, Phosphorus and Sediment	Yes & No	Results from water quality sampling do not necessarily indicate a major issue with sediment; more sampling of high flow events is needed. Modeled results and observations indicate that sedimentation is an issue during high-flow events and is impacting wetlands that drain adjacent crop ground. A TMDL was completed for phosphorus, and sampled water quality indicates exceedences in state standards. Modeled phosphorus results indicate reductions are needed. Nitrogen was not noted as a concern by stakeholders, however, water quality results indicate numerous exceedences in the 10mg/L threshold.
3. Drainage	Yes	Drainage is the number one concern for farmers in the watershed. Watershed soils, the extent of tiling and topography support the fact that drainage is difficult to manage for production agriculture.
4. Degraded Wetlands and Ecological Habitat	Yes	Extensive data and observations support the fact that the acreage of historical wetlands has been significantly reduced. Wetlands are degraded and under stress; wetland restoration and enhancement is a recommended strategy.
5. Flooding	Yes	Data exists that supports the idea that flooding frequency and severity in the watershed has been increasing. As noted in Section

Concern	Supported by Data (yes/no)	Notes/Analysis
		4.2.3, peak flood stage in the last 36 years has been exceeded in 17 of those years. There is also anecdotal evidence from landowners that flooding does occur and it is still a concern for many.
6. Urban and Rural Runoff	Yes	Modeled results and an assessment of watershed data indicate that both urban and rural runoff is contributing to water quality impairments.
7. Financial Concerns	No	Relating to the availability of funding, a review of past watershed success and an understanding of current funding programs, there is no indication that financial concerns are an issue. Various state and federal programs exist and the SWCD has been extremely successful in receiving funds to date. Particular "un-fundable" projects may be limited in funding. The limited ability for individuals to fund projects (matching funds), combined with landowner interest, or lack thereof, to implement specific practices, are likely why there are concerns with financing. Flexibility in state and federal cost-sharing could increase participation.

Water Quality Brochure Distributed in the Watershed

6.0 Problems & Causes

Based on the data and information presented in the watershed inventory and analysis of the data, problems and causes are correlated to the seven individual stakeholder concerns as identified in Section 5.2 and previously in the plan. Four major problem areas are identified based on the stakeholder concerns:

1. Water Quality, Bacteria
2. Water Quality, Nutrients and Sediment
3. Flooding & Drainage
4. Degraded Wetland and Ecological Habitat

Chapter 7 further details and characterizes major sources of pollution in the watershed.

Table 40 - Categories of Key Problems

Key Categories	Major Causes/Sources	Supporting Information
1. Water Quality, Bacteria	Urban and rural land runoff, point source pollution, septic systems, pasture and small animal feed areas, wildlife, and legacy sediment.	Water quality data, pollutant load modeling, TMDL plan, septic analysis, windshield survey, and local reports and data.
2. Water Quality, Nutrients & Sediment	Agricultural runoff, sheet, rill, and gully erosion, urban and residential farm runoff, small animal feeding operations and pasture, hydrologic modifications and tiling, and wastewater treatment plants and CSOs (to a lesser degree)	Water quality data, pollutant load modeling, TMDL plan, septic analysis, windshield survey, local reports and data, water quality from permitted dischargers, and GIS analysis of landuse.
3. Flooding & Drainage	Urban runoff and impervious surfaces, soil types, hydrologic modifications, channelization, and tiling.	Windshield survey, water flow data, runoff modeling, and GIS analysis.
4. Degraded Wetlands & Ecological Habitat	Agricultural and urban runoff, urban development, and drainage.	Windshield survey, runoff and pollution load modeling, GIS analysis of existing and degraded wetlands and of hydrologic modifications.

6.1 Water Quality, Bacteria

As noted in the previous sections, high concentrations of fecal coliform and *E. coli* bacteria have been consistently recorded in the watershed, confirming bacteria as a water quality problem. Bacteria can have a negative impact on both human and biological health.

The State of Indiana has water quality standards only for *E. coli* bacteria, and *E. coli* values are presented and discussed throughout the plan. *E. coli* represents a portion or subset of fecal coliform bacteria. The pollution load modeling performed for this plan represents fecal coliform bacteria, of which *E. coli* typically represents up to 90% of the total fecal coliform count.

Based on the watershed inventory and assessment, *E. coli* bacteria-related problems exist watershed-wide in all 10 subwatersheds. Table 41 outlines the key problems, anticipated causes and the relevant sections of the plan that were applied to derive these conclusions.

Table 41 – Bacteria-Related Problems & Causes

Problem	Causes/Sources	Subwatershed (s)	Supporting Information
A majority of the streams and waterways in the watershed are at sometimes unsafe for full contact recreational uses due to elevated levels of bacteria.	Urban and rural land runoff, and confinement operations, septic systems, pasture and small animal feed areas, wildlife, legacy sediment and, to a lesser extent, point source pollution from wastewater treatment plants (CSOs).	All Subwatersheds	Water quality data, impairment data, wastewater discharge data, pollutant load modeling, TMDL plan, septic analysis, windshield survey, local reports and data, and GIS analysis of landuse.
Three subwatersheds are considered high priority for bacterial contamination and are degraded.	Rural farm runoff, pasture and small feed areas, confinement operations, and septic systems.	1. Little Turkey Lake – Turkey Creek 2. Long Lake – Pigeon Creek 3. Silver Lake – Pigeon Creek	Water quality data, pollutant load modeling, critical areas analysis, septic analysis, windshield survey, distance of pasture and feed areas to a stream, and GIS analysis of landuse.

6.2 Water Quality, Nutrients & Sediment

Based on the watershed inventory and assessment, sediment and nutrient problems exist watershed-wide, however, there are areas where the problems are more focused than others. Table 42 outlines the key problems, anticipated causes and the relevant sections of the plan that were applied to derive these conclusions.

The quality of water within the watershed has a direct impact on several resources, including lakes and wildlife habitat. It can be expected that as the water quality in the watershed decreases, so will the quality of recreational resources and wildlife. This section of the plan attempts to link the most commonly identified stakeholder concerns to actual problems and causes identified in the watershed through an analysis of water quality data, GIS information, and modeled pollution loading results.

Table 42 - Sediment & Nutrient-Related Problems & Causes

Problem	Causes/Sources	Relevant Subwatershed (s)	Supporting Information or Relevant Plan Sections
Excessive sedimentation is degrading fish habitat and affecting recreational and aesthetic value.	Sheet and rill erosion, gully erosion and, to a lesser degree, streambank erosion, cropped HEL soils, and overgrazed pasture.	1. Mud Creek – Pigeon Creek 2. Long Lake – Pigeon Creek 3. Pigeon Lake – Pigeon Creek 4. Headwaters Turkey Creek	Water quality data, pollutant load modeling, HEL soils analysis, windshield survey, and critical area analysis.
Eutrophic conditions are known to exist in Golden Lake,	Excess nutrients from agricultural runoff, livestock	1. Long Lake – Pigeon Creek	Long Lake and Little Turkey Lake are impaired for total

Problem	Causes/Sources	Relevant Subwatershed (s)	Supporting Information or Relevant Plan Sections
Hogback Lake, Little Turkey Lake, and Long Lake have degrading water quality, affecting recreational and aesthetic value.	Operations, septic systems, hydrologic modifications and drainage tiles, and urban runoff.	2. Headwaters Turkey Creek 3. Little Turkey Lake – Turkey Creek 4. Mongo Millpond – Pigeon Creek	phosphorus, 2010-2011 trophic index data, pollutant load modeling, GIS analysis of landuse, and hydrologic modifications.
Phosphorus and nitrogen are too high in some streams and are impacting aquatic life.	Hydrologic modifications and drain tiles, excess nutrients from agricultural runoff and erosion, pasture and small feed areas, and septic systems.	1. Long Lake – Pigeon Creek 2. Headwaters Turkey Creek 3. Pigeon Lake – Pigeon Creek 4. Mud Creek – Pigeon Creek	2010 impairment data, water quality data, pollutant load modeling, GIS analysis of landuse and hydrologic modifications, septic analysis, windshield survey, critical areas analysis.

6.3 Flooding & Drainage

Flooding continues to be a problem in the watershed. Although there are many causes for flood occurrences, the primary reason for flooding in the Pigeon Creek watershed is the lack of storage in upstream areas and, as a result, the lack of drainage capacity in the waterways to drain flood events. The watershed often experiences overbank flooding in agricultural areas, as the runoff peaks exceed the capacity of the channels. Most flooding, and likewise the most damage, is reported near the lake chain due to development within the floodplain along the lakeshore, and a flow restriction at the Hogback Lake outlet. In addition to property damage, flooding also impacts water quality in the watershed, as residential septic units can be impacted by the floodwaters. Table 43 outlines the key problems, anticipated causes and the relevant sections of the plan that were applied to derive these conclusions.

Table 43 - Flooding & Drainage-Related Problems & Causes

Problem	Causes/Sources	Relevant Subwatershed (s)	Supporting Information or Relevant Plan Sections
Overall peak floods in the watershed have increased significantly since 1976.	Increase in impervious surface, historical loss of wetlands, hydrologic modifications and drainage tiles, and soil characteristics.	1. Long Lake – Pigeon Creek 2. Headwaters Turkey Creek 3. Mud Creek – Pigeon Creek	Stream gage data analysis, GIS analysis of soil types, landuse, current and historical wetlands, impervious surfaces, and hydrologic modifications, and annual runoff volume modeling.

6.4 Degraded Wetlands & Ecological Habitat

Degraded wetlands and ecological habitat is a key concern of stakeholders and, based on the inventory and assessments, there are problems throughout the watershed. Table 44 outlines the key problems, anticipated causes and the relevant sections of the plan that were applied to derive these conclusions.

Table 44 - Degraded Wetlands & Ecological Habitat Problems & Causes

Problem	Causes/Sources	Relevant Subwatershed (s)	Supporting Information or Relevant Plan Sections
Presettlement wetlands have been reduced by 50% and this is impacting water quality and available wildlife habitat.	Increase in impervious surface, historical loss of wetlands, drainage tiles.	1. Pigeon Lake – Pigeon Creek 2. Mud Creek – Pigeon Creek 3. Long Lake – Pigeon Creek 4. Headwaters Turkey Creek	Stream impairments for IBC, GIS analysis of landuse, current and historical wetlands, and existing and protected habitat.
Stream habitat and biological integrity is low overall, indicating a stressed biological community.	Excessive nutrients, sediment, and bacteria from both point and nonpoint source pollution, and hydrologic modifications.	1. Green Lake – Pigeon Creek 2. Little Turkey Lake – Turkey Creek 3. Big Turkey Lake – Turkey Creek 4. Long Lake – Pigeon Creek	Biological stream data (IBI & mIBI) and GIS analysis of existing and protected habitat and landuse.

7.0 Pollution Sources & Loading

Like many Midwestern watersheds, water pollution can originate from both point and nonpoint sources. Point-source pollution is any single identifiable source of pollution from which pollutants are discharged, such as a pipe. Nonpoint-source (NPS) pollution is caused by rainfall or snowmelt moving over and through the ground. As the runoff moves, it picks up and carries away natural and human-made pollutants, finally depositing them into lakes, rivers, wetlands, and even groundwater. This section will describe, in detail, pollution sources, as well as quantities or total loading.

7.1 Pollution Sources

In order to limit the impact of stressors on critical characteristics of the watershed, the sources of the stressors should be examined and addressed. Pollution sources can be broken down into point-source and nonpoint-source pollution. This section will examine specific watershed point and nonpoint pollution sources for the treatable problems and causes listed in the previous sections.

7.1.1 Point-Source Discharges

Potential sources of bacteria, phosphorus, nitrogen, and sediment in the watershed include both permitted and non-permitted point sources. As of 2012, there are seven National Pollutant Discharge Elimination System (NPDES) permitted point sources in the Pigeon Creek watershed, which include wastewater treatment plants, combined sewer overflows, and stormwater runoff from IDEM stormwater Phase II communities. Other NPDES point sources include a state rest area and a local business. As of 2012, there are two (2) CAFOs and six (6) CFOs also considered permitted point sources and exist within the watershed. According to their general permits, these CFOs are considered to be no-discharging. Septic systems can also be considered point-source pollution and are discussed below.

Septic Systems

Septic systems provide treatment of wastewater from individual properties. Failing septic systems are typically an active source of pollutants. Faulty or leaking septic systems are sources of bacteria, nitrogen, and phosphorus. According to the 2012 TMDL, there is an estimated total of 9,108 septic systems (Table 45) and, of these, 1,365 (15%) are estimated to be failing. In the TMDL plan, the number of septic systems was estimated based on landuse, and was not tied to a specific location. Areas identified as developed open space, low intensity development, and medium intensity development were assumed to be served by onsite septic systems at a rate of: one system per four acres of open space, one system per acre of low intensity, and five systems per acre of medium intensity. The TMDL plan applied a 15% failure rate.

Table 45 - 2012 TMDL Septic System Estimates

Subwatershed Name	HUC 12 Subwatershed Codes	Total Estimated Number of Septic Systems	Total Estimated Number of Failing Septic Systems
Pigeon Lake-Pigeon Creek	040500011001	1,134	170
Mud Creek-Pigeon Creek	040500011002	1,780	267
Long Lake-Pigeon Creek	040500011003	2,101	315
Headwaters Turkey Creek	040500011004	765	115
Big Turkey Lake-Turkey Creek	040500011005	530	79
Silver Lake-Pigeon Creek	040500011006	1,154	173
Otter Lake-Pigeon Creek	040500011007	366	55
Little Turkey Lake-Turkey Creek	040500011008	547	82
Green Lake-Pigeon Creek	040500011009	442	66
Mongo Millpond-Pigeon Creek	040500011010	289	43
Grand Total		**9,108**	**1,365**

Actual locations of failing systems are unknown so an analysis of available GIS data was conducted to identify the potential for water quality impacts from septic systems. Data layers used included: residential (urban and farm) boundaries, areas within a waste treatment district, areas connected to a municipal waste treatment facility, and soils limited for septic fields. These layers were combined to determine the location and acreage of those residential areas with the highest likelihood of failing septic systems. Out of a total of 4,936 acres of residential area believed to be on septic, 3,647 acres (74%) are located on limiting soils. Out of these 3,647 acres, 2,667 residential acres (73%) are within 500 feet of a stream or lake and should be targeted for the application of septic system BMPs. The highest percentage of residential area on septic, on limiting soils, and within proximity to a stream or lake is in the Long Lake and Silver Lake subwatersheds (Table 46 and Figures 35 and 36); priority should be given to these subwatersheds. Pollution load estimates and specific treatment recommendations for septic systems can be found in Sections 7 and 9.

Table 46 - Septic Systems

Subwatershed Names	HUC 12 Subwatershed Codes	Subwatershed Acres	Area (acres) Residential Septic Systems on Limiting Soils	% Area (acres) Residential Septic Systems on Limiting Soils	Area (acres) Residential Septic Systems on Limiting Soils and within 500ft of a Stream or Lake	% Area (acres) Residential Septic Systems on Limiting Soils and within 500ft of a Stream or Lake
Pigeon Lake-Pigeon Creek	040500011001	22,036	646	2.93%	435	67%
Mud Creek-Pigeon Creek	040500011002	11,641	330	2.84%	221	67%
Long Lake-Pigeon Creek	040500011003	18,620	786	4.22%	623	79%
Headwaters Turkey Creek	040500011004	11,798	237	2.01%	85	79%
Big Turkey Lake-Turkey Creek	040500011005	11,015	174	1.58%	135	78%
Silver Lake-Pigeon Creek	040500011006	12,954	514	3.97%	468	91%
Otter Lake-Pigeon Creek	040500011007	10,491	275	2.62%	212	77%
Little Turkey Lake-Turkey Creek	040500011008	13,255	208	1.57%	161	77%
Green Lake-Pigeon Creek	040500011009	13,581	253	1.86%	173	68%
Mongo Millpond-Pigeon Creek	040500011010	10,520	224	2.13%	153	68%
Grand Total		**135,911**	**3,647**	**2.68%**	**2,667**	**73%**

Steuben Lakes RWD Waste Water Treatment Plant

Figure 35 – Upper Pigeon Creek Septic Systems

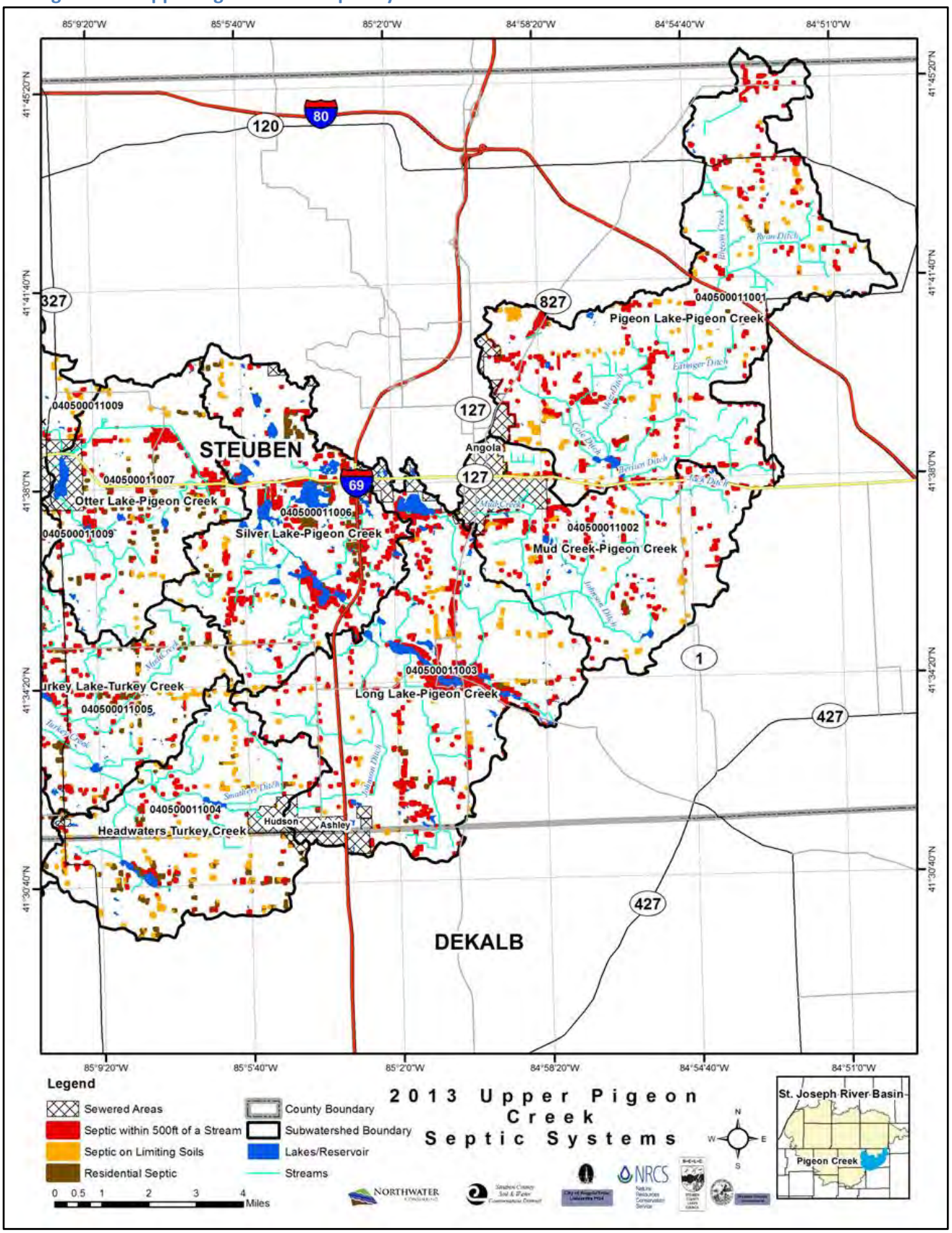
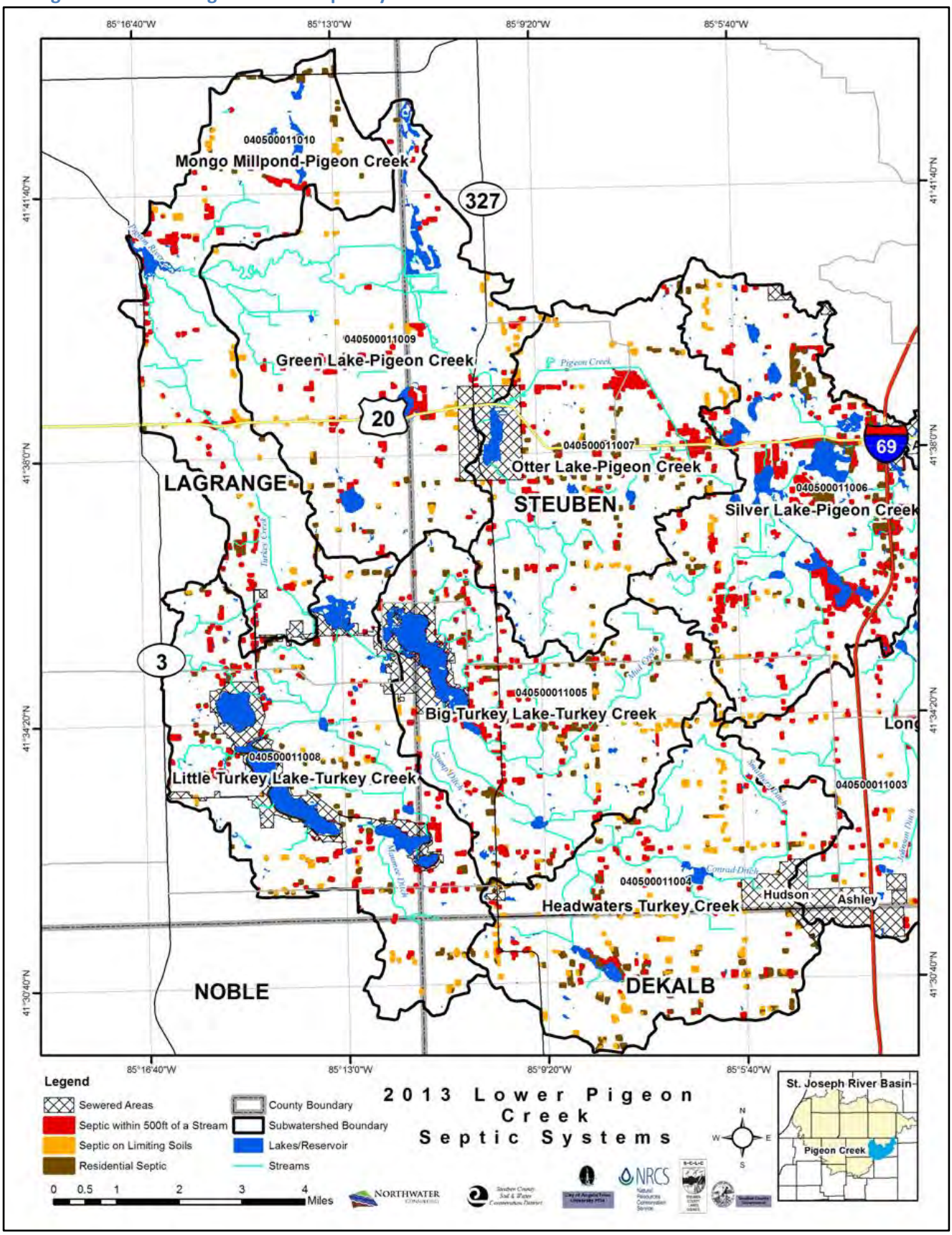


Figure 36 - Lower Pigeon Creek Septic Systems



Wastewater Treatment Plants & Permitted Discharges

Wastewater Treatment Plants (WWTPs) and industrial facilities are permitted dischargers authorized to discharge specific pollutants up to regulated thresholds, and are a source of bacteria, phosphorus, and nitrogen. Wastewater treatment plants and industrial facilities can contribute both pollutants and flow volume to the system. The regulated parameters and thresholds are specified in each permit. Municipal separate storm sewer systems (MS4s) dischargers are authorized to discharge stormwater and are regulated through Best Management Practices and not Water Quality-Based Effluent Limits. Only one MS4 (permit INR040005), with co-permittees of the City of Angola and Trine University (formerly Tri-State University), is located within the Pigeon River Watershed. This is a Phase II MS4 that includes land area within three HUC12s: 040500011001 (398 acres), 040500011002 (1308 acres), and 040500011003 (192 acres).

Seven existing WWTPs that are regulated for *E. coli*, total suspended solids, total phosphorus, and other constituents, such as ammonia and chloride, were identified in the Pigeon Creek watershed. Table 47 lists the existing WWTPs and permitted discharges and Figure 37 shows the location of all NPDES permit pipes and the areas served by WWTPs; all other areas of the watershed are assumed to be on septic. Only 4% (5,977 acres) of the watershed is serviced by a WWTP.

Table 47 - NPDES Permitted Discharges

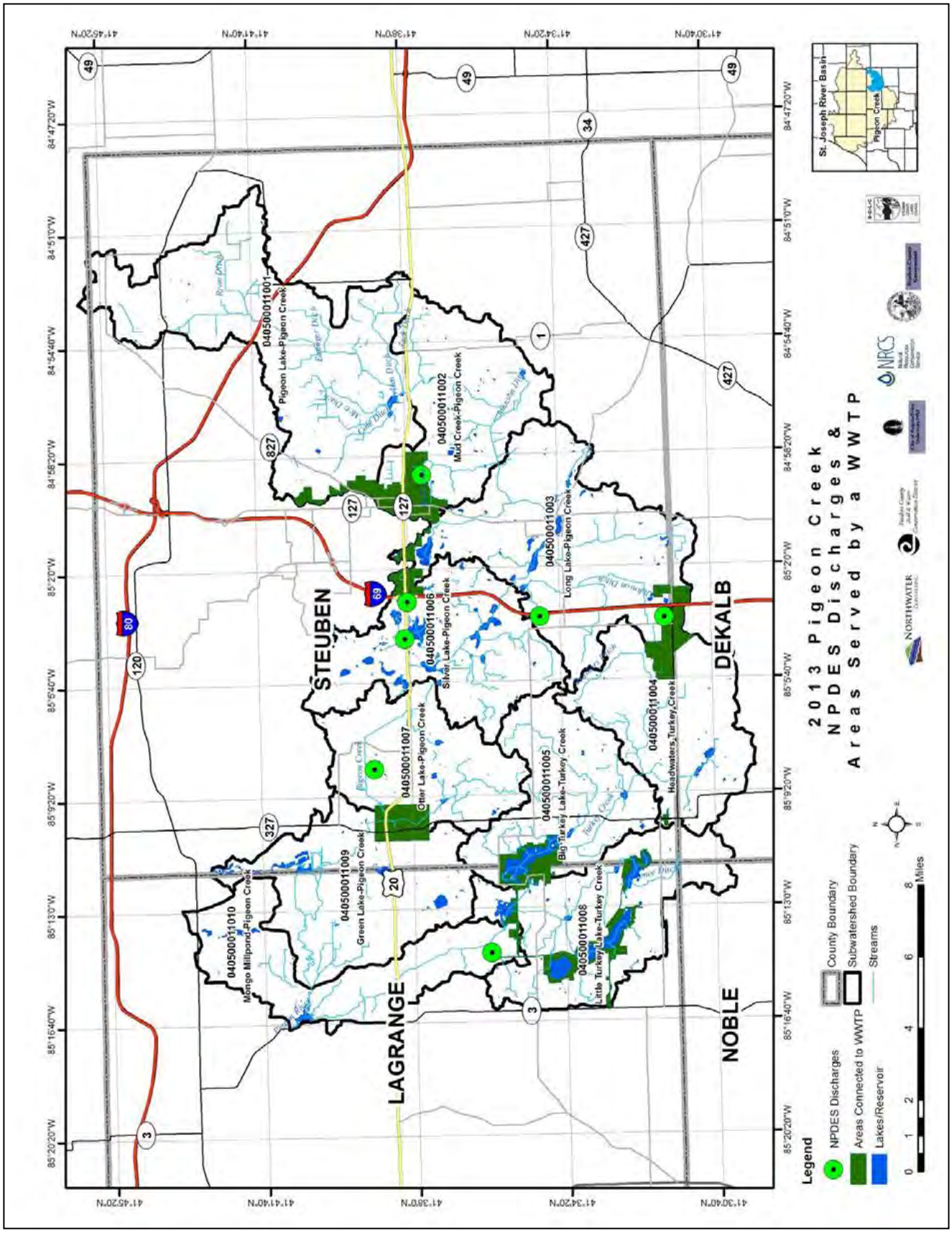
Site Name	Type	Permit Number	HUC 12	Design Flow (MGD)	Average Daily Flow (MGD)[1]
Angola Municipal STP	WWTP	IN0021296	Mud Creek-Pigeon Creek - 040500011002	1.70	1.190 (2005-2006)
Ashley Municipal STP	WWTP	IN0022292	Long Lake-Pigeon Creek - 040500011003	0.40	0.197 (2005-2007)
LaGrange Region B	WWTP	IN0060097	Mongo Millpond-Pigeon Creek - 040500011010	0.75	0.201 (2004-2009)
Pigeon Creek Rest Area I-69 SB	WWTP	IN0052043	Long Lake-Pigeon Creek - 040500011003	0.01	N/A
Silver Lake Group of Angola	WWTP	IN0039543	Silver Lake-Pigeon Creek - 040500011006	0.03	0.024 (2003-2004)
Steuben Lakes RWD	WWTP	IN0061557	Otter Lake-Pigeon Creek - 040500011007	1.00	0.390 (2005-2006, 2008-2010)
Best Western[2] Angola Inn	WWTP	IN0042196	Otter Lake-Pigeon Creek - 040500011007	N/A	N/A

[1] From 2012 TMDL

2 Although this permit is still active according to current state records, it is not known to be actively discharging; the Best Western is no longer located at this site.

An assessment of the Angola Wastewater Treatment Plant and other treatment facilities in the watershed has also confirmed that plant discharge is not the sole or primary source of bacteria, sediment, nitrogen or phosphorus. Other sources are present in the watershed, as well as bacteria that are naturally occurring such as from wildlife and biological processes. A detailed assessment of four permitted WWTPs is provided below. Permitted discharges and areas of the watershed served by a WWTP are shown on Figure 37.

Figure 37 - Pigeon Creek Permitted Discharges & Areas Served by a WWTP



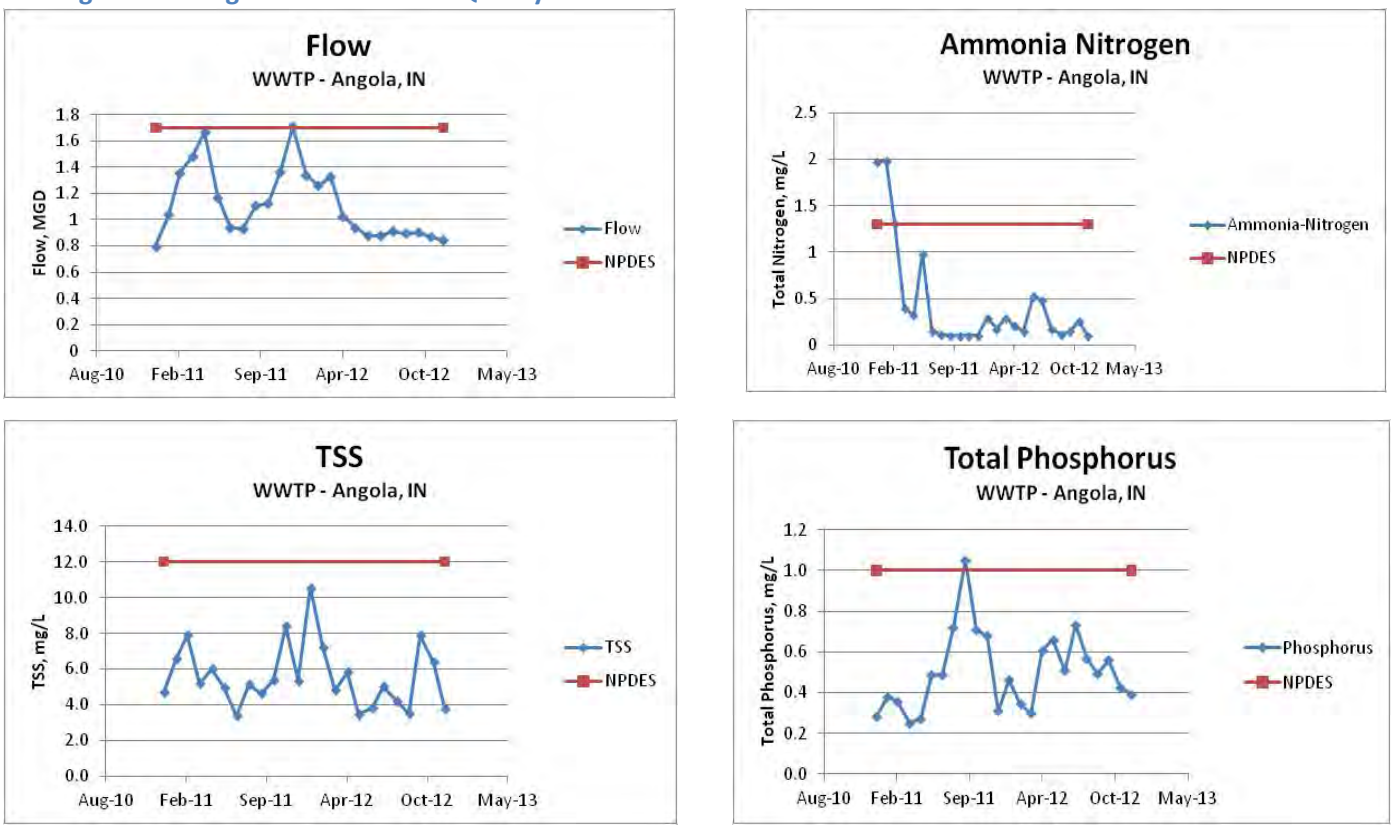
Angola Waste Water Treatment Plant

Angola operates a Class III conventional activated sludge treatment facility. The capacity is 1.7 Million Gallons per Day (MGD). The facility consists of a bar screen, degritter, two (2) flow equalization basins, three (3) primary clarifiers, three (3) aeration tanks, three (3) secondary clarifiers, ultraviolet light disinfection and an effluent flow meter. Class B biosolids are aerobically digested and belt filter pressed, stored, and land-applied by a licensed hauler. The collection system is comprised of combined sanitary and storm sewers with two (2) CSO locations. The CSO locations have been identified and are permitted. The long-term plan is to minimize/eliminate these two CSO discharges through sewer separation projects and removal of illicit connections

The facility discharges to Outfall 001, which is located at latitude: 41° 37’ 38” N, Longitude: 84° 58’ 59” W. The receiving water is Wood Ditch, which empties to Mud Creek and, eventually, Pigeon Creek. The CSOs also discharge to Wood Ditch.

A water quality analysis compared effluent flow, *E. coli*, TSS, ammonia-nitrogen, and phosphorus to NPDES permit limits. Monthly averages for each data set have been plotted for the period between January 2011 and December 2012. The results of the analysis are shown in Figure 38.

Figure 38 - Angola WWTP Water Quality Results



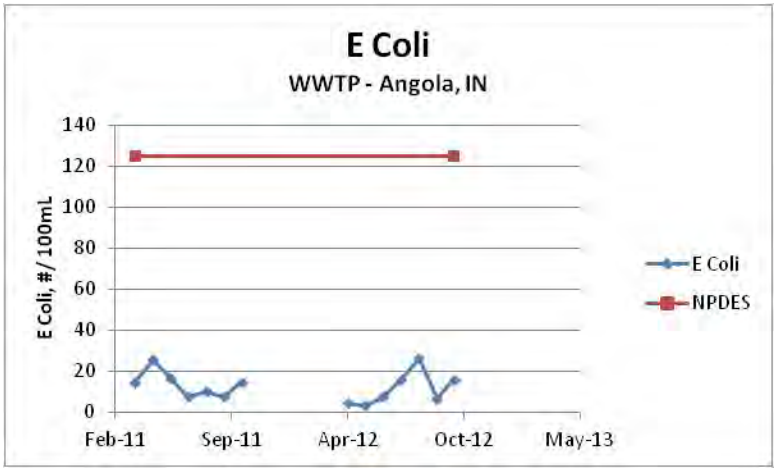


Table 48 shows permit limit exceedances (by monthly average) between January 2011 and December 2012. The results show that permit limits were exceeded, by monthly average. Results also show that effluent is well below permitted limits the majority of the time.

Table 48 - Angola WWTP Permit Exceedances

Parameter	Monthly Average exceeded NPDES Permit	Remarks
Flow	December 2012	The NPDES permit does not necessarily limit flow. Flow is a reported value only.
Ammonia Nitrogen	January 2011 February 2011	The winter limit is 1.6 mg/L. The reported monthly average for these two months was 1.99 and 1.99 mg/L.
Total Phosphorus	September 2011	The limit is 1.0 mg/L. The reported monthly average for this month was 1.05 mg/L. There is an exception to the limit when the influent raw wastewater phosphorus is less than 5 mg/L, in which case, a degree of reduction is prescribed and calculated based on monthly average raw and final concentrations. However, influent phosphorus was 7.15 mg/L for the month in question.
TSS	None	
E. Coli	None	

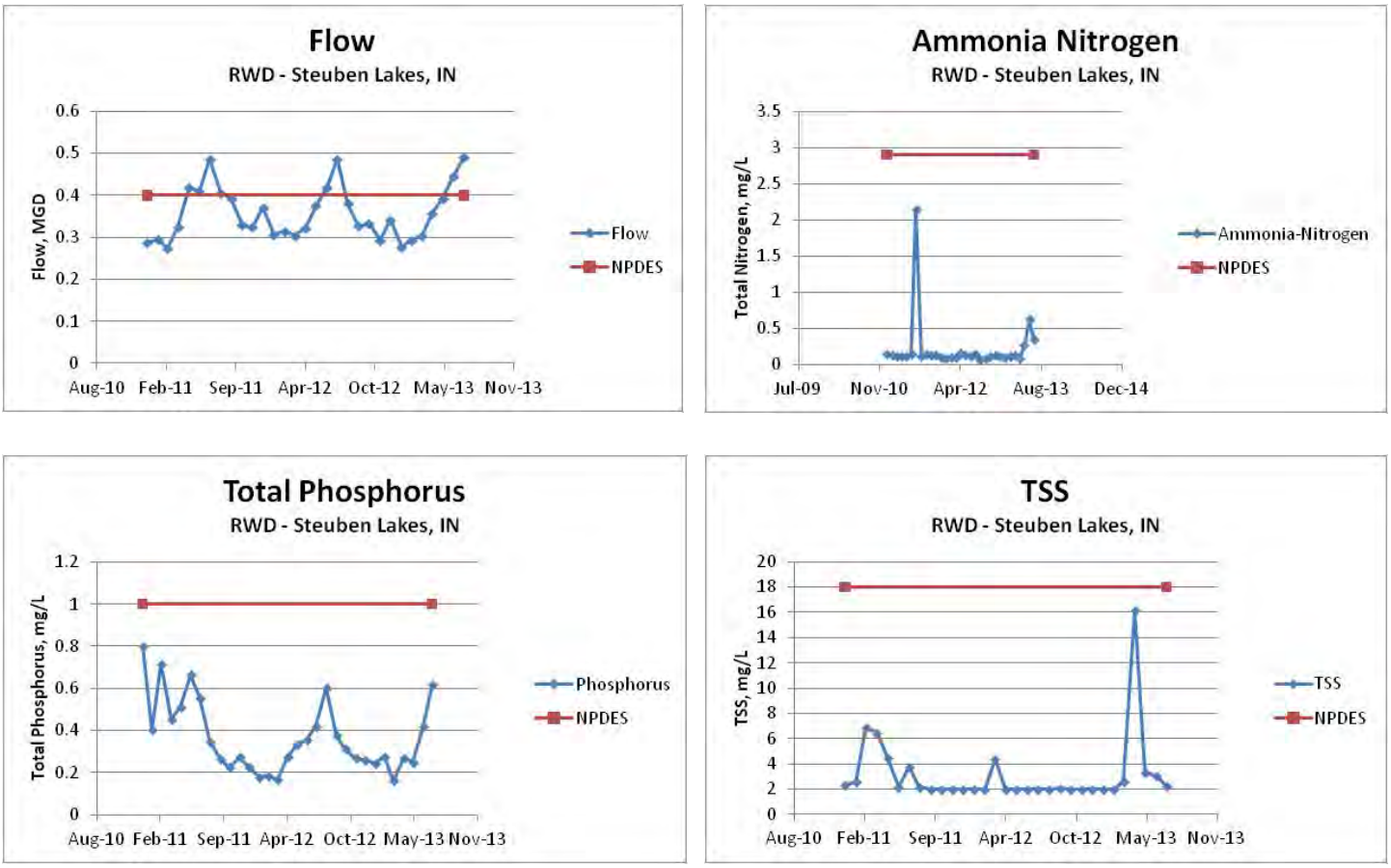
Steuben Lakes Waste Water Treatment Plant

The Steuben Lakes Regional Waste District currently operates a Class III, 1.0 MGD treatment facility consisting of three sequencing batch reactors (SBR), a two-day polishing pond, cascade aeration, and an ultraviolet light disinfection unit. Solids handling includes a sludge holding tank, a two-day polishing pond, an alkaline treatment system, and a sludge storage pad. The supernatant from the sludge storage tank is pumped back to the headworks of the plant.

