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Little Calumet River, East Branch

Watershed Management Plan

Save the Dunes
444 Barker Rd., Michigan City, IN 46360

October 2015

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ACRONYM LIST

BMP	Best Management Practice
CCAP	Coastal Change Analysis Program
CALM	Consolidated Assessment and Listing Methodology
CCWC	Coffee Creek Watershed Conservancy
CELCP	Coastal and Estuarine Land Conservation Program
CFO	Confined Feeding Operation
CSO	Combined Sewer Overflow
CWP	Center for Watershed Protection
CWS	Comprehensive Wildlife Strategy
CZARA	Coastal Zone Act Reauthorization Amendments
DO	Dissolved Oxygen
DNR	Department of Natural Resources
E. coli	*Escherichia coli* (bacteria)
EAB	Emerald Ash Borer (beetle)
FEMA	Federal Emergency Management Agency
FIRM	Flood Rate Insurance Maps
GIS	Geographic Information System
GLISTEN	Great Lakes Innovative Stewardship Through Education Network
HES	Highly Erodible Soil
HUC	Hydrologic Unit Code
IBI	Index of Biotic Integrity
IC	Impervious Cover
ICM	Impervious Cover Model
IDEM	Indiana Department of Environmental Management
IDNR	Indiana Department of Natural Resources
INDOT	Indiana Department of Transportation
INDU	Indiana Dunes National Lakeshore
ISDA	Indiana State Department of Agriculture
IUN	Indiana University Northwest
kg	Kilograms
L	Liters
LCEB	Little Calumet East Branch
lb	Pounds
LTCP	Long Term Control Plan
µg	Microgram
mg	Milligrams
MGD	Million Gallons per Day
NIRPC	Northwestern Indiana Regional Planning Commission
NPDES	National Pollutant Discharge Elimination System
NPS	National Park Service
NRCS	Natural Resources Conservation Service
NTHCS	National Technical Committee for Hydric Soils
NWI	National Wetlands Inventory

NWIPA	Northwest Indiana Paddling Association
PCB	Polychlorinated Biphenyls
ppm	Parts per million
QHEI	Qualitative Habitat Evaluation Index
SHLT	Shirley Heinze Land Trust
SIPES	Social Indicator Planning and Evaluation System
SSURGO	Soil Survey Geographic (database)
SWCD	Soil and Water Conservation District
SWOT	Strength-Weakness-Opportunity-Threat (assessment)
TMDL	Total Maximum Daily Load
TSS	Total Suspended Solids
USGS	United States Geological Survey
USEPA	United States Environmental Protection Agency
USFS	United States Forestry Service
USFWS	United States Fish and Wildlife Service
WASP6	Water Quality Analysis Simulation Program, version 6
WHPA	Well Head Protection Area
WMP	Watershed Management Plan
WWTP	Waste Water Treatment Plant

1.0 Watershed Community Initiative

The Little Calumet River East Branch (LCEB) watershed is located within the Lake Michigan drainage basin. The LCEB is a watershed of interest due to its contribution of nutrients (primarily nitrogen and phosphorus), and potentially dangerous bacteria, *Escherichia coli* (*E. coli*), to the Great Lakes basin. A watershed is the area of land where all the water that drains off it goes to the same place. That drainage place is typically a river, a lake, or the ocean. All activities that take place in a watershed can affect the water quality of the surface and ground waters that drain it. Activities such as building construction, driving cars and trucks, growing crops, and fertilizing lawns can affect local water quality and the natural biological communities that live in our surface waters. A healthy watershed is essential for healthy waterways, enhancing the quality of life in our communities and supporting our local economies. Watershed planning is an important tool for helping communities come together to decide the best ways to preserve ecosystem functions, prevent and/or limit water quality impairments, and promote long-term environmental and economic health.

The LCEB watershed comprises approximately 47,293 acres (19,139 hectares or 74 square miles) and accounts for 12% of Lake Michigan's Little Calumet-Galien watershed that spans across Illinois, Indiana, and Michigan. The LCEB begins in unincorporated LaPorte County and flows west through unincorporated Porter County, the Indiana Dunes National Lakeshore (INDU), the towns of Burns Harbor, Chesterton, Ogden Dunes, Porter, and the City of Portage before converging with the West Branch of the Little Calumet River and discharging into Lake Michigan via the Burns Waterway (Figure 1). The LCEB watershed includes forest, grassland, wetland, agricultural, residential, commercial, industrial, and recreational land uses.

For nearly a decade, the Indiana Department of Environmental Management (IDEM) has reported water quality impairments for portions of the LCEB. The draft 303(d) listing for 2014 states that nearly all stream lengths in the LCEB watershed are impaired. These impairments include: *E. coli*, nutrients, impaired biological communities, chloride, and dissolved oxygen. Water quality impairments are further identified in the Little Calumet and Portage Burns Waterway Total Maximum Daily Load (TMDL) for *E. coli* bacteria (2004) (covering the larger Little Calumet River watershed), and in the Coffee Creek Watershed Management Plan (WMP) (2003), which covers portions of the Coffee Creek subwatershed. More information is necessary to identify pollutant sources and critical areas so that appropriate goals are clarified, which will help prioritize the most appropriate activities for long-term success. The 2004 TMDL states, "The current body of data clearly indicates that the system is impaired by *E. coli*. The indication is that the source of this impairment is from nonpoint sources." The Coffee Creek WMP confirms *E. coli* impairment in Coffee Creek. It also indicates high water temperature in the mainstem, low dissolved oxygen (DO), high total suspended solids (TSS), and impaired biotic community concerns in certain tributaries. While the Coffee Creek WMP provides historic water chemistry and biotic community data specific to Coffee Creek, little consistent, historic data exists related to other LCEB subwatersheds, including Reynolds Creek, Kemper Ditch, and their tributaries.

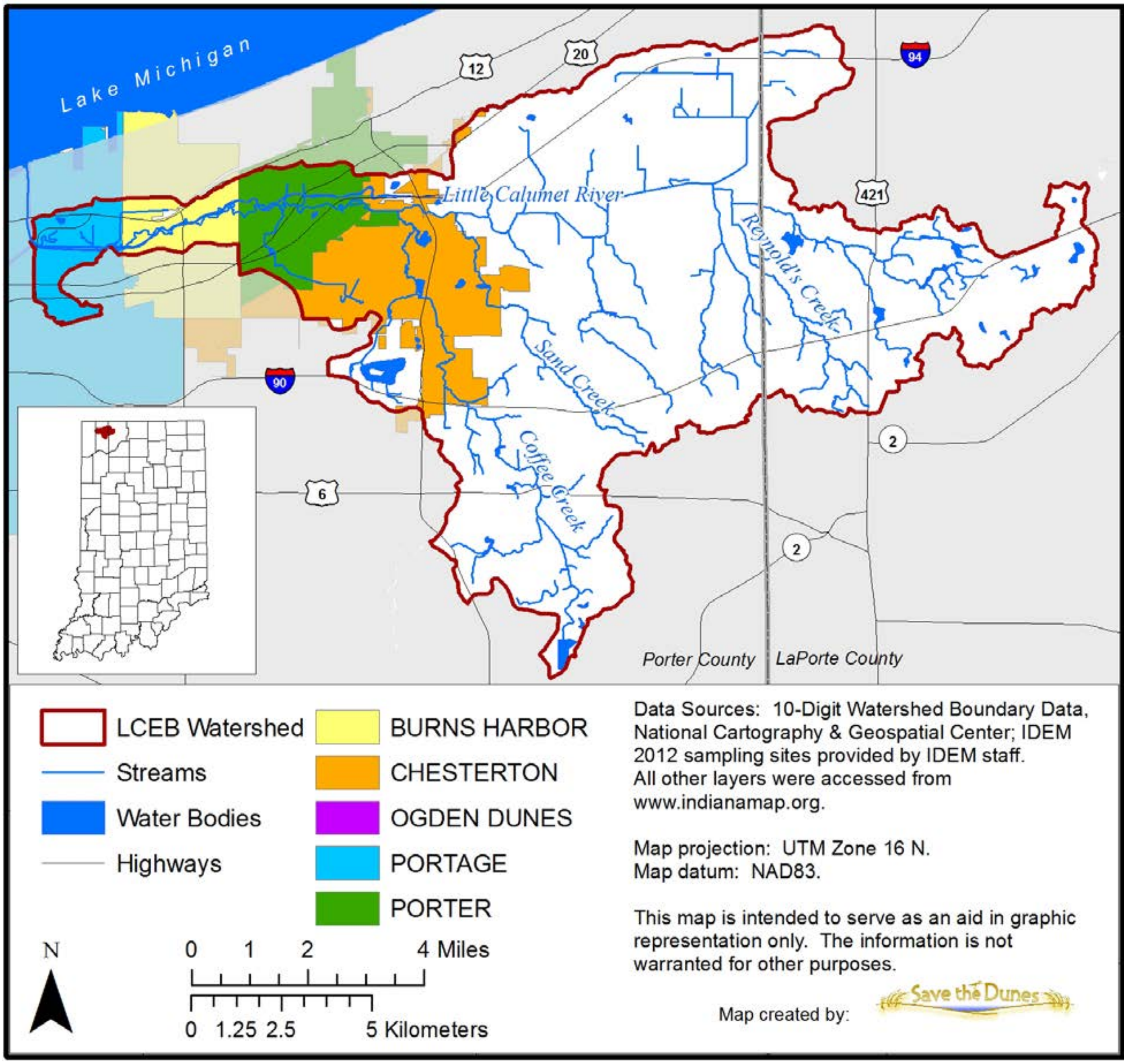

Figure 1. Little Calumet River East Branch watershed

1.1 Stakeholder Involvement

Save the Dunes is a non-profit organization whose mission is to preserve, protect and restore the Indiana Dunes and all natural resources of northwest Indiana's Lake Michigan watershed for an enhanced quality of life. Save the Dunes has coordinated successful watershed planning and implementation efforts in the adjacent Salt and Dunes Creek watersheds. The LCEB watershed is of particular importance to Save the Dunes because a significant stretch of the river flows through the Indiana Dunes National Lakeshore (INDU).

The organization also recognizes that as a major tributary to Lake Michigan, the LCEB has a large impact on Lake Michigan water quality and northwest Indiana's beaches.

Save the Dunes noted interest from northwest Indiana partners and stakeholders in developing the LCEB WMP. Between 2009 and 2011, while developing grant proposals to develop a LCEB WMP, Save the Dunes contacted and engaged many LCEB stakeholders. Stakeholder interest from the 2003 Coffee Creek WMP has remained high. The Town of Chesterton also expressed interest in a LCEB WMP, because much of the town drains to the LCEB. The National Park Service (NPS) acknowledged the impact of the LCEB watershed on INDU and expressed interest in developing a WMP. The NPS has also initiated an environmental assessment for the evaluation of recreation opportunities for parklands in the LCEB watershed. The Northwest Indiana Paddling Association (NWIPA) has begun working to implement Northwestern Indiana Regional Planning Commission's (NIRPC's) Greenways and Blueways Plan, which includes a 16-mile stretch of the LCEB.