The collection system is comprised of 100% separate sanitary sewers by design with no overflow points. There is one bypass point around the two-day polishing pond following the SBR units.

A water quality analysis compared effluent flow, *E. coli*, TSS, ammonia-nitrogen, and phosphorus to NPDES permit limits. Monthly averages for each data set have been plotted for the period between January 2011 and July 2013. The results of the analysis are shown in Figure 39.

Figure 39 - Steuben Lakes RWD Water Quality Results



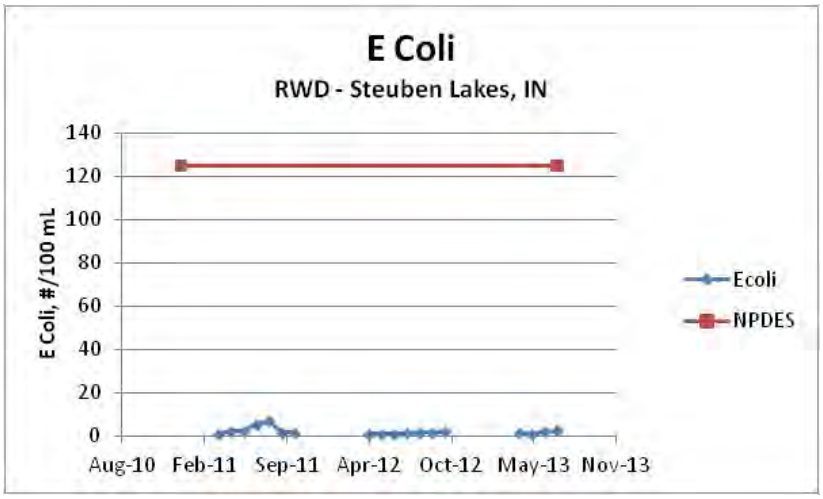


Table 49 shows permit limit exceedances (by monthly average) between January 2011 and July 2013. The results show that only permit limits for flow were exceeded, by monthly average. Results also show that effluent is well below permitted limits the majority of the time.

Table 49 - Steuben Lakes WWTP Permit Exceedances

Parameter	Monthly Average exceeded NPDES Permit Limit	Remarks
Flow	May, June, July, August, 2011 June, July 2012 June, July 2013	The NPDES permit does not necessarily limit flow. Flow is a reported value only.
Ammonia Nitrogen	None	
Total Phosphorus	None	
TSS	None	
E. Coli	None	

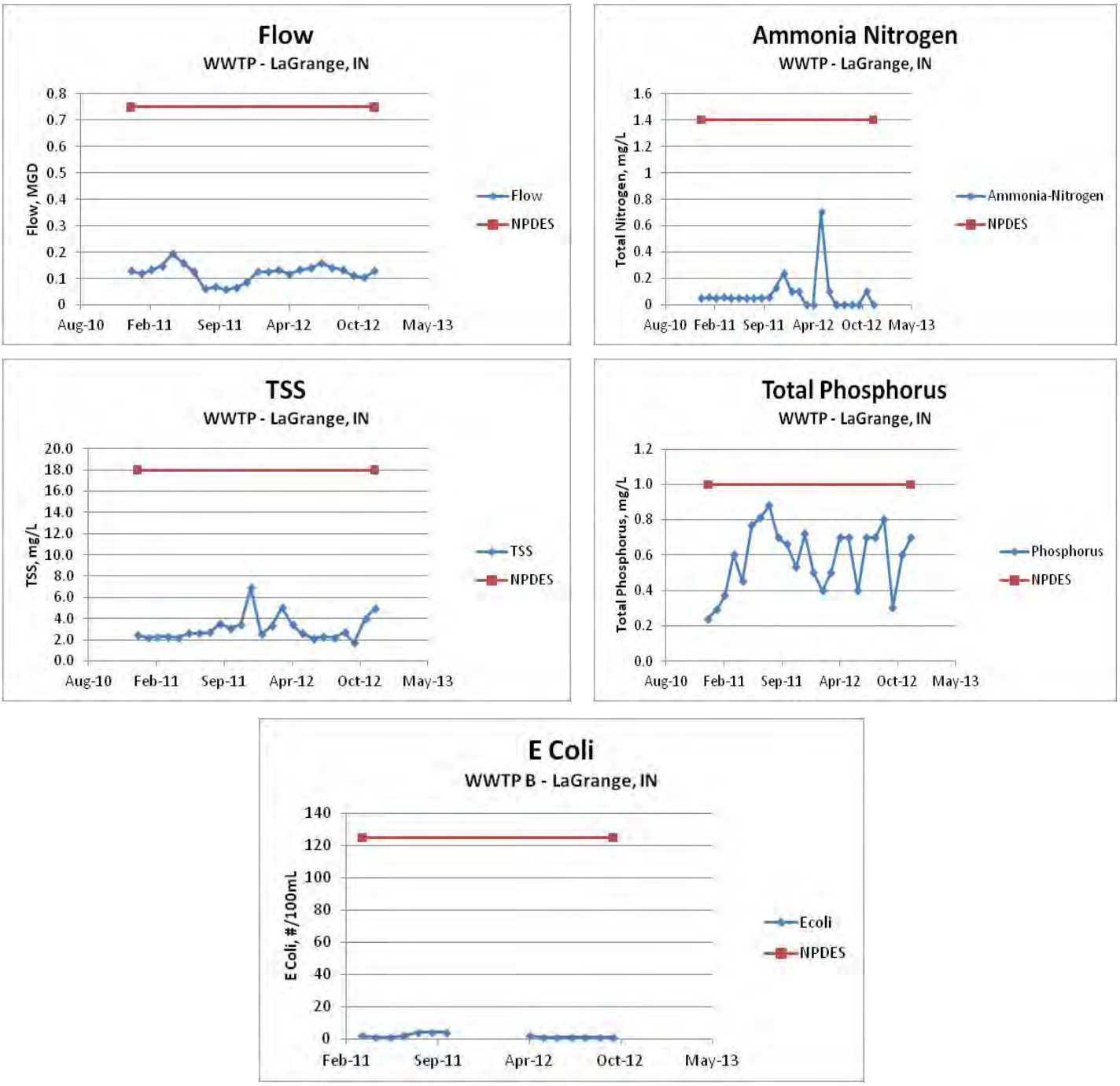
LaGrange County Regional Waste Water Treatment Plant

The LaGrange County Regional Utility District currently operates a Class II treatment facility with a maximum rated flow of 750,000 gallons per day. The treatment facility consists of an equalization tank, an influent flowmeter, a ferric chloride tank with injection, an oxidation ditch, two secondary clarifiers, an aerobic digester, post cascade aeration, an ultraviolet light disinfection unit, and an effluent flowmeter. Biosolids are stored in a 277,000-gallon storage tank for land application by a licensed hauler. The collection system is comprised of 100% separate sanitary sewers by design with no overflow or bypass points.

The discharge point, Outfall 001, is located at Latitude: 41° 36’ 11” N, Longitude: 85° 14’ 05” W. The receiving waterbody is Turkey Creek. A water quality analysis compared effluent flow, *E. coli*, TSS, ammonia-nitrogen, and phosphorus to NPDES permit limits. Monthly averages for each data set have

been plotted for the period between January 2011 and December 2012. The results of the analysis are shown in Figure 40.

Figure 40 - LaGrange WWTP Water Quality Results



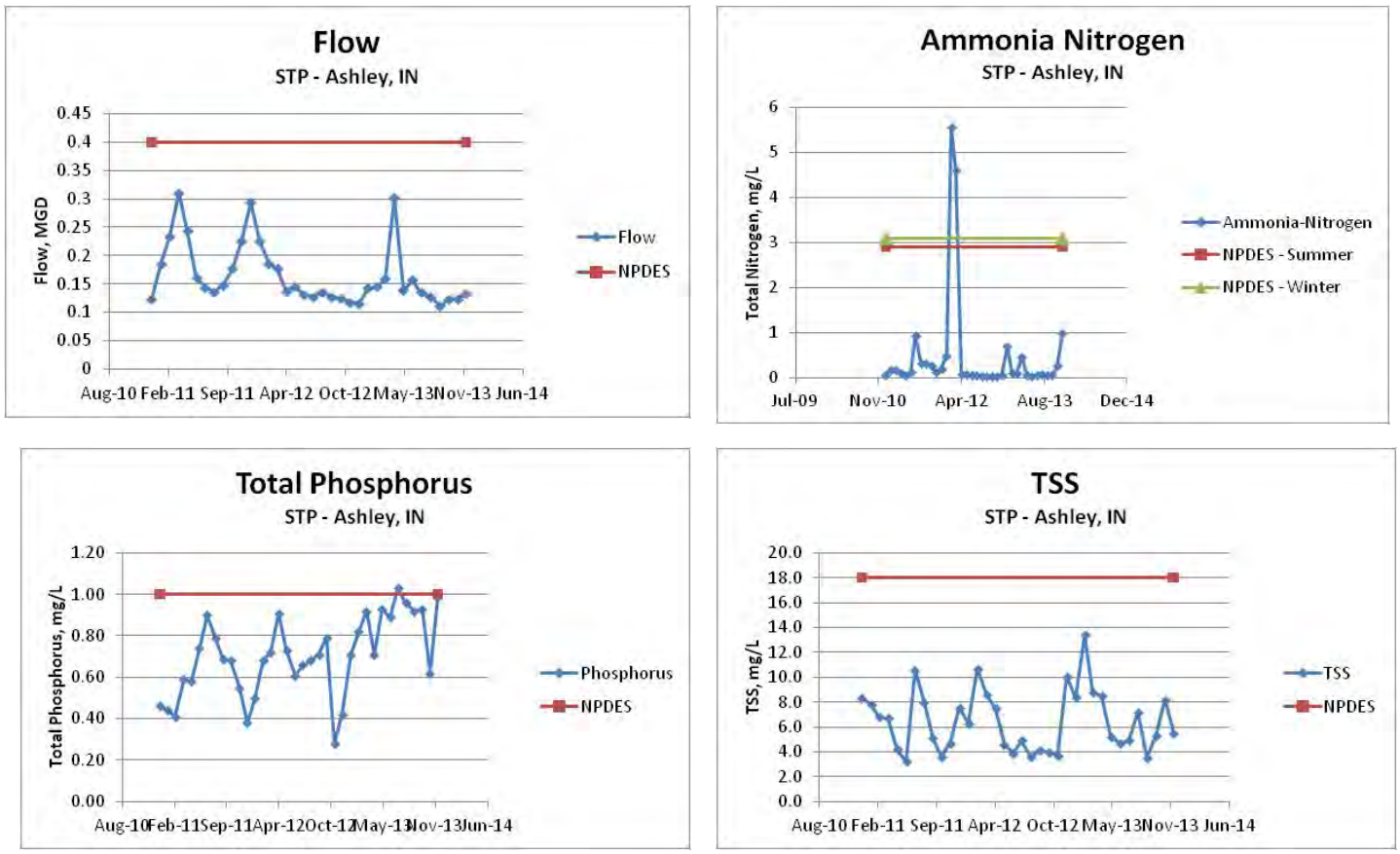
There were no permit limit exceedances (by monthly average) between January 2011 and December 2012. Results also show that effluent is well below permitted limits all of the time.

Ashley Waste Water Treatment Plant

The Town of Ashley maintains a Sequencing Batch Reactor (SBR) style wastewater treatment facility for the Towns of Ashley and Hudson. The capacity is 400,000 gallons per day. The new wastewater facility was completed in the fall of 2006. The facility consists of an influent flowmeter, a comminutor, a manually cleaned bar screen, two sequential batch reactors, phosphorus removal via liquid alum injection, ultraviolet light disinfection, post cascade aeration, and an effluent flowmeter. Sludge handling includes two aerobic digesters and five sludge drying beds. Final solids are sent to a landfill for disposal. The collection system is comprised of 100% separate sanitary sewers by design with no overflow or bypass points.

The discharge point, Outfall 001, is located at latitude: 41° 36' 11" N, Longitude: 85° 14' 05" W. The receiving waterbody is Johnson Ditch. The water quality analysis compared effluent flow, ammonia-nitrogen, *E. coli*, TSS and Phosphorus to NPDES permit limits for the wastewater treatment facility. Monthly averages for each data set have been plotted for the period between January 2011 and December 2013. The results show that permit limits were exceeded, by monthly average. The results of the analysis are shown in Figure 41.

Figure 41 – Ashley WWTP Water Quality Results



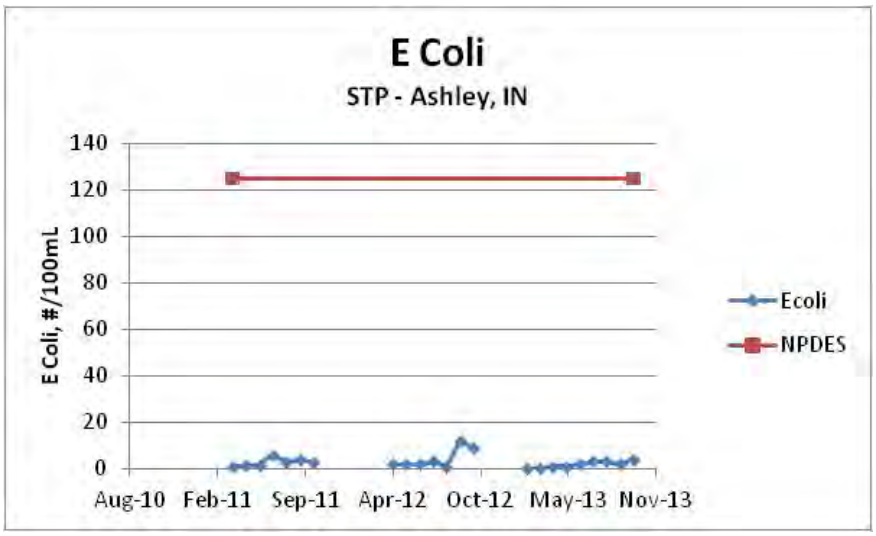


Table 50 shows permit limit exceedances (by monthly average) between January 2011 and December 2013. The results show that only permit limits for nitrogen and phosphorus were exceeded, by monthly average. Results also show that effluent is well below permitted limits the majority of the time.

Table 50 - Ashley WWTP Permit Exceedances

Parameter	Monthly Average exceeded NPDES Permit Limit	Remarks
Flow	None	
Ammonia Nitrogen	February 2012, March 2012	The winter limit is 3.1 mg/L. The reported monthly average for these two months was 5.56 and 4.6 mg/L.
Total Phosphorus	July 2013	The limit is 1.0 mg/L. The reported monthly average for this month was 1.03 mg/L. There is an exception to the limit when the influent raw wastewater phosphorus is less than 5 mg/L in which case, a degree of reduction is prescribed and calculated based on monthly average raw and final concentrations. However, influent phosphorus was 6.49 mg/L for the month in question.
TSS	None	
E. Coli	None	

Confinement Operations

Animal feeding operations can be sources of nutrients and bacteria to downstream waterbodies through the mobilization and transportation of phosphorus and bacteria-laden materials from feeding, holding, and manure storage areas.

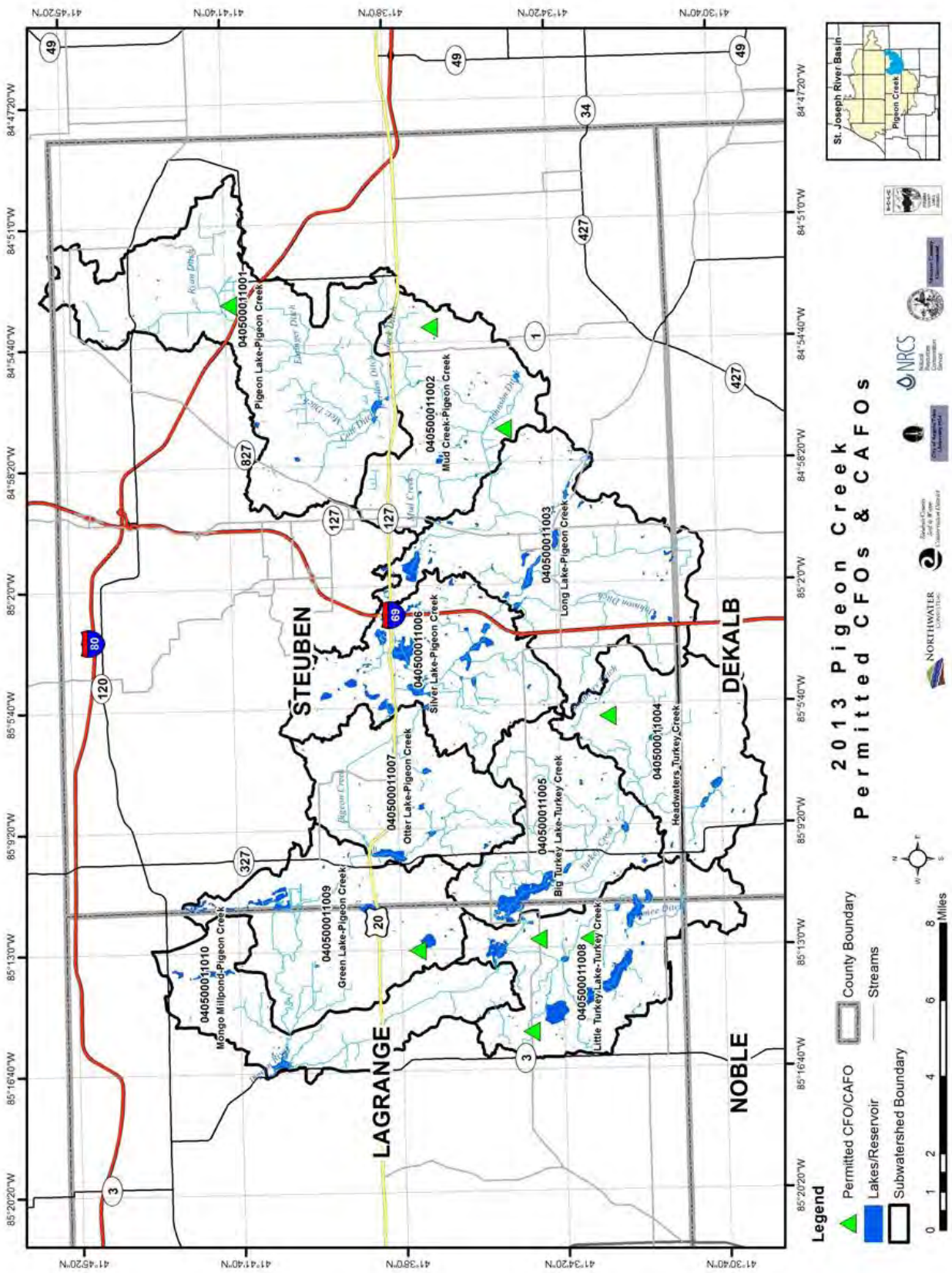
IDEM's Office of Land Quality regulates CFOs and has established and enforced standards that prohibit discharge from CFOs. Confined Feeding Operations are any animal feeding operations engaged in the confined feeding of at least 300 cattle, or 600 swine or sheep, or 30,000 fowl, such as chickens, turkeys, or other poultry. Compliance issues may occur that result in discharges, and land application of collected manure is common. Eight CFOs were identified in the Pigeon Creek watershed. Little Turkey Lake-Turkey Creek has the highest density of CFOs in the basin. The animals permitted for each site are listed in Table 51 and locations are shown in Figure 42. None of these sites are identified as having boars, beef calves, veal calves, layers, pullets, broilers, turkeys, ducks, sheep, or horses.

There are two (2) CAFOs within the watershed. The removal and disposal of manure, litter, or processed wastewater that is generated as a result of confined feeding operations falls under the regulations for CFOs and CAFOs. The CFO and CAFO regulations require that operations "not cause or contribute to an impairment of surface waters of the state." IDEM regulates these confined feeding operations under IC 13-18-10, the Confined Feeding Control Law. Due to size, some confined feeding operations are defined as CAFOs, although all CAFOs are confined feeding operations. The CAFO regulation, however, contains more stringent operational requirements and slightly different application requirements.

Table 51 - Confined Feeding Operations

CFO/CAFO	Type	Farm ID #	HUC 12	Nursery Pigs	Finishers (pigs or hogs)	Sows	Beef Cattle	Dairy Cattle	Dairy Calves	Dairy Heifers
Twin Pines Farm Incorporated	CFO	291	Little Turkey Lake-Turkey Creek - 04050001108	0	1,300	0	0	0	0	0
Hilltop Dairy LLC	CFO	1005	Little Turkey Lake-Turkey Creek - 04050001108	0	0	0	0	220	15	0
Springfield Swine	CFO	4004	Green Lake-Pigeon Creek - 040500011009	920	2,376	288	0	0	0	0
Perkins Twin Creek Farm	CFO/CAFO	6390	Little Turkey Lake-Turkey Creek - 04050001108	0	0	0	0	400	74	0
John D Smith & Sons Inc.	CFO	1082	Mud Creek-Pigeon Creek - 040500011002	2,880	0	0	0	0	0	0
John D Smith & Sons Inc.	CFO	1108	Mud Creek-Pigeon Creek - 040500011002	2,880	0	0	0	0	0	0
Stockwell Acres Inc.	CFO	6650	Headwaters Turkey Creek - 040500011004	0	0	0	0	451	85	315
NEI Dairy LLC	CFO/CAFO	6067	Pigeon Lake -Pigeon Creek - 040500011002	0	0	0	0	1,620	0	0

Figure 42 - Pigeon Creek Confinement Operations



7.1.2 Nonpoint Source Pollution

Nonpoint-source pollution in the Pigeon Creek watershed makes up a considerable percentage of the overall pollution load. The majority of bacteria, phosphorus, sediment, and nitrogen impacting water quality in the watershed are the direct result of nonpoint-source pollution and runoff. Despite the fact that significant progress has already been made to address nonpoint-source pollution through on-the-ground project implementation and education, more work is needed to achieve any substantial reductions in the overall watershed pollutant load.

Agricultural Runoff; Row Crops

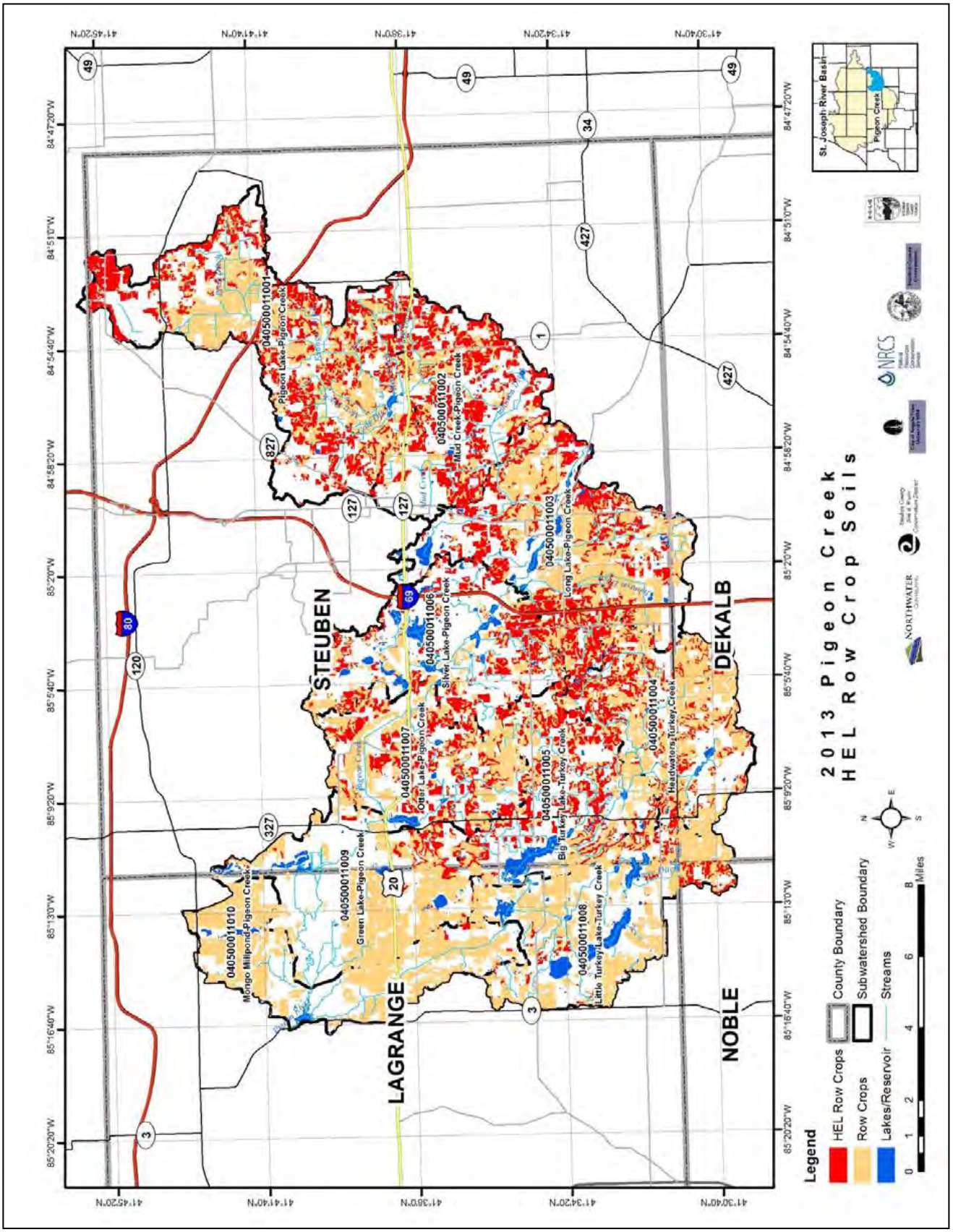
Cropland is a source of sediment, phosphorus and nitrogen due to fertilizer use and disturbed soils. Rainfall events can cause soils and nutrients to run off the land and be transported to waterbodies. Additionally, cropland can be a source of bacteria, if manure is applied to the field. Soil erosion from crop ground is not only a watershed problem or concern by itself, but is a source of particulate phosphorus as well. Highly Erodible Land in close proximity to a waterbody or unrestricted tile inlet, where conventional or traditional tillage is occurring, produces higher sediment and nutrient loads per acre. A custom landuse GIS layer identifies the location and extent of row crops within the Pigeon Creek watershed indicating a total land area of 69,396 acres (51%) of the watershed. There are currently 22,767 acres of row crop ground also considered to be HEL representing 33% of all row crops in the watershed. Table 52 breaks down the area of HEL soils in each subwatershed; Figure 43 shows the extent of these areas and the potential sources of sediment, nutrients and bacteria from row crops in the watershed.

Table 52 - Highly Erodible Row Crop Soils

Subwatershed Names	HUC 12 Subwatershed Codes	Subwatershed Acres	Area (acres) HEL Row Crop Soils	Percent Subwatershed Area (acres)
Pigeon Lake-Pigeon Creek	040500011001	22,036	5,508	25%
Mud Creek-Pigeon Creek	040500011002	11,641	3,455	30%
Long Lake-Pigeon Creek	040500011003	18,620	4,134	22%
Headwaters Turkey Creek	040500011004	11,798	1,965	17%
Big Turkey Lake-Turkey Creek	040500011005	11,015	2,278	21%
Silver Lake-Pigeon Creek	040500011006	12,954	2,111	16%
Otter Lake-Pigeon Creek	040500011007	10,491	2,103	20%
Little Turkey Lake-Turkey Creek	040500011008	13,255	683	5%
Green Lake-Pigeon Creek	040500011009	13,581	474	3%
Mongo Millpond-Pigeon Creek	040500011010	10,520	56	0.5%
Grand Total		**135,911**	**22,767**	**17%**

Information gathered from the Steuben County SWCD indicates that agricultural producers in the county have implemented conservation practices throughout the watershed. The majority of producers use some type of conservation tillage practice (no-till, mulch-till, or reduced-till). Many producers also have erosion control BMPs in place on HEL ground and are actively managing for erosion. Croplands with effective conservation practices have lower rates of nutrient, sediment, and bacteria runoff than similar ground without these practices.

Figure 43 - Pigeon Creek HEL Row Crop Soils



Agricultural Runoff; Small Animal Feeding Operations

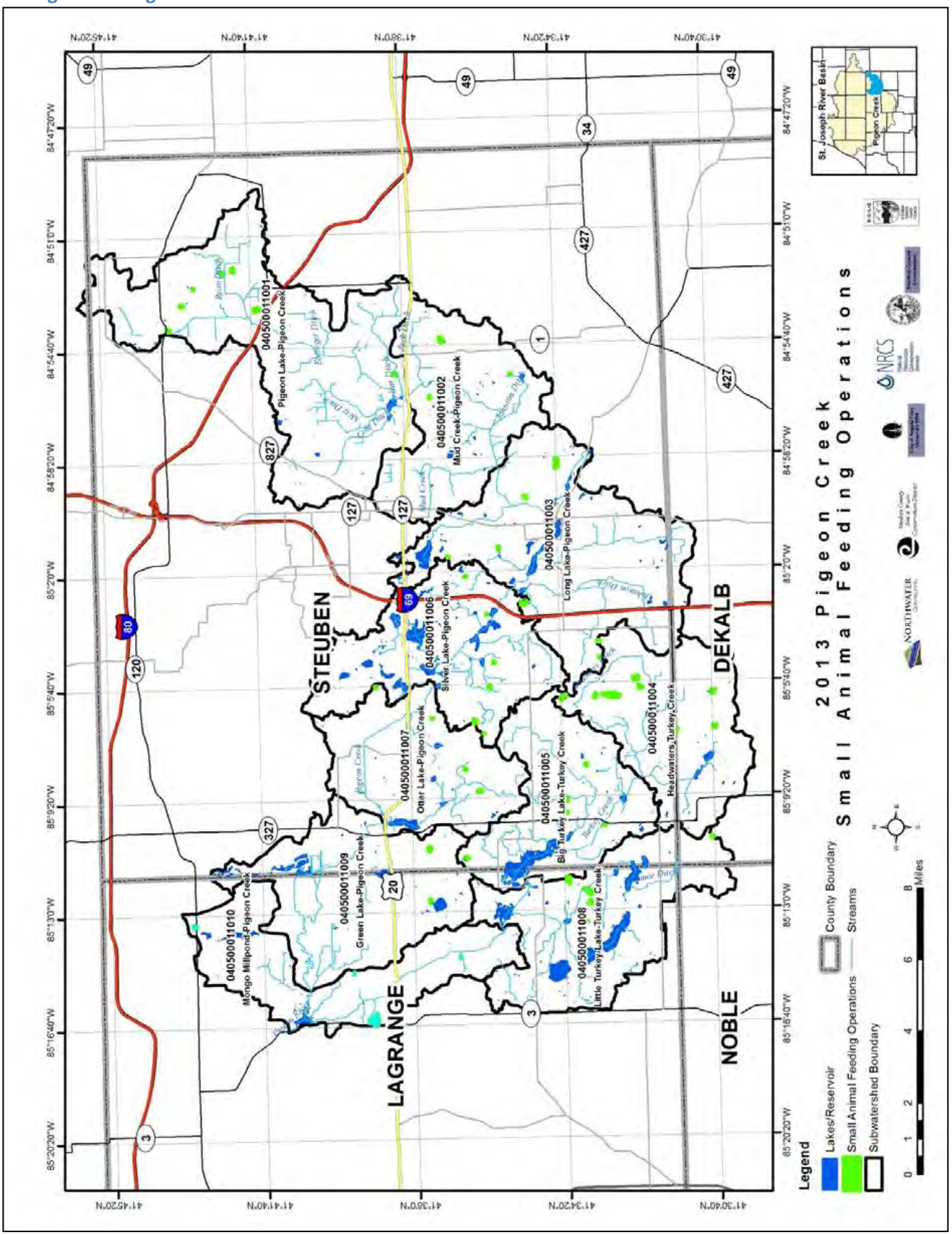
Small animal feeding operations can also be a source of bacteria and nutrients to waterbodies. Operations raising a smaller number of animals are not regulated as a CFO or CAFO, but still result in production of manure. Smaller animal facilities may add bacteria to surface waters via wastewater from these facilities or stormwater runoff from near-stream pastures. Livestock management practices for small operations may include manure storage and application at rates needed for crop growth; collection and treatment of runoff from feeding pens; grazing plans, fencing, and buffers to limit animal access to wetlands, streams, and other waterbodies; along with other practices. These types of livestock management practices are expected to reduce the rate of nutrient and bacteria runoff from agricultural properties when compared to similar ground without these practices.

An analysis of existing landuse information gathered during a watershed survey helped to locate many of these small feed operations. During the survey, an attempt was made to rank each feed area in terms of potential impact to water quality. A ranking of high indicates evidence of substantial waste runoff, close proximity to a receiving waterbody, and a relatively high number of animals. A ranking of low indicates minimal runoff with controls such as buffers or lagoons in place, a substantial distance from a receiving waterbody, and a small number of animals. Table 53 lists the breakdown in acres for each subwatershed, a summary of potential water quality impacts, and the average distance of all operations to the closest watercourse. The summary of potential water quality impacts represents an average by subwatershed based on visual observations and a ranking of each individual feeding operation. Figure 44 shows the location of these operations in the watershed. There are a total of 85 (161 acres) known small animal feeding operations in the Pigeon Creek watershed; these operations are located an average of 577 feet from the nearest watercourse. It is important to note that several small feed areas in the watershed are very well managed and have extensive best management practices in place to control runoff. Information on pollution loading and specific BMPs for these areas are listed in subsequent sections.

Table 53 - Small Animal Feeding Operations

Subwatershed Names	HUC 12 Subwatershed Codes	Subwatershed Acres	Area (acres) Small Animal Feed Areas	Average Distance to Watercourse (feet)	Potential Impact on Water Quality
Pigeon Lake-Pigeon Creek	040500011001	22,036	21	518	Medium
Mud Creek-Pigeon Creek	040500011002	11,641	6	433	High
Long Lake-Pigeon Creek	040500011003	18,620	15	594	Medium-High
Headwaters Turkey Creek	040500011004	11,798	37	1,293	Medium-High
Big Turkey Lake-Turkey Creek	040500011005	11,015	5	558	High
Silver Lake-Pigeon Creek	040500011006	12,954	10	440	Medium
Otter Lake-Pigeon Creek	040500011007	10,491	6	607	Medium-High
Little Turkey Lake-Turkey Creek	040500011008	13,255	17	456	High
Green Lake-Pigeon Creek	040500011009	13,581	6	354	High
Mongo Millpond-Pigeon Creek	040500011010	10,520	38	535	High
Grand Total		**135,911**	**161**	**577 (avg)**	

Figure 44 - Pigeon Creek Small Animal Feed Areas



Agricultural Runoff; Pastured Animals

Pastured animals are a potential source of bacteria and nutrients to nearby waterbodies, especially if animals have access to the waterbodies. Livestock with direct access to stream environments may add bacteria directly to surface waters or re-suspend particles that had settled on the stream bottom. Direct deposit of animal wastes can result in high bacteria counts and can also contribute to downstream impairments. Observations made during a windshield survey noted numerous instances of livestock access to adjacent streams or ponds. Stormwater runoff from near-stream pastures may add bacteria and nutrients to nearby waterbodies. The landuse of the Pigeon Creek watershed includes hay or pasture land on 7,471 acres (5%) of the land area, all with varying levels of pasture quality and proximity to receiving waterbodies. Table 54 breaks out pasture area by subwatershed and Figure 45 shows the distribution throughout Pigeon Creek.

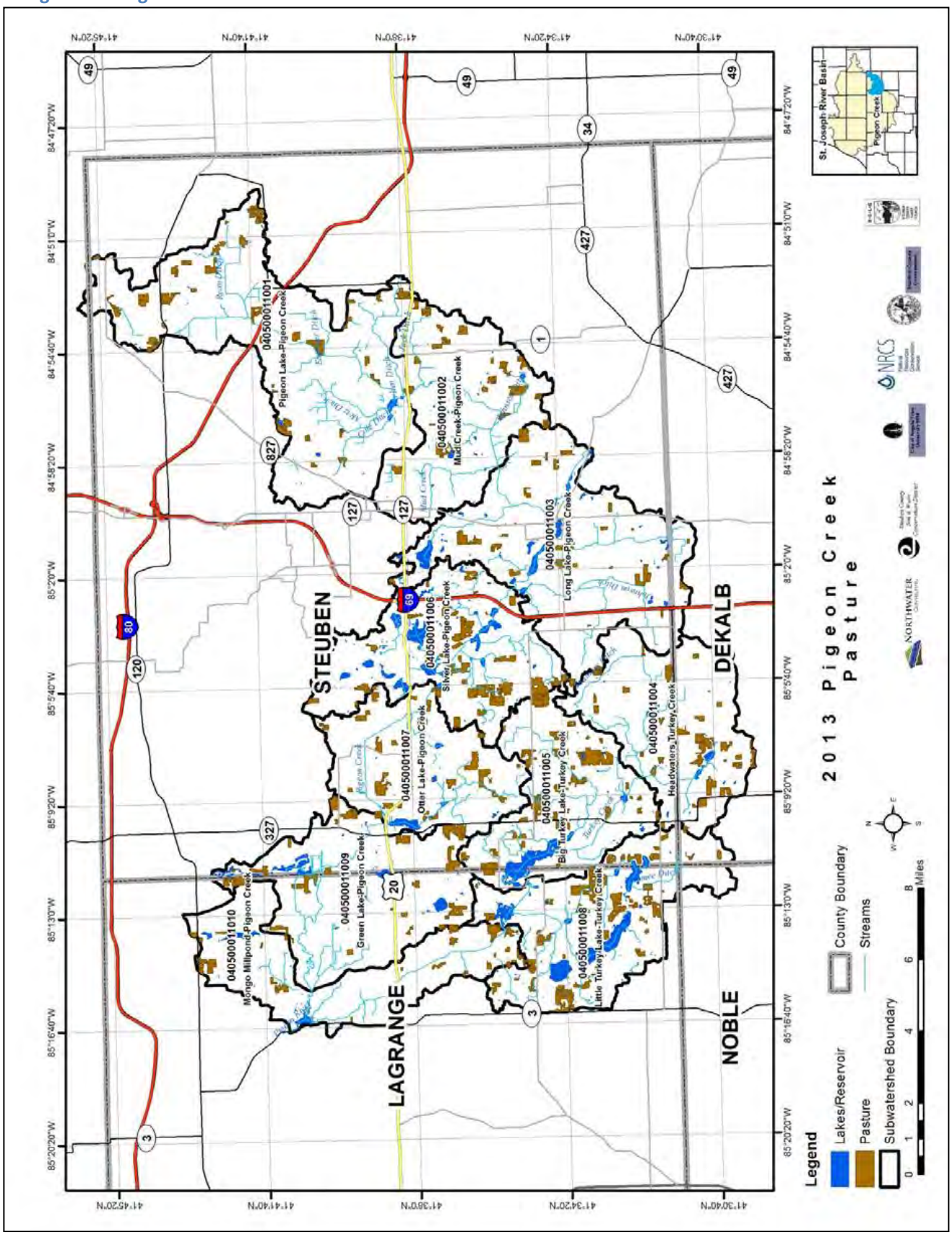
Table 54 - Pasture

Subwatershed Names	HUC 12 Subwatershed Codes	Subwatershed Acres	Area (acres) Pasture	Percent Subwatershed Area (acres)
Pigeon Lake-Pigeon Creek	040500011001	22,036	874	4%
Mud Creek-Pigeon Creek	040500011002	11,641	533	5%
Long Lake-Pigeon Creek	040500011003	18,620	558	3%
Headwaters Turkey Creek	040500011004	11,798	608	5%
Big Turkey Lake-Turkey Creek	040500011005	11,015	954	9%
Silver Lake-Pigeon Creek	040500011006	12,954	1,007	8%
Otter Lake-Pigeon Creek	040500011007	10,491	615	6%
Little Turkey Lake-Turkey Creek	040500011008	13,255	1,142	9%
Green Lake-Pigeon Creek	040500011009	13,581	774	6%
Mongo Millpond-Pigeon Creek	040500011010	10,520	406	4%
Grand Total		**135,911**	**7,471**	**5%**

Agricultural Runoff; Land Application of Manure

Improper land application of manure from animal feeding operations is an additional source of nutrients and bacteria to downstream waterbodies. There are no existing records regarding location, volume, and frequency of land application of manure. IDEM assumes that land application of manure occurs within five miles of animal feeding operations. The Pigeon Creek watershed contains two regulated CAFOs and eight (8) CFOs, two of which are also considered CAFOs. These operations contain a total of 12,654 animals. There are also 85 unregulated small animal feeding operations in the watershed where land application of manure may be occurring.

Figure 45 - Pigeon Creek Pasture



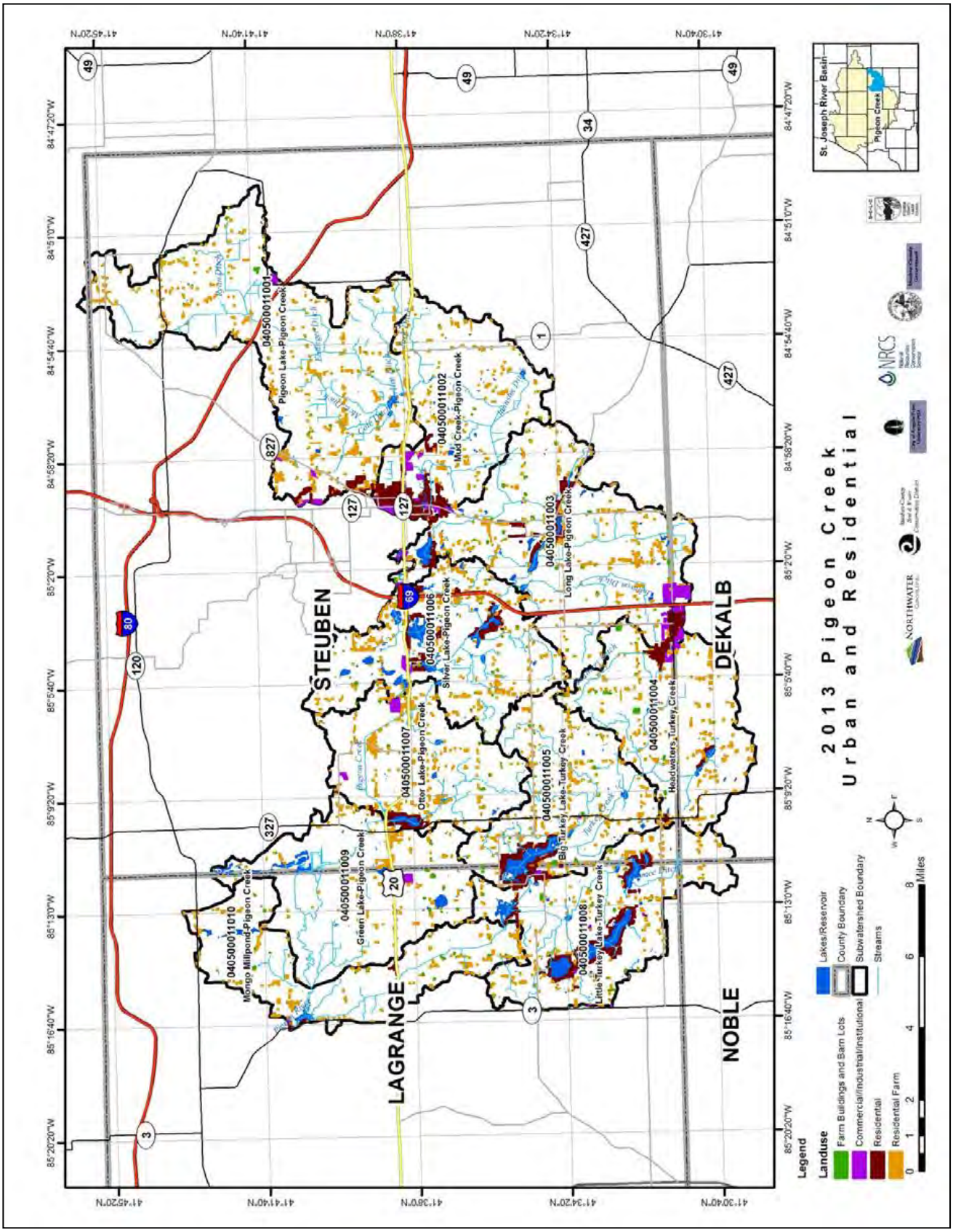
Urban & Residential Farm Runoff

Surface runoff from urban and residential areas in the watershed is also a potential source of phosphorus, nitrogen, sediment, and bacteria. An analysis of current landuse indicates that the watershed contains 371 acres (0.3%) farm buildings and barn lots; 845 acres, or 0.6%, commercial, industrial and institutional landuse; 2,466 acres (1.8%) urban or urban residential areas; and 4,516 acres (3.3%) residential farm homes. Table 55 provides a breakdown by subwatershed and Figure 46 shows the distribution throughout the watershed.

Table 55 - Urban & Residential Landuse

Subwatershed Names	HUC 12 Subwatershed Codes	Area (acres) Farm Buildings & Barn Lots	Percent Area	Area (acres) Commercial, Industrial and Institutional	Percent Area	Area (acres) Urban Residential	Percent Area	Area (acres) Residential Farm	Percent Area
Pigeon Lake-Pigeon Creek	040500011001	39	0.2%	80	0.4%	148	0.7%	740	3.36%
Mud Creek-Pigeon Creek	040500011002	15	0.1%	181	1.5%	590	5.1%	283	2.43%
Long Lake-Pigeon Creek	040500011003	60	0.3%	302	1.6%	486	2.6%	608	3.27%
Headwaters Turkey Creek	040500011004	53	0.4%	43	0.4%	91	0.8%	463	3.93%
Big Turkey Lake-Turkey Creek	040500011005	46	0.4%	14	0.1%	262	2.4%	386	3.50%
Silver Lake-Pigeon Creek	040500011006	19	0.1%	82	0.6%	298	2.3%	568	4.39%
Otter Lake-Pigeon Creek	040500011007	18	0.2%	60	0.6%	98	0.9%	472	4.50%
Little Turkey Lake-Turkey Creek	040500011008	52	0.4%	17	0.1%	449	3.4%	360	2.72%
Green Lake-Pigeon Creek	040500011009	26	0.2%	66	0.5%	14	0.1%	326	2.40%
Mongo Millpond-Pigeon Creek	040500011010	43	0.4%	1	0.01%	30	0.3%	309	2.94%
Grand Total		**371**	**0.3%**	**845**	**0.6%**	**2,466**	**1.8%**	**4,516**	**3.3%**

Figure 46 - Pigeon Creek Urban & Residential Areas



Legacy Stream Sediment

On December 4th, 2013, two samples of water were taken at sample site 1A (Ray Clarke Rd.), one under normal conditions and one after stirring up sediment in the stream. Under normal conditions, results showed *E. coli* levels of 52 cfu/100ml and, after stirring up sediment, *E. coli* concentrations jumped to 300 cfu/100ml. Although this is only a single sample event, results indicate that a source of bacteria could be originating from deposited or legacy streambed sediment. This sediment is likely re-suspended during high flow or storm events, resulting in higher bacteria concentrations in the water column. To support this theory, two reports (listed below) relevant to Indiana can be referenced. Both reports covering the same study looked at riparian sediment as a source of bacteria in the Dunes Creek Watershed in Indiana Dunes State Park and concluded that Dunes Creek is a source of bacteria. Results showed that bacteria from nonpoint sources are common in shallow, submerged sections of the creek and are held and subsequently released by soil and sediment erosion.

1. *Distribution and Characterization of E. coli within the Dunes Creek Watershed, Indiana Dunes State Park*
2. *Ubiquity and Persistence of Escherichia coli in a Midwestern Coastal Stream*

Wildlife

According to the 2012 TMDL plan, wildlife waste is a source of bacteria in the watershed. The statewide population of Greater Canada geese in Indiana was estimated to be 84,215 in 2009. Steuben and LaGrange counties are expected to have large deer populations as these counties have a high deer harvest. Also noted in the 2012 TMDL document, while wildlife waste is a source of bacteria to waterbodies, it appears to be a minor source in this watershed compared to other sources. Management of wildlife to reduce the delivery of feces to waterbodies is not a priority in the Pigeon Creek watershed. Large tracts of high quality wildlife habitat exist in the lower reaches and headwaters of the watershed, as well as isolated patches or Conservation Reserve Program (CRP) ground. These areas, in addition to existing forest and grassland, are home to both resident and migrating wildlife and a source of bacteria.

Field Tiles & Hydrologic Modifications

Drainage tiles in agricultural fields create direct conduits to downstream waterbodies through which nutrients and bacteria may be discharged. Data on the specific location of all field tiles is unavailable for the watershed but observations made during a watershed survey indicate tiling is used extensively. Regulated drainage systems and open ditches are also present throughout the Pigeon Creek watershed; these systems capture and subsequently drain much of the existing tile flow. Cultivated cropland covers about 51% of the Pigeon Creek watershed and many producers rely on tile drainage for production. As a result of local geology and topography, many farm fields drain to a central location or depressional zone such as a wetland. Tiles are installed in these areas and through adjacent wetlands to ensure standing water does not damage crops. As noted previously in Section 3.2.3 (hydrologic modifications), the Pigeon Creek watershed has 177 miles of channelized ditches, 222 miles of known tile, 929 acres of legal ditches and over 6,000 acres of irrigated ground.

7.2 Pollution Loads

A spatial, event-based pollution load model was used as a tool to predict and quantify soil erosion, phosphorus, nitrogen, and bacteria loading in the watershed. The Spatial Watershed Assessment and Management Model (SWAMM) accounts for slope, soil type, precipitation and land use to estimate annual and storm-event sediment, phosphorus, nitrogen, and bacteria loading. SWAMM is customized to the watershed, is map-based, and can be used to target high loading areas. Another strength of SWAMM is that it can aid in estimating site-specific load reductions based on the placement of BMPs. It is calibrated to local in-stream water quality and can provide estimates of watershed pollutant yields. It is important to note that a model's output is only as good as the data provided to it.

The SWAMM prepared for Pigeon Creek includes high-resolution input data unique to the watershed and is calibrated to analytical water quality data. The Pigeon Creek SWAMM was not built to include groundwater flow and, due to the lack of information on the location of gully and streambank erosion, it does not directly estimate loading from these sources. To address this, observed estimates of gully erosion, and general estimates of septic system loading, are presented separately in this section. Gullies that were measured in the field during the windshield survey are also included in this section (Table 57) and factored into the overall watershed loading. Total watershed pollution loading is presented in Table 56 and includes all modeled nonpoint source totals, all wastewater loading, observed gully erosion loading, and failing septic system loading. Due to the fact that septic loading totals are calculated for the watershed as a whole, they have been divided up equally among subwatersheds in Table 56.

Table 56 - Pigeon Creek Watershed Total Pollution Load

Subwatershed Name	2012 HUC12 Subwatershed Codes	Watershed Acres	Phosphorus Load (lbs/yr)	Nitrogen Load (lbs/yr)	Sediment Load (tons/ yr)	Fecal Coliform (billion CFU/yr)
Pigeon Lake-Pigeon Creek	40500011001	22,036	28,745	190,871	23,581	53,337
Mud Creek-Pigeon Creek	40500011002	11,641	19,351	99,877	14,485	38,933
Long Lake-Pigeon Creek	40500011003	18,620	25,186	159,298	20,213	49,853
Headwaters Turkey Creek	40500011004	11,798	15,721	100,827	14,045	34,690
Big Turkey Lake-Turkey Creek	40500011005	11,015	11,296	73,206	9,685	32,204
Silver Lake-Pigeon Creek	40500011006	12,954	11,236	73,461	9,904	36,608
Otter Lake-Pigeon Creek	40500011007	10,491	12,896	63,731	8,920	30,109
Little Turkey Lake-Turkey Creek	40500011008	13,256	13,980	93,259	12,455	38,507
Green Lake-Pigeon Creek	40500011009	13,581	9,038	57,312	8,275	28,189
Mongo Millpond-Pigeon Creek	40500011010	10,520	11,107	57,500	6,448	27,053
Total		**135,911**	**158,556**	**969,341**	**128,012**	**369,481**

7.2.1 Nonpoint-Source Pollution Loading

The Pigeon Creek nonpoint-source SWAMM incorporates landuse data, soils and precipitation to calculate annual runoff using the Curve Number approach; literature-based Event Mean Concentrations (EMCs) and the Universal Soil Loss Equation (USLE) are incorporated to calculate loading. The model assumes uniform rainfall over the study area and uses a distance-based delivery ratio. The Pigeon Creek SWAMM was calibrated using data obtained during a windshield survey and an analysis of existing water quality data. Calibrated model values are within acceptable ranges. Appendix F includes a complete SWAMM methodology.

Due to project limitations and property access concerns, streambank erosion estimates are excluded from the overall loading totals. General watershed observations of streambanks during the windshield survey and discussions with local agency staff indicate that although streambank erosion is occurring in the watershed, it is not a major source of sediment or nutrients.

Gully erosion was assessed during a watershed-wide windshield survey where active gullies were visible. A total of twenty-one (21) actively eroding gullies were observed. Using formulas derived from Region 5 EPA's spreadsheet tool for "Estimating Pollutant Load Reductions for Nonpoint Source Pollution Control BMPs," sediment and nutrient loads are assessed. Results indicate that observed active gully erosion is contibuting 508 tons/year of sediment, 1,017 lbs/year of nitrogen and 610 lbs/year of phosphorus. Table 57 provides a breakdown of gully erosion by subwatershed.

Table 57 - Gully Erosion Pollution Loading

Subwatershed Name	2012 HUC12 Subwatershed Codes	Number of Gullies	Phosphorus Loading (lbs/yr)	Nitrogen Loading (lbs/yr)	Sediment Loading (tons/ yr)
Pigeon Lake-Pigeon Creek	40500011001	1	2.8	4.7	2.3
Mud Creek-Pigeon Creek	40500011002	2	199	331	166
Long Lake-Pigeon Creek	40500011003	4	152	253	126
Headwaters Turkey Creek	40500011004	3	58	97	48
Big Turkey Lake-Turkey Creek	40500011005	1	27	46	23
Silver Lake-Pigeon Creek	40500011006	8	164	273	137
Otter Lake-Pigeon Creek	40500011007	0	0	0	0
Little Turkey Lake-Turkey Creek	40500011008	2	7.6	13	6.3
Green Lake-Pigeon Creek	40500011009	0	0	0	0
Mongo Millpond-Pigeon Creek	40500011010	0	0	0	0
Grand Total		**21**	**610**	**1,017**	**508**

Table 58 lists total and per-acre modeled pollution loading results by subwatershed and Figures 47 through 50 show the spatial distribution of loading in the watershed. Results show that annual loading in the watershed is 0.98 lbs/ac for phosphorus, 6.75 lbs/ac for nitrogen, 0.94 tons/ac for sediment, and 1.57 billion CFU/ac. The Pigeon Lake subwatershed contributes the higest total and per- acre loads of phosphorus and nitrogen and the highest total sediment and bacteria load. Mud Creek contributes the highest per-acre sediment load and Long Lake contributes the highest per-acre bacteria load.

Table 58 - Modeled Pollution Loading Results

Subwatershed Name	2012 HUC12 Subwatershed Codes	Acres	Annual Runoff (ac-ft)	P (lbs/yr)	Per Acre P (lbs/yr)	N (lbs/yr)	Per Acre N (lbs/yr)	TSS (tons/ yr)	Per Acre TSS (tons/yr)	Fecal Coliform (billion colony-forming units/yr)	Per Acre Fecal Coliform (billion colony-forming units/yr)
Pigeon Lake-Pigeon Creek	40500011001	22,036	17,588	27,374	**1.24**	187,374	**8.50**	23,579	1.07	38,390	1.74
Mud Creek-Pigeon Creek	40500011002	11,641	9,741	12,674	1.09	87,773	7.54	14,242	**1.22**	21,066	**1.81**
Long Lake-Pigeon Creek	40500011003	18,620	15,491	22,449	**1.21**	153,970	**8.27**	20,072	**1.08**	34,212	**1.84**
Headwaters Turkey Creek	40500011004	11,798	8,794	14,295	**1.21**	97,237	**8.24**	13,997	**1.19**	19,743	1.67
Big Turkey Lake-Turkey Creek	40500011005	11,015	7,900	9,901	0.90	69,668	6.32	9,662	0.88	17,257	1.57
Silver Lake-Pigeon Creek	40500011006	12,954	9,331	9,704	0.75	69,695	5.38	9,767	0.75	21,661	1.67
Otter Lake-Pigeon Creek	40500011007	10,491	6,345	8,484	0.81	57,711	5.50	8,897	0.85	13,446	1.28
Little Turkey Lake-Turkey Creek	40500011008	13,256	9,905	12,605	0.95	89,754	6.77	12,449	0.94	23,560	**1.78**
Green Lake-Pigeon Creek	40500011009	13,581	6,635	7,670	0.56	53,819	3.96	8,275	0.61	13,242	0.98
Mongo Millpond-Pigeon Creek	40500011010	10,520	5,688	7,456	0.71	50,582	4.81	6,421	0.61	10,828	1.03
Total		**135,911**	**97,419**	**132,611**	**0.98**	**917,585**	**6.75**	**127,361**	**0.94**	**213,405**	**1.57**

Pigeon Creek; Streambank Erosion

Figure 47 - Annual Per Acre Phosphorus Loading

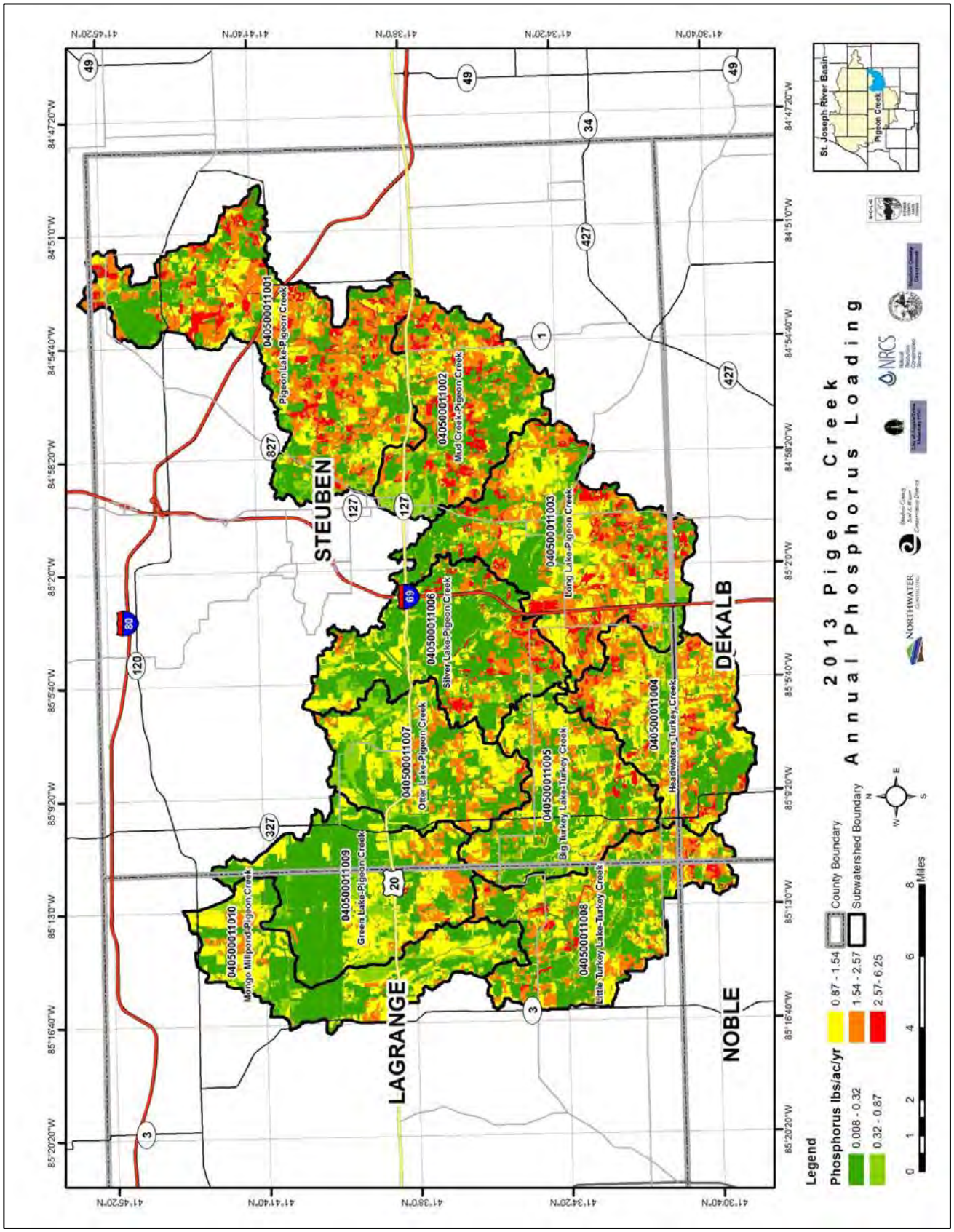


Figure 48 - Annual Per Acre Nitrogen Loading

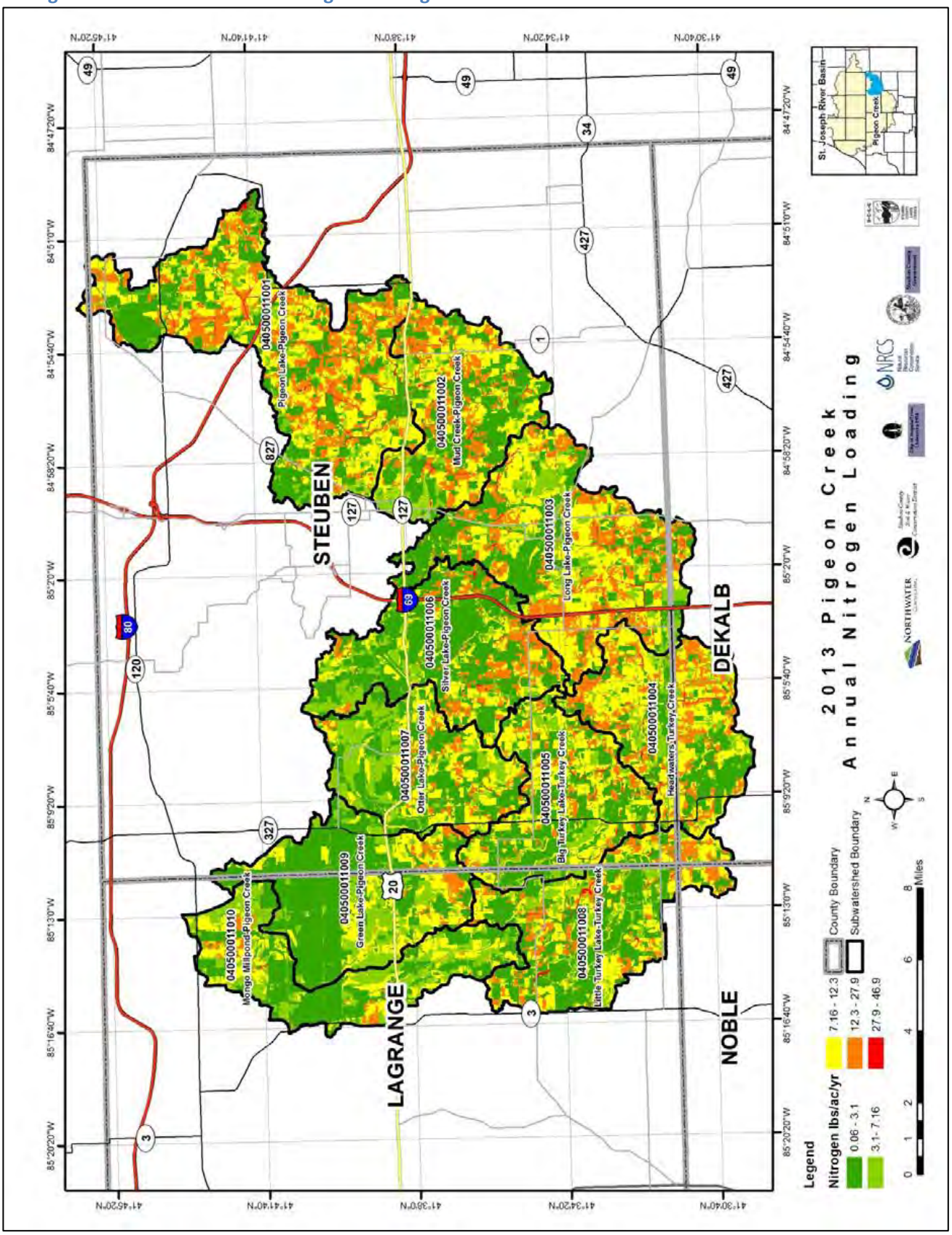


Figure 49 - Annual Per Acre Bacteria Loading

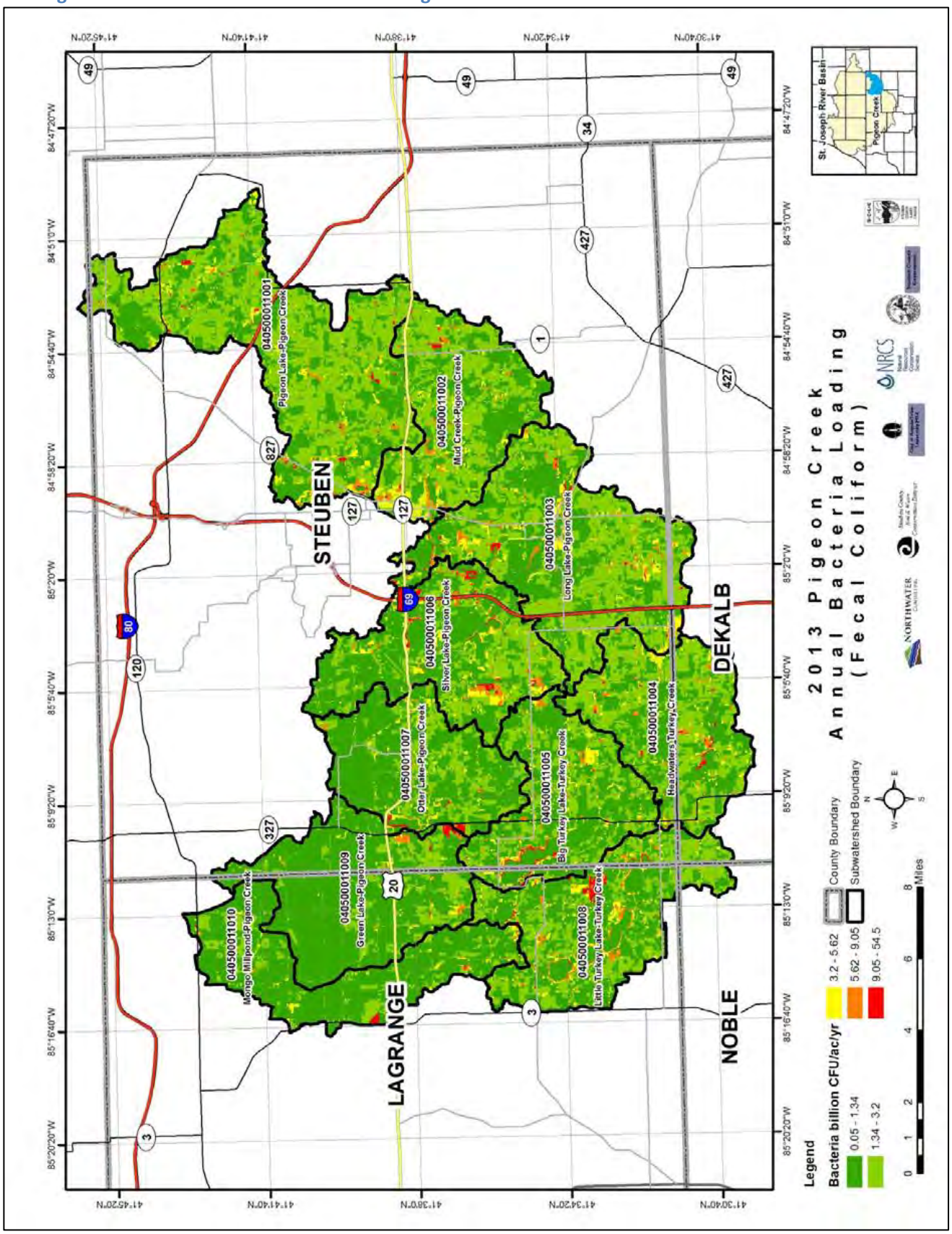
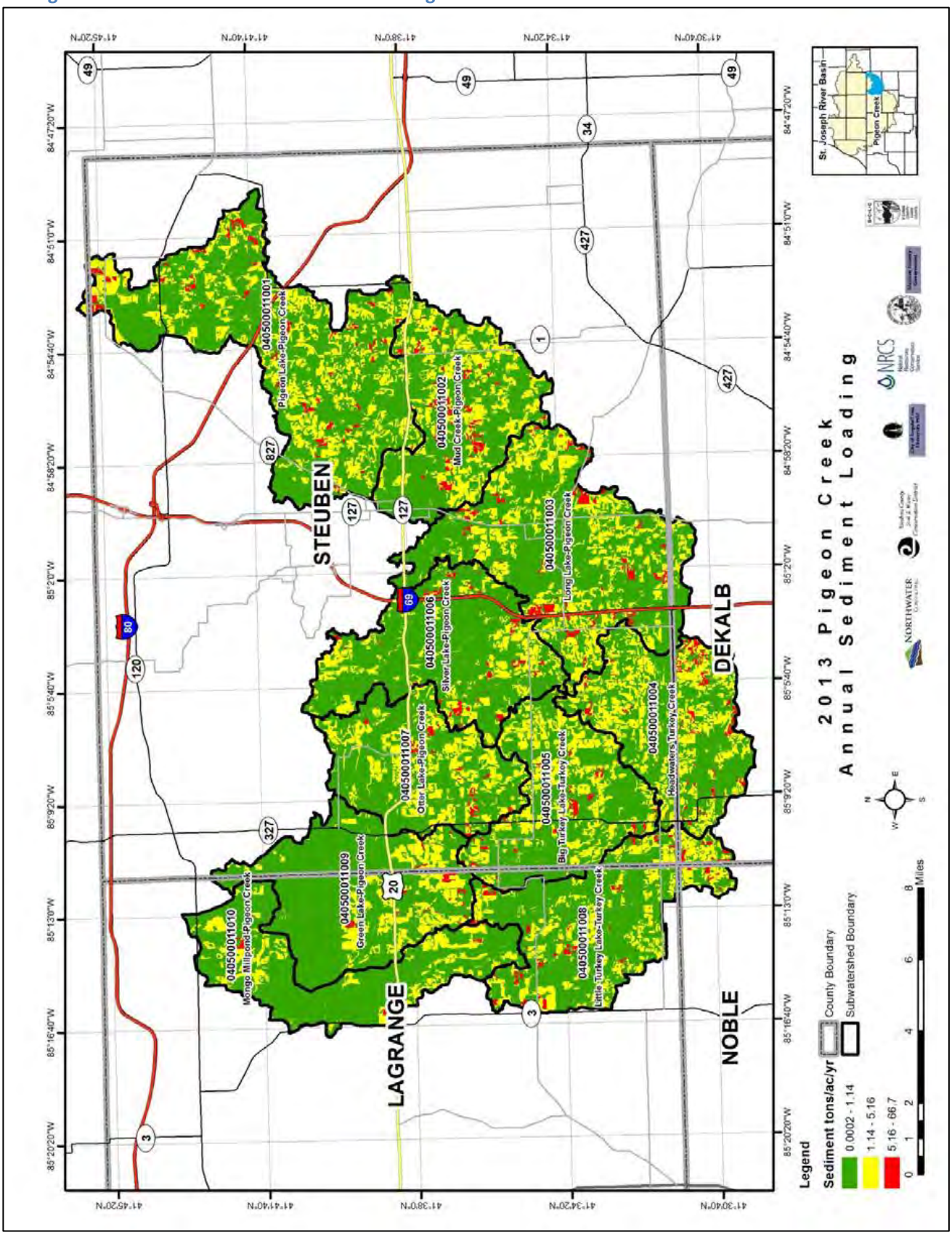


Figure 50 - Annual Per Acre Sediment Loading



7.2.2 Point-Source Pollution Loading

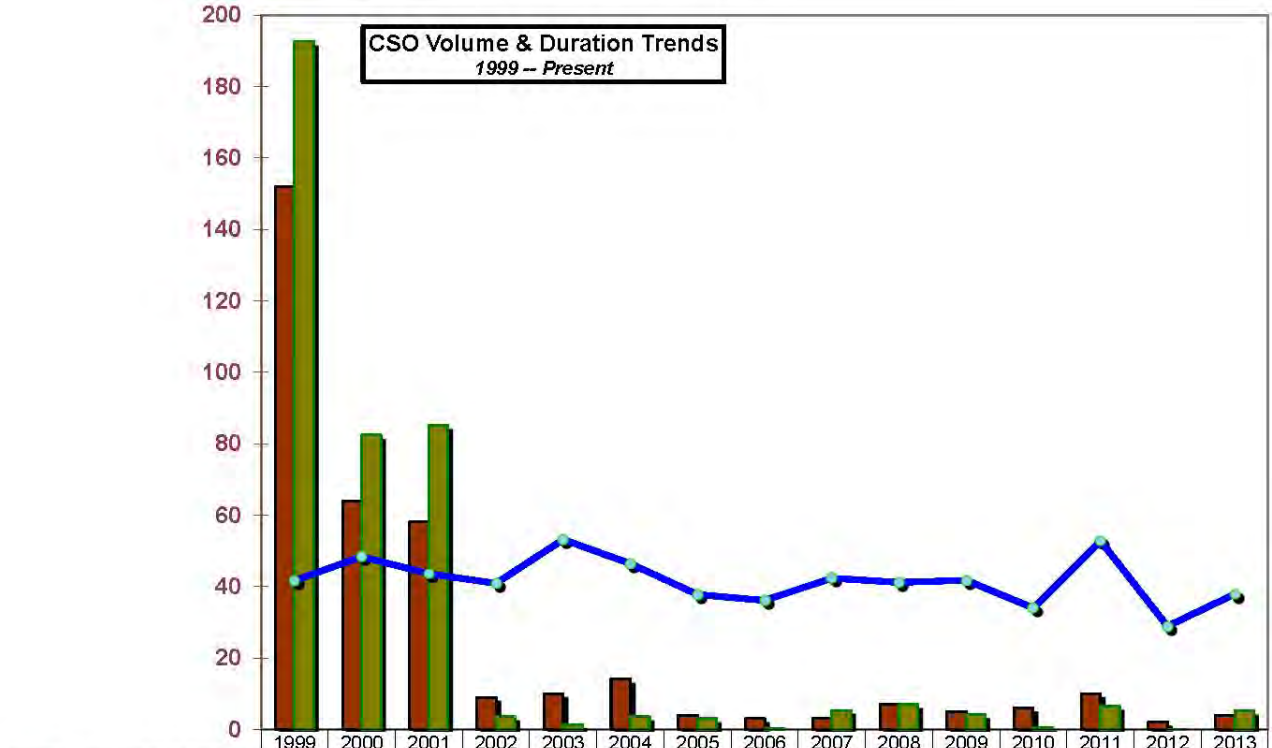
Taken directly from the 2012 Pigeon Creek TMDL plan, there are four (4) regulated point sources for which Waste Load Allocations (WLAs) have been calculated. The TMDL defines WLAs as an allocation of loads to these regulated discharges. WLAs were calculated based on each facility's design flow and permit limits. The permit limits used to calculate annual point source loading are as follows:

- *E. coli* permit limit of 125 cfu/100 mL for all facilities.
- Phosphorus permit limit of 1.0 mg/l for all facilities.
- TSS permit limit of 30 mg/l for Angola, 24 mg/l for LaGrange and Ashley and 15 mg/l for Steuben Lakes.
- Nitrogen using an ammonia-nitrogen standard of 1.6 mg/l for Angola, 1.5 mg/l for LaGrange, 1.3 mg/l for Ashley and 0.83 mg/l for Steuben Lakes.

The Angola Municipal WWTP also discharges to streams impaired due to nitrogen and phosphorus and, therefore, the TMDL plan calculated WLAs for these pollutants based on design flow and permit limits. Point-source pollution loading estimates presented in Table 59 are calculated from the TMDL WLA for phosphorus, nitrogen (only Angola WWTP) and *E. coli*. Sediment and nitrogen loads not included in the TMDL are calculated based on annual design flow and limits gathered from NPDES permits.

There are two CSOs within the project area, and they each have the potential to discharge to surface waters impaired for bacteria, nitrogen, and phosphorus. Both CSOs are in the watershed and are associated with the Angola Municipal WWTP. Figure 51 shows trends in CSO volume and duration from 1999-2013. Results indicate a sharp drop-off in CSO events starting in 2002 and remaining relatively steady though 2013, with a higher number of events during wet years. The two CSO events listed in 2012 occurred on July 18th and August 18th. The July event resulted in 12,520 gallons from Outfall 002 during a 1.12-inch rain. In August, a 0.7-inch rain resulted in a CSO volume from Outfall 003 of 969 gallons. In 2013, four CSO events were recorded including: two continuous events on April 23rd through April 24th, one on June 1st, one on June 25th, and one on July 10th. The first continuous event recorded April 23rd through April 24th occurred from Outfalls 002 and 003 and resulted in a combined 1.29 million gallons over three days under 1.57 inches of rain and saturated conditions where the WWTP was already at capacity. The June 1st event occurred at Outfalls 002 (0.045 million gallons) and 003 (0.031 million gallons) under 1.63 inches of rain. The third CSO event of 2013 on June 25th occurred at Outfalls 002 (0.06 million gallons) and 003 (0.07 million gallons), from 1.57 inches of rain. The fourth CSO event of 2013 occurred at Outfall 002 and resulted in 0.31 million gallons from 0.47 inches of rain.

Figure 51 - Angola CSO Volume & Duration Trends



	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Number of CSO Events	152	64	58	9	10	14	4	3	3	7	5	6	10	2	4
Volume (MG)	192.5	82.4	85.1	3.5	1.3	3.5	3.0	0.163	5.299	6.911	4.097	0.527	6.484	0.011	5.081
Annual Rain (Inches)	41.6	48.4	43.6	40.9	53.1	46.4	37.7	36.1	42.3	41.1	41.7	34.0	52.7	28.8	37.8

There is one MS4 permit in the watershed, which is a joint permit between the City of Angola and Trine University (formerly Tri-State University). These communities discharge to waters impaired for *E. coli* and, therefore, received WLAs in the 2012 TMDL. Within the HUC 12 watershed 040500011002, the MS4 discharges to waters impaired for nitrogen and phosphorus, therefore, for these areas, the MS4 received WLAs for total nitrogen and total phosphorus in the TMDL.

Annual flow from WWTPs in the watershed is 3.85 million gallons per day, annual phosphorus load is 11,655 pounds, annual nitrogen load is 15,815 pounds, annual bacteria load totals approximately 6,608 billion colony-forming units, and annual sediment load is 142.4 tons. Table 59 provides detail regarding annual point source loads.

Table 59 – Annual Point Source Pollution Loading

HUC 12 Name	HUC 12 Code	Facility Name	Permit ID	Design Flow (million gallons/day)	Annual Phosphorus (lbs/yr)	Annual Nitrogen (lbs/yr)	Annual *E. coli* Load (billion CFU/yr)	Annual TSS Load (tons/yr)
Mud Creek-Pigeon Creek	040500011002	Angola Municipal WWTP	IN0021296	1.7	5,110	8,280	2,920	77.6
Long Lake-Pigeon Creek	040500011003	Ashley Municipal STP	IN0022292	0.4	1,218	1,583	694	14.6
Otter Lake-Pigeon Creek	040500011007	Steuben Lakes RWD	IN0061557	1	3,044	2,527	1,716	22.8
Mongo Millpond-Pigeon Creek	040500011010	LaGrange Region B WWTP	IN0060097	0.75	2,283	3,425	1,278	27.4
Grand Total				**3.85**	**11,655**	**15,815**	**6,608**	**142.4**

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Septic System Loading

Using an estimated 1,365 failing septic systems utilized by two people per system, bacteria and nutrient loading can be calculated for the watershed. Phosphorus and nitrogen loading was calculated using STEPL (Spreadsheet Tool for Estimating Pollution Loading) and bacteria loading was calculated using research done by the Water Environment Research Foundation (WERF) where, on average, bacteria loading from a failing septic system can equal 0.15 billion colony-forming units per person, per day. Table 60 lists loading totals from failing septic systems.

Table 60 - Nutrient & Bacteria Loading from Septic

Number of Failing Septic Systems	Number of People per structure	Annual Phosphorus Load (lbs/yr)	Annual Nitrogen Load (lbs/yr)	Annual bacteria Load (billion CFU/year)
1,365	2	13,679	34,926	149,468

7.3 Load Reductions

This section provides an overview of expected load reductions from recommended site-specific and basin-wide BMPs. These load reductions are compared against load-reduction targets presented in Section 8.1. A detailed description of BMPs and their individual load reductions are included in Section 9.0.