Several local agencies and organizations provided letters of support for the grant proposals and committed to serving on a LCEB steering committee. The steering committee was assembled with representatives from local governmental agencies, environmental organizations, recreational organizations, and industry representatives (Table 1).

Stakeholder involvement is essential for the long-term success of the LCEB Watershed Management Plan. The plan ultimately belongs to the stakeholders who live and work in and around the LCEB watershed. To acquire input from the many residents, government agencies, industries, and businesses potentially impacted by the LCEB WMP, stakeholder involvement was generated through various education and outreach efforts. WMP activities, resources, and information were distributed to the public through local media, newsletters, public meetings, and local events. Overall, there were 12 public stakeholder meetings. A social indicator survey was also mailed to residents throughout the watershed. The survey gathered information on local knowledge of water quality issues and views on various water related topics. The survey also helped to inform residents of the WMP development and how to get involved.

Education and outreach events were conducted throughout the development of the WMP. The Watershed Education Unit for Brummitt Elementary School, which was conducted over an entire semester, included both indoor and outdoor activities for kindergarten through fourth grade students. The activities included water quality and macroinvertebrate sampling in the LCEB watershed. This program was well received by students, teachers and the Duneland School Administration. A field-training event was held at Indiana University Northwest. This event introduced IUN environmental science students to the Great Lakes Innovative Stewardship Through Education Network (GLISTEN) Program and the stringent field sampling protocols required for the collection of water quality data. GLISTEN students ultimately assisted with water quality sampling of the LCEB, providing useful data for the WMP. Other education and outreach events included a Day of Leisure and Learning on the Little Calumet River, Get Outdoors Day (hosted by the Dunes Learning Center), and Nature Night at Brummitt Elementary (hosted by the Izaak Walton League)

Table 1. LCEB steering committee members and affiliations

Affiliation	Committee Member
Town of Burns Harbor	Gene Weibel
Town of Chesterton	Jennifer Gadzala
Chesterton/Duneland Chamber of Commerce	Hesham Khalil
Coffee Creek Watershed Conservancy	Katie Rizer
Indiana Department of Natural Resources – Lake Michigan Coastal Program	Dorreen Carey
Indiana University Northwest/GLISTEN	Erin Argyilan
Izaak Walton League	Charlotte Read
LaPorte County Parks	Tim Morgan
LaPorte County Soil and Water Conservation District	Nicole Messacar
National Park Service	Lynda Lancaster
Northwest Indiana Forum	Kay Nelson
Northwestern Indiana Regional Planning Commission	Joe Exl
Northwest Indiana Paddling Association	Daniel Plath
Northwest Indiana Steelheaders	Michael Ryan
Town of Ogden Dunes/Nature Conservancy	Susan MiHalo
City of Portage	Jenny Orsburn
Porter County Planning Commission	Robert Thompson
Porter County Convention Recreation and Visitor Commission	Christine Livingston
Porter County Parks	Walter Lenckos
Porter County Soil and Water Conservation District	Jim Lambert
Town of Porter	Brenda Bruckheimer
Urban Waters Federal Partnership	Natalie Johnson
Shirley Heinze Land Trust	Kris Krouse
US Fish and Wildlife Service	Liz McCloskey

1.2 Stakeholder Concerns

In 2011, Save the Dunes, NPS, and NWIPA partnered to convene meetings of LCEB stakeholders. Initial stakeholder meetings included a Strength-Weakness-Opportunity-Threat (SWOT) assessment to evaluate the viability of the LCEB watershed plan stakeholders as a group. In 2012, Save the Dunes was awarded an IDEM Section 319 grant to coordinate the development of a WMP for the LCEB watershed. Save the Dunes held the first official LCEB WMP stakeholder meeting in February 2012. The meeting included an exercise to elicit stakeholder concerns. All expressed stakeholder concerns are listed in Figure 2.

Figure 2. LCEB stakeholder concerns

Elevated Pathogens

- **Pathogen loading from combined sewer and sanitary sewer overflows**
- **Public health effects from high *E. coli* concentrations**
- **High *E. coli* concentrations increased due to failing septic systems**
- **Pathogen loading polluting groundwater**
- **Integrate 2004 *E coli* TMDL**
- **Not meeting water standards**

Excessive Sediment and Nutrient Loading

- **Streambank erosion and sedimentation**
- **Degraded riparian corridors allow sediment and nutrient loading from runoff**
- **Highly erodible soils on cropland may contribute sediment**
- **Nutrient loading from combined sewer and sanitary sewer overflows**
- **Increased volume and flow causing erosion**
- **Erosion caused by woody debris**

Habitat, Biotic Communities and Hydrology

- **Need to protect fisheries and habitat**
- **Failing to meet water standards**
- **Fish consumption**
- **Need to understand geology and hydrology. Several habitat types in watershed**
- **Need permits for woody debris management and fisheries and habitat protections**
- **Promote conservation easements**
- **Need more environmentally friendly methods for ditch maintenance**
- **Need to protect bottomland, slopes, and highland**
- **Emerald ash borer killing trees, source of debris**
- **Invasive plants impact biodiversity and have impact on water quality/wetlands**
- **Fish habitat and passage for native non jumping fish**
- **Sedimentation in streams has a negative impact on fish habitat**
- **Need to fix tributary ditches environmentally or remove them**
- **Stormwater management, flood prevention efforts need improvement**
- **Methods of dredging ditches are having multiple negative impacts on the LCEB**
- **Increased volume and flow due to altered hydrology (regulated drains, ditches)**
- **LaPorte County Waste Management landfill, closed but may have impact**

Lack of Multijurisdictional Coordination

- Lack of funding to achieve all watershed goals
- Lack of septic system inspection and operation and maintenance programs
- Lack of cooperation between agencies to achieve watershed goals
- Conflicting missions between agencies and organizations
- No long term maintenance plan for watershed goals
- Local government adoption of the plan once complete
- Aging culverts and infrastructure
- Varied waterway use for owners and municipalities creates lack of mutual respect
- Need industry and land owners at the table
- Respect for each perspective. Find mutual benefit through process
- Need robust, long-term, sustained, meaningful monitoring

Public Access

- Lack of safe passage for paddlers due to excessive log jams/woody debris
- Culverts, bridges, beaver dams, and physical features to be addressed
- ADA compliance at existing and future access sites
- No continuous walking trail along LCEB
- Need to respect private property rights, locate access points in easements
- Create incentives and diminish disincentives for private property owners
- Need data and information on positive impact of trails for property owners
- Inventory and identify land owners
- Engage land owners in WMP process and increase communication
- Lack of river access sites – river and tributaries are out of public sight
- Advocating for full body contact despite *E. coli* and contaminants
- Need environmental assessment to evaluate paddling access in INDU
- Acquisition of land from farmers
- Two major branches flow under Highway 421
- Fishermen may be eating fish, despite 303(d) impairment for PCBs in fish tissue

Public Education and Involvement

- Public does not have enough access to information about LCEB or water quality
- Lack of press coverage for LCEB management efforts and water quality
- Not enough private property owners are directly involved in WMP process
- Environmental assessment should have public component
- Dumping of trash

Development of the LCEB WMP was funded in part through a Section 319 grant from IDEM. Public outreach associated with plan development was funded in part through a grant from the Indiana Department of Natural Resources (IDNR) Lake Michigan Coastal Program. IDEM's Watershed Assessment and Planning Branch conducted monthly watershed sampling. Save the Dunes partnered with Great Lakes Innovative Stewardship Through Education Network (GLISTEN) to have Indiana University Northwest (IUN) and Valparaiso University students conduct weekly sampling during the summer recreational period of 2012. A donation from a private donor was used to fund additional weekly sampling.

1.3 Social Indicator Survey

The social indicator survey provides a method to evaluate the attitudes, knowledge, and behavior of the LCEB residents. The LCEB WMP utilized the Social Indicator Planning and Evaluation System (SIPES) for Nonpoint Source Management. A regional team of researchers from University of Illinois, Purdue University, Michigan State University, University of Minnesota, The Ohio State University, and University of Wisconsin developed this system. The survey produced for the LCEB watershed was a subset of relevant questions provided by SIPES. The Social Indicators Data Management and Analysis (SIDMA) tool was also utilized to develop and administer our survey to all residents and landowners in the LCEB watershed. Addresses specific to the watershed were determined using GIS software.

SIPES protocols for constructing and disseminating the surveys were carefully followed. Five separate mailings of the survey were conducted to increase response rates (Dillman 2000). An advance notice letter was sent to potential respondents to inform them of the survey's purpose and to notify them of the survey's future delivery. The response rate for our survey was 28%, which is below the minimum suggested response rate of 40%. Consequently, care should be taken when interpreting the results of this study. Detailed responses to the survey can be found in Appendix 1.

Overall, respondents rated water quality of the LCEB as "okay," with "scenic beauty" as the most important quality related to water quality. "Scenic beauty" was also the most important activity related to water resources. Over 67% of respondents claimed to know where the rainwater goes when it runs off their property. However, it was unclear if those respondents were aware that their runoff eventually flows to Lake Michigan. Attitudes toward local water quality demonstrate that the majority of respondents believe that water quality is important, their actions do have an impact on water quality, and they are responsible for helping to protect the water quality. Respondents indicated they were willing to change certain behaviors (related to water quality), but were less enthusiastic toward paying to help improve water quality. A majority of respondents indicated they were unaware of the current level of water quality impairments in the LCEB. As an average, all identified sources of water pollution were considered a "slight problem" to "moderate problem." The consequences of poor water quality (e.g. contaminated drinking water, beach closures, and eutrophication) were viewed as a "slight" to "moderate" problem.

The most popular practices to improve water quality were proper disposal of household wastes (74%), keeping grass clippings out waterways (65%), and following manufacturer's instructions when fertilizing (56%). Nearly a quarter of respondents were unfamiliar with common non-point source (NPS) best management practices (BMP) such as grass swales (28%), wetland detention (22%), and porous pavement (26%). Constraints for implementing four specific management practices were evaluated. Many respondents were familiar with rain gardens, phosphate-free fertilizer, and rain barrels, yet over a quarter had never heard of the practices. A smaller portion of respondents is currently implementing the practices (11-17%). The majority of respondents (47%) did not consider proper pet waste disposal relevant because they did not have a pet. Respondents were fairly willing to implement the four practices: 29% for rain gardens, 37% for phosphate-free fertilizer, 47% for proper pet waste disposal, and 43% for rain barrels. Constraints for implementing the practices were limited. Only 23% of respondents were willing to participate in a cost-share program to implement the practices, while 46% were unsure.