The implementation of BMPs detailed in Section 9 will have significant reductions in watershed pollution loading. Tables 61 and 62 list the total percent load reductions expected for both site-specific and basin-wide BMPs; percentages in red represent numerical load reduction goals for the watershed. Results indicate that widespread adoption of all basin-wide BMPs will meet, come close to meeting, or significantly exceed the percent reduction targets established by the 2012 TMDL and noted in Table 63 (Section 8.1). It should be noted that many basin-wide BMPs do overlap with each other and that total pollution loads do not account for streambank erosion or all gully erosion in the watershed. Also, modeled results are calibrated to sampled water quality data, which likely contributes to an underestimation of sediment load. As a result, percent reductions for sediment may be elevated. Site-specific BMPs will result in reductions; however, they alone are not sufficient enough to achieve the desired load reduction targets.

Table 61 - Expected Load Reduction Percentages from Basin-Wide BMPs

Subwatershed Name	2012 HUC12 Subwatershed Codes	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Sediment (tons/yr)	Load Reduction Bacteria (billion CFU/yr)
Pigeon Lake-Pigeon Creek	40500011001	82%/49%	93%/94%	100%/43%	63%/76%
Mud Creek-Pigeon Creek	40500011002	62%/87%	87%/37%	100%/50%	62%/79%
Long Lake-Pigeon Creek	40500011003	80%/48%	95%/89%	100%/44%	63%/68%
Headwaters Turkey Creek	40500011004	74%/48%	87%/88%	93%/49%	68%/51%
Big Turkey Lake-Turkey Creek	40500011005	75%/29%	81%/44%	100%/31%	67%/50%
Silver Lake-Pigeon Creek	40500011006	67%/15%	69%/23%	90%/19%	59%/97%
Otter Lake-Pigeon Creek	40500011007	58%/22%	80%/25%	100%/28%	68%/52%
Little Turkey Lake-Turkey Creek	40500011008	54%/33%	64%/54%	70%/35%	54%/87%
Green Lake-Pigeon Creek	40500011009	48%/0%	52%/0%	51%/0%	62%/23%
Mongo Millpond-Pigeon Creek	40500011010	35%/11%	49%/10%	40%/0%	64%/18%
Total		**67%**	**81%**	**96%**	**63%**

Table 62 - Expected Load Reduction Percentages from Site-Specific BMPs

Subwatershed Name	2012 HUC12 Subwatershed Codes	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Sediment (tons/yr)	Load Reduction Bacteria (billion CFU/yr)
Pigeon Lake-Pigeon Creek	40500011001	5%/49%	5%/94%	1%/43%	2%/76%
Mud Creek-Pigeon Creek	40500011002	5%//87%	5%/37%	9%/50%	6%/79%
Long Lake-Pigeon Creek	40500011003	5%/48%	5%/89%	4%/44%	2%/68%
Headwaters Turkey Creek	40500011004	3%/48%	4%/88%	2%/49%	2%/51%
Big Turkey Lake-Turkey Creek	40500011005	5%/29%	6%/44%	2%/31%	1%/50%
Silver Lake-Pigeon Creek	40500011006	3%/15%	2%/23%	4%/19%	1%/97%
Otter Lake-Pigeon Creek	40500011007	1%/22%	1%/25%	1%/28%	0.4%/52%
Little Turkey Lake-Turkey Creek	40500011008	2%/33%	3%/54%	1%/35%	5%/87%
Green Lake-Pigeon Creek	40500011009	0.5%/0%	1%/0%	0.1%/0%	1%/23%
Mongo Millpond-Pigeon Creek	40500011010	1%/11%	1%/10%	1%/0%	2%/18%
Total		**4%**	**4%**	**3%**	**2%**

8.0 Critical Areas, Goals & Measurement Indicators

The 2006 watershed plan determined critical areas based on project locations within the Upper Lake Chain and Lower reaches of the watershed; those project locations were determined to be "critical areas." A significantly different approach was taken with the current plan where "critical areas" are defined as those HUC 12 sub watersheds where implementation will have the greatest likelihood of reducing flooding and bacteria, phosphorus, nitrogen, and sediment loading. The intent is that implementation efforts targeted to these subwatersheds will maximize load reductions and achieve the "biggest bang-for-the-buck."

Water quality goals and targets typically represent a desired water quality endpoint. To determine if water quality goals are being met, measurement indicators are established. In the current Pigeon Creek Watershed Management Plan, watershed stakeholders established the water quality goals. Consideration was given to load reduction goals outlined in the 2012 Pigeon Creek TMDL along with past and current water quality impairments and data; narrative goals are directly supported by available water quality data.

Numerical reduction targets have been applied to the narrative goal statements identified by watershed stakeholders. These targets are based on TMDL pollutant reduction percentages, modeled pollutant loads and instream water quality data. Existing state water quality standards have been utilized to establish measurement indicators for each goal and goal target, which are discussed in more detail in Section 8.2.

Since flooding is still a major concern for watershed residents, narrative goals were also established for flooding. Specific flood reduction calculations are outside the scope of this watershed plan update and, therefore, only narrative flood reduction goals are provided. Narrative measurement indicators are also

used for flooding. A comprehensive flood study and detailed hydrologic modeling is needed to truly evaluate the current impacts of flooding along with the most appropriate solutions. However, an effort was made in this plan to address watershed concerns for flooding by making the assumption that virtually any strategy proposed to improve water quality will also have a positive effect on flooding. For example, a wetland or pond constructed to trap nutrients will also detain stormwater and the construction of a two-stage drainage ditch will reduce both nutrient loads and increase the channel's ability to store and transport floodwaters; two-stage ditches do provide localized flood reduction benefits. Section 9.0 includes the location of proposed two-stage ditches, their pollutant load reductions and any relevant changes in stream capacity and hydraulics.

8.1 Water Quality Goals

The following three goals have been identified by watershed stakeholders and are supported through an analysis of existing watershed data. Reduction percentages noted for each goal represent an average for the watershed based on Table 63:

1. Reduce bacteria loading by 30% in ten years and 60% in twenty-five years.
    - includes numeric reduction target as presented in Table 63
2. Reduce sediment and nutrient loading (phosphorus and nitrogen) by 20% in ten years and 40% in twenty-five years.
    - Includes numeric reduction target as presented in Table 63
3. Reduce flooding by increasing flood storage areas by 500 acres in ten years and 1,000 acres in twenty-five years.
    - narrative goal only; no numeric target

To support these narrative goal statements, specific percent reduction targets for *E. coli* bacteria, phosphorus, nitrogen, and sediment are used and listed in Table 62. Similar to a TMDL plan, numeric goal targets represent percent load reductions and can be used to evaluate how well plan recommendations or implementation strategies reduce overall subwatershed pollutant loadings. The targets presented below are based on the 2012 TMDL, modeled pollution loads, and water quality data.

The 2012 TMDL for Pigeon Creek established percent reductions for bacteria and a percent reduction target for phosphorus and nitrogen in one subwatershed (Mud Creek). The TMDL does not provide any percent reduction targets for sediment. In order to establish phosphorus and nitrogen reduction targets for the remaining nine subwatersheds and sediment targets for all ten subwatersheds, the following method was used:

1. Select two reference subwatersheds representing desired phosphorus, nitrogen and sediment load. Referenced subwatersheds represent the lowest per-acre phosphorus, nitrogen and sediment loads from both modeled results and available water quality data.
2. Green Lake (HUC 040500011009) and Mongo Millpond (HUC 040500011010) were selected as reference watersheds. Green Lake has an annual per-acre phosphorus load of 0.56 lbs/ac and 3.96 lbs/ac for nitrogen, and Mongo Millpond has an annual per-acre phosphorus load of 0.71

lbs/ac and a nitrogen load of 4.81 lbs/ac. Both Green Lake and Mongo Millpond have an annual TSS load of 0.61 tons/ac.

3. Determine a baseline target value equal to the average annual per-acre load of 0.635 lbs/ac for phosphorus, 4.39 lbs/ac for nitrogen and 0.61 tons/ac for sediment.
4. Calculate the percentage reductions required for the remaining subwatersheds to meet the desired reference condition of 0.635 lbs/ac for phosphorus, 4.39 lbs/ac for nitrogen and 0.61 tons/ac for sediment.

Table 63 - Percentage Load Reduction Goals

Subwatershed Name	HUC 12 Subwatershed Codes	Bacteria Goal: 2012 TMDL Load Reduction Percentages; Bacteria*	Nutrient Goal: Load Reduction Percentages; Nitrogen	Nutrient Goal: Load Reduction Percentages; Phosphorus	Sediment Goal: Load Reduction Percentages; Sediment
Pigeon Lake-Pigeon Creek	040500011001	76%	94%	49%	43%
Mud Creek-Pigeon Creek	040500011002	79%	37%**	87%**	50%
Long Lake-Pigeon Creek	040500011003	68%	89%	48%	44%
Headwaters Turkey Creek	040500011004	51%	88%	48%	49%
Big Turkey Lake-Turkey Creek	040500011005	50%	44%	29%	31%
Silver Lake-Pigeon Creek	040500011006	97%	23%	15%	19%
Otter Lake-Pigeon Creek	040500011007	52%	25%	22%	28%
Little Turkey Lake-Turkey Creek	040500011008	87%	54%	33%	35%
Green Lake-Pigeon Creek	040500011009	23%	0%	0%	0%
Mongo Millpond-Pigeon Creek	040500011010	18%	10%	11%	0%

*Reduction percentages are established for multiple stream segments within the subwatershed. The percent reduction target represents an average of all the stream segments within that subwatershed.

**Represents TMDL target

8.2 Measurement Indicators

Indicators are used for measuring each goal in order to determine whether progress is being made toward achieving the goal. For the Pigeon Creek Watershed Management Plan, indicators are based on existing and future monitoring, state water quality standards and any exceedences in those standards. For bacteria, phosphorus, nitrogen and sediment reduction goals/targets, numerical indicators are simply the number of times a given water quality sample exceeds the state standard. Where state standards do not exist, such as in the case of sediment, a protective value is used. A protective value of 30 mg/L was established for sediment; this represents the highest HUC 12 subwatershed average based on sampled water quality data. The intent here was to limit future sediment loads from exceeding this threshold. The number of sample exceedences against state standards and the protective sediment value are, therefore, used as the primary numerical measurement indicators for water quality. In the absence of water quality results, or when local monitoring efforts are scaled down, secondary narrative indicators can be used. As with goals for flood reduction, primary measurement indicators are also narrative.

Often times, watershed plans will provide a large and detailed list of measurement indicators. This can become cumbersome and difficult to manage and track effectively. The approach taken with the PCWMP was to simplify this process by providing an easy-to-track list of indicators. Table 64 lists primary and secondary measurement indicators for each goal area. Implementation milestones for each indicator are provided in Section 10.2.

Table 64 - Measurement Indicators

Goal	Primary Indicator	Notes	Secondary Indicator	Notes
Reduce Bacteria Loading	Number of water quality samples exceeding 235 CFU/100 mL	1) Results should be tracked separately for each subwatershed at existing monitoring locations 2) SWAMM should be utilized to track load reductions from BMP implementation and compare against pollution reduction goals	Number of category 4 & 5 impaired streams and lakes for *E. coli* (bacteria)	Currently, 34 streams are listed for *E. Coli* (bacteria). No Lakes are listed. The number of listed streams should be reduced and the number of listed lakes should be maintained
Reduce Phosphorus Loading	Number of water quality samples exceeding 0.3 mg/L	1) Results should be tracked separately for each subwatershed using existing monitoring locations 2) SWAMM should be utilized to track load reductions from BMP implementation and compare against pollution reduction goals	Number of category 4 & 5 impaired streams and lakes for phosphorus and Impaired Biotic Communities (IBC)	Currently, no streams are listed for phosphorus. Two lakes are listed for phosphorus. There are 12 streams and 2 lakes listed for IBC. The number of streams listed for phosphorus should be maintained and the number of lakes should be reduced. The number of IBC impairments should be reduced for streams and lakes

Goal	Primary Indicator	Notes	Secondary Indicator	Notes
Reduce Nitrogen Loading	Number of water quality samples exceeding 10 mg/L	1) Results should be tracked separately for each subwatershed using existing monitoring locations 2) SWAMM should be utilized to track load reductions from BMP implementation and compare against pollution reduction goals	Number of category 4 & 5 impaired streams and lakes for nitrogen and Impaired Biotic Communities (IBC)	Currently, no streams are listed for nitrogen. No lakes are listed for nitrogen. There are 12 streams and 2 lakes listed for IBC. The number of streams and lakes listed for nitrogen should be maintained. The number of IBC impairments should be reduced for streams and lakes.
Reduce Sediment	Number of water quality samples exceeding 30 mg/L	1) Results should be tracked separately for each subwatershed using existing monitoring locations 2) SWAMM should be utilized to track load reductions from BMP implementation and compare against pollution reduction goals	Number of category 4 & 5 impaired streams and lakes for TSS (sediment)	Currently, no streams or lakes are listed as impaired for TSS (sediment). Maintaining this is the target.
Reduce Flooding by increasing storage	1) Acres of restored wetland in headwaters 2) Feet of two-stage drainage ditches		That flooding is no longer a concern for watershed stakeholders	Although flooding is still a concern, it is less of a concern since the 2006 plan according to a recent poll of Steering Committee members.

8.3 Critical Areas

Five primary, secondary, and tertiary critical HUC 12 subwatersheds and one critical urban area have been identified for Pigeon Creek. Primary critical subwatersheds include Long Lake/Pigeon Creek (HUC 040500011003) and Little Turkey Creek/Turkey Lake (HUC 040500011008). Secondary critical subwatersheds include Pigeon Lake/Pigeon Creek (HUC040500011001) and Mud Creek/Pigeon Creek (HUC 040500011002). Tertiary subwatersheds include Silver Lake/Pigeon Creek (HUC 040500011006) and Headwaters Turkey Creek (HUC 040500011004). Summaries of subwatershed rankings are provided in Table 65 including the secondary and tertiary critical subwatersheds. Subwatersheds with a ranking of one are considered primary, two are secondary, and three are tertiary. Work should focus first on those subwatersheds with the highest ranking and those where a subwatershed is ranked high in multiple goal categories. An urban critical area is also delineated and includes the City of Angola. Figure 52 shows all critical subwatersheds and the urban critical area.

The process for the establishment of critical areas included:

- Defining three primary watershed goal areas: 1) reduce bacteria loads; 2) improve water quality by reducing phosphorus, nitrogen and sediment; 3) reduce flooding.
- Establishing a set of data-driven indicators that represent each goal statement. For example, to reduce bacteria loads, focus should be on those areas with the highest current bacteria loads

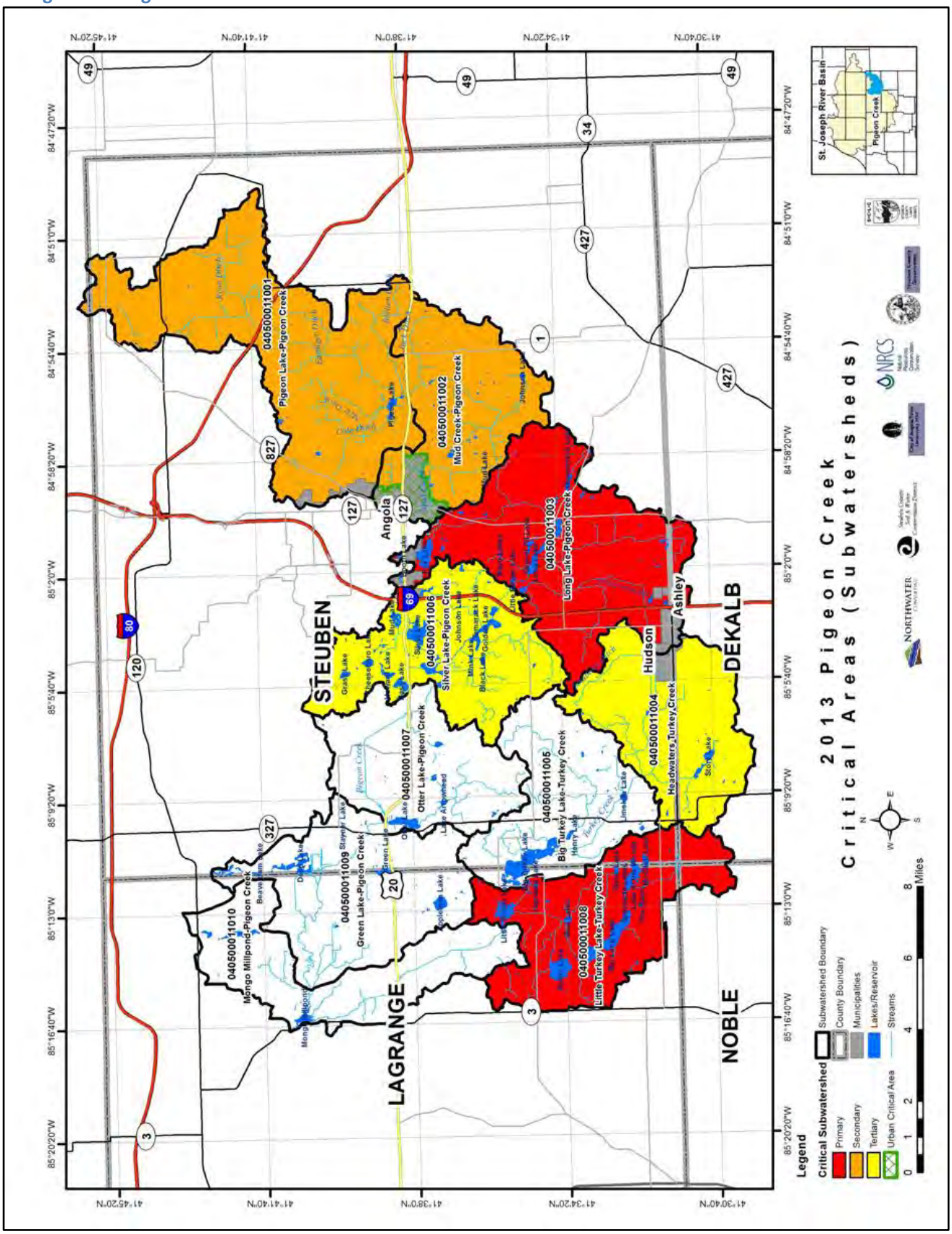
and greatest potential for bacteria load reductions. Here, indicators would include: per-acre modeled bacteria load, number of water quality standard violations, and total expected bacteria load reduction. To reduce sediment, focus should be on areas with the highest percentage of erodible soils and the least amount of protected soils. Here, indicators would include: percent area highly erodible soils and percent area grassland and woodland.

- A detailed GIS analysis of each indicator by HUC 12 subwatershed.
- The application of weighting factors for each indicator based on overall importance.
- Normalization of indicator results by subwatershed.
- A subwatershed ranking.

Table 65 - Critical Subwatershed Ranking Summary

Subwatershed Names	HUC 12 Subwatershed Codes	Rank; Goal of Reducing Bacteria	Rank; Goal of Reducing Sediment and Nutrients	Rank; Goal of Reducing Flooding
Pigeon Lake-Pigeon Creek	040500011001	6	*2*	4
Mud Creek-Pigeon Creek	040500011002	4	*3*	*2*
Long Lake-Pigeon Creek	040500011003	*2*	*1*	*1*
Headwaters Turkey Creek	040500011004	8	4	*3*
Big Turkey Lake-Turkey Creek	040500011005	5	5	5
Silver Lake-Pigeon Creek	040500011006	*3*	7	7
Otter Lake-Pigeon Creek	040500011007	7	8	8
Little Turkey Lake-Turkey Creek	040500011008	*1*	6	6
Green Lake-Pigeon Creek	040500011009	10	10	10
Mongo Millpond-Pigeon Creek	040500011010	9	9	9

Figure 52 - Pigeon Creek Critical Areas



As previously noted, critical areas are defined based on three major goals areas; two subwatersheds are ranked high in multiple goal areas; Mud Creek in two of the three goal areas and Long Lake in all of the goal areas. Pigeon Lake, Silver Lake and Little Turkey Lake are ranked high in only one goal area. Table 66 summarizes the data or criteria used to generate the critical subwatershed rankings.

Table 66 - Critical Area Criteria

Critical Area Criteria	Reduce Bacteria Loads	+ or -*	Improve Water Quality; Reduce Sediment, Nitrogen and Phosphorus	+ or -*	Reduce Flooding	+ or -*
Per-Acre Bacteria Load	X	+				
% Area on Septic and on Limited Soils within 500 ft of a Stream	X	+				
# Water Wells	X	+				
% Area Wetlands Needing Restoration	X	-	X	-		
% Area Pasture	X	+				
Average Distance of Feed Operations & Confinements to a Watercourse	X	-				
# Water Quality Samples Exceeding Standard for Bacteria	X	+				
% Area of Wetlands	X	-				
# NPDES Permits	X	+				
Total Number of Past Projects	X	-	X	-		
Total Per-Acre Bacteria Load Reductions from Needed Projects	X	+				
% Area Open Space	X	-	X	-	X	-
% Area Public Land	X	-	X	-	X	-
# T&E Occurrences	X	-	X	-		
% Area Hydrologic Group C & D Soils	X	+	X	+	X	+
Per-Acre P and N Load			X	+		
Per-Acre TSS Load			X	+		
% Area Residential			X	+	X	+
# Water Quality Samples Exceeding Standard for P and N			X	+		
# Water Quality Samples Exceeding 30mg/L Threshold For TSS			X	+		
% Urban Area			X	+	X	+
% Area HEL Soils			X	+		
% Area Non-Hel Soils					X	+
% Area HEL Agricultural Soils			X	+		
Acres of Filter Strips Needed			X	+		
% Area Wetland	X	-	X	-	X	-
Per Acre Runoff (Ac-Ft)			X	+	X	+
Length Tiled Ditches			X	+		
% Area Row Crops			X	+	X	+
% Area Lakes/Open Water			X	+		
Acres Irrigated Fields			X	+		
Total Per Acre P, N and TSS Load Reductions from Needed Projects			X	+		
Length Two-Stage Ditch Recommended					X	+
% Area Hydric Soils					X	+
Length Channelized Ditch					X	+
% Area Legal Ditch					X	+
% Area 100-Year Floodplain					X	-

*+ represents high score for a high number; - represents a high score for a low number

9.0 Best Management Practices

Best Management Practices can be described as a practice or procedure to prevent or reduce water pollution and address stakeholder concerns. BMPs typically include treatment requirements, operating procedures, and practices to control runoff and abate the discharge of pollutants. This section of the plan will describe both site-specific BMPs, as well as those that can be applied basin-wide to achieve measurable load reductions in phosphorus, nitrogen, sediment, and bacteria. A watershed-wide survey was conducted to evaluate point-source discharges, document watershed features, and the location of potential BMPs. Basin-wide BMPs were identified using GIS and other locally available information.

Recommended practices focus on both point source and NPS pollution. Estimates of the expected pollution load reductions associated with recommended practices are included in this section. Load reductions are calculated using pollutant removal efficiency percentages based on existing literature and local expertise. Pollutant removal efficiencies can be found in Table 67.

Table 67 - Pigeon Creek BMP Pollutant Removal Effeciencies

Best Management Practice	Nitrogen Reduction Percentage	Phosphorus Reduction Percentage	Sediment Reduction Percentage	Bacteria Reduction Percentage
Rain Garden/barrel (together)	50%-70%	60%-75%	65%-80%	35%-45%
Rain Barrel	30%	30%	30%	30%
Wetland Restoration	25%-55%	30%-50%	50%-70%	40%-65%
Detention Basin	20%-55%	25%-60%	40%-75%	30%-65%
Waste Basin Treatment System	65%	70%	75%	90%
Cover crop/Hay/Critical Area Seeding	35%-40%	40%-45%	35%-40%	35%-40%
Terrace/WASCOB	25%-30%	30%-40%	50%-65%	25%-35%
Restrictor/Blind Inlet/Drop Inlet Structure	30%	50%	70%	35%
Livestock Fence	15%-25%	20%-30%	20%-30%	25%-35%
Filter Strip/Riparian Buffer	25%-50%	30%-55%	35%-70%	25%-50%
Grass Waterway	55%	45%	80%	50%
Porous Pavement	60%	55%	70%	40%
Tree Planting	45%	50%	55%	45%
Combined Pasture BMPs (can include fence, diversion, crossings, water system, detention)	35%-65%	40%-70%	45%-80%	35%-80%
Grade Control Structure*	30%	40%	60%	20%
Denitrifying Bioreactor	50%	0%	0%	0%

* treats 100% of sediment from gully erosion

9.1 – Basin-Wide Best Management Practices

Basin-wide BMPs are those practices or procedures that can be applied throughout the watershed where exact project locations may be unknown or where locations may not have been verified through a site visit. Basin-wide BMPs include practices such as cover crops, blind inlets or tile restrictor plates, septic inspections and monitoring, or field terraces. Basin-wide BMP recommendations cover 135,750 acres in the watershed. It is important to note that many of these practices overlap with each other, such as cover crops and blind inlets and, therefore, these BMPs result in coverage of over 99% of the basin.

Many standard BMPs exist that will reduce pollution loading. Basin-wide BMPs specifically recommended for the Pigeon Creek watershed include:

1. Cover Crops: a cover crop is a temporary vegetative cover that is grown to provide protection for the soil and improve soil conditions.
2. Terraces/Water and Sediment Control Basin (WASCOB): earth embankment and/or channel constructed across the slope to intercept runoff water and trap soil.
3. Blind Inlet: a blind inlet is defined as an excavated earthen box with perforated collector tubing placed in the bottom and filled to the surface with rock or gravel. The rock is the inlet for surface water.
4. Denitrifying Bioreactor: a structure containing a carbon source, installed to reduce the concentration of nitrate nitrogen in subsurface agricultural drainage flow via enhanced denitrification.
5. Wetland Restoration: Using a hybrid NWI data set developed and provided by the Friends of the St. Joe River Association, a selection of existing wetlands are identified for restoration. These sites received a combined water quality score of greater than 100. Wetland restoration activities include restoring natural hydrology and the habitat diversity of existing wetlands.
6. Septic system recommendations to evaluate/mitigate the effects of septic systems:
    a. Certify septic pumpers to inspect septic tanks.
    b. Recommend homeowners have their septic tanks pumped and inspected every 3 years.
    c. Septic pumpers file an inspection report with the SWCD.
    d. Define a “sensitive area” boundary in the watershed close to creeks and waterways. Base boundary on soil types and slopes – where seepage from a drain field could reasonably be expected to reach a watercourse before being adequately treated. Septic systems within this boundary would receive additional attention and/or regulation.
7. Rain Barrel: a barrel used as a cistern to hold rainwater from residential roof runoff.
8. Rain Garden: a planted depression that allows rainwater runoff from impervious urban areas, including roofs, driveways, walkways, parking lots, and compacted lawn areas, the opportunity to be absorbed.
9. Porous/Permeable Pavement: permeable or porous pavement is a method of paving that allows stormwater to seep into the ground as it falls rather than running off into storm drains and waterways. Permeable pavements function similarly to sand filters, in that they filter the water by forcing it to pass through different aggregate sizes and typically some sort of filter fabric.

Therefore, most of the treatment is through physical (or mechanical) processes. As precipitation falls on the pavement, it infiltrates down into the storage basin where it is slowly released into the surrounding soil.

10. Education and Outreach Programs: an effective strategy for improving water quality and promoting conservation is through targeted education and outreach. Education and outreach programs can be designed to promote particular conservation practices or educate stakeholders on the importance of water quality in general.

Absent from recommendations above are no-till, mulch-till, and reduced-tillage practices. These tillage practices are currently in good use throughout the watershed and, therefore, have not been addressed in this plan. Although not specifically recommended, no-till, mulch-till, and reduced-tillage practices should continue to be promoted in Pigeon Creek.

Priority should be given to those BMPs with the greatest load reductions and/or that fall within a designated critical area (highlighted red in the table below). Table 68 provides a summary of all basin-wide BMPs by subwatershed, their treated area, and expected load reductions. Comparing the anticipated load reduction results of site-specific and basin-wide BMPs to water quality targets indicate that in order to achieve significant reductions in the watershed, there must be widespread adoption of BMPs.

Cover crop adoption is a logical strategy for reducing sediment and nutrients due to their relatively low cost and high anticipated per acre and overall load reductions. Blind inlets will achieve the highest overall reductions in sediment and nutrients, although, the cost of these practices may be prohibitive and recent work has shown reluctance on the part of landowners to install blind inlets. Addressing leaking septic tanks will result in the highest overall reduction in bacteria loading and, although urban BMPs such as rain barrels, rain gardens, and porous pavement are high in cost, they are relatively efficient at reducing pollutant loads (with the exception of sediment) and, more importantly, will help to reduce urban runoff volumes. Denitrifying bioreactors will significantly reduce overall nitrogen loads and should be considered, at least as demonstration projects, to gauge landowner willingness to adopt. Terraces and water and sediment control basins are very efficient at reducing sediment and phosphorus loads and are already popular practices in the watershed and, therefore, should be considered a high priority for implementation. Despite the fact that wetland restoration ranks the lowest in terms of overall sediment, phosphorus and bacteria reductions, this practice will result in high nitrogen reductions; additional considerations with respect to wetland restoration include flood control, wildlife habitat and biodiversity.

Table 68 - Basin-Wide BMP Load Reduction Totals

Subwatershed Name	HUC 12 Subwatershed Codes	Acres Benefited by BMP	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Pigeon Lake-Pigeon Creek	040500011001	29,581	23,560	178,320	33,512	26,434
Mud Creek-Pigeon Creek	040500011002	13,889	12,010	87,267	24,156	17,024
Long Lake-Pigeon Creek	040500011003	27,130	20,182	151,327	31,199	23,163
Headwaters Turkey Creek	040500011004	14,395	11,646	88,059	23,487	13,004
Big Turkey Lake-Turkey Creek	040500011005	11,896	8,519	59,335	21,520	9,954
Silver Lake-Pigeon Creek	040500011006	9,257	7,523	50,910	21,469	8,939
Otter Lake-Pigeon Creek	040500011007	11,060	7,513	50,872	20,393	9,194
Little Turkey Lake-Turkey Creek	040500011008	8,784	7,611	59,305	20,921	8,728
Green Lake-Pigeon Creek	040500011009	5,208	4,315	29,746	17,596	4,215
Mongo Millpond-Pigeon Creek	040500011010	4,550	3,914	28,352	17,231	2,585
Total		**135,750**	**106,792**	**783,491**	**231,484**	**123,239**

Pigeon Creek; Streambank Stabilization

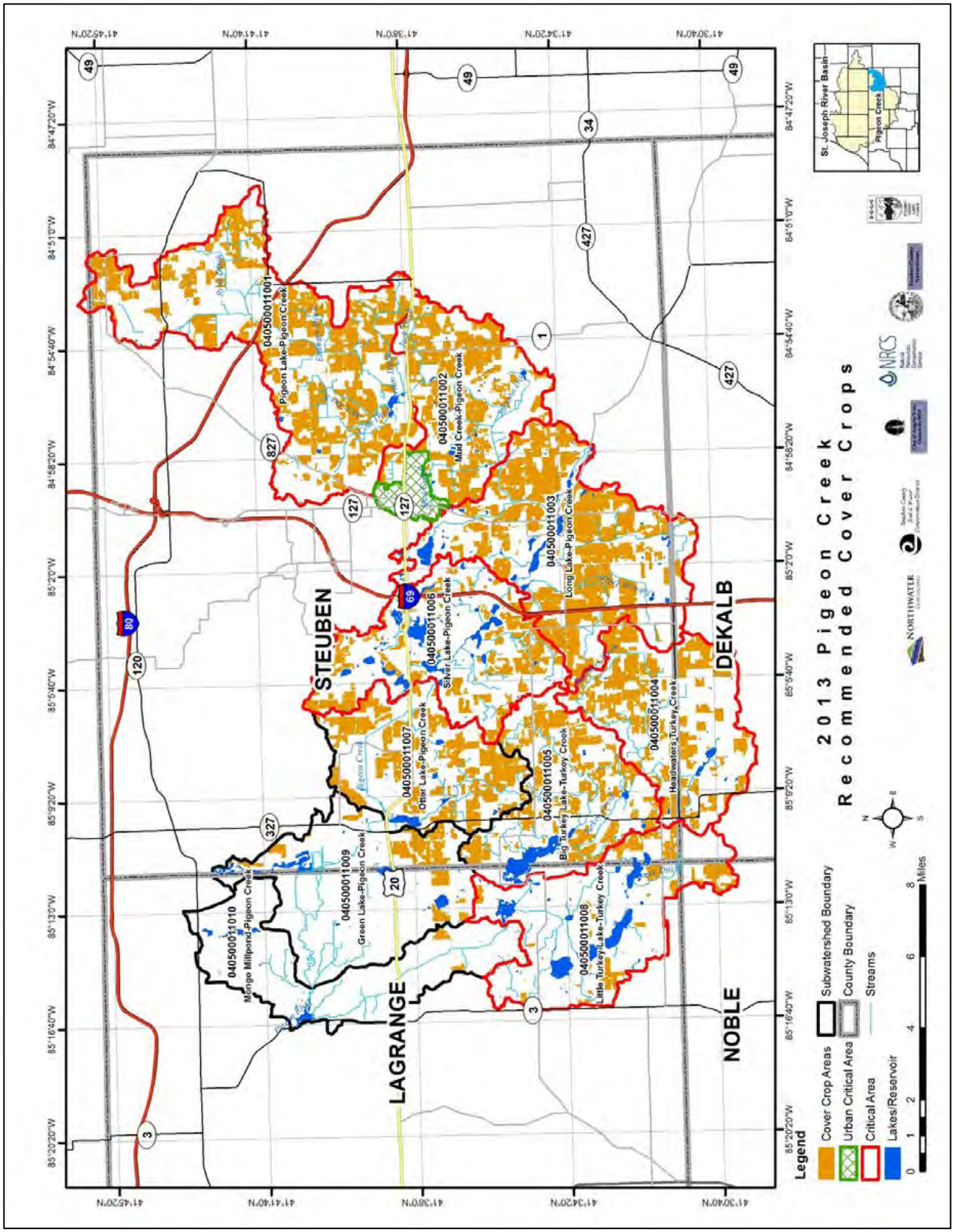
9.1.1 – Cover Crops

Cover Crops are recommended on 39,186 (29%) acres throughout the watershed. Areas targeted for cover crops include primarily flat to gently sloping crop ground. Table 69 lists acreage and load reductions by subwatershed and Figure 53 shows the distribution throughout the watershed. The implementation of cover crops in the watershed will achieve significant reductions in phosphorus (0.7 lbs/ac/yr), nitrogen (3.9 lbs/ac/yr), and sediment (0.7 tons/ac/yr) and, to a lesser extent, bacteria (0.57 billion CFU/ac/yr). Implementation should be prioritized to critical nutrient and sediment reduction subwatersheds (highlighted red in the table below) and on fields currently practicing no-till. For those fields not currently in no-till, a no-till system should be promoted prior to implementing cover crops.

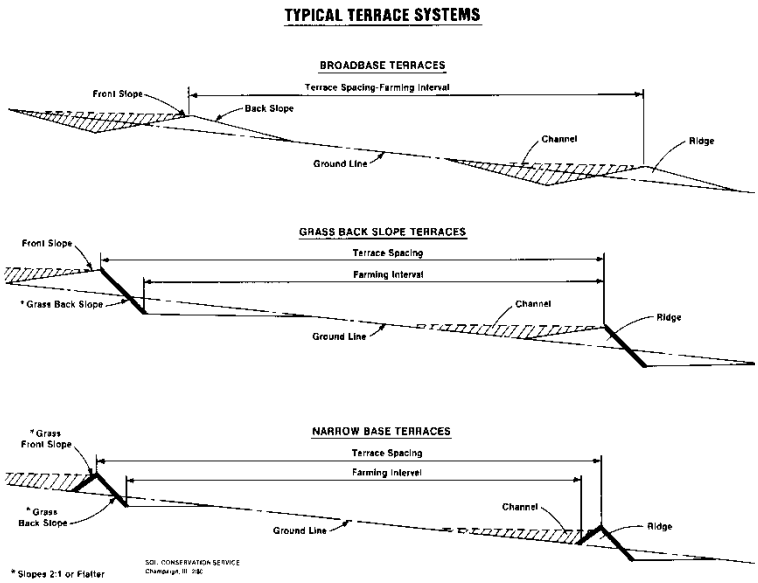
Table 69 - Cover Crop Load Reductions

Subwatershed Name	HUC 12 Subwatershed Codes	Acres Cover Crop	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Pigeon Lake-Pigeon Creek	040500011001	8,696	6,590	37,221	5,418	6,027
Mud Creek-Pigeon Creek	040500011002	4,524	3,516	19,859	2,891	4,128
Long Lake-Pigeon Creek	040500011003	8,105	5,723	32,321	4,705	5,310
Headwaters Turkey Creek	040500011004	4,436	3,032	17,125	2,493	2,958
Big Turkey Lake-Turkey Creek	040500011005	3,515	2,139	12,081	1,759	2,241
Silver Lake-Pigeon Creek	040500011006	2,960	2,062	11,647	1,696	2,431
Otter Lake-Pigeon Creek	040500011007	3,950	2,111	11,925	1,736	2,343
Little Turkey Lake-Turkey Creek	040500011008	1,578	1,080	6,099	888	1,091
Green Lake-Pigeon Creek	040500011009	1,291	761	4,297	626	887
Mongo Millpond-Pigeon Creek	040500011010	130	59	333	48	85
Grand Total		**39,186**	**27,074**	**152,909**	**22,258**	**27,502**

Figure 53 - Pigeon Creek Recommended Cover Crops



9.1.2 – Terraces & Water & Sediment Control Basins

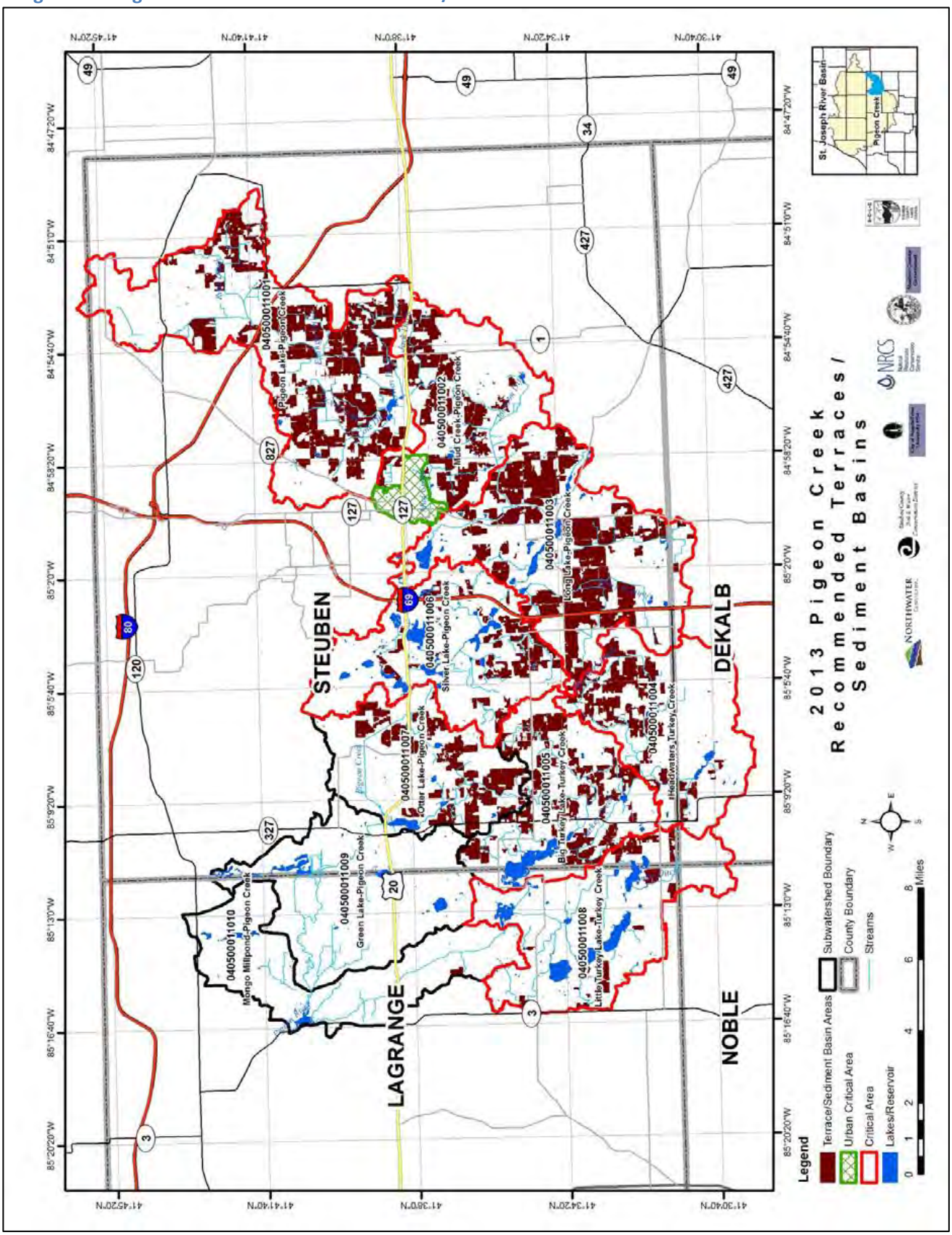


Terraces, or Water and Sediment Control Basins, are recommended to treat 25,916 acres (19%) throughout the watershed. Areas targeted for these practices include cropped HEL soils. Table 70 lists acreage and load reductions by subwatershed and Figure 54 shows the distribution throughout the watershed. The implementation of terraces on sloping crop ground in the watershed will achieve significant reductions in sediment (1 ton/ac/yr) and phosphorus (0.53 lbs/ac/yr) and to a lesser extent, nitrogen (2.8 lbs/ac/yr) and bacteria (0.41 billion CFU/ac/yr). Implementation should be prioritized to critical nutrient and sediment reduction subwatersheds (highlighted red in the table below).

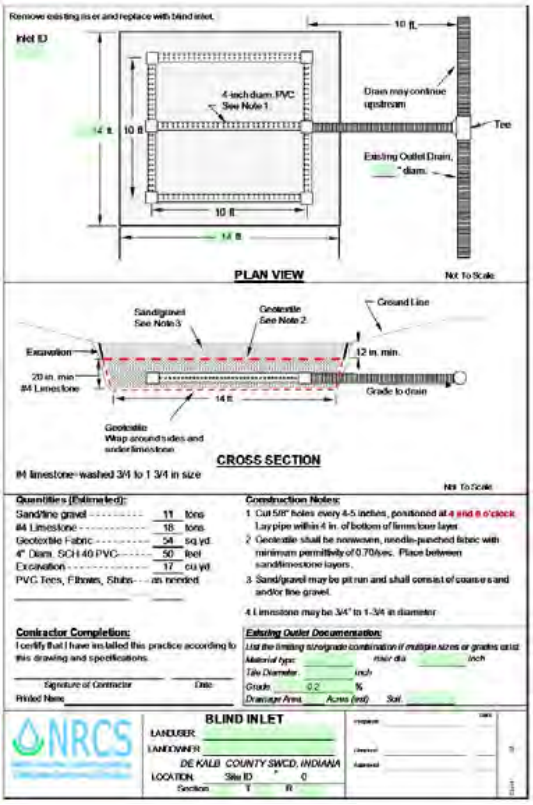
Table 70 - Terrace & Water & Sediment Control Basin Load Reductions

Subwatershed Name	HUC 12 Subwatershed Codes	Treated Area (acres) Terraces	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Pigeon Lake-Pigeon Creek	040500011001	6,793	3,844	20,674	3,009	6,045
Mud Creek-Pigeon Creek	040500011002	2,777	1,669	8,979	1,307	3,788
Long Lake-Pigeon Creek	040500011003	6,251	3,286	17,673	2,573	5,521
Headwaters Turkey Creek	040500011004	2,221	1,120	6,024	877	1,849
Big Turkey Lake-Turkey Creek	040500011005	2,952	1,338	7,198	1,048	2,582
Silver Lake-Pigeon Creek	040500011006	1,558	935	5,028	732	1,995
Otter Lake-Pigeon Creek	040500011007	2,403	1,033	5,556	809	2,290
Little Turkey Lake-Turkey Creek	040500011008	915	450	2,421	352	893
Green Lake-Pigeon Creek	040500011009	0	0	0	0	0
Mongo Millpond-Pigeon Creek	040500011010	47	14	77	11	36
Grand Total		**25,916**	**13,689**	**73,631**	**10,718**	**24,999**

Figure 54 - Pigeon Creek Recommended Terrace/Water & Sediment Control Basin Areas



9.1.3 – Blind Inlets

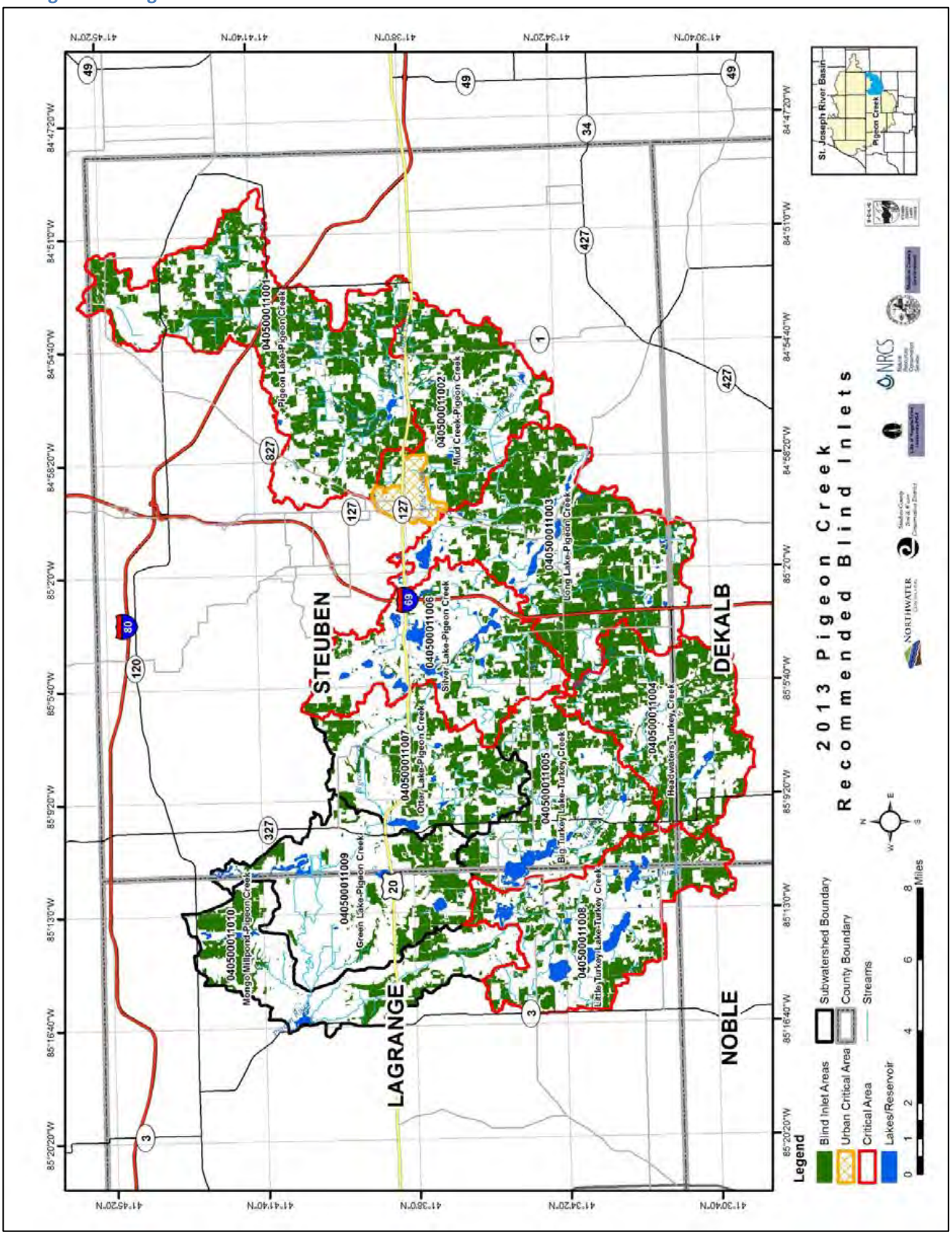


Blind Inlets are recommended for the treatment of 51,870 acres (38%) throughout the watershed. Table 71 lists acreage and load reductions by subwatershed and Figure 55 shows the distribution throughout the watershed. Areas targeted for blind inlets include both flat and sloping crop ground and those tillable fields that drain to a central "pot hole" or depressional area. The widespread implementation of blind inlets in the watershed will achieve significant reductions in sediment (1.32 tons/ac/yr) and phosphorus (0.9 lbs/ac/yr) and, to a lesser extent, nitrogen (3.4 lbs/ac/yr) and bacteria (0.58 billion CFU/ac/yr). Implementation should be prioritized to critical nutrient and sediment reduction subwatersheds (highlighted red in the table below).

Table 71 - Blind Inlet Load Reductions

Subwatershed Name	HUC 12 Subwatershed Codes	Treated Area (acres) Blind Inlet	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Pigeon Lake-Pigeon Creek	040500011001	10,371	9,994	38,706	6,573	13,726
Mud Creek-Pigeon Creek	040500011002	5,062	4,861	18,827	3,197	8,918
Long Lake-Pigeon Creek	040500011003	9,363	8,467	32,792	5,569	11,951
Headwaters Turkey Creek	040500011004	6,219	5,481	21,226	3,605	7,975
Big Turkey Lake-Turkey Creek	040500011005	4,029	3,178	12,306	2,090	4,994
Silver Lake-Pigeon Creek	040500011006	2,677	2,511	9,724	1,651	4,284
Otter Lake-Pigeon Creek	040500011007	3,582	2,677	10,367	1,760	4,449
Little Turkey Lake-Turkey Creek	040500011008	4,796	4,198	16,258	2,761	6,603
Green Lake-Pigeon Creek	040500011009	2,606	1,963	7,603	1,291	3,262
Mongo Millpond-Pigeon Creek	040500011010	3,164	2,124	8,225	1,397	2,340
Grand Total		**51,870**	**45,454**	**176,031**	**29,895**	**68,503**

Figure 55 - Pigeon Creek Recommended Blind Inlet Areas



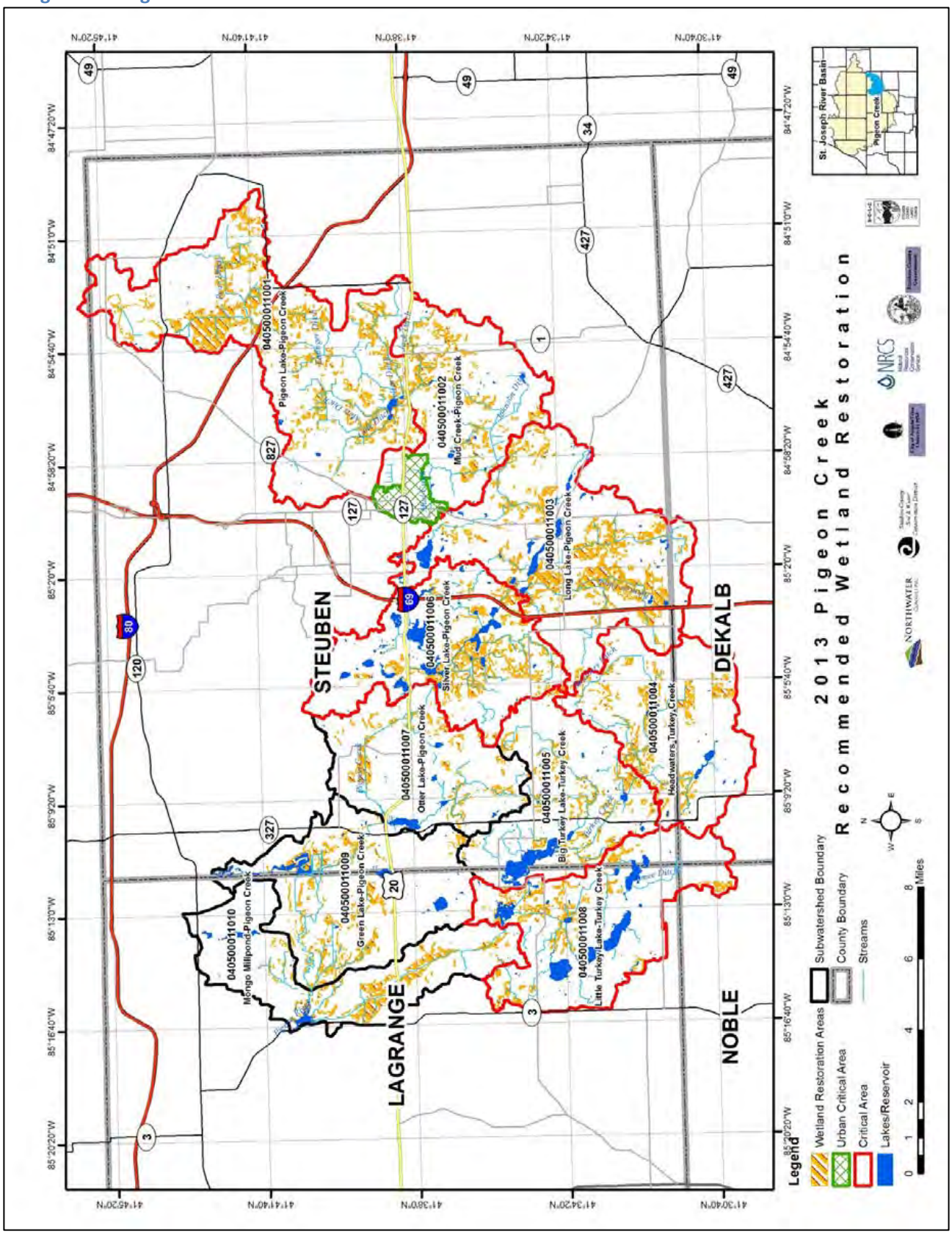
9.1.4 – Wetland Restoration

Wetland restoration is recommended on 12,054 acres (9%) throughout the watershed. Wetland restoration sites include existing and degraded wetlands; restoring these sites will improve filtering, storage capacity, and habitat diversity. Restoration actions can include sediment removal and minor excavation, installing buffer strips around wetlands, the removal of drain tiles and native vegetation planting. Table 72 lists acreage and load reductions by subwatershed and Figure 56 shows the distribution throughout the watershed. Conducting wetland restoration will achieve nominal reductions in sediment (0.14 tons/ac/yr) phosphorus (0.37 lbs/ac/yr), and nitrogen (3 lbs/ac/yr). Wetland restoration will result in higher per-acre bacteria reductions (0.56 billion CFU/ac/yr). Implementation should be prioritized to critical bacteria reduction subwatersheds (highlighted red in the table below). It is also important to note that protection of the existing high-quality wetlands described in Section 3.2.4 will also result in addressing flood storage and nutrient reductions as a healthy and protected wetland will maximize both water storage and filtration.

Table 72 - Wetland Restoration Load Reductions

Subwatershed Name	HUC 12 Subwatershed Codes	Treated Area (acres) Wetland Restoration	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Pigeon Lake-Pigeon Creek	40500011001	2,839	1,398	11,554	1,875	559
Mud Creek-Pigeon Creek	40500011002	841	363	3,086	542	137
Long Lake-Pigeon Creek	**40500011003**	2,338	938	7,728	1,327	293
Headwaters Turkey Creek	40500011004	973	438	3,587	593	181
Big Turkey Lake-Turkey Creek	40500011005	758	256	2,107	403	79
Silver Lake-Pigeon Creek	**40500011006**	1,207	317	2,664	763	150
Otter Lake-Pigeon Creek	40500011007	561	140	1,132	256	71
Little Turkey Lake-Turkey Creek	**40500011008**	692	231	1,866	376	68
Green Lake-Pigeon Creek	40500011009	972	124	1,123	286	47
Mongo Millpond-Pigeon Creek	40500011010	874	247	1,929	360	104
Grand Total		**12,055**	**4,451**	**36,778**	**6,781**	**1,690**

Figure 56 - Pigeon Creek Recommended Wetland Restoration Areas



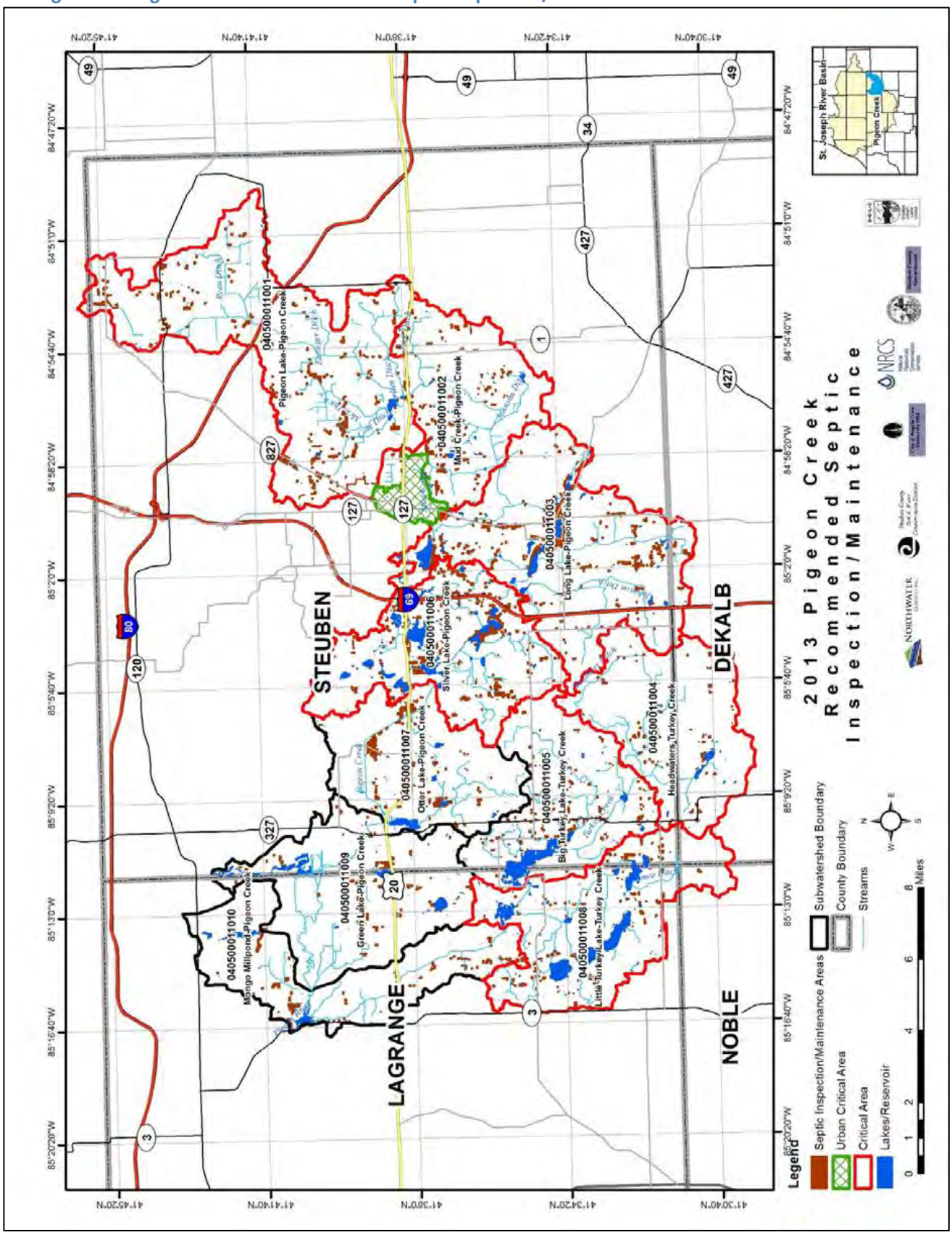
9.1.5 – Septic Systems

Recommendations to address septic systems through an inspection and maintenance program can be directed to 2,667 acres (2%) throughout the watershed. Assuming a conservative average lot size of 0.5 acres, this could translate into 5,334 individual homes. As noted in Section 7.1.2, there are an estimated 9,108 septic systems within the watershed and 1,365 of these are likely to be failing. It can be assumed that an inspection and maintenance program targeted to the 2,667 acres recommended in this section will capture all or most of the failing septic systems within the watershed. Table 73 lists acreage by subwatershed and Figure 57 shows the distribution throughout the watershed. Due to the lack of specific knowledge on the location of failing septic systems, load reductions are estimated basin-wide as a total. It is assumed that addressing failing septic systems will result in 100% reduction in phosphorus, nitrogen and bacteria and no reductions in sediment. Implementation should be prioritized to critical bacteria reduction subwatersheds (highlighted red in the table below).

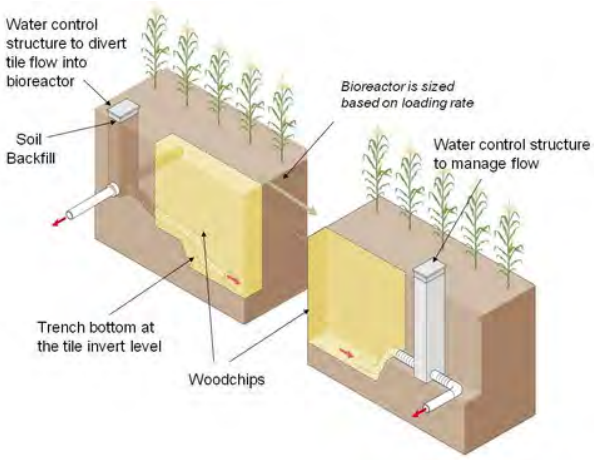
Table 73 - Septic System Load Reductions

Subwatershed Name	HUC 12 Subwatershed Codes	Inspection/ Maintenance Area (acres) Septic	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)
Pigeon Lake-Pigeon Creek	40500011001	435	13,679	34,926	149,468
Mud Creek-Pigeon Creek	40500011002	222			
Long Lake-Pigeon Creek	**40500011003**	623			
Headwaters Turkey Creek	40500011004	85			
Big Turkey Lake-Turkey Creek	40500011005	135			
Silver Lake-Pigeon Creek	**40500011006**	468			
Otter Lake-Pigeon Creek	40500011007	212			
Little Turkey Lake-Turkey Creek	**40500011008**	161			
Green Lake-Pigeon Creek	40500011009	173			
Mongo Millpond-Pigeon Creek	40500011010	153			

Figure 57 - Pigeon Creek Recommended Septic Inspection/Maintenance Areas



9.1.6 – Denitrifying Bioreactors

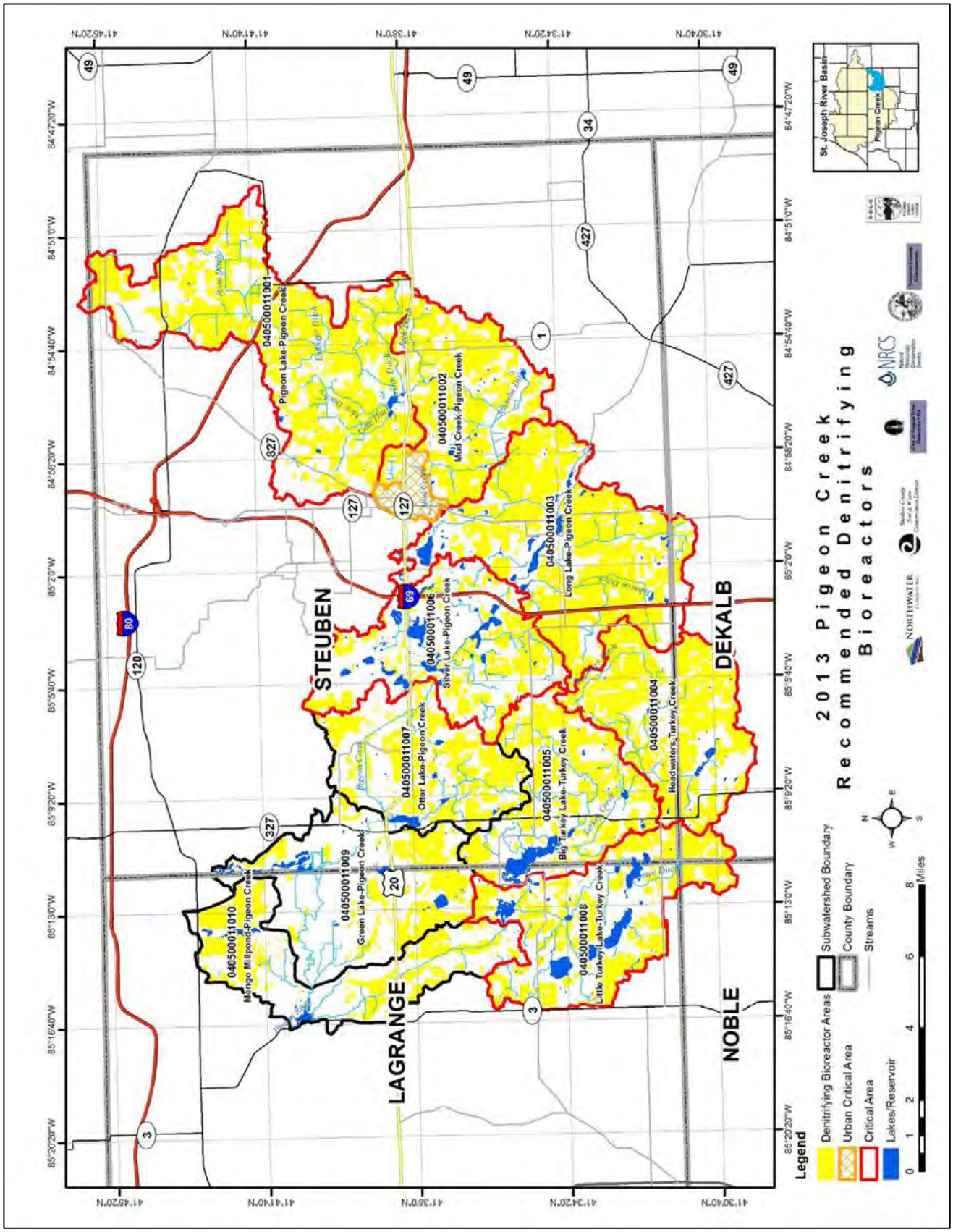


Similar to blind inlets or controls on tile systems, denitrifying bioreactors are an NRCS eligible practice designed to treat or manage tile or subsurface flow. These practices are specific to controlling nitrogen and are recommended for the same areas targeted for blind inlets. Denitrifying bioreactors are recommended for the treatment of 51,870 acres (38%) throughout the watershed. Table 74 lists acreage and load reductions by subwatershed and Figure 57 shows the distribution throughout the watershed. The implementation of denitrifying bioreactors in the watershed will achieve significant reductions in nitrogen (5.7 lbs/ac/yr). Implementation should be prioritized to critical nutrient and sediment reduction subwatersheds (highlighted red in the table below).

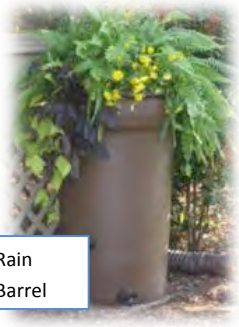
Table 74 - Denitrifying Bioreactor Load Reductions

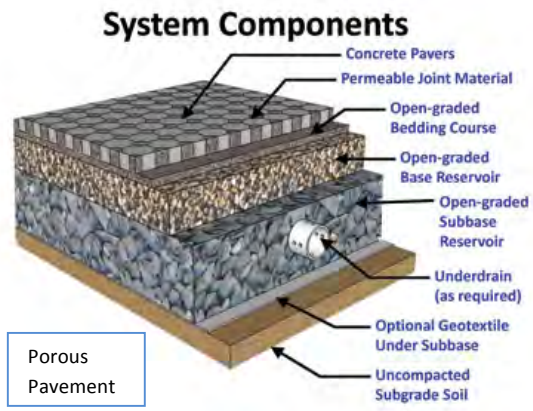
Subwatershed Name	HUC 12 Subwatershed Codes	Treated Area (acres) Nitrogen Bioreactor	Load Reduction Nitrogen (lbs/yr)
Pigeon Lake-Pigeon Creek	40500011001	10,371	64,509
Mud Creek-Pigeon Creek	40500011002	5,062	31,378
Long Lake-Pigeon Creek	40500011003	9,363	54,653
Headwaters Turkey Creek	40500011004	6,219	35,376
Big Turkey Lake-Turkey Creek	40500011005	4,029	20,510
Silver Lake-Pigeon Creek	40500011006	2,677	16,206
Otter Lake-Pigeon Creek	40500011007	3,582	17,278
Little Turkey Lake-Turkey Creek	40500011008	4,796	27,096
Green Lake-Pigeon Creek	40500011009	2,606	12,671
Mongo Millpond-Pigeon Creek	40500011010	3,164	13,709
Grand Total		51,870	293,386

Figure 58 - Pigeon Creek Recommended Denitrifying Bioreactor Areas



9.1.7 – Rain Barrels, Rain Gardens & Porous/Permeable Pavement



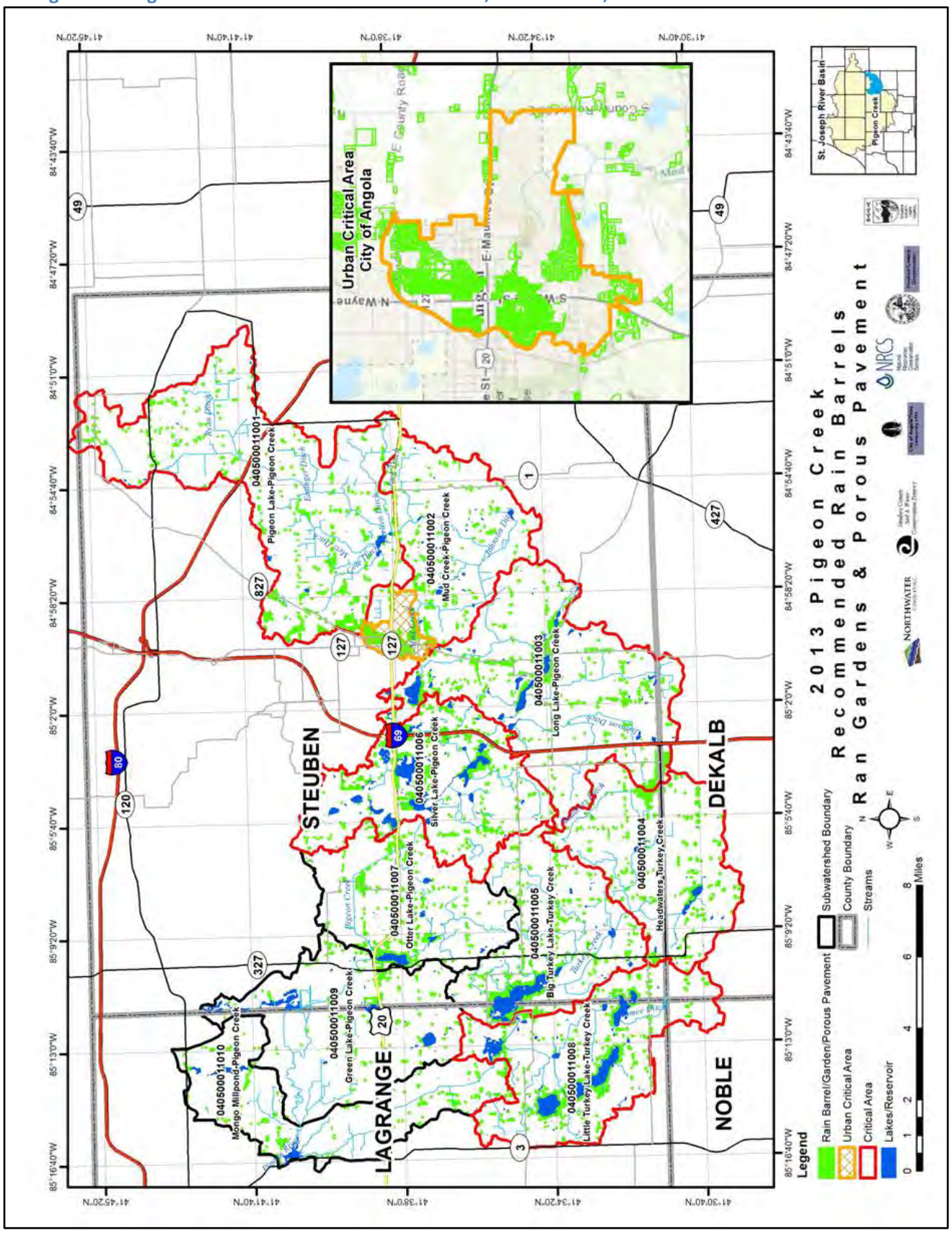


A combination of rain barrels, rain gardens, and porous pavement are recommended, primarily in the urban or residential areas of the watershed. Installation of rain barrels, rain gardens, and porous pavement can be applied to 6,724 acres (5%) throughout the watershed. Assuming a conservative average lot size of 0.5 acres, this could translate into 3,362 individual homes/properties. Table 75 lists acreage and load reductions by subwatershed and Figure 59 shows the distribution throughout the watershed. Installing rain barrels, rain gardens, and porous pavement to treat each acre will achieve nominal reductions in sediment (0.14 tons/ac/yr) and moderate reductions in phosphorus (0.37 lbs/ac/yr) and nitrogen (3 lbs/ac/yr). Due to relatively high concentrations of bacteria loading from residential areas, these practices will result in significant reductions (0.56 billion CFU/ac/yr) despite being low in terms of removal efficiencies for bacteria. Implementation should be prioritized to critical bacteria reduction subwatersheds (highlighted red in the table below), as well as the critical urban area that covers the City of Angola (Mud Creek-Pigeon Creek in red).

Table 75 - Rain Barrel, Rain Garden, & Porous Pavement Load Reductions

Subwatershed Name	HUC 12 Subwatershed Codes	Treated Area (acres) Rain Garden, Rain Barrel, Porous Pavement	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Pigeon Lake-Pigeon Creek	40500011001	883	366	2,163	1,690	76
Mud Creek-Pigeon Creek	**40500011002**	686	233	1,647	1,272	52
Long Lake-Pigeon Creek	**40500011003**	1,073	400	2,667	2,079	87
Headwaters Turkey Creek	40500011004	546	207	1,229	973	42
Big Turkey Lake-Turkey Creek	40500011005	642	240	1,640	1,274	58
Silver Lake-Pigeon Creek	**40500011006**	854	330	2,147	1,680	79
Otter Lake-Pigeon Creek	40500011007	563	184	1,121	885	41
Little Turkey Lake-Turkey Creek	**40500011008**	803	284	2,072	1,597	72
Green Lake-Pigeon Creek	40500011009	339	100	559	446	20
Mongo Millpond-Pigeon Creek	40500011010	334	103	586	467	21
Grand Total		**6,724**	**2,445**	**15,830**	**12,364**	**546**

Figure 59 - Pigeon Creek Recommended Rain Barrel, Rain Garden, & Porous Pavement Areas



9.1.8 – Education & Outreach

The adoption of many of the conservation practices or BMPs listed in this plan will include some form of education and outreach. In addition, specific campaigns should be developed to educate landowners on practices or actions that can be implemented to improve water quality. Pollution load reductions are not provided for education and outreach. Specific education and outreach recommendations include:

1. Host one (1) annual agricultural field day or workshop to promote a particular practice or combination of practices such as cover crops or pasture management.
2. Host one (1) annual urban workshop. A workshop could include community rain garden planting or a rain barrel distribution and maintenance workshop.
3. Organize one (1) annual watershed bus tour.
4. Organize one (1) annual community ditch cleanup day.
5. Develop (or utilize existing) and distribute educational pamphlets or brochures on agricultural BMPs and available resources, septic system maintenance and available resources, and appropriate lawn fertilizer application and urban BMPs.
6. Host one (1) annual youth conservation field day
7. Participate in one (1) annual youth "Duck Days" in participation with the Delta Waterfowl Alliance.
8. Continue hosting "Lake Life" workshop series. Lake Life is a six-week class focusing on different aspects of lake living in Steuben County, including conservation. The class includes meeting once a week for two and a half hours.
9. Focus on developing a conservation series on a local cable channel, radio, or newspaper. This could include a regular "conservation column" in the local newspaper.

9.2 – Site-Specific Best Management Practices

Site-specific BMPs are those practices where a field visit has resulted in the identification of a specific project and project location. Site-specific practices are located throughout the watershed and include:

1. Grassed Waterway: a grassed strip in fields that acts as an outlet for water to control silt, filter nutrients and limit gully formation.
2. Terraces/Water and Sediment Control Basin (WASCOB): earth embankment and/or channel constructed across the slope to intercept runoff water and trap soil.
3. Detention Basin/Pond: a sediment or water impoundment made by constructing an earthen dam. Detention basins are recommended for both urban and agricultural areas.
4. Feed Lot BMP; Waste Lagoon: an impoundment made by constructing an earthen dam used to trap and filter livestock waste from concentrated feeding areas. Solids are trapped in a sediment basin installed upstream of the lagoon.
5. Rock Riffle: a rock structure constructed in a stream channel or gully to stabilize grade.
6. Wetland Creation: a shallow water area constructed by creating an earth embankment or excavation. Wetland creation practices can include a water control structure and are designed to mimic natural wetland hydrology.

7. Two-Stage Ditch: two-stage ditches are drainage ditches that have been modified by adding benches that serve as floodplains within the overall channel. This form is more consistent with fluvial form and process and, therefore, leads to greater channel stability. The benches can also function as wetlands during certain times of the year, reducing ditch nutrient loads.
8. Filter Strip: a filter strip is a narrow band of grass or other permanent vegetation used to reduce sediment, nutrients, pesticides, and other contaminants.
9. Pasture BMPs: a variety of individual livestock management practices designed to manage runoff and improve profitability. Specific practices included under pasture management are fencing (stream, and interior), stream crossings, alternative watering systems, filter/buffer strips and diversions.
10. Other: additional BMPs include detention basin for a future truck stop and streambank stabilization.

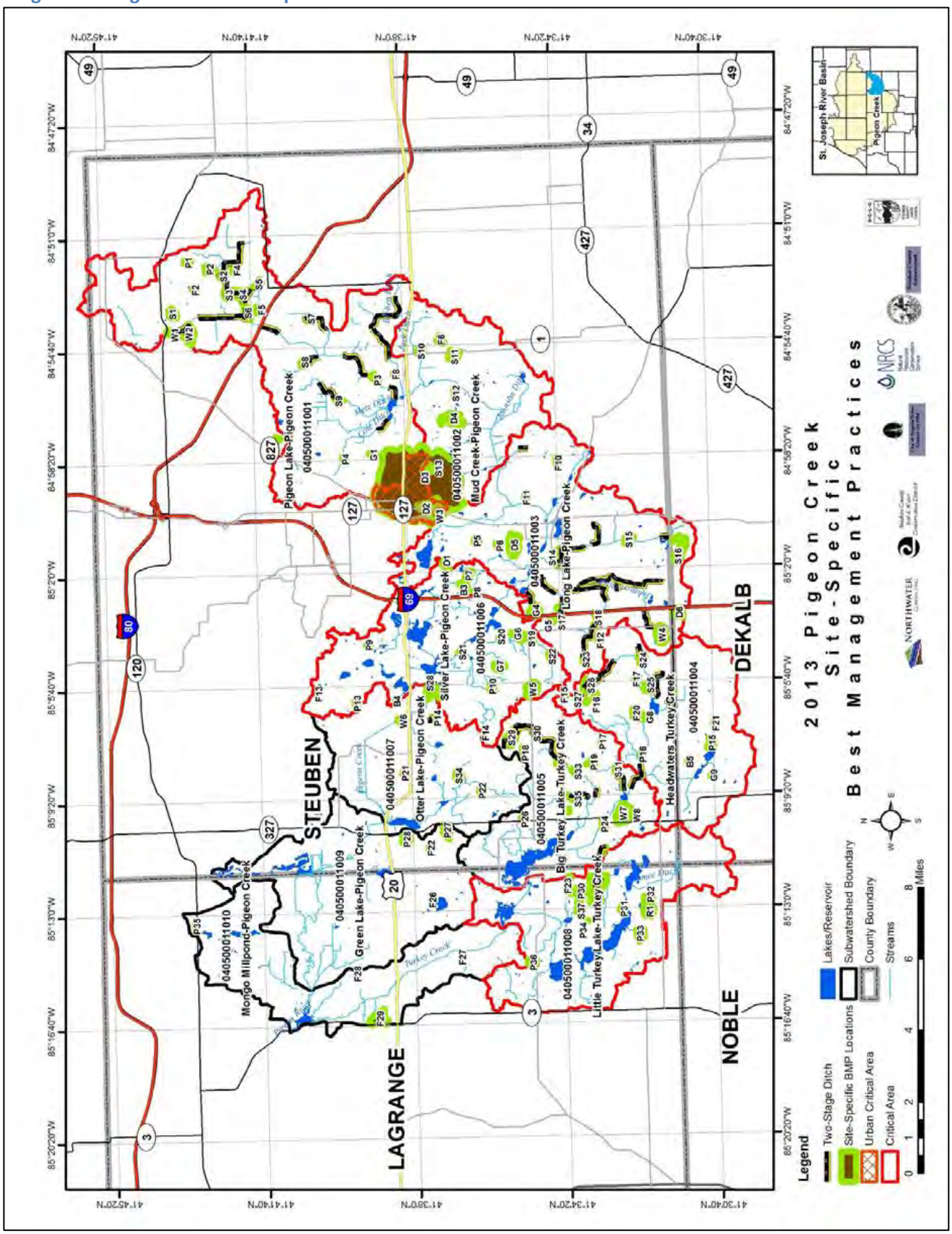
Priority should be given to those BMPs with the greatest load reductions and/or that fall within a designated critical area (highlighted red in the table below). Site-specific BMP recommendations for Pigeon Creek will treat 5,300 acres in the watershed (4%). Table 76 provides a summary of all site-specific BMPs by subwatershed, their treated area, and expected load reductions; per-acre figures are based on total watershed area. Figure 60 shows the location of all site-specific practices based on their drainage/benefited area. Also highlighted red in Table 76 are the top three highest per-acre load reductions. Results at the subwatershed level show that the implementation of site-specific practices in Mud Creek, Long Lake, Big Turkey and Little Turkey Lake will provide the highest per-acre reductions.