Nearly half of respondents in the LCEB have a septic system (46%), while 52% have city sewer. The mean septic system is 27 years old and 79% indicated no problems in the past 5 years. Just over half the septic systems (53%) have an absorption field. 40% of respondents do not know if their septic system is designed to treat sewage or to just get rid of waste. Most recognized that slow drains (47%), sewage backups in the house (50%), toilet backups (47%), and bad smells (50%) are indicators of a dysfunctional septic system. Only 23% do not know the symptoms of a poorly functioning septic system. Owners of septic systems do not want maintenance/inspection reminders from their local health department (70%) and nearly half (48%) do not believe a local government agency should handle the inspection and maintenance of septic systems.

The average respondent was a 57-year-old male (57% male, 43% female) who has attended college (54%). More than 99% of respondents own their home, 55% of which are located in a city, town, or village. Total household income is fairly evenly divided from $25,000-to over $100,000. The average time at current residence was 20 years. Most respondents do not use a professional lawn care service (79%). When asked where they are likely to seek information about water quality issues, most respondents identified the internet (46%), and newspapers/magazines (43%). When asked about which information sources were trusted, most respondents indicated only moderate trust in all identified sources.

2.0 Watershed Inventory 1 – Watershed Description

2.1 Geology and Topography

The surficial topography and deposits of the LCEB watershed have been influenced by complex processes associated with glaciation and deglaciation of the region during the Wisconsin glacial stage and the subsequent evolution of the southern shoreline of Lake Michigan. The glacial deposits of the Valparaiso Morainal complex define the southern boundary of the Little Calumet-Galien (Hydrologic Unit Code (HUC - 04040001) watershed and function as the drainage divide with the Kankakee River (HUC- 07120001) watershed to the south.

The LCEB watershed is positioned across two physiographic regions including the Lake Michigan Border and Valparaiso Morainal Complex (Figure 3). The physiographic regions are based on topography and the surficial deposits. The watershed drains from an elevation of 950 feet along the Valparaiso Moraine to a low of 574 feet near Lake Michigan (Figure 4). The Valparaiso Morainal Complex physiographic region forms a 13-20 mile wide area that is characterized by morainal and alluvial deposits that grade to the southeast. Lakes can be found in the depressions of till areas and tunnel valleys formed by meltwater. Few natural lakes exist in the depressions of the alluvial fans because of their sandy nature and low water table. The Lake Michigan Border physiographic region forms a 4 to 11-mile wide area along the southern shore of Lake Michigan that includes a complex of beach ridge, dune, morainal, palustrine and lacustrine deposits (Figure 3).

The surficial sediments of the southern portion of the watershed consist primarily of mixed glacial drift deposits, which have eroded to form the subwatersheds and channels of Sand Creek, Coffee Creek, and Reynolds Creek. The percent slope of the landscape was calculated from the 30-meter resolution elevation data from the National Elevation Dataset and was analyzed using ArcMap 10's Spatial Analyst. The steepest slopes in the watershed approach nearly 23% and can be found at the headwaters along the Valparaiso Moraine where the clay component of glacial till provides cohesion for surface sediments and also limits the infiltration capacity of the landscape. IDEM's Indiana Storm Water Quality Manual (IDEM 2007) defined steep slopes as those exceeding 15 percent.

The surficial sediments of the northern portion of the basin are a complex of lacustrine silt and clay, shoreline beach and dune deposits, and exposures of clay-rich till deposits of the underlying Lake Border moraine (Figure 5). The main channel of the LCEB flows westward through the lacustrine beach and dune sands until eroding into lake silt, clay and alluvium deposits as the river nears Burns Waterway. The northeast portion of the watershed consists of alluvium and clay-rich deposits associated with exposure of deposits of the Lake Border Moraine.

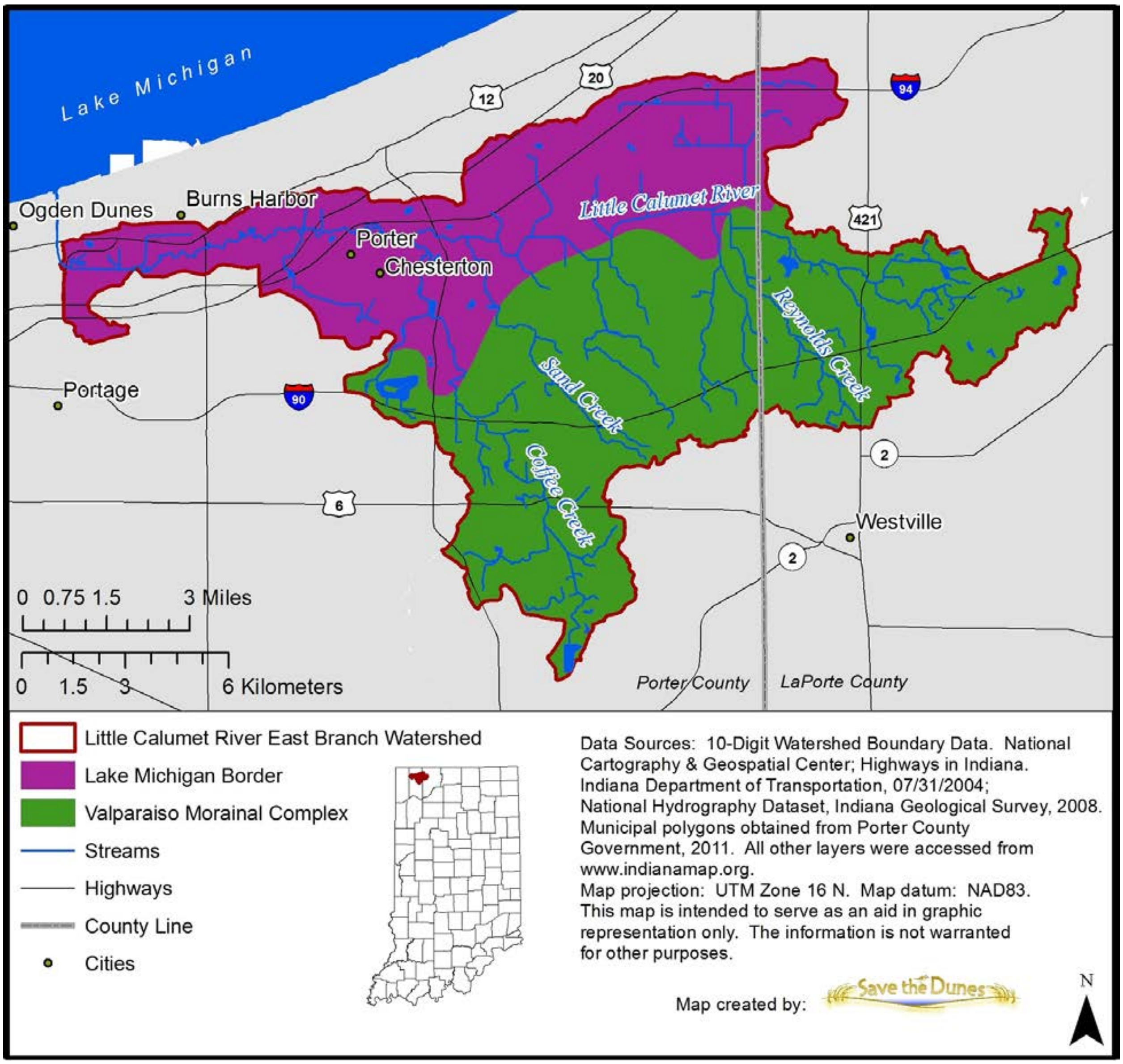

Figure 3. Physiographic regions in the LCEB watershed

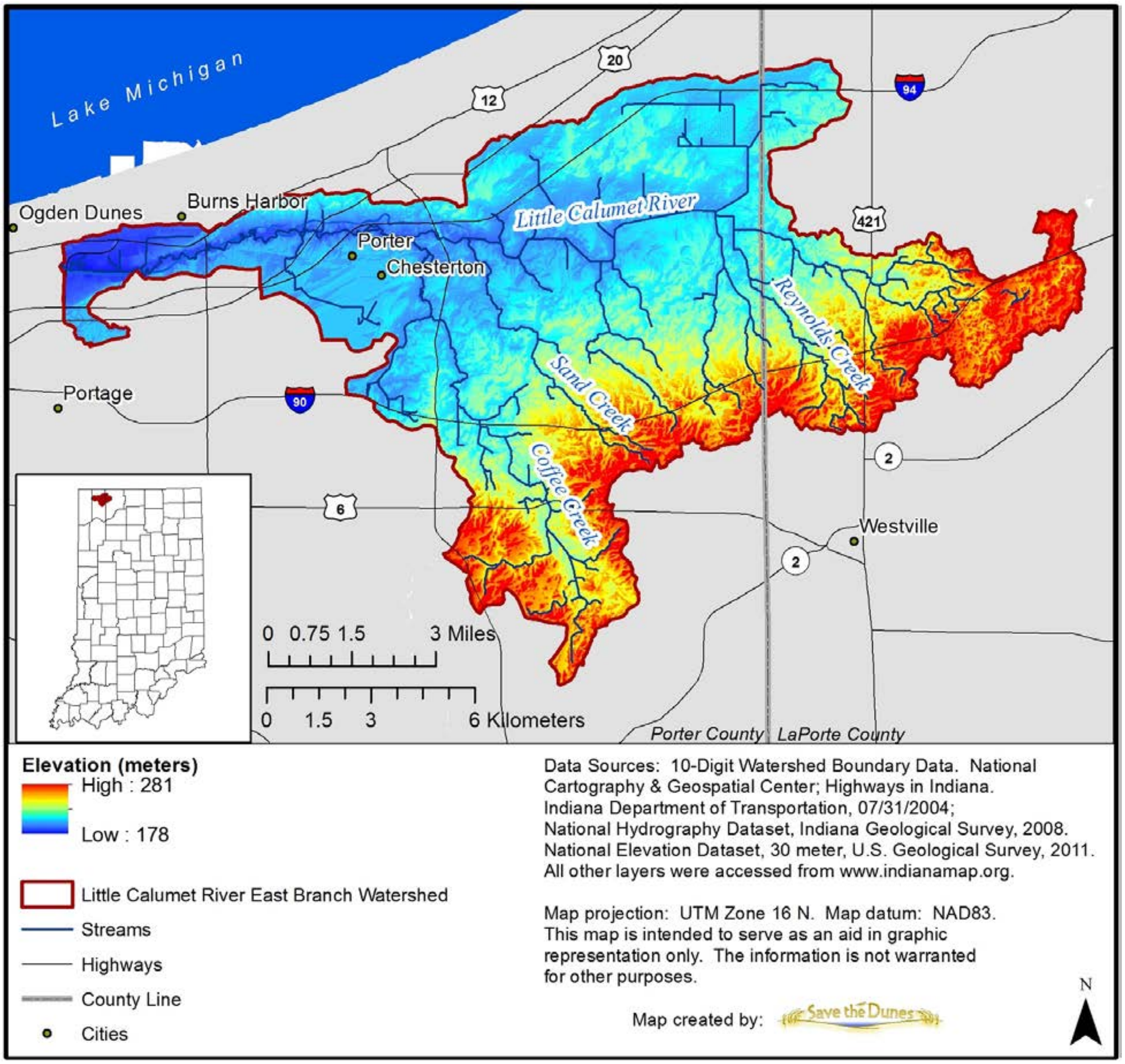

Figure 4. Physiographic relief in the LCEB watershed

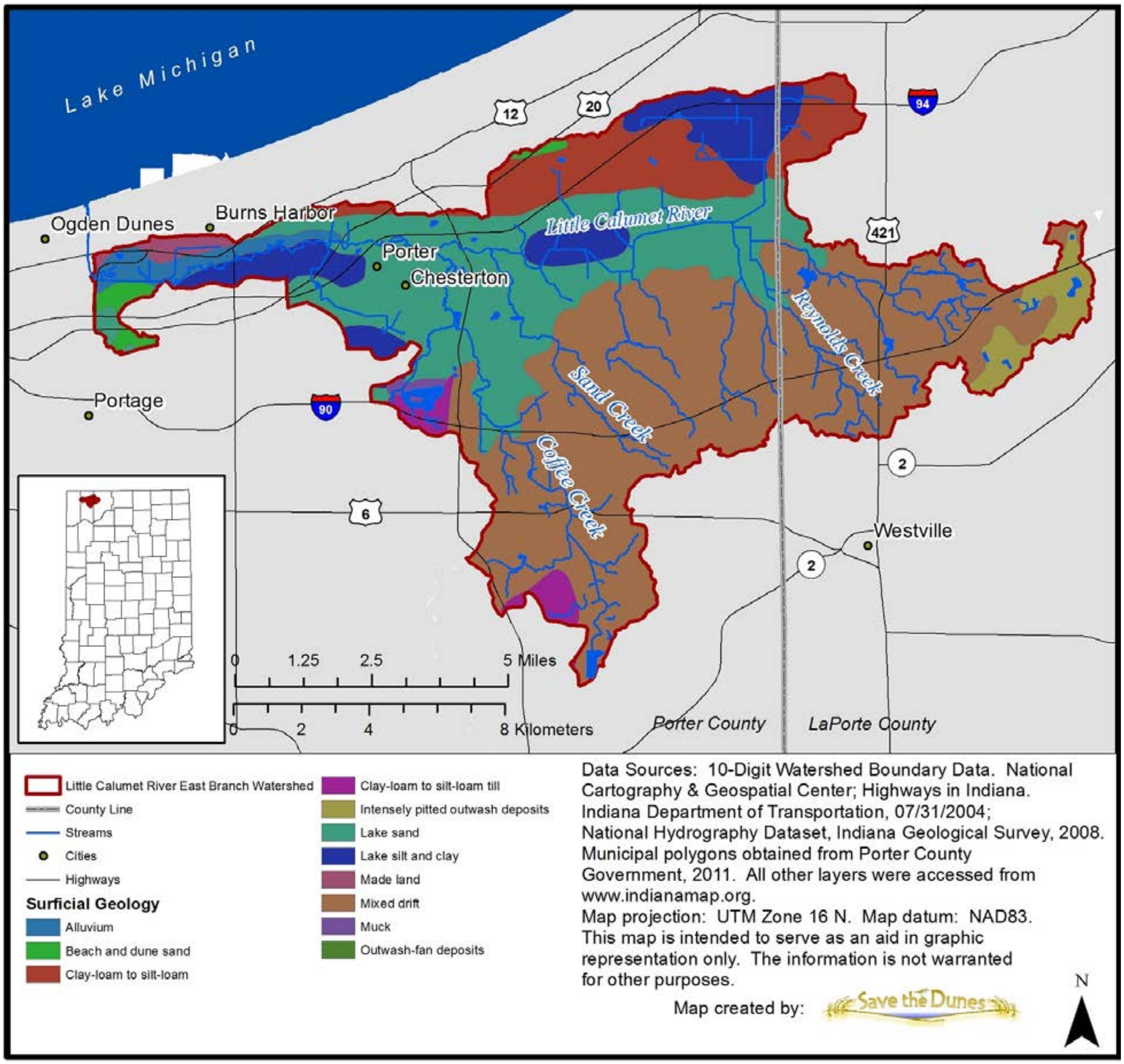

Figure 5. Surficial geology in the Little Calumet River East Branch watershed

2.2 Hydrology

The LCEB watershed (HUC 10 - 0404000104) is a subwatershed of the Little Calumet-Galien watershed (HUC 8 - 04040001). HUCs, or hydrologic unit codes, can be thought of as numeric addresses, or designations, that describe both the size and location of a watershed.

Table 2. Hydrological Unit Code (HUC) designations for the LCEB

HUC 8	HUC 10	HUC 12	Name
04040001			Little Calumet-Galien
	0404000104		Little Calumet-East Branch
		040400010401	Reynolds Creek
		040400010402	Kemper Ditch
		040400010403	Coffee Creek

Watershed HUCs with 8 digits are the largest in Indiana, 10 digit HUCS represent smaller, medium-sized watersheds nested within the 8 digit watersheds (such as the LCEB watershed), and 12 digit HUCs represent even smaller watersheds nested within the 10 digit HUC basins. All of the 10 digit HUCs share the first 8 digits of the larger basin in which they are located, and the 12 digit HUCs share the first 10 digits of the HUC 10 watersheds in which they are located. Within the LCEB watershed, there are three 12-digit HUC subwatersheds: Coffee Creek (HUC 12- 040400010403), Kemper (Carver) Ditch (HUC 12 - 040400010402), and Reynolds Creek (HUC 12 - 040400010401) (Figure 6).

Stream order is a common stream classification system which helps describe a river's size and watershed area; the greater the stream order, the greater the size and watershed area (Allen, 1995). Headwater streams, such as Reynolds Creek, are considered first order. As additional streams join, the order is increased. The LCEB mainstem is a fourth order stream just before it enters Burns Waterway.

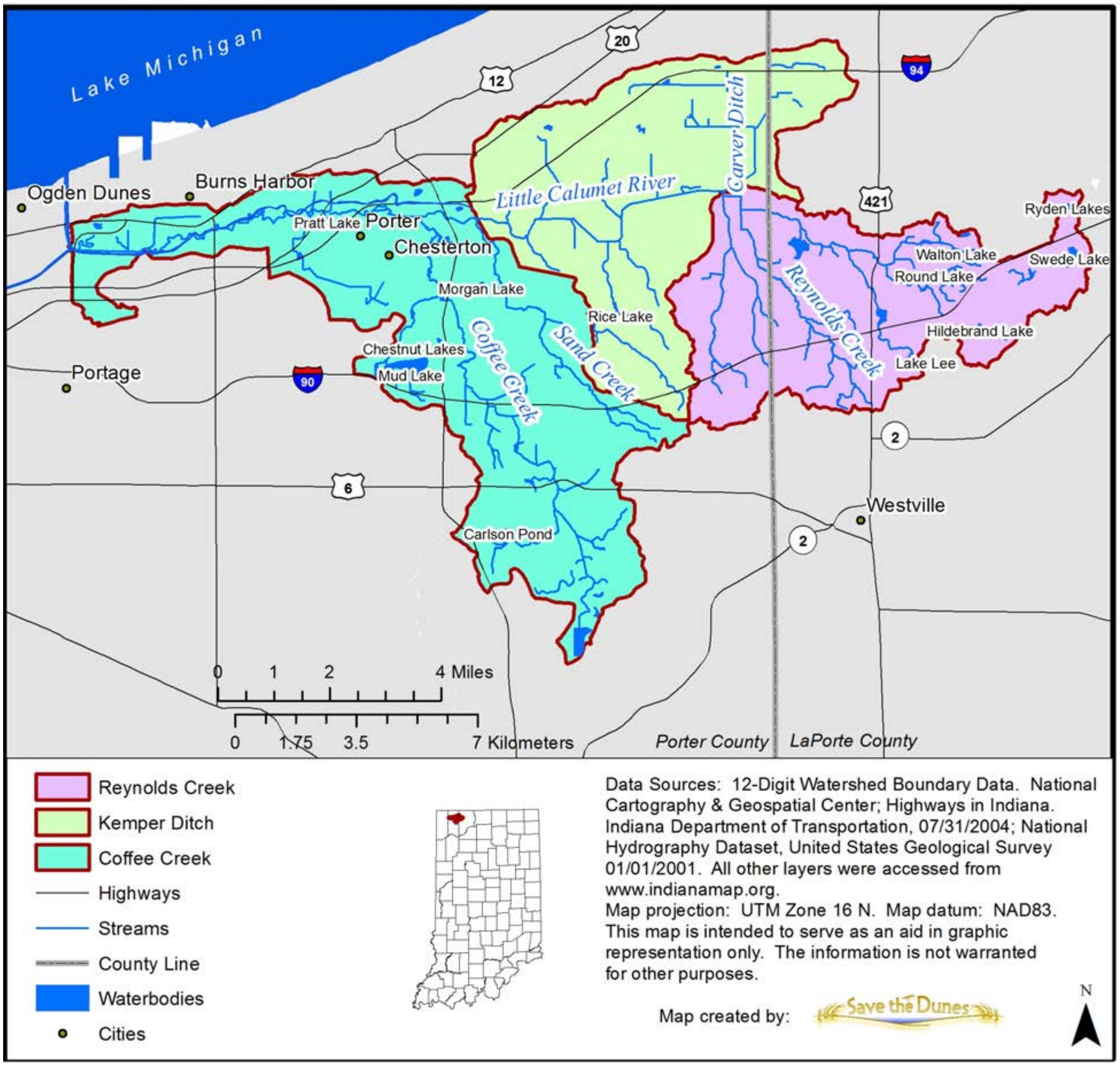

Figure 6. 12-digit hydrologic unit code subwatersheds

Table 3 contains the lengths of streams and areas of lakes in the LCEB watershed.