Table 76 - Site-Specific BMP Load Reduction Summary

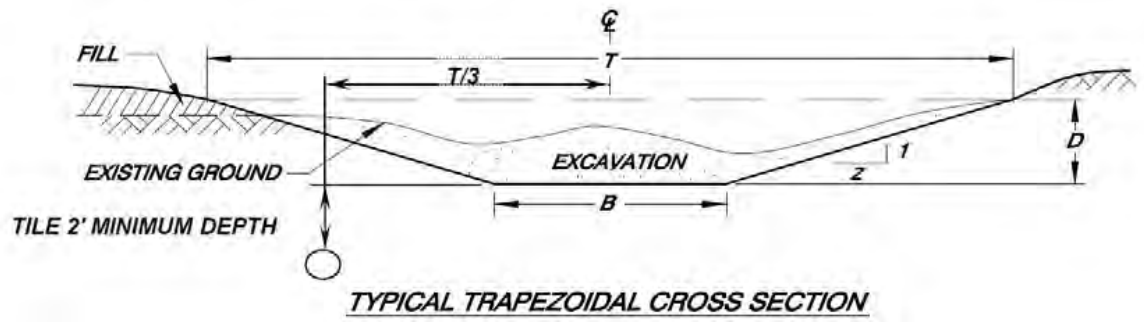
Subwatershed Name	HUC 12 Subwatershed Codes	Acres Benefited by BMP	Load Reduction Phosphorus (lbs/yr)	Per acre	Load Reduction Nitrogen (lbs/yr)	Per acre	Load Reduction Bacteria (billion CFU/yr)	Per acre	Load Reduction Sediment (tons/yr)	Per acre
Pigeon Lake-Pigeon Creek	**040500011001**	441	1,345	0.06	10,339	0.47	1,265	0.06	309	0.01
Mud Creek-Pigeon Creek*	**040500011002**	2,827	1,044	**0.09**	5,445	**0.48**	2,409	**0.21**	1,275	**0.11**
Long Lake-Pigeon Creek	**040500011003**	565	1,252	**0.07**	8,688	**0.47**	944	**0.05**	763	**0.04**
Headwaters Turkey Creek	**040500011004**	234	542	**0.05**	3,729	0.32	567	0.05	255	0.02
Big Turkey Lake-Turkey Creek	040500011005	297	559	0.05	4,048	**0.37**	402	0.04	163	0.01
Silver Lake-Pigeon Creek	**040500011006**	274	355	0.03	1,786	0.14	515	0.04	352	**0.03**
Otter Lake-Pigeon Creek	**040500011007**	84	69	0.01	473	0.05	125	0.01	57	0.01
Little Turkey Lake-Turkey Creek	**040500011008**	414	298	0.02	2,806	0.21	1,923	**0.15**	115	0.01
Green Lake-Pigeon Creek	040500011009	73	43	0.003	426	0.03	384	0.03	10	0.001
Mongo Millpond-Pigeon Creek	040500011010	91	93	0.01	763	0.07	540	0.05	62	0.01
	Grand Total	**5,300**	**5,599**	**0.04**	**38,503**	**0.28**	**9,074**	**0.07**	**3,361**	**0.02**

*The Mud Creek – Pigeon Creek subwatershed includes a large regional detention area at Bill Deller Rd and load reductions reflect the implementation of this BMP. Removing this practice would reduce load reductions in phosphorus to 475 lbs/yr, 2,188 lbs/yr for nitrogen, 677 billion CFU/yr for bacteria, and 449 tons/yr for sediment. The area benefited from this BMP would reduce the total to 350 acres, a reduction of 2,477 acres.

Figure 60 - Pigeon Creek Site-Specific BMPs



9.2.1 – Grassed Waterways

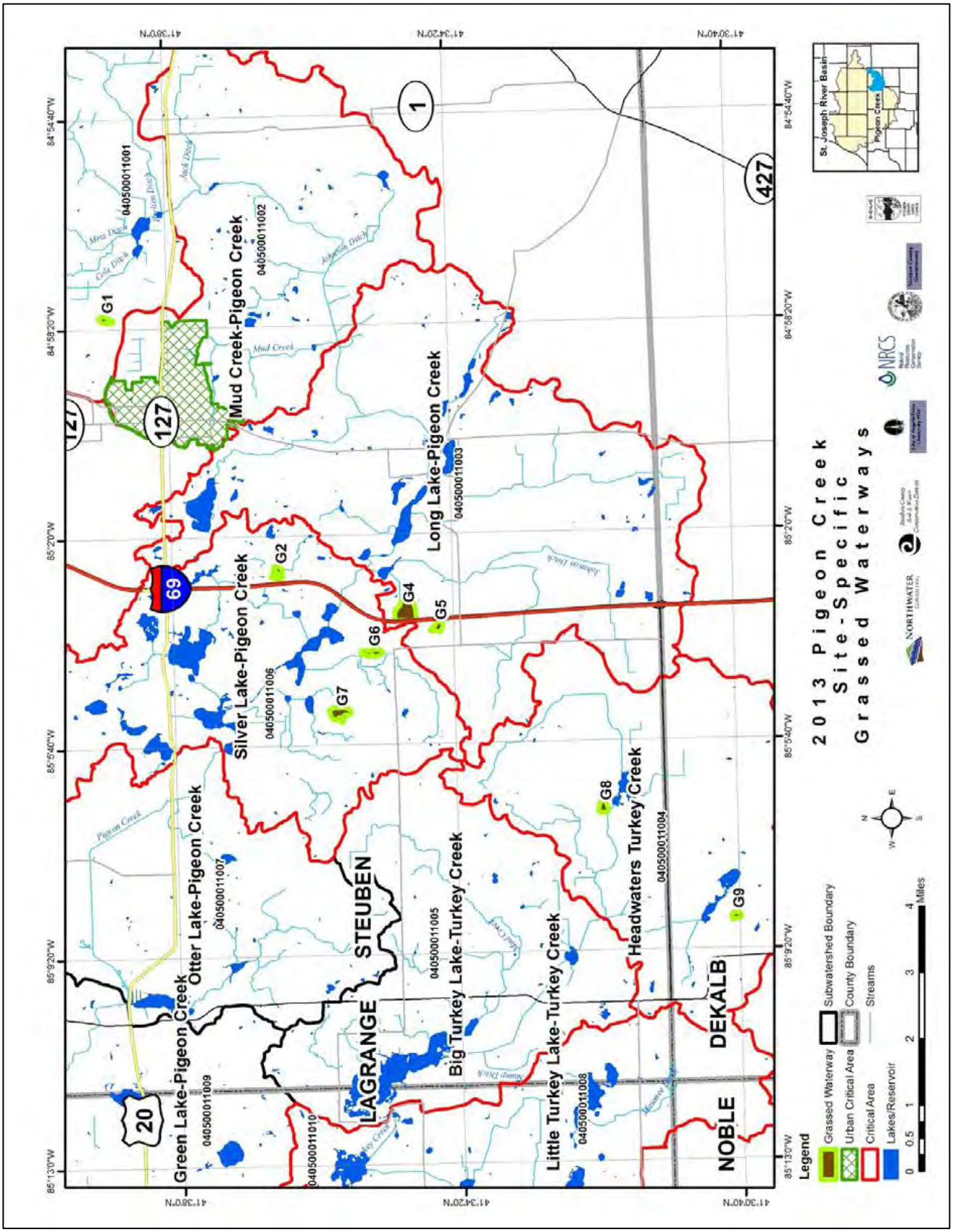


Site-specific grassed waterways are recommended at nine (9) sites throughout the watershed. If implemented, these practices will benefit 157 acres and will reduce phosphorus loads by 350 lbs/yr, nitrogen loads by 1,532 lbs/yr, bacteria loads by 168 billion CFU/yr, and sediment by 659 tons/yr. Priority should be given to those sites within critical subwatersheds and with the highest pollutant load reduction potential (highlighted red in the Table 77). Figure 61 shows the location of these practices in the watershed.

Table 77 - Site-Specific Grassed Waterways Load Reductions

Subwatershed Name	HUC 12 Subwatershed Code	BMP Code	BMP Type	Acres Benefited	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Pigeon Lake-Pigeon Creek	40500011001	G1	Grassed Waterway	9.3	8.3	48.1	5.8	7.6
Silver Lake-Pigeon Creek	40500011006	G2	Grassed Waterway	8.3	12.2	74.0	9.0	22.8
Silver Lake-Pigeon Creek	40500011006	G3	Grassed Waterway	7.3	22.8	76.7	11.0	22.8
Long Lake-Pigeon Creek	40500011003	G4	Grassed Waterway	53.8	173.4	720.4	73.6	412.7
Long Lake-Pigeon Creek	40500011003	G5	Grassed Waterway	12.6	13.6	65.1	7.4	17.3
Silver Lake-Pigeon Creek	40500011006	G6	Grassed Waterway	16.2	27.6	155.2	18.7	59.5
Silver Lake-Pigeon Creek	40500011006	G7	Grassed Waterway	29.2	30.2	210.9	27.0	52.4
Headwaters Turkey Creek	40500011004	G8	Grassed Waterway	12.3	29.9	94.3	7.7	31.2
Headwaters Turkey Creek	40500011004	G9	Grassed Waterway	7.6	32.1	87.3	8.3	33
	Grand Total			157	350	1,532	168	659

Figure 61 - Pigeon Creek Site-Specific Grassed Waterway Locations



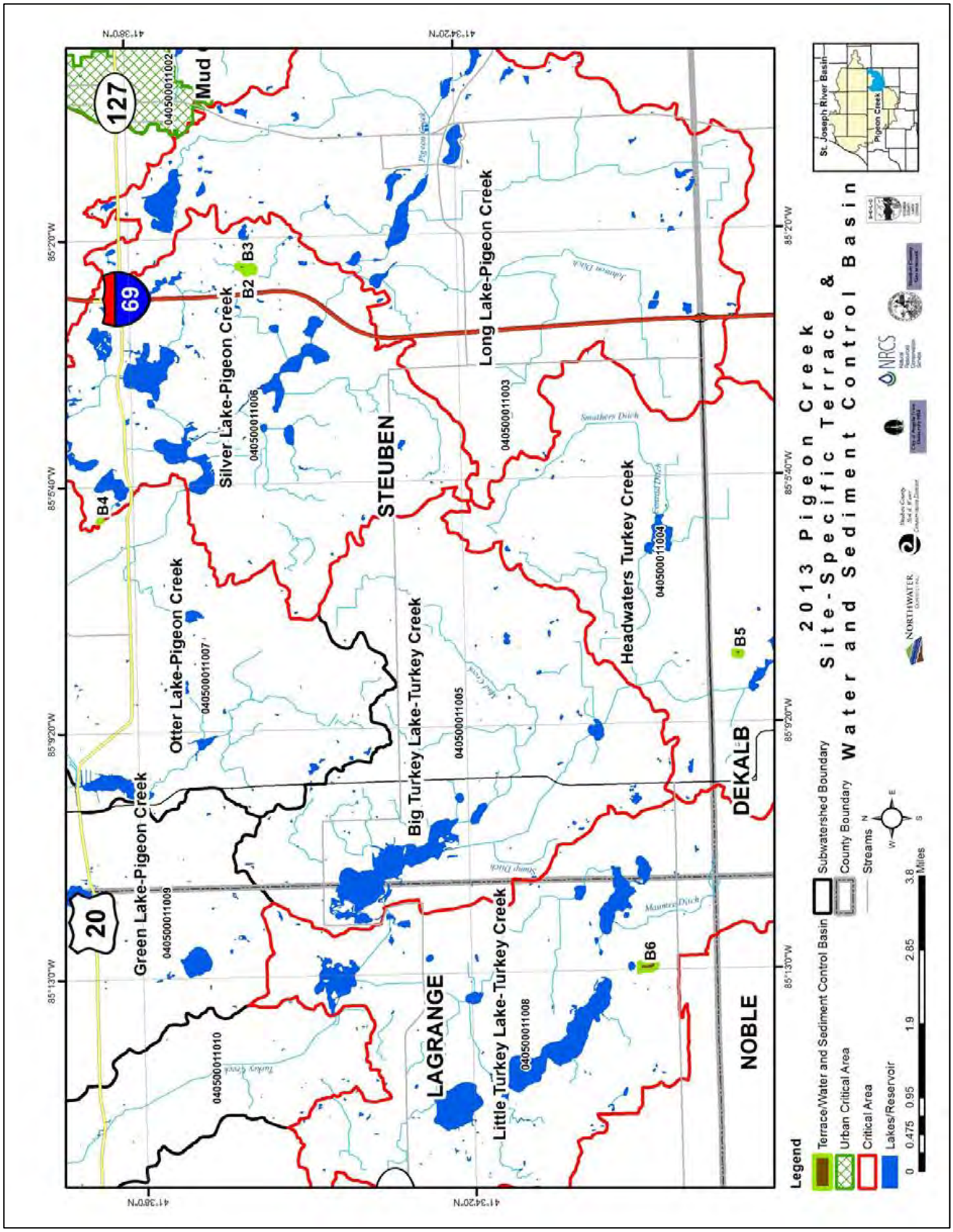
9.2.2 – Terraces & Water & Water & Sediment Control Basins

Site-specific terraces and/or water and sediment control basins are recommended at five (5) sites throughout the watershed. If implemented, these practices will benefit 33 acres and will reduce phosphorus loads by 158 lbs/yr, nitrogen loads by 324 lbs/yr, bacteria loads by 17 billion CFU/yr, and sediment by 148 tons/yr. Priority should be given to those sites within critical subwatersheds and with the highest pollutant load reduction potential (highlighted red in the Table 78). Figure 62 shows the location of these practices in the watershed.

Table 78 - Site-Specific Terrace/Water & Sediment Control Basin Load Reductions

Subwatershed Name	HUC 12 Subwatershed Code	BMP Code	BMP Type	Acres Benefited	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Silver Lake-Pigeon Creek	**40500011006**	B2	Water and Sediment Control Basin	**4.6**	**36.7**	**75.0**	**3.6**	**34.8**
Silver Lake-Pigeon Creek	**40500011006**	B3	Water and Sediment Control Basin	**8.3**	**31.4**	**61.2**	**2.9**	**27.7**
Silver Lake-Pigeon Creek	**40500011006**	B4	Water and Sediment Control Basin	**0.8**	**65.7**	**109.6**	**0.1**	**54.7**
Headwaters Turkey Creek	40500011004	B5	Water and Sediment Control Basin	5.2	12.6	33.4	3.7	11.6
Little Turkey Lake-Turkey Creek	40500011008	B6	Water and Sediment Control Basin	14.4	11.5	44.9	7.2	19.2
	Grand Total			**33**	**158**	**324**	**17**	**148**

Figure 62 - Pigeon Creek Site-Specific Terraces/Water & Sediment Control Basin Locations



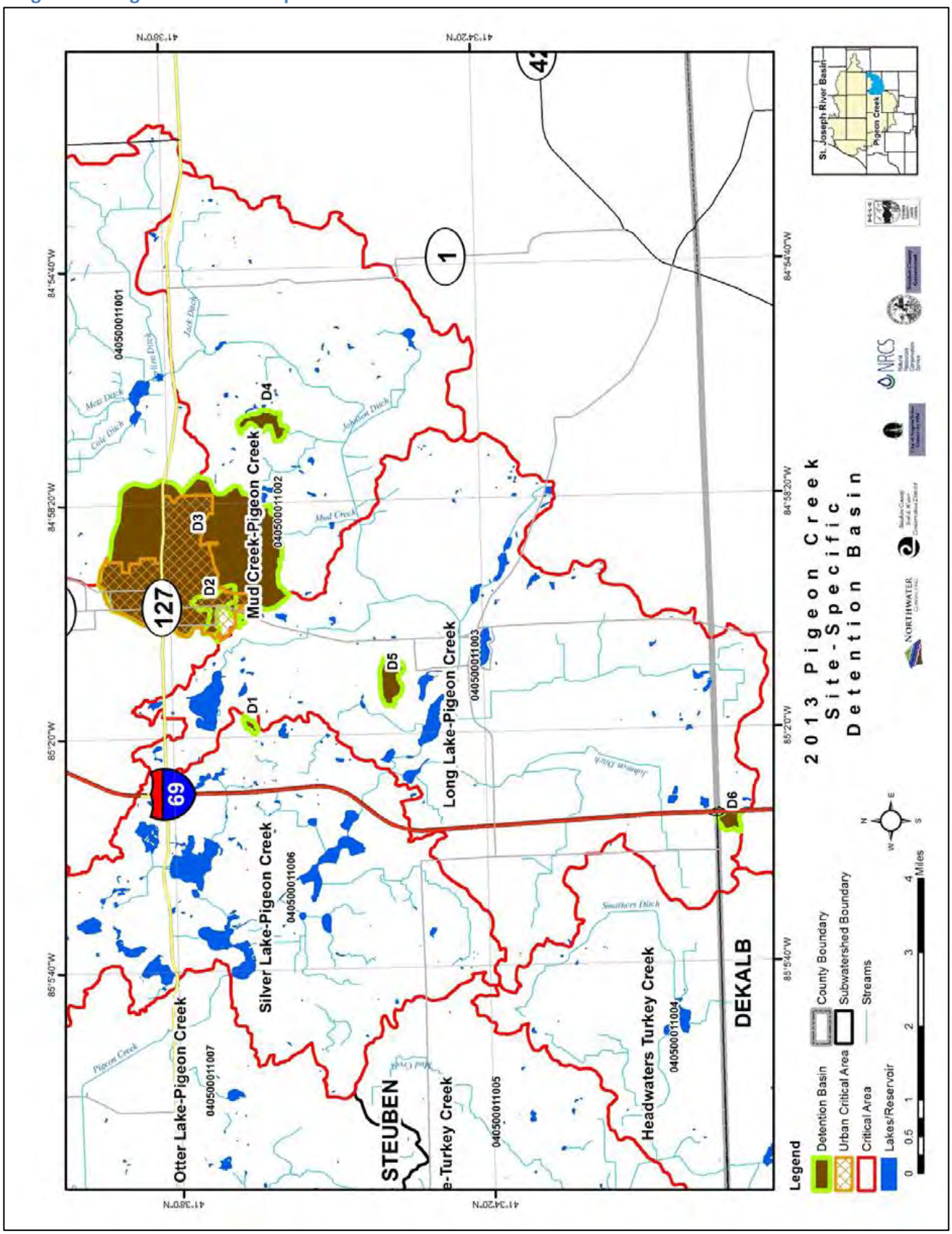
9.2.3 – Detention Basins/Ponds

Site-specific detention basins or ponds are recommended at six (6) sites throughout the watershed. If implemented, these practices will benefit 2,832 acres and will reduce phosphorus loads by 990 lbs/yr, nitrogen loads by 4,943 lbs/yr, bacteria loads by 2,208 billion CFU/yr, and sediment by 1,247 tons/yr. Priority should be given to those sites within critical subwatersheds and with the highest pollutant load reduction potential (highlighted red in Table 79). Figure 63 shows the location of these practices in the watershed.

Table 79 - Site-Specific Detention Basin Load Reductions

Subwatershed Name	HUC 12 Subwatershed Code	BMP Code	BMP Type	Acres Benefited	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Silver Lake-Pigeon Creek	40500011006	D1	Detention Basin	16.9	6.9	40.5	20.9	8.51
Mud Creek-Pigeon Creek	40500011002	D2	Detention Basin	106.4	212.3	590.8	207.9	157.2
Mud Creek-Pigeon Creek	40500011002	D3	Detention Basin	2,477	568.9	3,257	1732	826.3
Mud Creek-Pigeon Creek	40500011002	D4	Detention Basin	91.4	121.3	620.1	136.2	184.9
Long Lake-Pigeon Creek	40500011003	D5	Detention Basin	97.5	73.2	388.3	82.1	68.1
Long Lake-Pigeon Creek	40500011003	D6	Detention Basin	43.7	7.1	46.1	29.0	1.52
	Grand Total			2,832	990	4,943	2,208	1,247

Figure 63 - Pigeon Creek Site-Specific Detention Basin Locations



9.2.4 – Feed Area Waste Lagoon System

Site-specific feed area waste lagoon systems are recommended at twenty-nine (29) sites throughout the watershed. A concept design is provided in Figures 64 through 67. The recommended system includes three individual practices working in series; a settling basin to capture solids, a rock spreader and vegetated swale for initial waste treatment and, finally, a treatment wetland to capture and treat the remaining waste. This conceptual system is recommended for small feed areas with less than 50 animal units and under one acre of drainage. For sites where drainage areas exceeding one acre or where building runoff is a concern, water diversions and gutter systems are also recommended.

If implemented, these systems will benefit 232 acres and will reduce phosphorus loads by 267 lbs/yr, nitrogen loads by 2,005 lbs/yr, bacteria loads by 1,836 billion CFU/yr, and sediment by 114 tons/yr. Priority should be given to those sites within critical subwatersheds and with the highest pollutant load reduction potential (highlighted red in the Table 80). Figure 68 shows the location of these practices in the watershed. Small feed area waste lagoon systems should receive priority over other practices due to their high per-acre reductions in bacteria loads.

Figure 64 - Feed Area Waste System Concept Plan

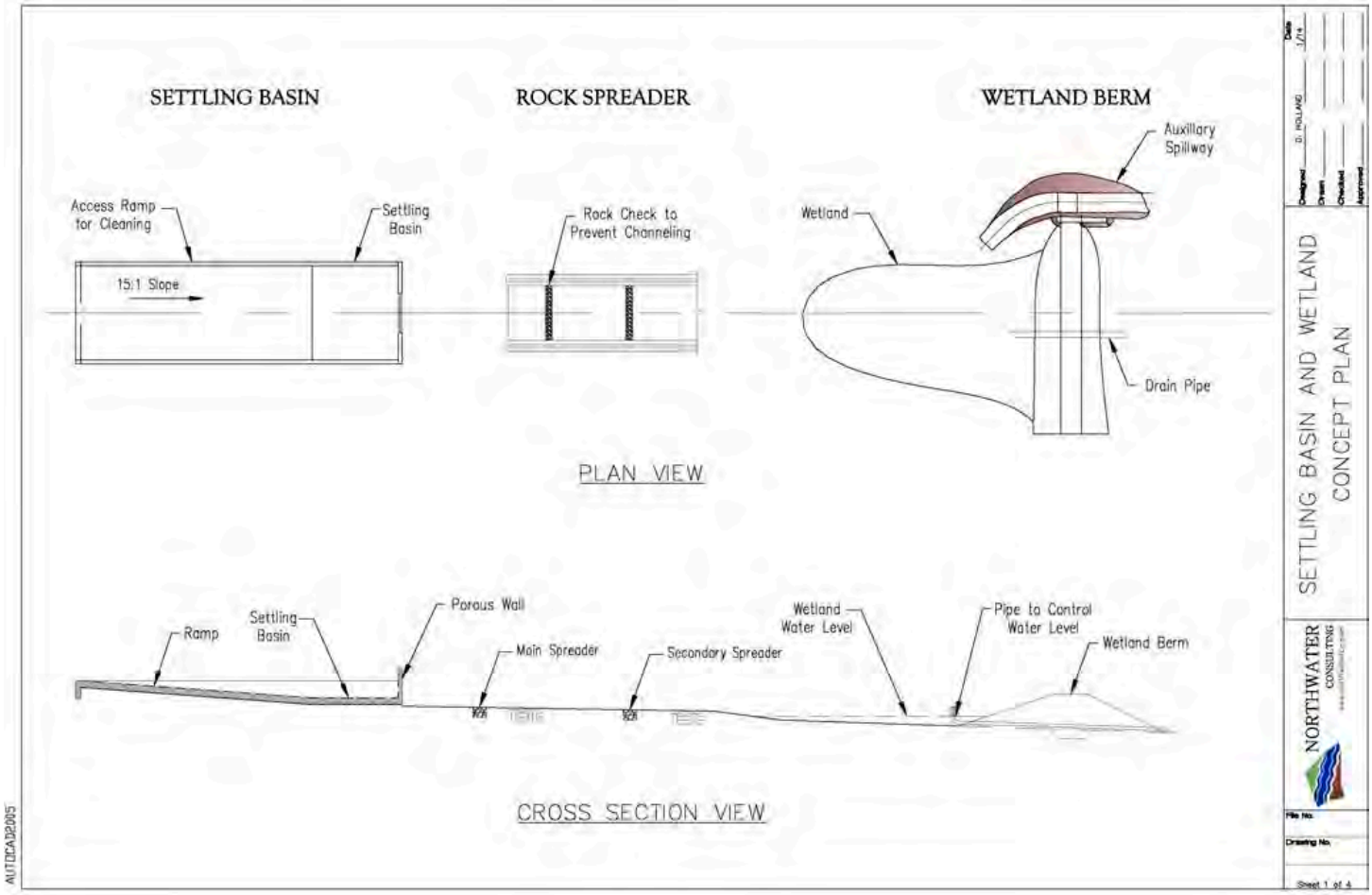


Figure 65 - Feed Area Waste System Concept Plan; Settling Basin

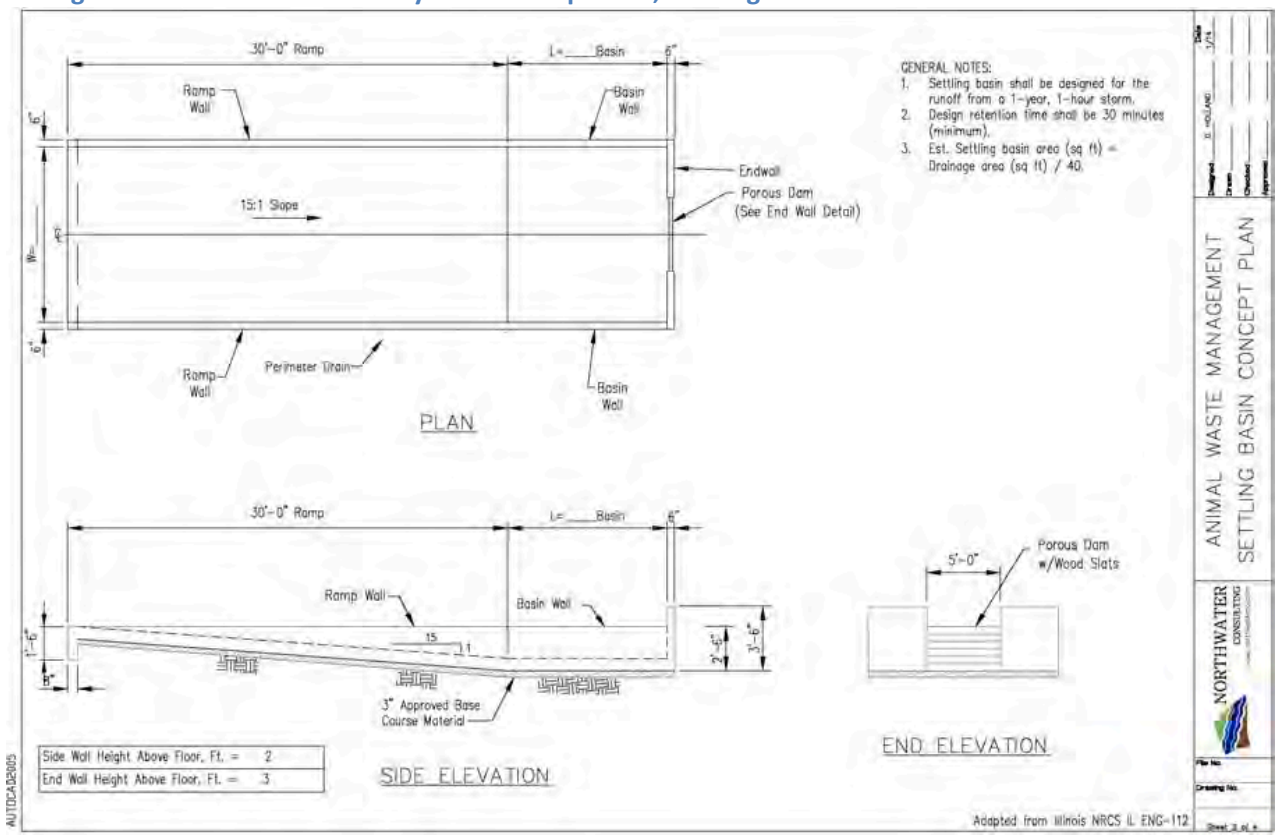


Figure 66 - Feed Area Waste System Concept Plan; Rock Spreader/Vegetated Swale

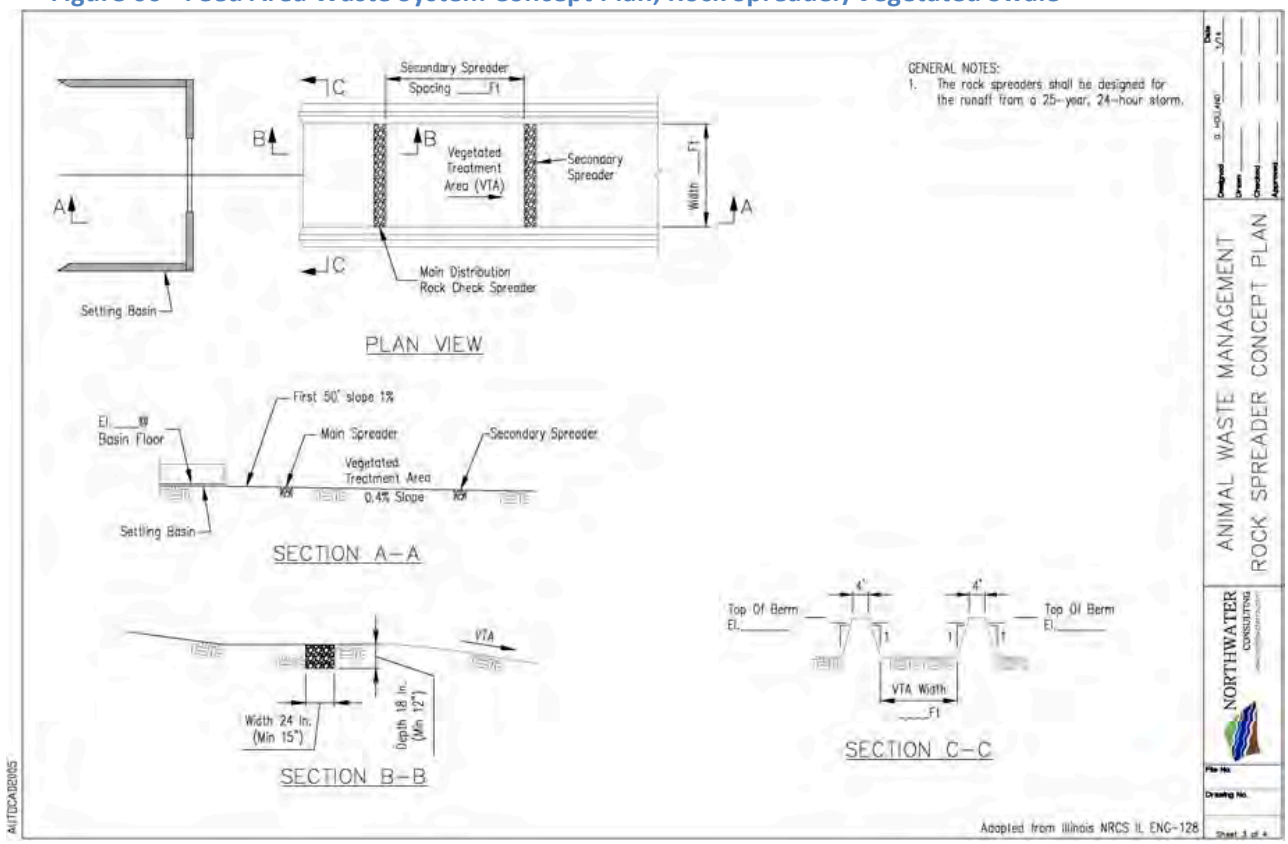


Figure 67 - Feed Area Waste System Concept Plan; Treatment Wetland

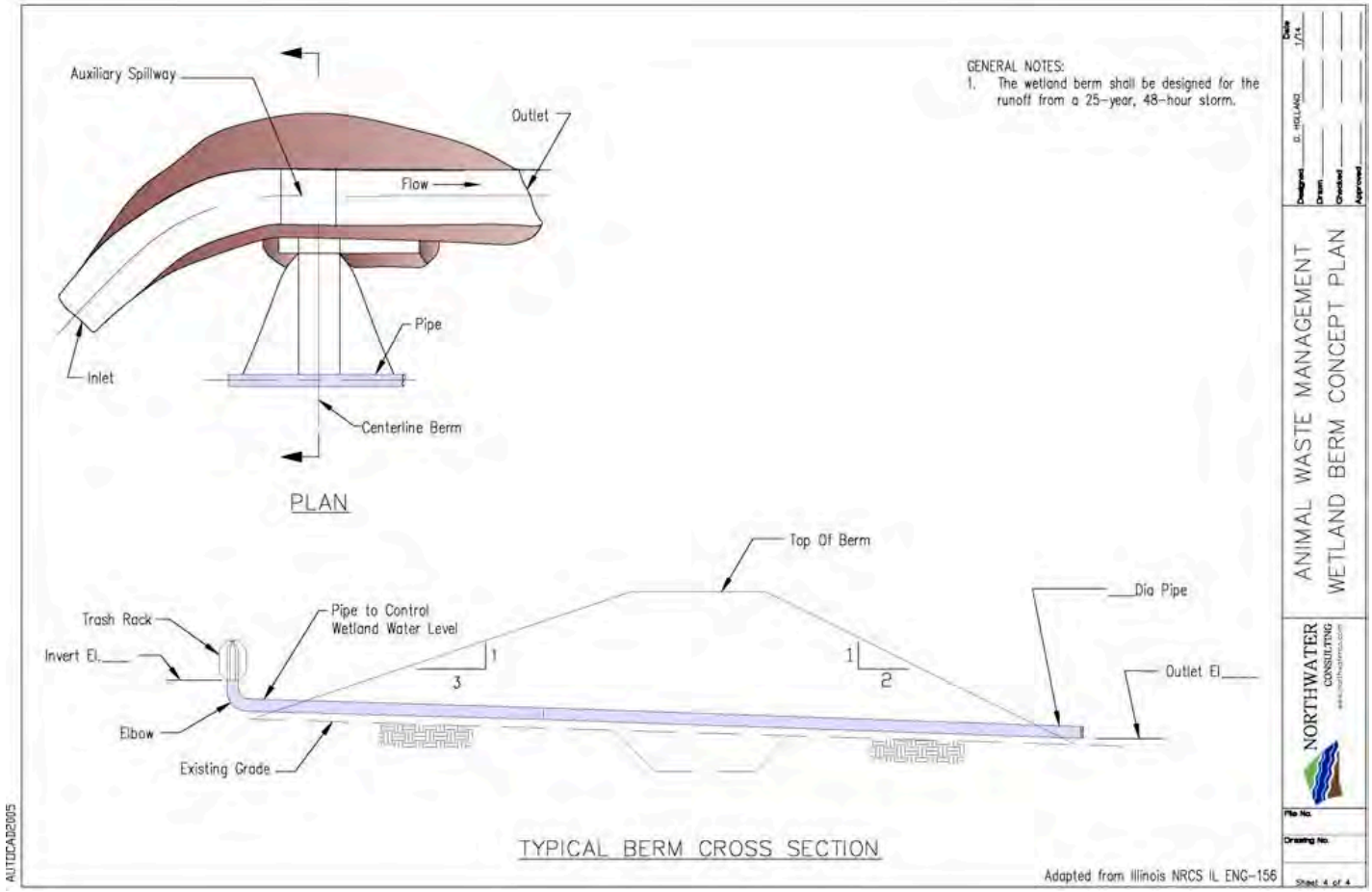
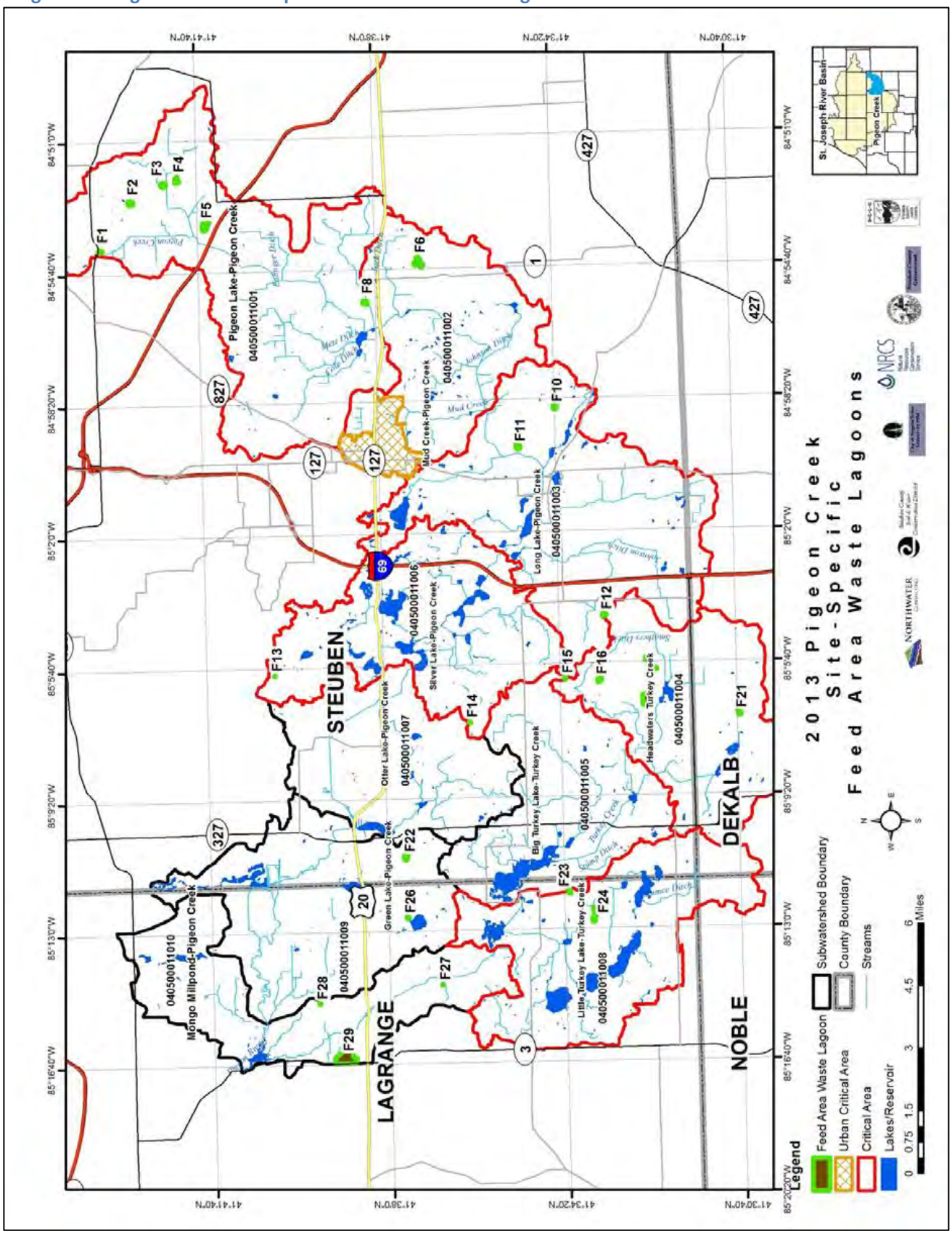


Table 80 - Site-Specific Feed Area Waste Lagoon Load Reductions

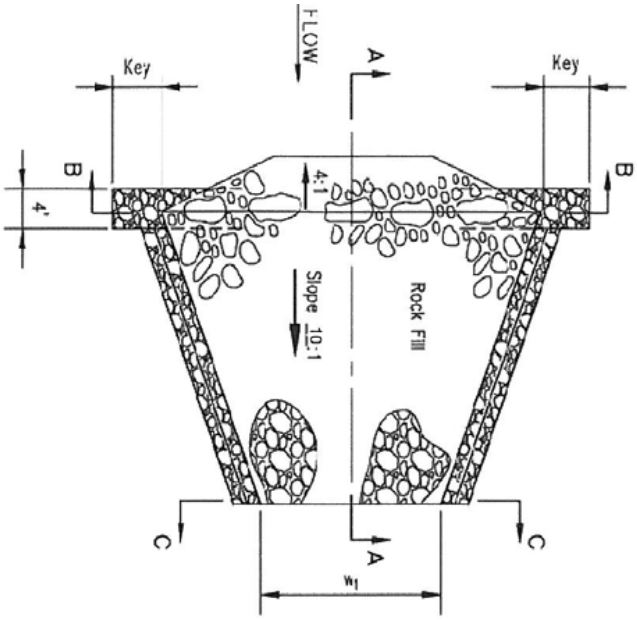
Subwatershed Name	HUC 12 Subwatershed Code	BMP Code	BMP Type	Acres Benefited	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Pigeon Lake-Pigeon Creek	40500011001	F1	Feed Area Waste Lagoon	3.5	6.8	35.2	44.3	0.48
Pigeon Lake-Pigeon Creek	40500011001	F2	Feed Area Waste Lagoon	6.7	6.7	69.4	51.4	3.75
Pigeon Lake-Pigeon Creek	40500011001	F3	Feed Area Waste Lagoon	**6.2**	**13.2**	**68.6**	**109.1**	**2.39**
Pigeon Lake-Pigeon Creek	40500011001	F4	Feed Area Waste Lagoon	6.2	7.6	45.2	58.3	1.30
Pigeon Lake-Pigeon Creek	40500011001	F5	Feed Area Waste Lagoon	13.6	10.1	70.0	75.7	0.41
Mud Creek-Pigeon Creek	40500011002	F6	Feed Area Waste Lagoon	**11.2**	**19.2**	**114.4**	**128.5**	**8.72**
Mud Creek-Pigeon Creek	40500011002	F7	Feed Area Waste Lagoon	4.0	6.2	49.1	58.9	0.39
Pigeon Lake-Pigeon Creek	40500011001	F8	Feed Area Waste Lagoon	5.2	8.8	83.7	70.7	1.48
Long Lake-Pigeon Creek	40500011003	F9	Feed Area Waste Lagoon	2.3	4.9	25.3	44.3	0.47

Subwatershed Name	HUC 12 Subwatershed Code	BMP Code	BMP Type	Acres Benefited	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Long Lake-Pigeon Creek	40500011003	F10	Feed Area Waste Lagoon	5.3	6.2	44.1	70.2	0.30
Long Lake-Pigeon Creek	40500011003	F11	Feed Area Waste Lagoon	6.7	7.0	60.7	41.5	2.81
Headwaters Turkey Creek	40500011004	F12	Feed Area Waste Lagoon	4.1	4.8	34.8	29.1	1.60
Silver Lake-Pigeon Creek	40500011006	F13	Feed Area Waste Lagoon	0.3	0.3	3.0	2.8	0.04
Silver Lake-Pigeon Creek	40500011006	F14	Feed Area Waste Lagoon	0.6	0.7	6.0	5.2	0.21
Headwaters Turkey Creek	40500011004	F15	Feed Area Waste Lagoon	1.1	1.2	10.7	9.6	0.15
Headwaters Turkey Creek	40500011004	F16	Feed Area Waste Lagoon	6.2	4.9	47.0	36.0	1.10
Headwaters Turkey Creek	40500011004	F17	Feed Area Waste Lagoon	2.7	2.8	25.9	21.6	0.49
Headwaters Turkey Creek	40500011004	F18	Feed Area Waste Lagoon	1.2	0.8	9.0	5.6	0.28
Headwaters Turkey Creek	40500011004	F19	Feed Area Waste Lagoon	2.7	4.3	23.4	21.0	2.0
Headwaters Turkey Creek	40500011004	F20	Feed Area Waste Lagoon	29.8	21.2	162.5	76.6	16.4
Headwaters Turkey Creek	40500011004	F21	Feed Area Waste Lagoon	3.8	4.0	33.5	25.5	1.79
Green Lake-Pigeon Creek	40500011009	F22	Feed Area Waste Lagoon	6.4	8.7	73.8	53.3	4.58
Little Turkey Lake-Turkey Creek	40500011008	F23	Feed Area Waste Lagoon	3.0	7.2	34.9	79.7	0.21
Little Turkey Lake-Turkey Creek	40500011008	F24	Feed Area Waste Lagoon	5.7	6.7	60.2	62.7	0.58
Little Turkey Lake-Turkey Creek	40500011008	F25	Feed Area Waste Lagoon	3.2	9.6	58.3	101.7	0.39
Green Lake-Pigeon Creek	40500011009	F26	Feed Area Waste Lagoon	1.7	3.5	21.1	34.3	0.45
Mongo Millpond-Pigeon Creek	40500011010	F27	Feed Area Waste Lagoon	0.3	0.6	6.0	5.2	0.11
Mongo Millpond-Pigeon Creek	40500011010	F28	Feed Area Waste Lagoon	0.5	0.3	2.9	2.1	0.06
Mongo Millpond-Pigeon Creek	40500011010	F29	Feed Area Waste Lagoon	**87.7**	**88.9**	**725.7**	**510.9**	**61.4**
	Grand Total			**232**	**267**	**2,005**	**1,836**	**114**

Figure 68 - Pigeon Creek Site-Specific Feed Area Waste Lagoon Locations



9.2.5 – Rock Riffle

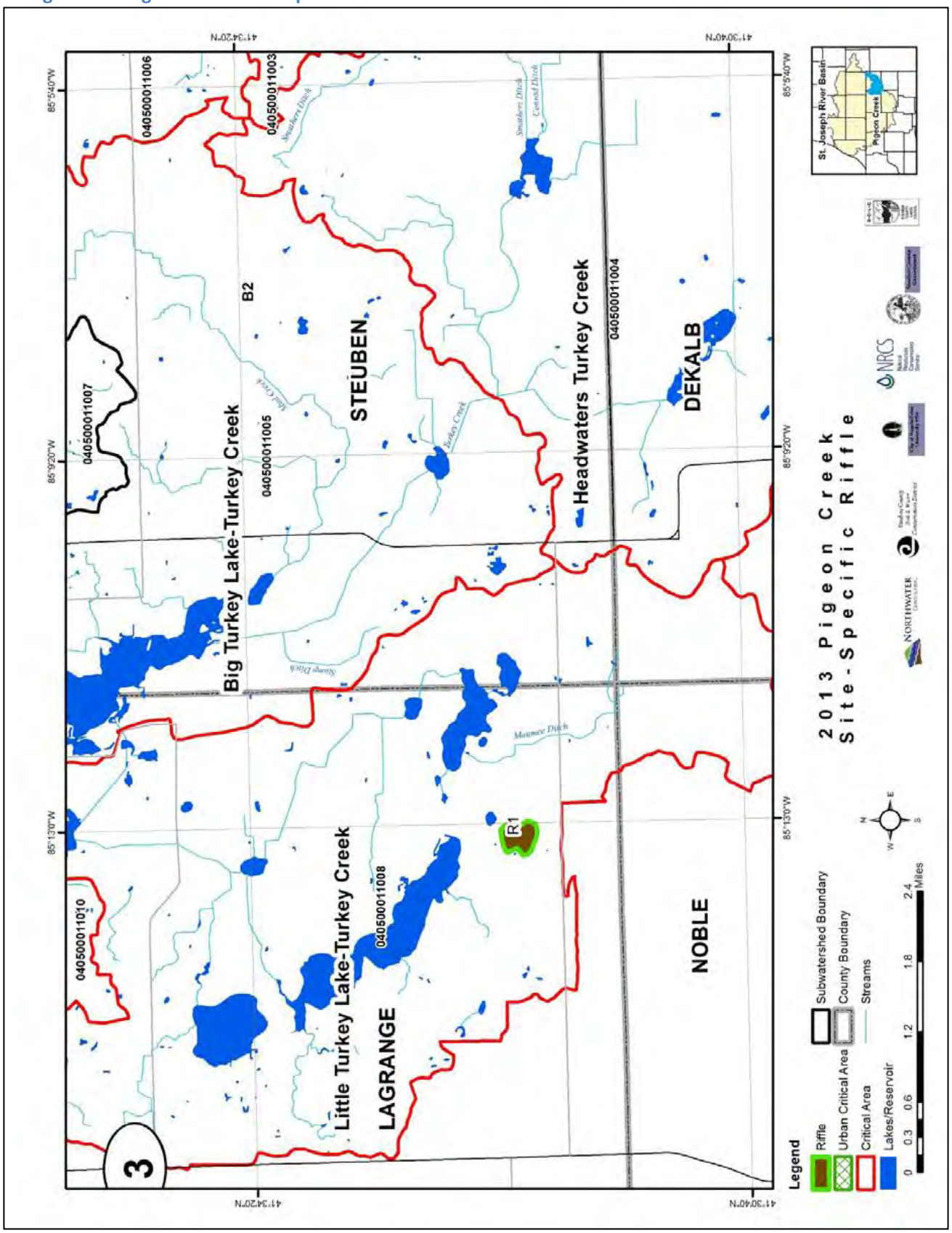


One (1) site-specific riffle (R1) is recommended in the watershed. If implemented, this practice will benefit 42 acres and will reduce phosphorus loads by 29 lbs/yr, nitrogen loads by 127 lbs/yr, bacteria loads by 13 billion CFU/yr, and sediment by 38 tons/yr. Priority should be given to this site as it is within a critical subwatershed (highlighted red in Table 81). Figure 69 shows the location of this practice in the watershed.

Table 81 - Site-Specific Riffle Load Reductions

Subwatershed Name	HUC 12 Subwatershed Code	BMP Code	BMP Type	Acres Benefited	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Little Turkey Lake-Turkey Creek	40500011008	R1	Rock Riffle	42	28.6	126.9	12.6	37.82

Figure 69 - Pigeon Creek Site-Specific Riffle Locations



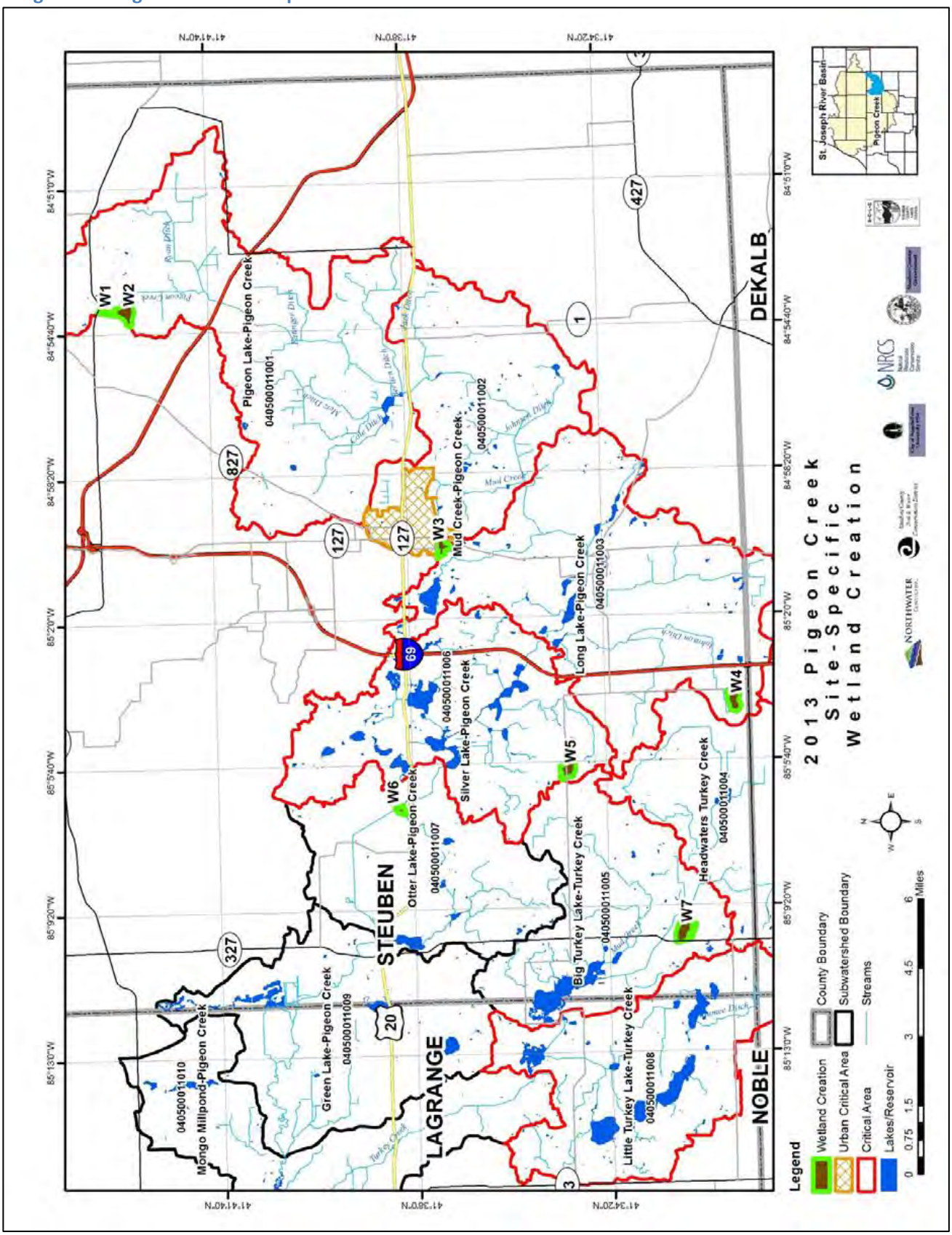
9.2.6 – Wetland Creation

Site-specific wetland creation is recommended at eight (8) sites throughout the watershed to treat urban and agricultural runoff. All of these sites are intended to be natural functioning wetlands. If implemented, these practices will benefit 441 acres and will reduce phosphorus loads by 251 lbs/yr, nitrogen loads by 1,773 lbs/yr, bacteria loads by 504 billion CFU/yr, and sediment by 172 tons/yr. Priority should be given to those sites within critical subwatersheds and with the highest pollutant load reduction potential (highlighted red in Table 82). Figure 70 shows the location of these practices in the watershed.

Table 82 - Site-Specific Wetland Creation Load Reductions

Subwatershed Name	HUC 12 Subwatershed Code	BMP Code	BMP Type	Acres Benefited	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Pigeon Lake-Pigeon Creek	**40500011001**	W1	Wetland Creation	19.9	10.2	72.1	16.4	5.76
Pigeon Lake-Pigeon Creek	**40500011001**	W2	Wetland Creation	**89.0**	**86.1**	**612.2**	**111.5**	**48.6**
Mud Creek-Pigeon Creek	**40500011002**	W3	Wetland Creation	55.2	10.4	108.6	61.4	2.79
Long Lake-Pigeon Creek	**40500011003**	W4	Wetland Creation	**77.9**	**39.4**	**291.6**	**88.2**	**34.3**
Silver Lake-Pigeon Creek	**40500011006**	W5	Wetland Creation	67.5	26.4	267.8	134.7	19.5
Otter Lake-Pigeon Creek	40500011007	W6	Wetland Creation	19.6	10.7	78.3	21.1	9.34
Big Turkey Lake-Turkey Creek	40500011005	W7	Wetland Creation	**92.9**	**56.8**	**263.5**	**56.7**	**44.8**
Big Turkey Lake-Turkey Creek	40500011005	W8	Wetland Creation	18.6	11.0	78.8	14.3	6.51
	Grand Total			**441**	**251**	**1,773**	**504**	**172**

Figure 70 - Pigeon Creek Site-Specific Wetland Creation Locations



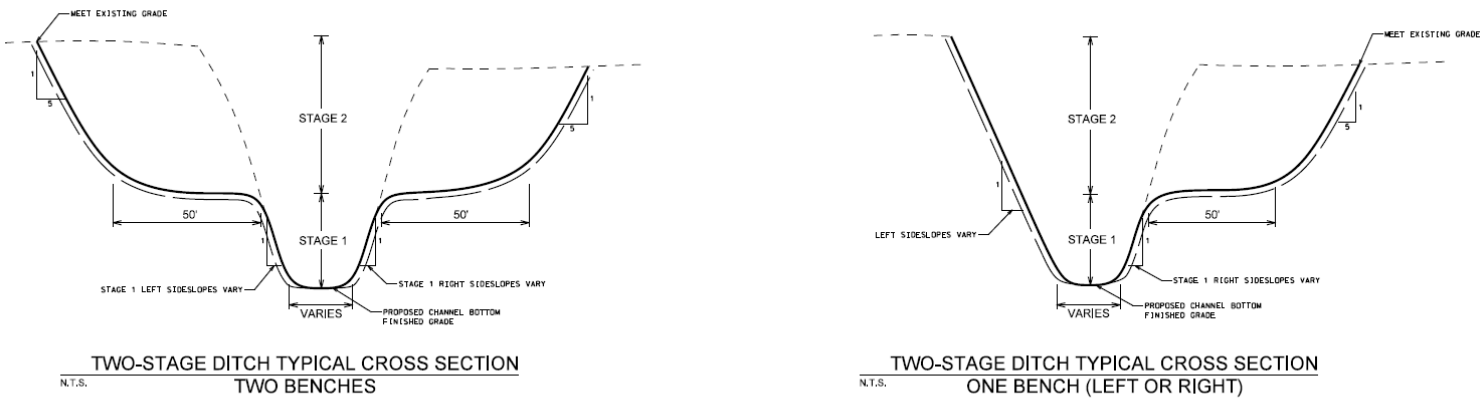
9.2.7 – Two-Stage Ditch

A windshield survey completed in April of 2013, landowner property visits and an analysis of existing GIS data resulted in the identification of over sixty (60) potential two-stage ditch sites. From these sites, a feasibility study was completed to determine the amount of potential new flood volume created by excavating and transforming existing one-stage ditches into two-stage ditches. Using available aerial 2-foot contour topography, the existing slope and bottom width at each site was calculated and then maintained in the proposed two-stage design. For each ditch location, the existing ditch cross-sectional area was calculated and compared to the proposed cross-sectional area that resulted from the addition of either one 50-foot-wide second stage shelf on one side of the ditch, or two 50-foot-wide second stage shelves, one on each side of the ditch. The increase in cross-sectional flow area was calculated by the length of the proposed two-stage improvements to calculate a net increase in flood storage volume. Despite location variability, the total bankfull flood storage volume associated with the proposed two-stage improvements is two to five times greater than the existing bankfull storage.

The bankfull capacity of the existing ditches was also calculated and compared to the bankfull capacity of the proposed two-stage ditch improvements. Similar to the total bankfull flood storage volume calculations, the total bankfull capacity associated with the proposed two-stage improvements is two to five times greater than the existing bankfull storage capacity. Additional calculations were also performed to calculate the theoretical reductions in ditch water surface elevations as the result of the two-stage ditch improvements (the calculations were based on existing bankfull flow with the new two-stage ditch capacity). Although the calculations indicate that the two-stage ditches result in water surface elevations that are approximately 1 to 3.5 feet lower (for existing bankfull flow conditions), it should be noted that this approach only provides a theoretical or conceptual evaluation that is intended to provide more qualitative information for consideration in the planning process. The calculated flood reduction benefits are not the result of a comprehensive flood study and the calculations performed do not take into account differences in storm events and downstream constraints that could reduce or eliminate the calculated flood reduction benefits. A more detailed design would require additional information regarding culverts and road crossings, nearby developments, more accurate topography and a detailed hydrologic analysis of the watershed.

A total of 176,485 feet of two-stage ditches are recommended for the Pigeon Creek watershed. If implemented, these practices will result in 881 acre-feet of water storage and will reduce phosphorus loads by 2,155 lbs/yr, nitrogen loads by 16,999 lbs/yr, bacteria loads by 475 billion CFU/yr, and sediment by 233 tons/yr. Priority should be given to those sites within critical subwatersheds and with the highest pollutant load reduction potential (highlighted red in the Table 83). Figure 72 shows the location of these practices in the watershed.

Figure 71 - Two-Stage Ditch Cross-Section

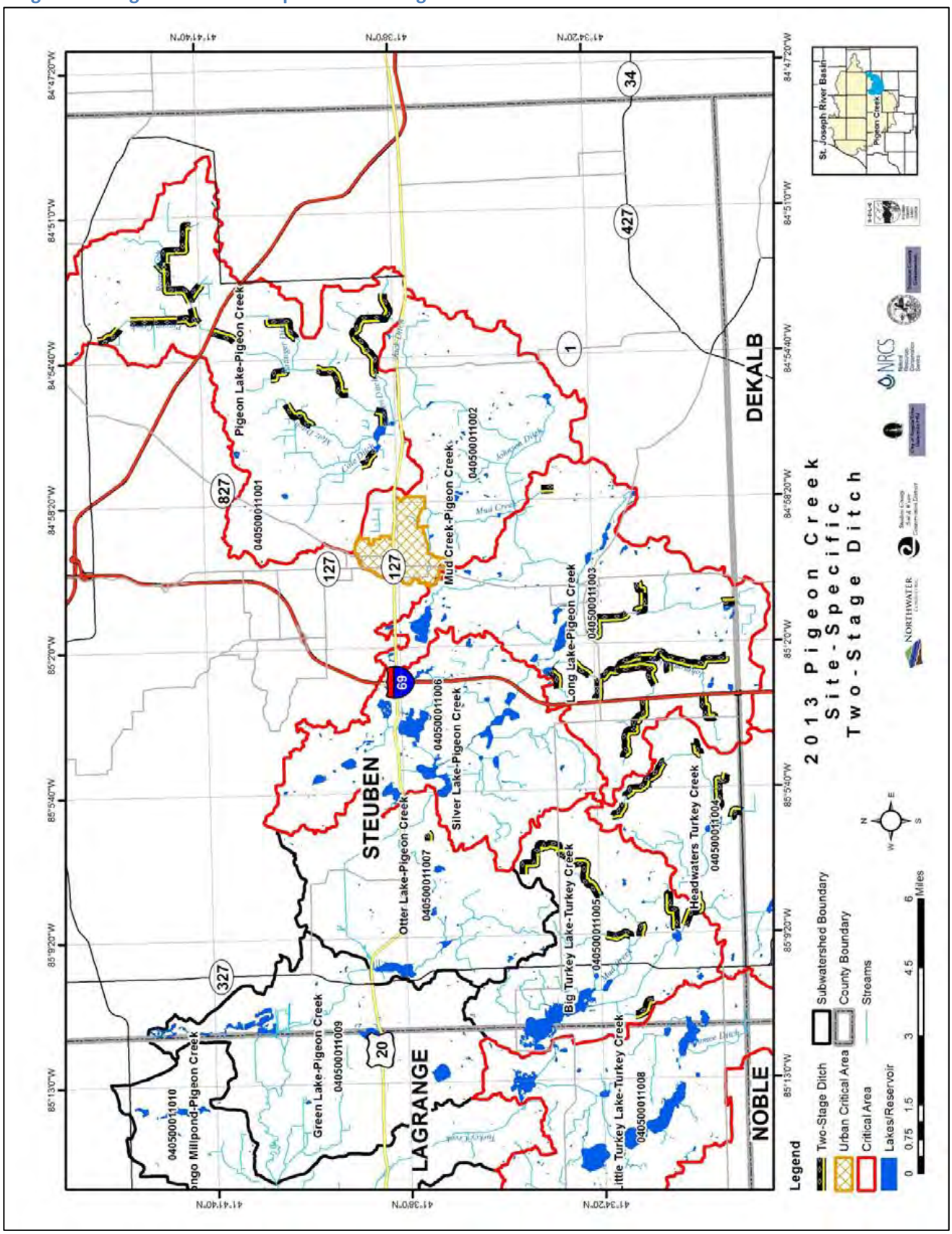


Note that the dimensions of the design shown in Figure 71 have been used to calculate load reductions and cost estimates for this plan. These dimensions provide the maximum benefits for improving water quality and flooding reductions and show an example cross-section with a generous bench width. More site-specific planning and design will be required based on landowner needs, hydrology and site constraints.

Table 83 - Site-Specific Two-Stage Ditch Load Reductions

Subwatershed Name	HUC 12 Subwatershed Codes	Length Two-Stage Ditch (ft)	Acre-ft of Water Storage	Phosphorus Load Reduction (lbs/yr)	Nitrogen Load Reduction (lbs/yr)	Bacteria Load Reduction (billion CFU/yr)	Sediment Load Reduction (tons/yr)
Pigeon Lake-Pigeon Creek	040500011001	64,590	368	900	7,096	199	4.97.4
Mud Creek-Pigeon Creek	040500011002	0	0	0	0	0	0
Long Lake-Pigeon Creek	040500011003	59,473	271	663	5,230	146	71.8
Headwaters Turkey Creek	040500011004	21,968	106	260	2,054	58	28.2
Big Turkey Lake-Turkey Creek	040500011005	29,513	131	321	2,532	71	34.8
Silver Lake-Pigeon Creek	040500011006	0	0	0	0	0	0
Otter Lake-Pigeon Creek	040500011007	941	4.51	11	87	2.4	1.2
Little Turkey Lake-Turkey Creek	040500011008	0	0	0	0	0	0
Green Lake-Pigeon Creek	040500011009	0	0	0	0	0	0
Mongo Millpond-Pigeon Creek	040500011010	0	0	0	0	0	0
Grand Total		**176,485**	**881**	**2,155**	**16,999**	**475**	**233**

Figure 72 - Pigeon Creek Site-Specific Two-Stage Ditch Locations



9.2.8 – Filter Strips

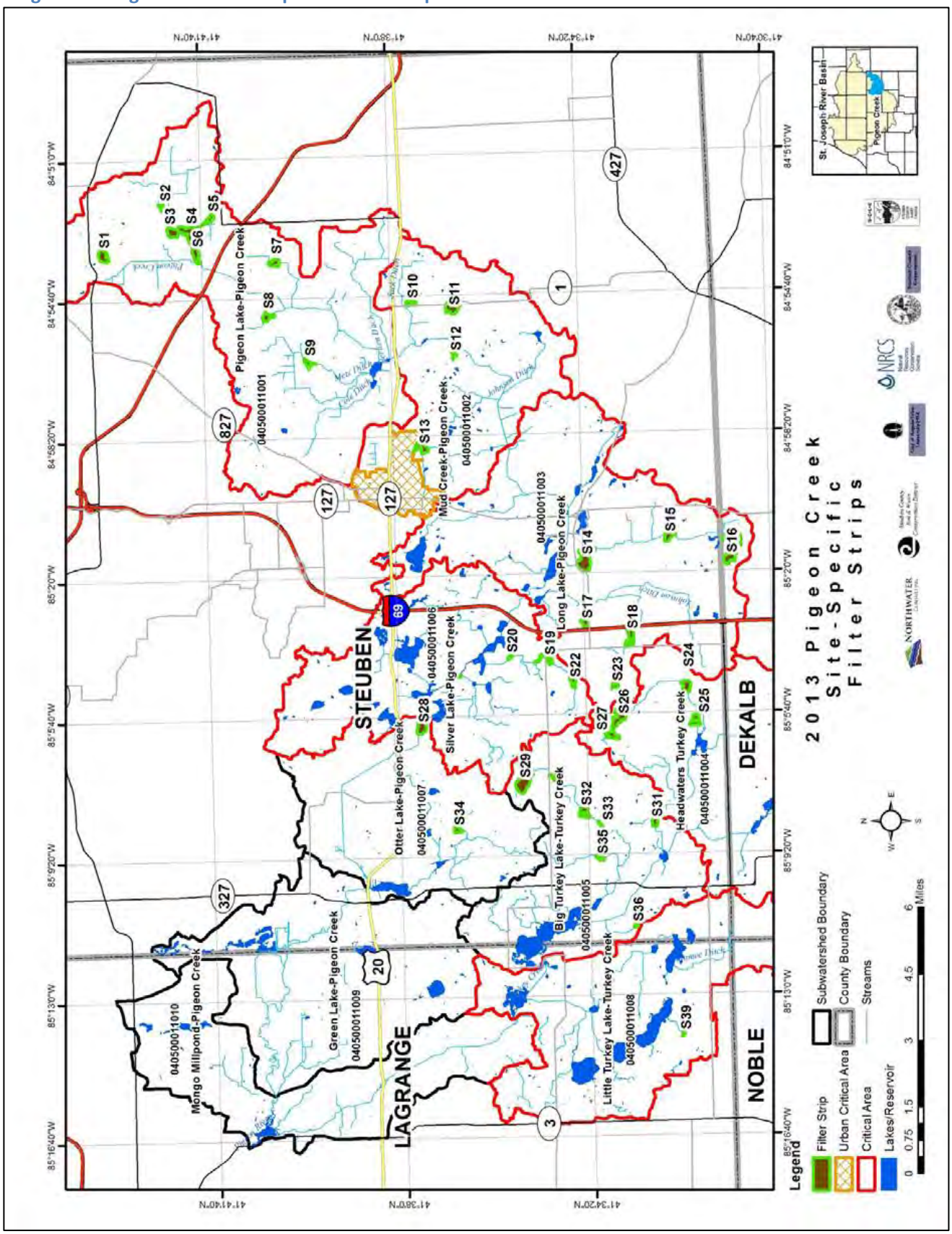
Site-specific filter strips are recommended at thirty-nine (39) sites throughout the watershed. If implemented, these practices will benefit 918 acres and will reduce phosphorus loads by 1,010 lbs/yr, nitrogen loads by 6,754 lbs/yr, bacteria loads by 817 billion CFU/yr, and sediment by 671 tons/yr. Priority should be given to those sites within critical subwatersheds and with the highest pollutant load reduction potential (highlighted red in the Table 84). Figure 73 shows the location of these practices in the watershed.

Table 84 - Site-Specific Filter Strip Load Reductions

Subwatershed Name	HUC 12 Subwatershed Code	BMP Code	BMP Type	Acres Benefited	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Pigeon Lake-Pigeon Creek	40500011001	S1	Filter Strip	29.4	21.7	154.6	16.6	10.9
Pigeon Lake-Pigeon Creek	40500011001	S2	Filter Strip	15.5	13.0	91.1	9.7	2.23
Pigeon Lake-Pigeon Creek	40500011001	S3	Filter Strip	28.5	26.1	183.5	18.8	8.92
Pigeon Lake-Pigeon Creek	40500011001	S4	Filter Strip	**58.4**	**75.0**	**506.2**	**57.1**	**79.6**
Pigeon Lake-Pigeon Creek	40500011001	S5	Filter Strip	14.5	14.8	104.0	10.7	0.58
Pigeon Lake-Pigeon Creek	40500011001	S6	Filter Strip	26.1	39.5	270.9	29.3	7.34
Pigeon Lake-Pigeon Creek	40500011001	S7	Filter Strip	18.1	17.7	125.6	13.1	2.86
Pigeon Lake-Pigeon Creek	40500011001	S8	Filter Strip	18.0	26.9	186.5	20.5	11.9
Pigeon Lake-Pigeon Creek	40500011001	S9	Filter Strip	13.4	19.0	130.2	14.0	11.5
Mud Creek-Pigeon Creek	40500011002	S10	Filter Strip	12.5	19.4	126.7	15.2	48.4
Mud Creek-Pigeon Creek	40500011002	S11	Filter Strip	36.9	35.2	222.1	32.2	30.7
Mud Creek-Pigeon Creek	40500011002	S12	Filter Strip	4.9	6.3	48.7	4.1	4.20
Mud Creek-Pigeon Creek	40500011002	S13	Filter Strip	27.8	44.5	307.9	32.8	11.7
Long Lake-Pigeon Creek	40500011003	S14	Filter Strip	87.5	43.1	321.3	55.0	12.1
Long Lake-Pigeon Creek	40500011003	S15	Filter Strip	20.1	22.4	149.6	17.2	12
Long Lake-Pigeon Creek	40500011003	S16	Filter	**77.7**	**99.7**	**697.4**	**79.0**	**45.5**

Subwatershed Name	HUC 12 Subwatershed Code	BMP Code	BMP Type	Acres Benefited	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
			Strip					
Long Lake-Pigeon Creek	40500011003	S17	Filter Strip	20.0	23.9	140.1	20.5	21.8
Long Lake-Pigeon Creek	40500011003	S18	Filter Strip	33.0	46.7	305.6	37.5	44.1
Silver Lake-Pigeon Creek	40500011006	S19	Filter Strip	18.8	29.2	189.7	23.4	16.9
Silver Lake-Pigeon Creek	40500011006	S20	Filter Strip	4.2	4.4	25.9	3.7	4.89
Silver Lake-Pigeon Creek	40500011006	S21	Filter Strip	1.4	4.1	15.0	1.7	1.94
Silver Lake-Pigeon Creek	40500011006	S22	Filter Strip	14.3	21.6	147.2	16.6	13.6
Long Lake-Pigeon Creek	40500011003	S23	Filter Strip	8.7	8.6	52.6	6.9	14.1
Headwaters Turkey Creek	40500011004	S24	Filter Strip	24.9	29.0	196.5	21.9	27.89
Headwaters Turkey Creek	40500011004	S25	Filter Strip	24.7	31.4	201.5	25.0	9.07
Headwaters Turkey Creek	40500011004	S26	Filter Strip	44.5	56.1	349.1	45.6	52.8
Headwaters Turkey Creek	40500011004	S27	Filter Strip	24.1	31.5	201.2	25.2	35.3
Otter Lake-Pigeon Creek	40500011007	S28	Filter Strip	39.0	23.8	141.4	23.9	27.2
Big Turkey Lake-Turkey Creek	40500011005	S29	Filter Strip	**70.3**	**62.8**	**407.0**	**50.6**	**21.2**
Big Turkey Lake-Turkey Creek	40500011005	S30	Filter Strip	7.3	9.1	62.1	7.2	14.7
Big Turkey Lake-Turkey Creek	40500011005	S31	Filter Strip	15.6	23.6	149.6	19.0	2.57
Big Turkey Lake-Turkey Creek	40500011005	S32	Filter Strip	26.4	28.7	186.1	22.6	13.7
Big Turkey Lake-Turkey Creek	40500011005	S33	Filter Strip	2.4	2.9	18.8	2.3	1.62
Otter Lake-Pigeon Creek	40500011007	S34	Filter Strip	12.6	12.2	71.6	10.4	15.3
Big Turkey Lake-Turkey Creek	40500011005	S35	Filter Strip	6.0	6.0	37.2	5.0	7.11
Big Turkey Lake-Turkey Creek	40500011005	S36	Filter Strip	7.4	8.6	63.8	6.0	2.89
Little Turkey Lake-Turkey Creek	40500011008	S37	Filter Strip	14.9	19.0	148.4	12.2	8.36
Little Turkey Lake-Turkey Creek	40500011008	S38	Filter Strip	5.4	0.4	4.0	2.9	0.02
Little Turkey Lake-Turkey Creek	40500011008	S39	Filter Strip	2.4	2.2	13.6	1.8	3.59
	Grand Total			**918**	**1,010**	**6,754**	**817**	**661**

Figure 73 - Pigeon Creek Site-Specific Filter Strip Locations



9.2.9 – Pasture BMPs

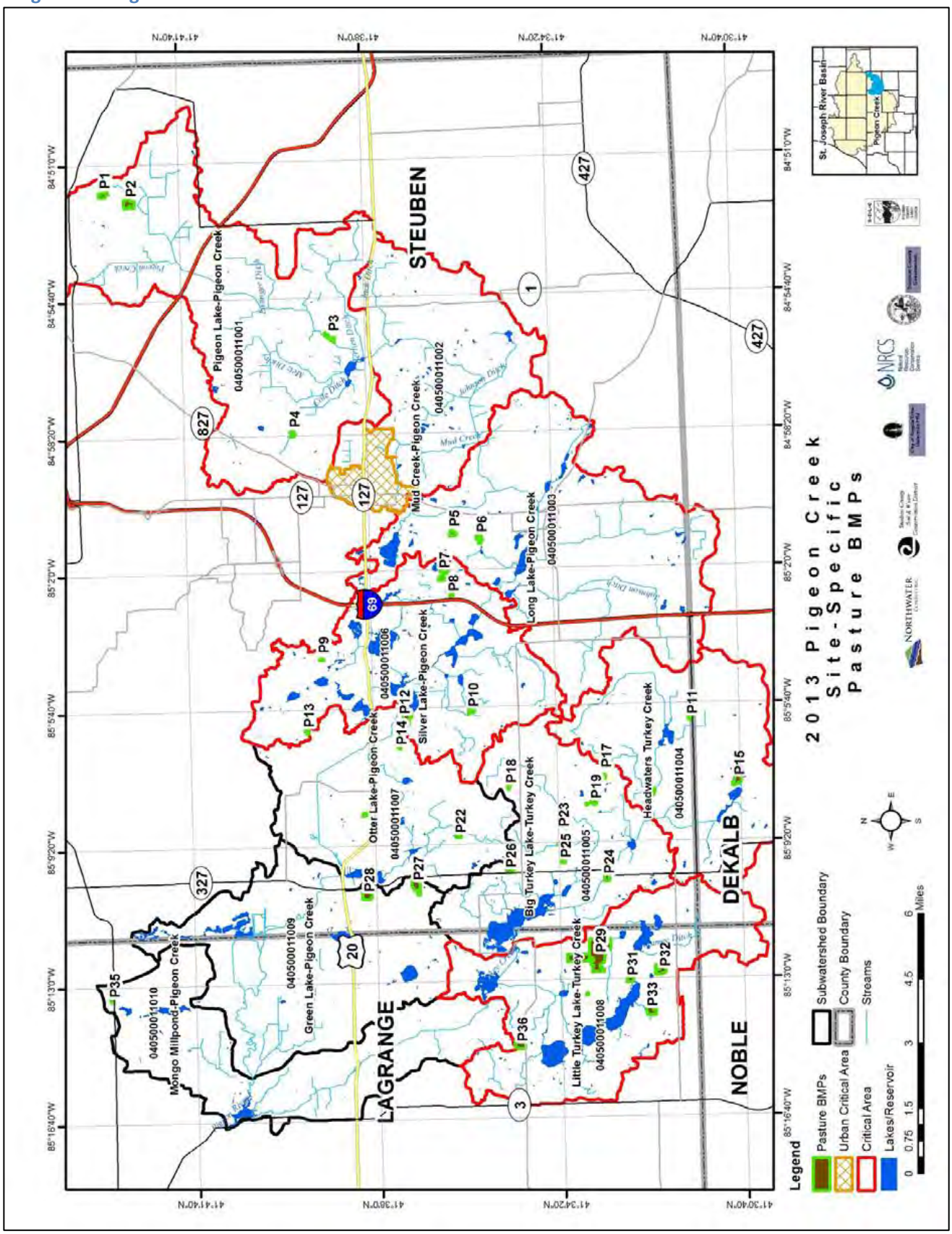
Site-specific pasture BMPs are recommended at thirty-six (36) sites throughout the watershed. As previously listed, pasture BMPs can include fencing (stream and interior), stream crossings, alternative watering systems, filter/buffer strips and diversions. If implemented, these practices will benefit 628 acres and will reduce phosphorus loads by 376 lbs/yr, nitrogen loads by 4,017 lbs/yr, bacteria loads by 3,016 billion CFU/yr, and sediment by 77 tons/yr. Priority should be given to those sites within critical subwatersheds and with the highest pollutant load reduction potential (highlighted red in the Table 85). Figure 74 shows the location of these practices in the watershed.