Table 3. Stream lengths and waterbody areas

	Length (miles)
Artificial Path	15
Canal/Ditch	28
Connector	0
Stream/Rivers	81
Regulated Drains	45
Total	**169**

	Area (acres)	Number
Swamp/Marsh	938	198
Lake/Pond	568	214
Reservoirs	3	11
Total	**1509**	**423**

Regulated Drains

In total, there are over 45 miles of regulated drain within the watershed. This figure is an underestimate, as it shows only the regulated drains that correspond with a stream segment in the National Hydrography Dataset (Figure 7). A regulated drain (legal drain) is an open channel or closed tile/sewer that is subject to the provisions of the Indiana drainage code, I.C.-36-9-27. Under this code, a drainage board has the authority to construct, maintain, reconstruct or vacate a regulated drain. The board can maintain the regulated drain by dredging, clearing, repairing tile, removing obstructions or other work necessary to keep the drain in proper working order based on its original specifications. The LCEB stakeholders noted ditch maintenance and dredging as a watershed concern (Figure 2).

Floodplains

Floodplains are a natural feature of streams and rivers. Flooding is a natural process that is critical to the health of a stream. Floodplains can temporarily store floodwater, dampen peak flows, maintain baseflow, dissipate energy and reduce erosive stress on streambanks. While water is stored in the floodplain, pollutants can settle out or be filtered by vegetation. Development in floodplains can lead to property damage due to flooding and can impair the ability of the floodplain to retain water. Figure 7 shows floodplains created from the Federal Emergency Management Agency (FEMA) 2004 Flood Insurance Rate Maps (FIRM). There are over 4,500 acres of floodplain in the LCEB watershed. The LCEB stakeholders noted flood prevention as a concern (Figure 2).

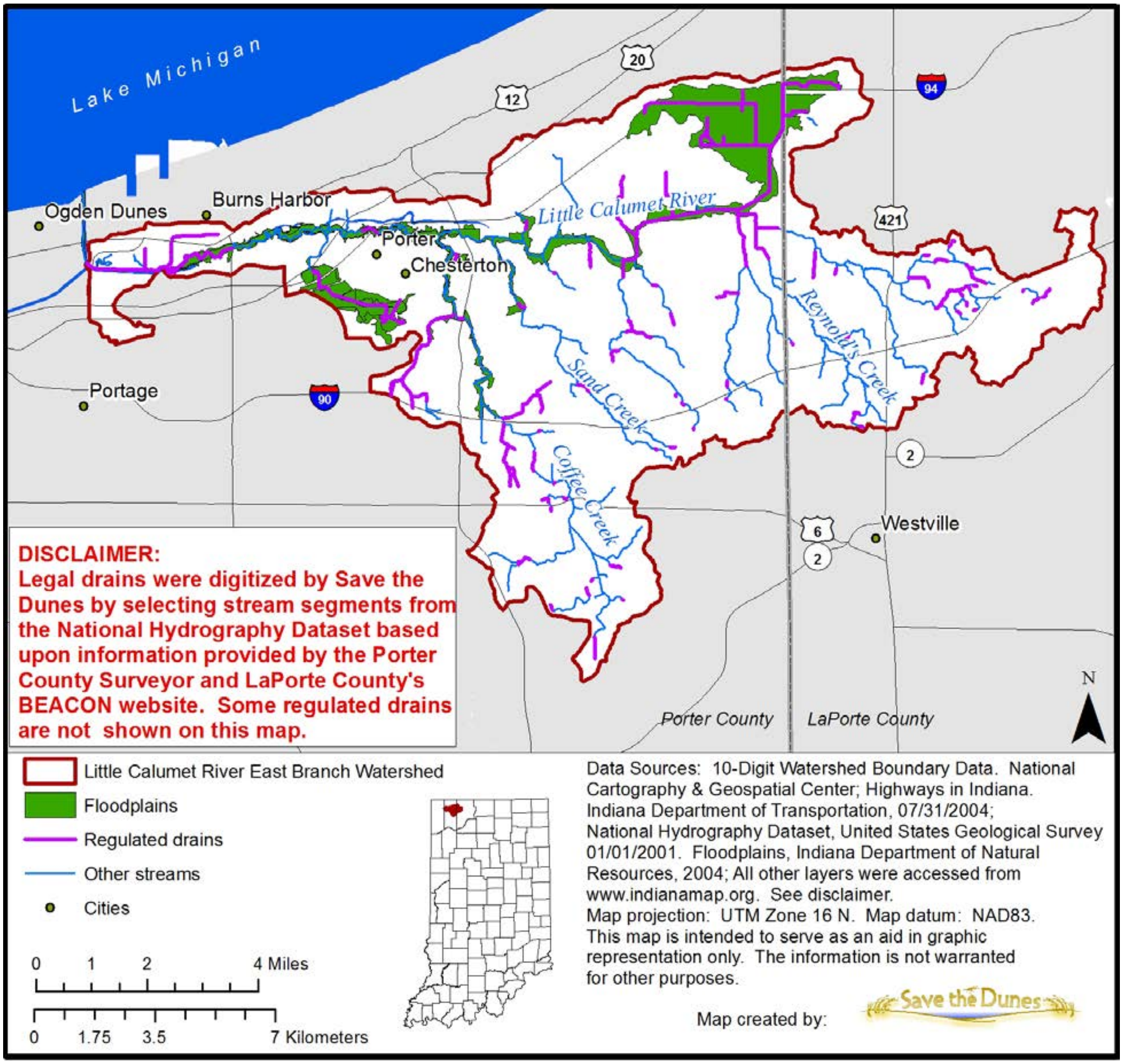

Figure 7. Floodplains and regulated drains in the LCEB watershed

There is one USGS stream gauge (04094000) in the LCEB watershed. Located on the mainstem at US Highway 20 and Mineral Springs Road in Porter, Indiana, this gauge is at the same location as our sampling site 9 (Figure 37). The USGS has recorded flow from this gauge since 1945 to present. Large amounts of historic and current flow data can be used to create a flow duration curve (Figure 8), which can show how current flow rates compare to the long-term flow regime. Load duration curves can also help inform us if pollutants are exceeding water quality targets during low-flow (dry) conditions or high-flow (storm) events, by plotting chemistry data against the flow duration curve. This can be useful during extreme weather years, such as the drought in 2012, because it can help with the interpretation of data collected during extreme conditions. Figure 8 shows the LCEB's historical flow from 1945 to 2011, while Figure 9 shows the LCEB's flow for 2012. The flow for the drought year (2012) does not appear to be substantially different from the long-term flow. Because the flow gage is located at the base of the watershed, it is not unusual that the 2012 drought did not greatly reduce discharge at this site. Many streams in the LCEB are groundwater fed, which would maintain a constant streamflow despite the lack of precipitation. The gage site is also downstream of Chesterton's wastewater treatment plant. Since Chesterton's drinking water is obtained from Lake Michigan, their wastewater did not originate from the LCEB. Therefore, effluent from the wastewater treatment plant supplements the downstream flow. The change in flow due to drought can also be depicted by comparing the mean monthly flows (Figure 10) to the long-term flow duration curve values for high and medium flow rates (Figure 8). The curves shown in Figure 8 and 9 were created using Purdue University's Load Duration Curve Tool.

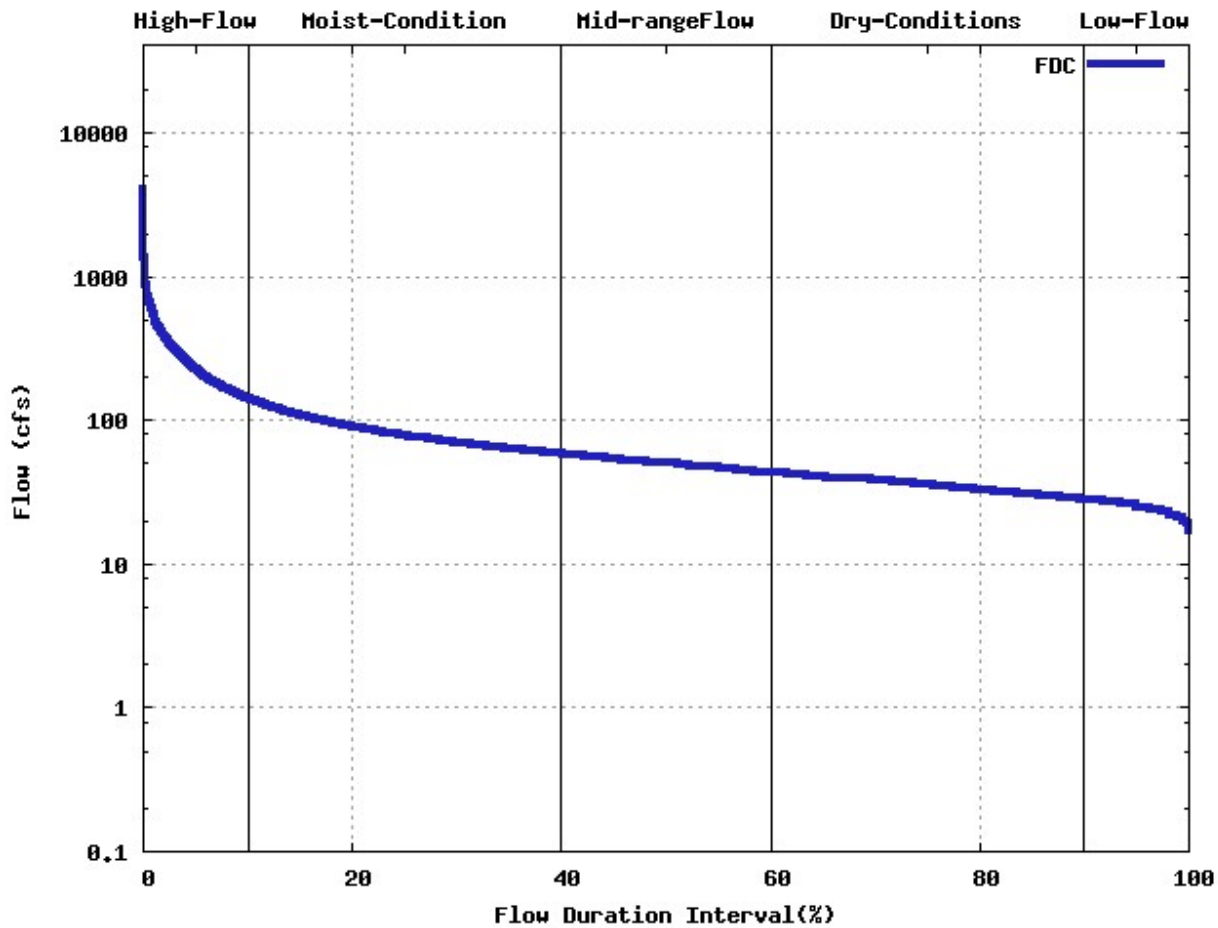

Figure 8. Historical flow duration curve for the LCEB (1945-2011)

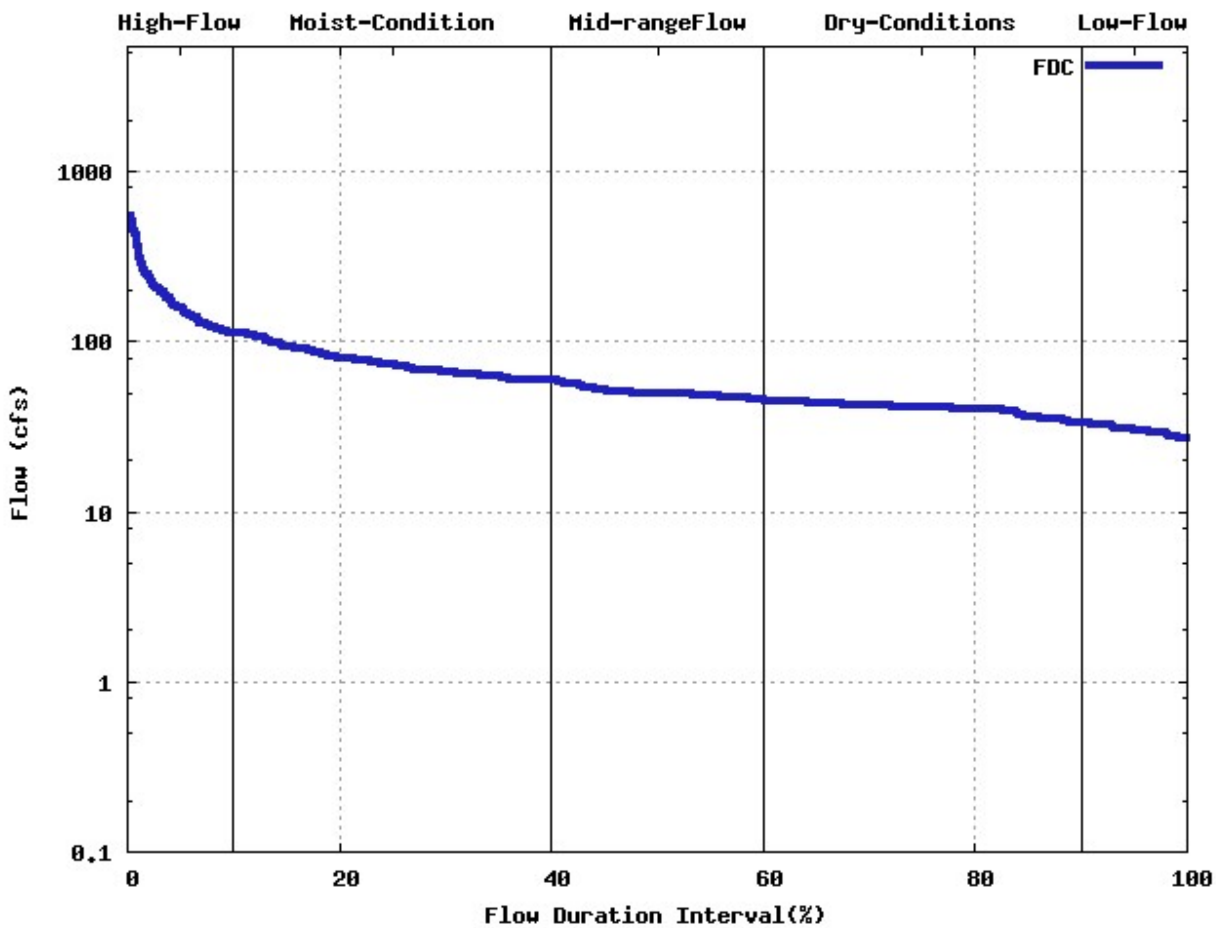

Figure 9. 2012 flow duration curve for the LCEB

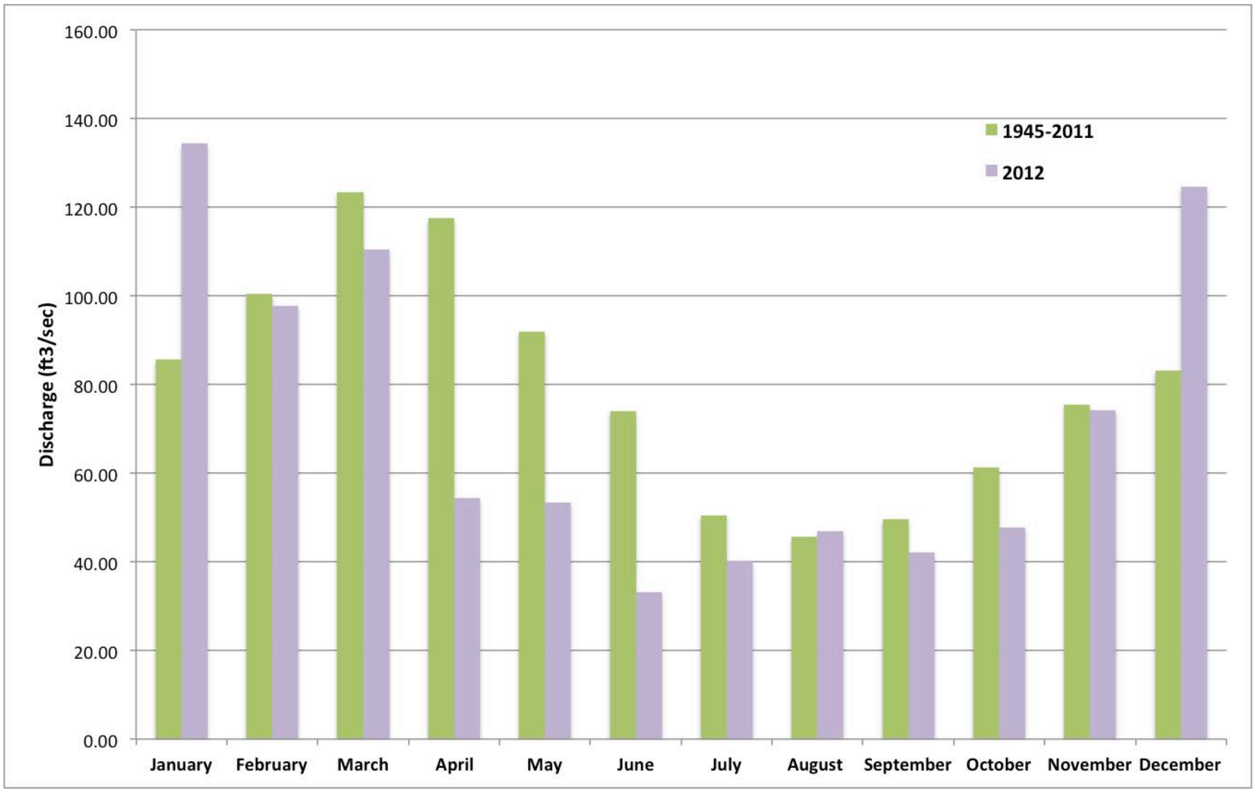

Figure 10. Mean monthly flows in the LCEB (USGS gage 04094000 at Porter, Indiana)

Wetlands

Wetlands provide numerous services, including flood control, plant and wildlife habitat, water filtration, and recreational opportunities. Wetlands function as natural sponges, temporarily storing water and slowly releasing it. This slows the peak volume and velocity of water reaching our streams after a storm, which can reduce streambank erosion and flooding. The slow release of water recharges groundwater and maintains base flow in streams. While water is stored in wetlands, suspended pollutants, such as sediment, settle out of the water column or are filtered by vegetation. Other pollutants, such as nitrogen and phosphorus, also settle to the bottom with the sediment. Wetland plants are then able to acquire these nutrients through their roots. Wetland plants are also able to remove dissolved nutrients directly from the water column. Another important benefit of wetlands is their aptitude for removing nitrogen through denitrification; this process converts nitrate to nitrogen gas. Individual wetlands vary in the functions they perform and how well they perform them. Wetland functions vary based upon soil characteristics, vegetation types, size, depth, location in the watershed, and the quality and quantity of water entering the wetland.

National Wetland Inventory (NWI) wetlands are shown in Figure 11. The NWI is a database of wetlands maintained by the USFWS (United States Fish and Wildlife Service). Aerial photograph interpretation techniques were used to compile the NWI. The NWI was not intended to produce maps that show exact wetland boundaries comparable to boundaries derived from ground surveys. Boundaries are generalized in most cases. There are over 5,683 acres of wetlands in the LCEB watershed, which is approximately 12% of the watershed. The NWI is a useful tool for reviewing wetlands, but field verification is essential.