Table 85 - Site-Specific Pasture BMP Load Reductions

Subwatershed Name	HUC 12 Subwatershed Code	BMP Code	BMP Type	Acres Benefited	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Pigeon Lake-Pigeon Creek	40500011001	P1	Pasture BMPs	13.1	12.6	146.8	128.5	1.02
Pigeon Lake-Pigeon Creek	40500011001	P2	Pasture BMPs	26.5	6.8	71.4	56.6	0.70
Pigeon Lake-Pigeon Creek	40500011001	P3	Pasture BMPs	12.8	10.9	119.7	108.4	1.69
Pigeon Lake-Pigeon Creek	40500011001	P4	Pasture BMPs	6.7	4.2	48.0	40.4	0.67
Long Lake-Pigeon Creek	40500011003	P5	Pasture BMPs	9.0	4.1	45.8	29.8	0.28
Long Lake-Pigeon Creek	40500011003	P6	Pasture BMPs	9.5	12.5	141.5	114.9	1.43
Silver Lake-Pigeon Creek	40500011006	P7	Pasture BMPs	17.3	11.4	125.8	101.7	0.97
Silver Lake-Pigeon Creek	40500011006	P8	Pasture BMPs	2.1	1.7	19.5	16.6	0.15
Silver Lake-Pigeon Creek	40500011006	P9	Pasture BMPs	2.4	1.2	12.6	10.0	0.34
Silver Lake-Pigeon Creek	40500011006	P10	Pasture BMPs	7.7	7.1	80.4	66.5	0.72
Headwaters Turkey Creek	40500011004	P11	Pasture BMPs	4.0	1.4	15.6	12.8	0.13
Silver Lake-Pigeon Creek	40500011006	P12	Pasture BMPs	25.8	0.6	5.6	4.9	0.06
Silver Lake-Pigeon Creek	40500011006	P13	Pasture BMPs	5.4	1.7	19.3	16.6	0.27
Otter Lake-Pigeon Creek	40500011007	P14	Pasture BMPs	1.6	1.8	12.2	6.2	2.35
Headwaters Turkey Creek	40500011004	P15	Pasture BMPs	28.3	7.9	81.1	77.8	0.85
Headwaters Turkey	40500011004	P16	Pasture	6.4	6.0	67.9	56.5	1.05

Subwatershed Name	HUC 12 Subwatershed Code	BMP Code	BMP Type	Acres Benefited	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Creek			BMPs					
Big Turkey Lake-Turkey Creek	40500011005	P17	Pasture BMPs	2.7	1.6	17.2	13.3	0.45
Big Turkey Lake-Turkey Creek	40500011005	P18	Pasture BMPs	4.4	2.3	15.9	5.1	2.27
Big Turkey Lake-Turkey Creek	40500011005	P19	Pasture BMPs	9.0	3.0	34.2	22.3	0.20
Big Turkey Lake-Turkey Creek	40500011005	P20	Pasture BMPs	1.3	1.5	14.4	11.9	0.14
Otter Lake-Pigeon Creek	40500011007	P21	Pasture BMPs	3.5	2.1	19.4	16.3	0.24
Otter Lake-Pigeon Creek	40500011007	P22	Pasture BMPs	4.8	6.9	62.4	44.5	1.76
Big Turkey Lake-Turkey Creek	40500011005	P23	Pasture BMPs	3.4	3.8	30.6	10.2	0.90
Big Turkey Lake-Turkey Creek	40500011005	P24	Pasture BMPs	14.9	9.8	64.3	24.5	7.81
Big Turkey Lake-Turkey Creek	40500011005	P25	Pasture BMPs	5.1	2.2	20.6	16.5	0.59
Big Turkey Lake-Turkey Creek	40500011005	P26	Pasture BMPs	9.0	4.5	51.1	43.4	0.40
Green Lake-Pigeon Creek	40500011009	P27	Pasture BMPs	**34.7**	**16.9**	**180.3**	**169.8**	**3.20**
Green Lake-Pigeon Creek	40500011009	P28	Pasture BMPs	30.3	13.5	150.8	126.6	1.56
Little Turkey Lake-Turkey Creek	**40500011008**	P29	Pasture BMPs	**173.1**	**144**	**1,653**	**1,269**	**13.4**
Little Turkey Lake-Turkey Creek	**40500011008**	P30	Pasture BMPs	**53.5**	**40.8**	**446.4**	**262.0**	**3.69**
Little Turkey Lake-Turkey Creek	**40500011008**	P31	Pasture BMPs	11.3	4.5	48.3	34.1	0.35
Little Turkey Lake-Turkey Creek	**40500011008**	P32	Pasture BMPs	25.9	4.7	40.9	32.9	1.05
Little Turkey Lake-Turkey Creek	**40500011008**	P33	Pasture BMPs	30.4	15.4	96.2	17.4	25.3
Little Turkey Lake-Turkey Creek	**40500011008**	P34	Pasture BMPs	1.1	0.6	5.5	2.7	0.72
Mongo Millpond-Pigeon Creek	40500011010	P35	Pasture BMPs	2.9	3.1	28.2	21.5	0.40
Little Turkey Lake-Turkey Creek	**40500011008**	P36	Pasture BMPs	27.8	2.7	24.9	23.8	0.26
	Grand Total			**628**	**376**	**4,017**	**3,016**	**77**

Figure 74 - Pigeon Creek Pasture BMP Locations



9.2.1 – Other BMPs

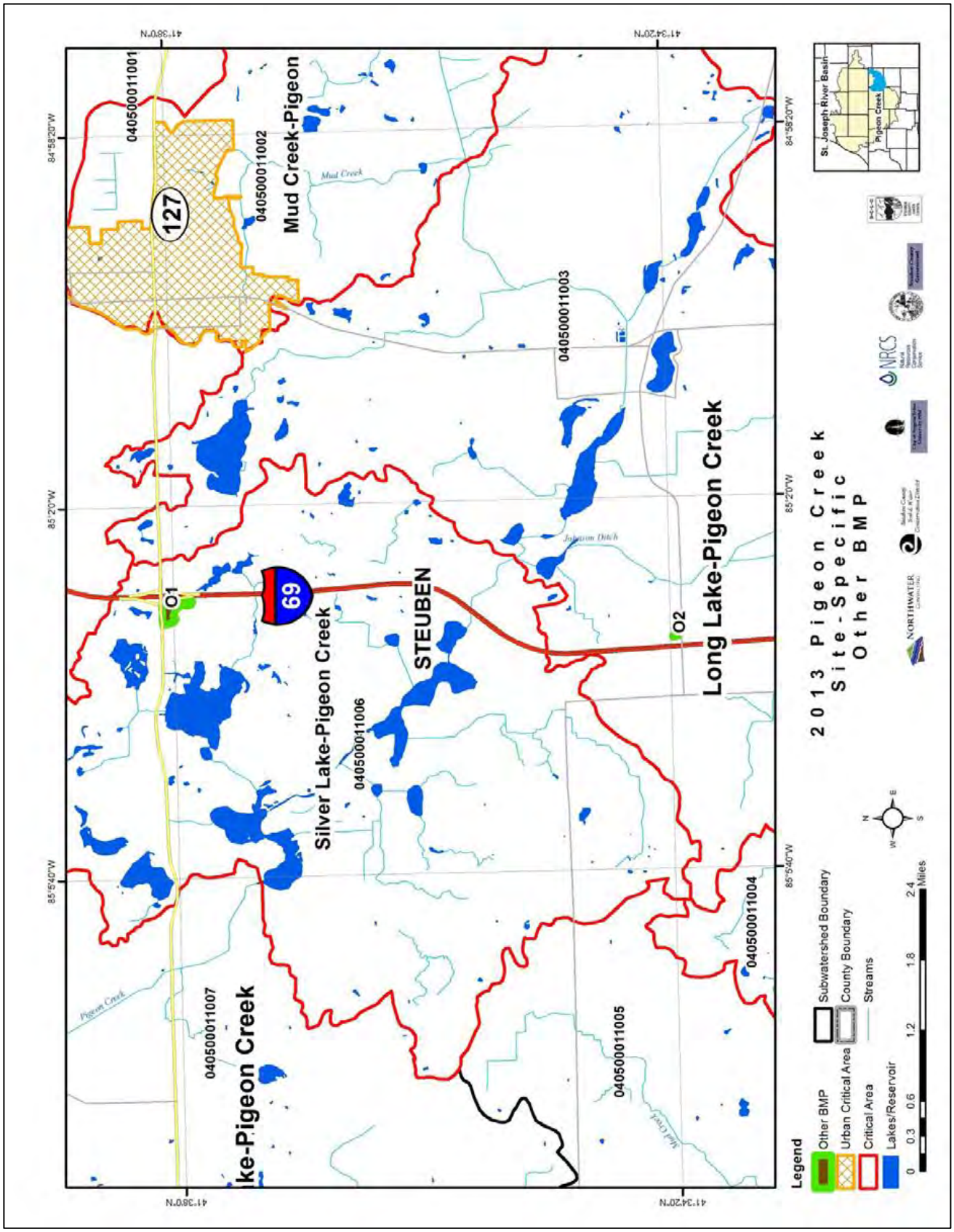
Site-specific other BMPs are recommended at two (2) sites in the watershed and include streambank stabilization and detention for a new truck stop development. If implemented, these practices will benefit 18 acres and will reduce phosphorus loads by 40 lbs/yr, nitrogen loads by 118 lbs/yr, bacteria loads by 19 billion CFU/yr, and sediment by 33 tons/yr. Priority should be given to those sites within critical subwatersheds and with the highest pollutant load reduction potential (highlighted red in the Table 86). Figure 75 shows the location of these practices in the watershed.

Table 86 - Site-Specific Other BMP Load Reductions

Subwatershed Name	HUC 12 Subwatershed Code	BMP Code	BMP Type	Acres Benefited	Load Reduction Phosphorus (lbs/yr)	Load Reduction Nitrogen (lbs/yr)	Load Reduction Bacteria (billion CFU/yr)	Load Reduction Sediment (tons/yr)
Silver Lake-Pigeon Creek	40500011006	O1	Detention for Truck Stop	17.6	10.5	65.8	18.0	8.7
Long Lake-Pigeon Creek	40500011003	O2	Streambank Stabilization	0.3	29.5	52.3	0.6	24.2
Grand Total				18	40	118	19	33

Pigeon Creek; Streambank Stabilization

Figure 75 - Pigeon Creek Other BMP Locations



9.3 – Existing Best Management Practices

Past efforts to improve water quality in the Pigeon Creek watershed have resulted in the implementation of over 140 individual BMPs. These efforts have already resulted in pollution load reductions and should receive credit for doing so. Only those known practices are included in this section; due to privacy issues, data on existing USDA practices implemented through the Conservation Reserve Program (CRP) and the Environmental Quality Incentive Program (EQIP) are unavailable. However, it is important to note that both CRP and EQIP practices exist in the watershed and are having a positive effect on water quality. Practices implemented by the Steuben County SWCD and the City of Angola are detailed in Section 3.6 and are currently treating 3,686 acres (2.7%); these practices include:

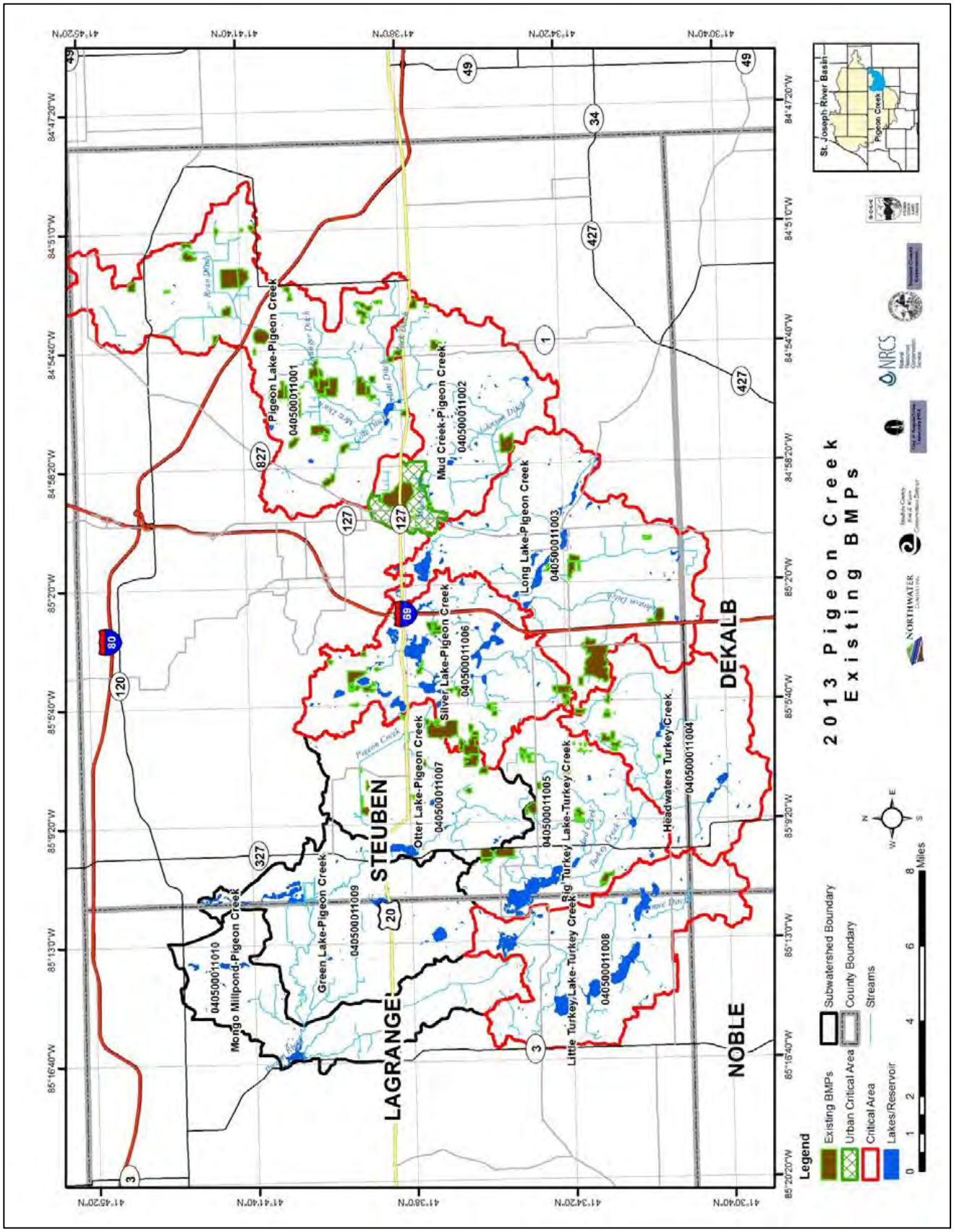
- Filter strips and grassed waterways.
- Water and Sediment Control Basins.
- Streambank stabilization.
- Livestock fencing and hay and tree planting.
- Wetland creation.
- Rain barrels and pervious concrete.
- Bioswales and rain gardens.

Load reductions were calculated for all existing BMPs using SWAMM and are summarized by subwatershed in Table 87. The locations of existing BMPs are also shown in Figure 76.

Table 87 - Existing BMP Load Reductions

Subwatershed Names	HUC 12 Subwatershed Codes	Treated Area (acres)	Phosphorus Load Reduction (lbs/yr)	Nitrogen Load Reduction (lbs/yr)	Bacteria Load Reduction (billion CFU/yr)	Sediment Load Reduction (tons/yr)
Pigeon Lake-Pigeon Creek	040500011001	1,283	1,109	6,331	1,001	953
Mud Creek-Pigeon Creek	040500011002	481	179	1,352	797	171
Long Lake-Pigeon Creek	040500011003	554	494	3,496	522	572
Headwaters Turkey Creek	040500011004	103	93	567	85	117
Big Turkey Lake-Turkey Creek	040500011005	272	173	1,086	178	247
Silver Lake-Pigeon Creek	040500011006	561	376	2,306	483	502
Otter Lake-Pigeon Creek	040500011007	432	222	1,306	242	208
Little Turkey Lake-Turkey Creek	040500011008	0	0	0	0	0
Green Lake-Pigeon Creek	040500011009	0	0	0	0	0
Mongo Millpond-Pigeon Creek	040500011010	0	0	0	0	0
Grand Total		**3,686**	**2,647**	**16,445**	**3,307**	**2,770**

Figure 76 - Pigeon Creek Existing BMP Locations



9.3.1 – Existing BMP Highlights

A selection of previously installed, on-the-ground BMPs is presented below. Included is the J Leach Wetland, rain gardens in the City of Angola, livestock fencing, streambank stabilization, tree planting, and pervious pavement at the Angola WWTP. These projects only represent a fraction of the work completed or underway in the watershed to improve water quality and habitat. Not present in this section are all the other efforts to conserve soil and reduce erosion such as grass waterways, filter strips, cover crops, water and sediment control basins, as well as the numerous education programs organized and implemented by the Steuben County SWCD.

1) J. Leach Wetland: work began on this 2.66-acre wetland project September 7th, 2012, and was completed October 15th, 2012. This large restoration project included a wetland detention area with an outlet structure. The goal of this project was to restore a wetland habitat in the Pigeon Creek watershed. Located on the property of the Angola Parks Department, the J. Leach Wetland is storing and filtering urban stormwater runoff, as well as improving local wildlife habitat.

2) Rain Garden, City of Angola: numerous green infrastructure BMPs have been installed within the City of Angola, including rain barrels, pervious/porous pavement, and riparian buffers. This rain garden, located in downtown Angola, is trapping and filtering roof and pavement runoff. Future plans include additional rain gardens and urban green infrastructure BMPs.

3) Rotational Grazing and Fencing: completed in 2011, this project included the installation of 4,295 feet of rotational grazing and exclusion fencing located on pasture ground southeast of the Jack Ditch. The landowner also replaced a tile riser in his grazing field with a blind inlet-style drain to further reduce sediment and runoff. Voluntary projects such as this help to improve both water quality and grazing productivity.

4) Streambank Stabilization: this project on the south bank of Pigeon Creek, just upstream of Long Lake, involved the Installation of a 307-foot log revetment. Bank erosion along this stretch has been significantly reduced and is estimated at roughly 40 tons per year. Natural bank stabilization projects such as this are more cost effective than rock systems and provide the same level of bank protection under the right conditions.

5) Tree Planting: through a combination of cost-share funds from the IDEM 319 grant program and LARE Watershed Land Treatment grant program, 30 acres of trees were planted along US 20, just east of the Jack Ditch and south of the Berlien Ditch, both of which flow into Pigeon Creek. Numerous other tree planting projects have been completed in the watershed.

6) Pervious (porous) Pavement & Bioswale: located at the Angola Wastewater Treatment Plant, a 5,000-square-foot parking lot was retrofitted with 324 sq. ft. (6'x54') of pervious concrete and is designed to handle a stormwater volume of 625 cubic feet. To complement the pervious pavement, a 4,100-square-foot Bio-Swale (bio-retention area) was also installed, increasing stormwater storage volume by an additional 8,310 cubic feet.

10.0 Action Register & Schedule

The Action Register describes each goal's scheduled objectives and milestones, estimated financial costs, and possible partners.

10.1 Objectives

Objectives incorporate the watershed goals but focus on specific processes that can be managed, such as pollutant loading and riparian conditions. Target audiences are those groups or individuals that will likely be involved in implementation. Objectives are directly tied to site-specific and basin-wide recommendations described in previous sections. Objectives are achievable; they represent realistic implementation targets.

Table 88 - Goals, Indicators, Objectives & Target Audience

Goal	Primary Indicator	Secondary Indicator	Objectives (S refers to site-specific / B refers to basin-wide)	Target Audience
Reduce Bacteria Loading	Number of water quality samples exceeding 235 CFU/100 mL	Number of category 4 & 5 impaired streams and lakes for *E. coli* (bacteria)	1. Implement a basin-wide septic inspection and tracking program; inspect 1,000 septic systems (B) 2. Install diversions and waste lagoons on 25 small animal feed operations (S) 3. Implement pasture management practices on 30 pasture operations (S) 4. Install 5 detention basins (B) 5. Continue local education and water quality monitoring (B)	1. Private residential -landowners and County Health Department 2. Agricultural (AG) landowners 3. Agricultural (AG) landowners 4. Agricultural (AG) landowners, City of Angola 5. All stakeholders
Reduce Phosphorus and Nitrogen Loading	Nitrogen: Number of water quality samples exceeding 10 Mg/L Phosphorus: Number of water quality samples exceeding 0.3 mg/L	Number of category 4 & 5 impaired streams and lakes for phosphorus and Impaired Biotic Communities (IBC)	1. Install cover crops on 5,000 acres (B) 2. Install 100 acres of filter strips (S) 3. Install 5 detention basins (S) 4. Create 2 wetlands in urban areas and 3 wetlands on agricultural ground (S) 5. Restore 100 acres of existing wetlands (B) 6. Treat 5,000 acres with denitrifying bioreactors (B) 7. Treat 500 acres of urban and residential areas with rain barrels, rain gardens, and porous pavement (B) 8. Continue local education and water quality monitoring (B)	1. Agricultural (AG) landowners 2. Agricultural (AG) landowners 3. Agricultural (AG) landowners, residential landowners and municipalities 4. Agricultural (AG) landowners, residential landowners and municipalities 5. Agricultural (AG) landowners, residential landowners and municipalities 6. Property owners and municipalities 7. All stakeholders
Reduce Sediment	Number of water quality samples exceeding 30 mg/L	Number of category 4 & 5 impaired streams and lakes for TSS (sediment)	1. Install blind inlets on 100 fields (B) 2. Install 5 detention basins (S) 3. Install 1 rock riffle (S) 4. Install terraces or WASCOB systems on 100 fields (B) & (S) 5. Install 9 grass waterways (S) 6. Continue local education and water quality monitoring (B)	1. Agricultural (AG) landowners 2. Agricultural (AG) landowners, residential landowners and municipalities 3. Residential landowner 4. Agricultural (AG) landowners 5. Agricultural (AG) landowners 6. All stakeholders

Goal	Primary Indicator	Secondary Indicator	Objectives (S refers to site-specific / B refers to basin-wide)	Target Audience
Reduce Flooding by increasing storage	1) Acres of restored wetland in headwaters 2) Feet of two-stage drainage ditches	Flooding is no longer a concern for watershed stakeholders	1. Install 25,000 feet of two-stage drainage ditch (S) 2. Implement 1 regional detention area; Bill Deller Rd. (S) 3. Restore 100 acres of existing wetlands (B) 4. Treat 500 acres of urban and residential areas with rain barrels, rain gardens, and porous pavement (B) 5. Continue local education programs (B)	1. Agricultural (AG) landowners and county surveyor 2. Agricultural (AG) landowners 3. Agricultural (AG) landowners, residential landowners and municipalities 4. Property owners, municipalities 5. All stakeholders

10.2 Measurable Milestones

Milestones represent a time period or a deadline for realizing watershed implementation objectives, as well as any specific tasks required. A simple scorecard was developed for the watershed. Scorecard milestones are based on short-term (1-5 years), medium-term (6-10 years) and long-term (10+ years) objectives. The milestones and "scorecard" can be used to identify and track plan implementation to ensure that progress is being made towards achieving the plan targets and to make corrections, as necessary. Scorecards for each goal and objective are provided in Appendix B and an example is included below (Figure 77).

Pigeon Creek Watershed; Completed Rain Garden

Figure 77 - Pigeon Creek Example Score Card

Goal #1 Milestone Scorecard: Reduce Bacteria Loading

Milestones: S = 1-5 yrs / M = 6-10 yrs / L = 10+ yrs

Objective	Indicator		Milestone	Grade
Implement a basin-wide septic inspection and tracking program; inspect 1,000 septic systems	Number of water quality samples exceeding 235 CFU/100 mL	S	250 systems	
		M	500 systems (cumulative)	
		L	1,000 systems (cumulative)	
Install diversions and waste lagoons on 25 small animal feed operations	Number of water quality samples exceeding 235 CFU/100 mL	S	5 operations	
		M	10 operations (cumulative)	
		L	25 operations (cumulative)	
Implement pasture management practices on 30 pasture operations	Number of water quality samples exceeding 235 CFU/100 mL	S	10 operations	
		M	20 operations (cumulative)	
		L	30 operations (cumulative)	
Install 5 detention basins	Number of water quality samples exceeding 235 CFU/100 mL	S	2 basins	
		M	2 basins (additional)	
		L	1 basin (additional)	
Continue local education and water quality monitoring programs.	Number of water quality samples exceeding 235 CFU/100 mL	S	2 education/outreach programs and continue monitoring	
		M	2 education/outreach programs and continue monitoring	
		L	2 education/outreach programs and continue monitoring	

Milestone Grading System
A=Met or exceeded milestone
B=Milestone 75% achieved
C=Milestone 50% achieved
D=Milestone 25% achieved
F=Milestone not achieved

10.3 Cost Estimates, Responsible Partners & Technical Assistance

This section summarizes costs associated with BMPs and those entities or individuals who will likely be responsible for implementation.

10.3.1 Cost Estimates

The costs presented in this section and associated with BMP recommendations in Pigeon Creek are only estimates and should be revised through project-specific planning. Built into all estimates are costs for technical assistance, engineering, salaries, travel, and expenses.

The following assumptions were used to determine the appropriate water quality implementation costs:

1. Basin-wide residential practices include a combination of rain barrels and rain gardens. Assumes an average treatment area of 0.25 acres. Each treatment area assumes 2, 60-gallon

rain barrels and one rain garden or infiltration trench. Assumed costs are $160 for rain barrels and $3,500 for each rain garden or infiltration trench.

2. Cost estimates for a denitrifying bioreactor were developed from an Iowa State study. The study provided per-acre cost estimates from six sites. The average per-acre cost is calculated at $152/ac.
3. Cost estimates for blind inlets are based on Steuben County cost-share rates and assume construction and material costs of $3000/inlet. Each inlet assumes treatment of 50 acres.
4. Porous/Permeable pavement retrofits assume an average material cost of $9/square foot and an average construction cost of $3.75/square foot.
5. The per-foot cost for two-stage ditches was calculated using a cost estimator Excel tool produced by TNC. All cost estimates are based on the assumptions that all recommended ditches are of equal dimensions with a 50-ft bench on both banks and a 4:1 side slope. Cost estimates also assume one outlet protection structure, one drop structure, one rock structure, a berm on both banks, all applicable seeding, and average land rental rates for a 250-ft stretch. Using these assumptions, per-foot cost estimates total $139.16 ($61.63 for construction and materials and $77.53 for land rental/payment).
6. Costs for filter and riparian buffer strips are calculated at $700/ac, assuming a minimum width of 50 feet. Costs are generated using NRCS cost-share rates and include land preparation, materials and seeding.
7. Costs for cover crops are based on NRCS cost-share rates and are assumed to cost $70/ac on average.
8. Costs for riffles and grade control structures are based on professional judgment and field experience, and total $8000 per individual structure.
9. Wetland creation and/or restoration assumes a cost of $2000 per water control structure and engineering and dirt work or excavation costs ranging from $10,0000-$14,000 per site.
10. Costs for detention basins and waste lagoons are based on site conditions and professional judgment/experience, and range from $14,000-$65,000.
11. Grassed waterways assume a cost of $3000/acre based on typical NRCS cost-share rates.
12. Water and sediment control basin costs are based on NRCS cost-share rates and professional experience, and assume $1000/basin.
13. Costs for terraces are based on professional experience and NRCS cost-share rates and assume a cost of $500 for every five acres of treatment.
14. Pasture management include a combination of costs for multiple practices and are based on a combination of NRCS cost-share rates and professional experience and judgment. Costs assume $2.50/ft for fencing, $10,000-$20,000 per detention basin, $8,000 for each stream crossing, $5000 for each diversion, and $10,000 for a water system.
15. The cost to establish a training and inspection program for septic pumpers is estimated to cost $50,000.

The total estimated cost to implement all basin-wide BMPs is *$1,362,177,180*. Cost to implement all site-specific recommendations is *$31,867,495* for a grand total of ***$1,394,044,674***. Table 89 lists estimated costs for all basin-wide and site-specific BMP recommendations.

Table 89 - Pigeon Creek BMP Cost Estimates

Best Management Practice	Area/Amount	Unit Cost	Total Cost
Basin Wide BMPs			
Cover Crops	39,186 acres	$70/acre	$2,743,020
Terraces and WASCOB	25,416 acres	$500 per 5 acres	$2,591,600
Blind Inlet	51,870 acres	$3,000 per 50 acres	$3,112,200
Wetland Restoration	12,054 acres	$12,000/acre	$144,648,000
Septic Inspection & Maintenance Program	2,667 ac	n/a	$50,000
Denitrifying Bioreactor	51,870 acres	$152/acre	$7,884,240
Rain Barrel/Garden	6,724 acres	$15,280/acre	$102,742,720
Porous Pavement	6,724 acres	$163,350/acre	$1,098,365,400
Education & Outreach (all recommendations in Section 9.1.8)	2 workshops, 1 bus tour, 1 ditch cleanup day, educational pamphlets, Lake Life Workshop, local conservation series	n/a	$40,000/year
Total			**$1,362,177,180**
Site-Specific BMPs (costs represent a sum of individual Installed BMPs)			
Detention Basin*	6	n/a	$5,236,000
Feed Area Waste Lagoon	29	n/a	$744,000
Filter Strip	38 (144 acres)	n/a	$100,842
Pasture BMPs	36	n/a	$888,500
Riffle	1	$8,000	$8,000
WASCOB/Terrace	6	n/a	$17,000
Grassed Waterway	9	n/a	$37,500
Wetland Creation	8	n/a	$239,000
Other BMP	2	n/a	$37,000
Two-Stage Ditch	176,485 feet	$139.16	$24,559,653
Total			**$31,867,495**
Grand Total			**$1,394,044,674**

*Includes an estimated $5,000,000 cost for Bill Deller Rd regional flood storage area

10.3.2 Responsible Parties & Technical Assistance

Responsible parties in the Pigeon Creek watershed include city and county government, private landowners (agricultural and urban), county SWCDs, and NRCS staff. City government includes Angola, Hudson, and Ashley. County government includes Steuben and LaGrange County, County Assessors, and the Department of Health. Private landowners are made up of residents within city limits, residents outside of city limits, agricultural producers and lake residents. The primary government agency responsible for plan implementation is the Steuben County SWCD and the Steuben County NRCS. In some cases, a project may include multiple responsible parties; for example, a project on private land within city limits may require participation from both the city and the landowner.

Various funding and financing mechanisms exist that can assist with the implementation of plan recommendations and provide technical assistance. Common programs already being utilized by the Steuben County SWCD include the EPA 319 Grant through the IDEM and the LARE program through IDNR. These competitive grant programs provide financial cost-share and technical assistance for various

BMPs and are usually administered through a local agency or SWCD, as is the case with the Steuben County SWCD.

Other Federal programs such as the USACE Continuing Authorities Program (CAP) or the Great Lakes Restoration Initiative (GLRI) may also be applicable in the watershed and should be researched to determine if opportunities for funding exist. The CAP program from Section 206 of the 1996 Water Resources Development Act targets wetland restoration with the objective to restore degraded ecosystem structure, function, and dynamic processes to a less degraded and more natural condition. The GLRI program is focused on improving the health of the Great Lakes and provides financial assistance for the implementation of BMPs to address water quality issues and other contaminants.

Most relevant to the Pigeon Creek watershed are those agricultural conservation and cost-share programs administered through the USDA – NRCS. All USDA – NRCS programs also provide technical assistance in the form of conservation planning and engineering and design. There are three incentive programs that have applicability in the watershed: the Environmental Quality Incentives Program (EQIP), the Wetland Reserve Easements program (WRE), and the Conservation Reserve Program (CRP). The goal of WRE is to restore and protect degraded wetlands such as farmed wetlands. WRE has three options available: permanent easements, 30-year easements and restoration agreements. The NRCS will reimburse the landowners for easements on the property plus a portion of the restoration costs based on the type of easement agreed to by the landowner.

EQIP is applicable to numerous practices identified in the PCWMP, including livestock and pasture recommendations, two-stage ditches, blind inlets, denitrifying bioreactors, wetlands, filter and buffer strips, grassed waterways, terraces, WASCOBs, riffles, streambank stabilization, cover crops, and many other practices. Typically, EQIP monies will fund 75% of land improvements and installation of conservation practices.

The goal of the CRP program is to give incentives to landowners who take frequently flooded and environmentally sensitive land out of crop production and plant specific types of vegetation. Participants earn annual rental payments and sign-up incentives. This program offers up to 90% cost share. Rental payments are boosted by 20% for projects such as installation of riparian buffers and filter strips.

Finally, funding and technical assistance can come from municipal, county, or private sources. In Pigeon Creek, the City of Angola, for example, has contributed financially to projects such as wetland restoration, rain gardens, rain barrels, and porous pavement. Private landowners who wish to participate can also contribute financially. Private funds or landowner contributions are required for all USDA-NRCS programs and being able to demonstrate a financial commitment from private landowners when applying for a competitive grant can often help to improve the likelihood of receiving funding. Local funding sources, such as the City of Angola and individual landowners, should be approached to participate in a grant application; often times, this can be critical in leveraging state or federal funds that require local matching dollars. Table 90 lists responsible parties and funding options for site-specific and basin-wide BMPs.

Table 90 - Responsible Entities, Financial & Technical Assistance

Best Management Practice/Objective	Responsible Party	Primary Technical Assistance/Funding Mechanism
	Basin Wide BMPs	
BMP: Cover Crops **Objective:** Install cover crops on 5,000 acres	Private Landowner/SWCD/NRCS	***Technical Assistance***: SWCD/NRCS ***Funding Mechanism***: 319 Grant/Private Funds/EQIP/LARE
BMP: Terraces and WASCOB **Objective**: Install terraces or WASCOB systems on 100 fields	Private Landowner/SWCD/NRCS	***Technical Assistance:*** SWCD/NRCS ***Funding Mechanism***:319 Grant/Private Funds/EQIP/LARE
BMP: Blind Inlet **Objective:** Install blind inlets on 100 fields	Private Landowner/SWCD/NRCS	***Technical Assistance***: SWCD/NRCS ***Funding Mechanism***:319 Grant/Private Funds/EQIP/LARE
BMP: Wetland Restoration **Objective:** Restore 100 acres of existing wetlands	Private Landowner/SWCD/County Assessor/City Government, if applicable	***Technical Assistance***: SWCD/NRCS/City and County Government ***Funding Mechanism***:319 Grant/Private, Municipal or County Funds/EQIP/LARE/WRP/USACE
BMP: Septic Inspection & Maintenance Program **Objective:** Implement a basin-wide septic inspection and tracking program; inspect 1,000 septic systems	Landowner/Health Department/SWCD	***Technical Assistance***: SWCD/NRCS/Health Department ***Funding Mechanism***: Private Funds/County/City/Health Department/ 319 Grant
BMP: Denitrifying Bioreactor **Objective:** Treat 5,000 acres with denitrifying bioreactors	Private Landowner/SWCD/NRCS	***Technical Assistance***: SWCD/NRCS ***Funding Mechanism***:319 Grant/Private Funds/EQIP/LARE
BMP: Rain Barrel/Garden **Objective:** Treat 500 acres with rain barrels and rain gardens	Private Landowner/SWCD/County/City Government	***Technical Assistance***: SWCD/NRCS/ City and County Government ***Funding Mechanism***:319 Grant/Private, Municipal or County Funds/EQIP/LARE
BMP: Porous Pavement **Objective:** Treat 500 acres with porous pavement	Private Landowner/SWCD/County/City Government	***Technical Assistance***: SWCD/NRCS/ City and County Government ***Funding Mechanism***:319 Grant/Private, Municipal or County Funds/EQIP/LARE
BMP: Education & Outreach (all recommendations in Section 9.1.8) **Objective:** Continue local education and monitoring programs	SWCD	***Technical Assistance***: SWCD/NRCS ***Funding Mechanism***:319 Grant/Private Funds/LARE
	Site-Specific BMPs	
BMP: Detention Basin **Objective:** Install 5 detention basins	City of Angola/Steuben County Assessor/SWCD/Landowner	***Technical Assistance***: SWCD/NRCS/ City and County Government ***Funding Mechanism***:319 Grant/Private Funds/County Funds
BMP: Feed Area Waste Lagoon **Objective:** Install diversions and waste lagoons on 25 small animal feed operations	Private Landowner/SWCD	***Technical Assistance***: SWCD/NRCS ***Funding Mechanism***:319 Grant/Private Funds/LARE
BMP: Filter Strip **Objective:** Install 100 acres of filter strips	Private Landowner/SWCD/NRCS	***Technical Assistance***: SWCD/NRCS ***Funding Mechanism***:319 Grant/Private Funds/EQIP/LARE
BMP: Pasture BMPs **Objective:** Implement pasture	Private Landowner/SWCD/NRCS	***Technical Assistance***: SWCD/NRCS ***Funding Mechanism***:319 Grant/Private

Best Management Practice/Objective	Responsible Party	Primary Technical Assistance/Funding Mechanism
management practices on 30 pasture operations		Funds/EQIP/LARE
BMP: Riffle **Objective:** Install 1 rock riffle	County Road Commissioner/Landowner	***Technical Assistance***: SWCD/NRCS/County Road Commissioner ***Funding Mechanism***:319 Grant/Private Funds
BMP: WASCOB/Terrace **Objective:** Install terraces or WASCOB systems on 100 fields	Private Landowner/SWCD/NRCS	***Technical Assistance***: SWCD/NRCS ***Funding Mechanism:*** 319 Grant/Private Funds/EQIP/LARE
BMP: Grassed Waterway **Objective:** Install 9 grassed waterways	Private Landowner/SWCD/NRCS	***Technical Assistance***: SWCD/NRCS ***Funding Mechanism***:319 Grant/Private Funds/EQIP/CRP/LARE
BMP: Wetland Creation **Objective:** Create 2 wetlands in urban areas and 3 wetlands on agricultural ground	Private Landowner/SWCD/NRCS	***Technical Assistance***: SWCD/NRCS ***Funding Mechanism***:319 Grant/Private Funds/EQIP/WRP/CRP/LARE
BMP: Other BMP **Objective:** N/A	Property Owner/County Assessor	***Technical Assistance***: SWCD/NRCS/County Assessor ***Funding Mechanism***: Private, County Funding/EQIP
BMP: Two-Stage Ditch **Objective**: Install 25,000 feet of two-stage drainage ditch	Private Landowner/SWCD/NRCS/County Assessor	***Technical Assistance***: SWCD/NRCS/County Assessor ***Funding Mechanism***:319 Grant/Private Funds/EQIP/County Funds/LARE

11.0 Tracking Effectiveness & Future Planning

This plan is meant to be a flexible tool to achieve water quality improvements within the Pigeon Creek watershed. The PCWMP can be evaluated by assessing the progress made toward implementing plan recommendations. The Steuben County SWCD and the Pigeon Creek Steering Committee are the primary responsible entities for both implementation and monitoring/tracking. The Steuben County NRCS and the City of Angola are two key partners that can assist in both plan implementation and monitoring. It is not anticipated that any financial resources will be required to track plan effectiveness above and beyond the cost of a continued water quality monitoring program.

The plan should be evaluated every five (5) years to assess the progress made, as well as to revise the plan based on the progress achieved. The plan should also have a comprehensive review every 15-20 years. Amendments and changes may be made more frequently as laws change or new information becomes available that will assist in providing a better outlook for the watershed. As goals are accomplished and additional information is gathered, efforts may need to be shifted to watershed issues of higher priority.

In addition to a five (5) year evaluation and update, local stakeholders and city/county/agency staff will have a key role in evaluating implementation progress on an annual basis. They can review the status of milestones annually and then identify the top priority actions for the following year's focus. The local Steering Committee, stakeholders and professional staff should identify how they will implement the plan (subcommittees, reporting structure, meeting schedule, etc.). Other opportunities for evaluating

the status of plan implementation can include the completion of quarterly project reports or group meeting minutes. Since this plan is a flexible tool, tracking changes/modifications are anticipated based on usability and changes in priorities throughout implementation.

11.1 Monitoring Strategy

Monitoring can be divided up into programmatic monitoring and water quality monitoring. Programmatic monitoring tracks progress made toward plan objectives and recommendations whereas water quality monitoring involves the orderly collection of chemical and biological data in order to determine if numerical water quality targets are being met.

11.1.1 Programmatic Monitoring

The purpose of the programmatic monitoring plan for the Pigeon Creek watershed is to define action items and assess the overall implementation success of BMPs and other plan recommendations. This can be accomplished by conducting the following actions:

1. Track implementation of management measures in the watershed.
2. Estimate effectiveness of management measures.
3. Implement water quality monitoring as outlined in Appendix D.

Tracking the implementation of plan recommendations can be used to address the following monitoring goals:

- Determine the extent to which plan recommendations and practices have been implemented over time compared to action needed to meet water quality targets.
- Establish a baseline from which decisions can be made regarding the need for additional incentives for implementation efforts.
- Measure the extent of voluntary implementation efforts.

Local resource agencies track program successes and implementation to satisfy internal requirements. For example, the USDA and SWCDs monitor program successes and report at the county level. Tracking implementation at the watershed level is rarely conducted unless local agencies are 1) willing to provide the information and 2) a formal request is made from local stakeholders. This only occurs if a watershed group or interested entity is active in the area.

In the Pigeon Creek watershed, the current Steering Committee could work with the appropriate parties to voluntarily establish a monitoring program to track plan implementation. This could involve an annual report that summarizes BMPs currently in place and the work stakeholders have already completed. This would form the baseline from which to measure success and monitor plan implementation.

The milestones “scorecard” presented in Section 10 are based on BMP recommendations and load reduction targets. This scorecard system can serve as the organizational monitoring plan and a tool for tracking progress toward meeting specific recommendations/action items. Realistic short-term (1-5 yr),

medium- (6-10 yr) and long-term (10+ yr) milestones and indicators are included in the scorecard. Each milestone is a specific action recommendation and is intended to fulfill plan objectives, if executed. Indicators are to be used as measurement tools when determining if each milestone has or has not been met. If the measurement of each indicator becomes problematic, the watershed Steering Committee should revisit and make adjustments, where needed. It is up to local stakeholders to determine the priority of each milestone based on their ability to follow through with them; Sections 8 and 9 provide direction for prioritization including critical subwatersheds and load reduction quantities. There are no anticipated costs or technical assistance needed to track progress; the Steuben County SWCD will be responsible providing information on implementation projects to the Steering Committee.

11.1.1 Water Quality Monitoring

Water quality monitoring for Pigeon Creek and watershed tributaries should follow the existing monitoring plan in place. A 2012 Quality Assurance Project Plan (QAPP) is included in Appendix D. Additional monitoring recommendations include:

1. Increase sampling frequency of high flow events
2. Flow data and discharge measurements are limited for high flow events. When conditions permit, make every effort to collect additional flow data.
3. Coordinate with IDEM and incorporate state water quality collection data into existing databases.

12.0 References

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