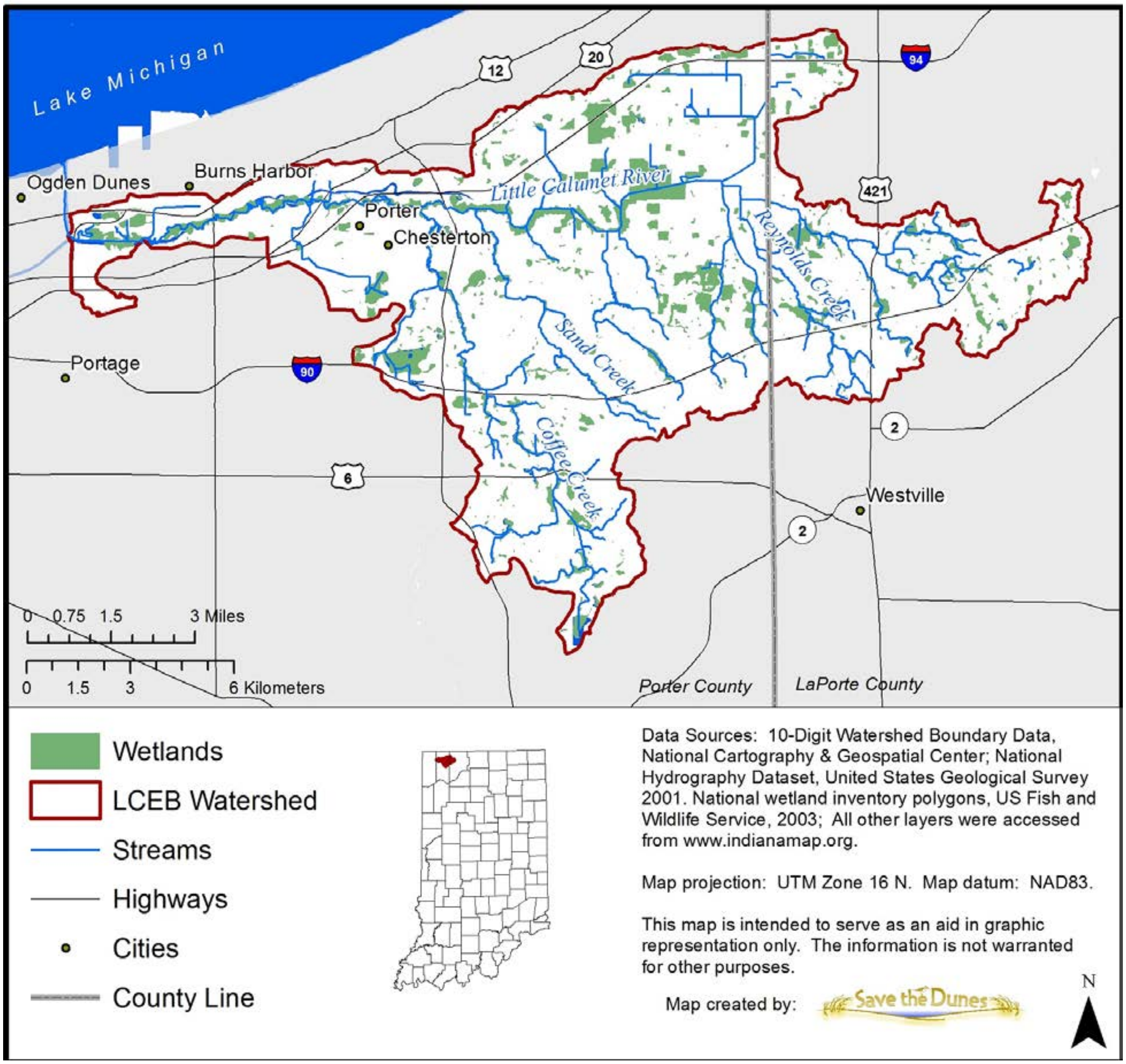

Figure 11. National wetland inventory wetlands in the LCEB watershed

Table 4. Wetland acreage by type

Wetland Type	Acres	Percent of total
Palustrine Forested	3402	60%
Palustrine Emergent	914	16%
Palustrine Unconsolidated Bottom	361	6%
Palustrine Scrub-shrub	211	4%
Palustrine Emergent Forested	193	3%
Palustrine Forested/Scrub-shrub	171	3%
Palustrine Emergent Scrub-shrub	147	3%
Palustrine Aquatic Bed	104	2%
Lacustrine Limnetic	64	1%
Lacustrine Littoral	56	1%
Palustrine Aquatic Bed Scrub-shrub	27	<1%
Riverine Lower Perennial	27	<1%
Palustrine Emergent Dead Forest	6	<1%
Palustrine Unconsolidated Excavated Shore	1	<1%
Total	5683	100%

2.2.a Historic Use and Hydrologic Modification

Hydrology has been extensively modified in the LCEB watershed. Prior to European settlement, Native Americans used the River for navigation and fishing. European explorers first entered the area in the mid-1600s with European settlement beginning in the early 1800s. Tributaries were used for mill power in the 1800s. Today, ten dams exist in the watershed (Figure 12). Commercial navigation plans for the LCEB River were developed as early as 1850s. Historically, the Little Calumet River began in unincorporated LaPorte County, meandered west through Porter and into Lake County, and turned back into Porter County, where it discharged into Lake Michigan. In 1926, the completion of Burns Waterway connected the river to Lake Michigan and split it into the East and West branches. The Towns of Chesterton and Porter developed along the LCEB in the mid-1800s and used the river for drainage and discharge of wastes. Sections of the LCEB were dredged and straightened from Chesterton Wastewater Treatment Plant upstream. Wetlands were once common throughout northwest Indiana, but were drained in the 1800s and early 1900s to allow for agriculture and urban development. Comparing the area of hydric soils to the area of existing wetlands in the NWI can yield an estimation of the area of drained historic wetlands. Using this approach, it was shown that approximately 4,054 acres of wetlands were converted to urban or agricultural land in the LCEB watershed.

Hydrologic modification in the watershed is evidenced by the large amount of ditches and artificial paths (Table 3). Tile drains in agricultural areas and storm drain systems in urban areas also contribute to altered hydrology. Over time, development in the LCEB watershed has increased, which has led to an accumulation of impervious surfaces in the watershed. Increase in development is described in further detail in Section 4 of this document, which discusses land use and land cover in the LCEB watershed. The increase in hard surfaces has reduced infiltration potential in developed areas and has led to increased velocities and volumes of runoff in some areas, which can lead to erosion of stream channels and excess sediment in streams. The increased runoff volume also contributes to nonpoint source pollution in the watershed, as the pollutants present on the land are carried over these impervious areas into receiving rivers and tributaries. Increased amounts of impervious surfaces in natural floodplains also reduce the ability of the floodplains to keep floodwater near the stream, which can lead to increased flooding in developed areas, and reduce the infiltration that those areas would otherwise provide. Increases in impervious surfaces are also associated with increased water temperatures. Pavement, rooftops, and other hard surfaces tend to absorb heat, which warms the runoff that eventually drains into a river, ditch, or storm drain. The LCEB watershed is naturally a cold water aquatic community- a salmonid hydrologic system- that requires much colder temperatures to support the aquatic ecosystem. The LCEB stakeholders noted increased volume and flow due to altered hydrology as well as the need to protect fisheries and habitat as concerns (Figure 2).

Dams

Dams are another common source of hydrological modification in the sub-basin. They were generally built to store and provide water for mechanical power generation (e.g., waterwheels to mill grain) and recreation (e.g., boating and fishing). However, dams can also be associated with a number of negative impacts including changes to hydrology, water quality, habitat, and river morphology. Human activities, such as agricultural and urban land uses, can contribute to contaminant and sediment loads to the impoundments by these dams. There are 10 dams located within the watershed (Figure 12). Drainage area, storage capacity, and hazard potential for each dam are shown in Table 5. Hazard potential refers to the "possible adverse consequences that result from the release of water or stored contents [of a reservoir] due to failure of a dam or mis-operation of the dam (FEMA 2004)." Adverse consequences refer to the risks associated with the failure of a dam, including loss of human life, economic losses (including property damage), lifeline disruption, and environmental impacts. It is important to note that the hazard potential rankings, described below, are not related to the present condition of the dam, including structural integrity, safety, or other factors.

Dam Hazard Potential Classification

1. Low Hazard Potential

Dams assigned the low hazard potential classification are those where failure or mis-operation will result in no probable loss of human life and low economic and/or environmental losses. Losses are principally limited to the owner's property.

2. Significant Hazard Potential

Dams assigned the significant hazard potential classification are those dams where failure or mis-operation will result in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or can impact other concerns.

Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.

3. High Hazard Potential

Dams assigned the high hazard potential classification are those where failure or mis-operation will probably cause loss of human life.

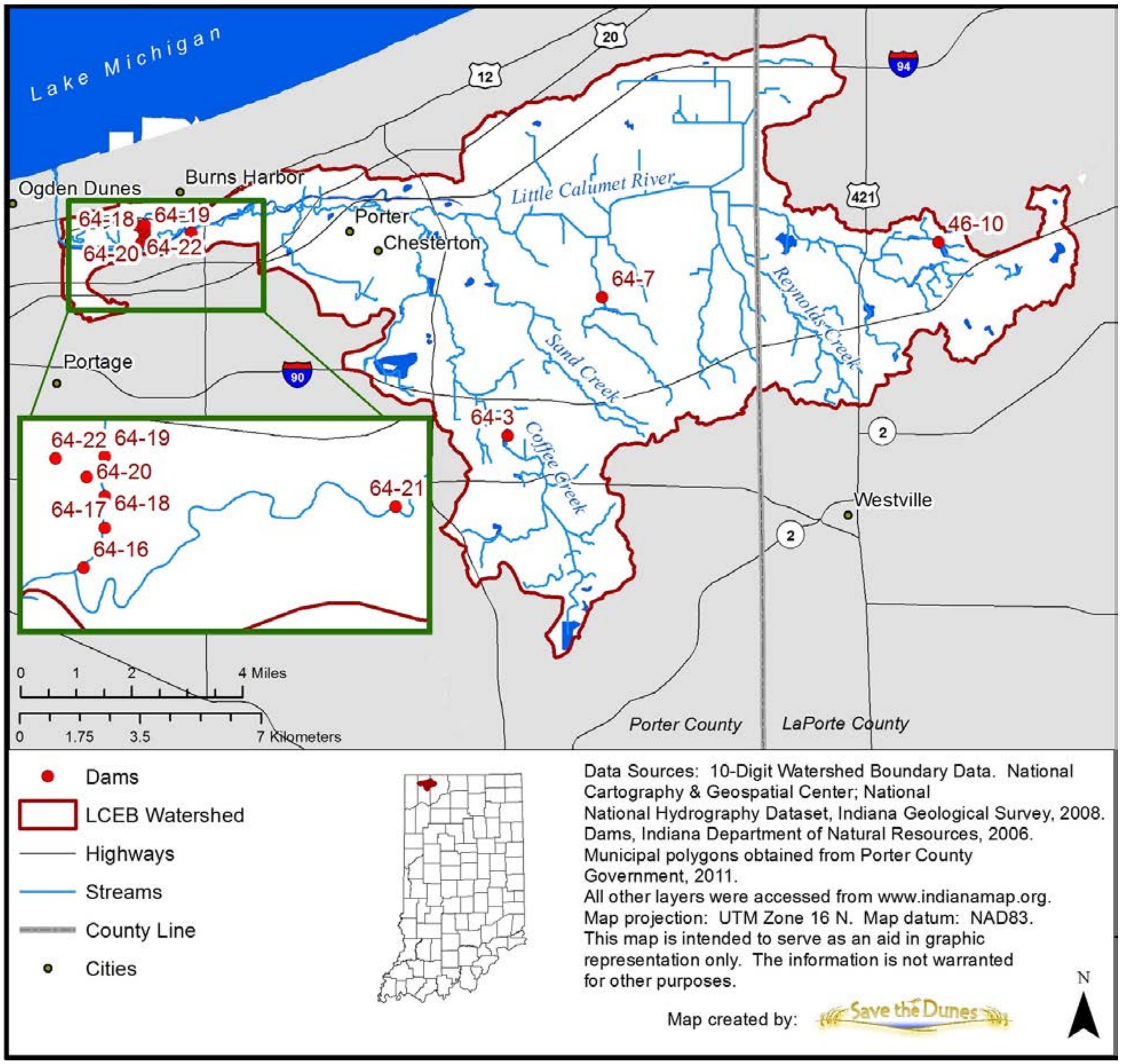

Figure 12. Dams in the LCEB watershed

Table 5. Dams in the LCEB watershed

State ID	Name	Drainage Area (mi^2)	Maximum Storage Capacity (Ac-Ft)	Potential Hazard
64-3	Old Longs Mill Dam	7.59	81	Significant
64-7	Rice Lake Dam	2.71	200	Significant
64-16	Bethlehem Steel Check Dam No. 1	2	0	Low
46-10	Walton Lake Dam	0.36	180	Low
64-17	Bethlehem Steel Check Dam No. 2	2	0	Low
64-21	Praxair Dam	70	0	Low
64-18	Bethlehem Steel Check Dam No. 3	2	0	Low
64-20	Bethlehem Steel Check Dam No. 5	0	0	Low
64-22	Bethlehem Steel Check Dam No. 6	0	0	Low
64-19	Bethlehem Steel Check Dam No. 4	2	0	Low

Stakeholders for the Praxair Dam, located on the LCEB mainstem in Burns Harbor, are engaged in ongoing discussions to evaluate the future of this dam. It is too early in this process to declare possible outcomes from these discussions.

2.2.b Current Use and Jurisdictions

Today, the LCEB and its tributaries are used by multiple entities for a number of purposes. The LCEB stakeholders expressed concern over the impacts associated with many of these uses, including dredging regulated drains; woody debris management; agricultural runoff; increased stormwater volumes; and combined sewer overflows (Figure 2). Several sections of the LCEB and its tributaries are designated as legal drains and are regularly maintained by the Porter County Surveyor's Office (Figure 7). The LCEB and its tributaries are extensively used for agricultural drainage, with tile drains and agricultural drainage ditches connecting to tributaries, particularly in the upstream portions in unincorporated LaPorte and Porter counties. Portions of the communities of Burns Harbor, Chesterton, Ogden Dunes, Portage, and Porter are within the watershed. The LCEB and its tributaries flow through these communities and are used for such purposes as recreation, drainage, and acceptance of wastewater treatment outflows. Similarly, industrial users, including ArcelorMittal, use the LCEB to discharge wastewater. Wetlands throughout the watershed are valuable for flood control and wildlife habitat. Due to a prevalence of open lands, hunting and fishing are popular outdoor activities in the LCEB watershed. Game such as waterfowl and fish, including trout and other salmonids are abundant in parts of the LCEB. Forests, grasslands, riparian areas, and wetlands provide appropriate habitat for these populations.

The LCEB and its tributaries are used for recreational purposes, including paddling, fishing, and aesthetic values. Several parks and preserves exist along the LCEB, including Red Mill County Park, Shirley Heinze Land Trust (SHLT) properties, and the INDU Heron Rookery.

The LCEB flows through INDU at its downstream end and ultimately discharges to Lake Michigan via Burns Waterway, near popular swimming beaches. Consequently, the LCEB directly impacts natural resources and recreational uses at INDU. The LCEB and its tributaries also impact aquatic communities in adjacent and connected habitats. All waterways within INDU boundaries, including portions of the LCEB, are designated as Outstanding State Resource Waters. Sections of the LCEB are designated as salmonid streams and are popular locations for fishing. Sections of the LCEB are designated by the State of Indiana as Navigable Waterways.

NWIPA was founded in 2009 as a non-profit organization dedicated to developing the region's paddling resources and opportunities, providing environmental stewardship of the region's waterways, education, and to be a link between the region's paddlers. NWIPA envisions a 16-mile-long water trail along the LCEB, spanning from the Heron Rookery in unincorporated Porter County to Lake Michigan. NWIPA and its volunteers are working to open up the LCEB for kayakers by clearing log jams and organizing trash clean ups. The Portage Public Marina is located on the Burns Waterway and is partially within the LCEB watershed. The Marina facilitates boat launching onto Lake Michigan and fishing from the pier. The LCEB stakeholders expressed concern over facilitating public access, while also respecting private property rights and protecting natural resources (Figure 2).

2.3 Soil Characteristics

Soils can play a large role in the water quality of a watershed. The physical, chemical and biological properties help to determine a soil's characteristics such as erodibility, water holding capacity, and fertility. Understanding a watershed's soil properties can assist with identifying the source of water quality pollutants or inform appropriate development/land uses that reduce or eliminate detrimental impacts to water quality. The diversity of soil characteristics present in the LCEB emphasizes the need for variable approaches to reduce nonpoint source water pollution.

Soil Associations

A soil association is a group of soils that are geographically related and located in characteristic repeating patterns across the landscape. The soil series for which the association is named are rarely; if ever, the only soils that exist in the soil association. Soil associations typically contain several different soils of minor extent. Actual soil types may vary widely within a given association, particularly in areas dominated by glacial till soil types, such as the LCEB watershed. Specific soil types will vary within a given parcel. The LCEB watershed is comprised of nine major soil associations, listed below and in Figure 13.

- Blount-Glynwood-Morley
- Blount-Rewamo-Glynwood
- Bourbon-Sebewa-Pinhook
- Coloma-Spinks-Oshtemo
- Houghton-Adrian-Carlisle

- Morley-Markham-Ashkum
- Rensselaer-Darroch-Whitaker
- Riddles-Crosier-Oshtemo
- Tracy-Chelsea-Tyner

Each name in a soil association refers to a specific soil series, which is precisely defined for for taxonomic classification. All soil series named in the above soil associations are described below.

Adrian: The Adrian series consists of very deep, very poorly drained soils formed in herbaceous organic materials over sandy deposits on outwash plains, lake plains, lake terraces, flood plains, moraines, and till plains. Slope ranges from 0 to 1 percent.
Ashkum: The Ashkum series consists of very deep, poorly drained soils on till plains. They formed in colluvial sediments and in the underlying silty clay loam till. Slope ranges from 0 to 3 percent.
Blount: The Blount series consists of very deep, somewhat poorly drained soils that are moderately deep or deep to dense till. Blount soils formed in till and are on wave-worked till plains, till plains, and near-shore zones (relict). Slope ranges from 0 to 6 percent.
Bourbon: The Bourbon series consists of deep, somewhat poorly drained soils that formed in sandy glacial deposits on outwash plains, valley trains and sandy lake plains. Permeability is moderately rapid over rapid. Slopes range from 0 to 2 percent.
Carlisle: The Carlisle series consists of very deep, very poorly drained soils formed in woody and herbaceous organic materials in depressions within lake plains, outwash plains, ground moraines, flood plains and moraines. Slope ranges from 0 to 2 percent.
Chelsea: The Chelsea series consists of very deep, excessively drained soils formed in eolian sand. These soils are on convex summits of interfluves, side slopes, and crests of escarpments, commonly along the eastern side of stream valleys. These soils also occur on dunes on valley trains along the major rivers containing sandy outwash. Slope ranges from 0 to 45 percent.
Coloma: The Coloma series consists of very deep, somewhat excessively drained or excessively drained soils formed in sandy drift. These soils are on moraines, outwash plains, deltas and stream terraces. Slope ranges from 0 to 70 percent.
Crosier: The Crosier series consists of very deep, somewhat poorly drained soils formed in till on till plains and moraines. They are moderately deep to dense till. Slope ranges from 0 to 4 percent.
Darroch: The Darroch series consists of very deep, somewhat poorly drained soils that formed in silty and loamy sediments. Darroch soils are on lake plains, outwash plains, and till plains. Slope ranges from 0 to 3 percent.
Glynwood: The Glynwood series consists of very deep, moderately well drained soils that are moderately deep or deep to dense till. They formed in a thin layer of loess and the underlying till. These soils are on ground moraines and end moraines. Slope ranges from 0 to 40 percent.
Houghton: The Houghton series consists of very deep, very poorly drained soils formed in herbaceous organic materials more than 130 cm (51 inches) thick in depressions on lake

plains, outwash plains, ground moraines, end moraines, and floodplains. Slope ranges from 0 to 2 percent.
Markham: The Markham series consists of very deep, moderately well drained soils on Wisconsin till plains. They formed in a thin layer of loess or silty material and in the underlying silty clay loam till. Slopes range from 0 to 20 percent.
Morley: The Morley series consists of very deep, moderately well drained soils that are moderately deep to dense till. Morley soils formed in as much as 46 cm (18 inches) of loess and in the underlying clay loam or silty clay loam till. They are on till plains and moraines. Slope ranges from 1 to 18 percent.
Oshtemo: The Oshtemo series consists of very deep, well drained soils formed in stratified loamy and sandy deposits on outwash plains, valley trains, moraines, and beach ridges. Slope ranges from 0 to 55 percent.
Pewamo: The Pewamo series consists of very deep, very poorly drained soils formed in till on moraines, near-shore zones (relict), and lake plains. Slope ranges from 0 to 2 percent.
Pinhook: The Pinhook series consists of deep, poorly drain soils on outwash plains. These soils are moderately permeable in the topsoil and rapidly permeable in the subsoil. These soils are formed in shaly glacial outwash sediment. Slopes are 0 to 2 percent.
Rensselaer: The Rensselaer series consists of very deep, poorly drained or very poorly drained soils formed in loamy sediments on till plains, stream terraces, outwash terraces, outwash plains, glacial drainage channels, and lake plains. Slope ranges from 0 to 2 percent.
Riddles: The Riddles series consists of very deep, well drained soils formed in loamy and sandy till on till plains and moraines. Slope ranges from 0 to 35 percent.
Sebewa: The Sebewa series consists of very deep, poorly drained or very poorly drained soils formed in loamy outwash and the underlying gravelly and sandy outwash on outwash plains, valley trains, and stream terraces on terrace landscapes. They are moderately deep to the gravelly and sandy outwash. Slope ranges from 0 to 3 percent.
Spinks: The Spinks series consists of very deep, well drained soils formed in sandy eolian or outwash material. They are on dunes, moraines, till plains, outwash plains, beach ridges, and lake plains. Slope ranges from 0 to 70 percent.
Tracy: The Tracy series consists of deep, well drained soils on outwash plains. These soils are formed in glacial outwash. Slopes range from 0 to 45 percent.
Tyner: The Tyner series consists of deep, somewhat excessively drained soils on outwash plains of uplands. Slope ranges from 0 to 2 percent.
Whitaker: The Whitaker series consists of deep, somewhat poorly drained soils on terraces, lake plains and outwash plains. Slopes are 0 to 2 percent. (USDA, 1981 and 1982)

The soils of the LCEB are diverse due to diverse geology. Nonetheless, there are two dominant soil associations in this watershed: Riddles-Crosier-Oshtemo and Rensselaer-Darroch-Whitaker (Figure 13). The Riddles-Crosier-Oshtemo association is comprised of very deep, well drained to somewhat poorly drained soils. Slopes range from zero to 55 percent. The Rensselaer-Darroch-Whitaker association is comprised of deep to very deep soils that are somewhat poorly drained to very poorly drained. Slopes range from zero to three percent.

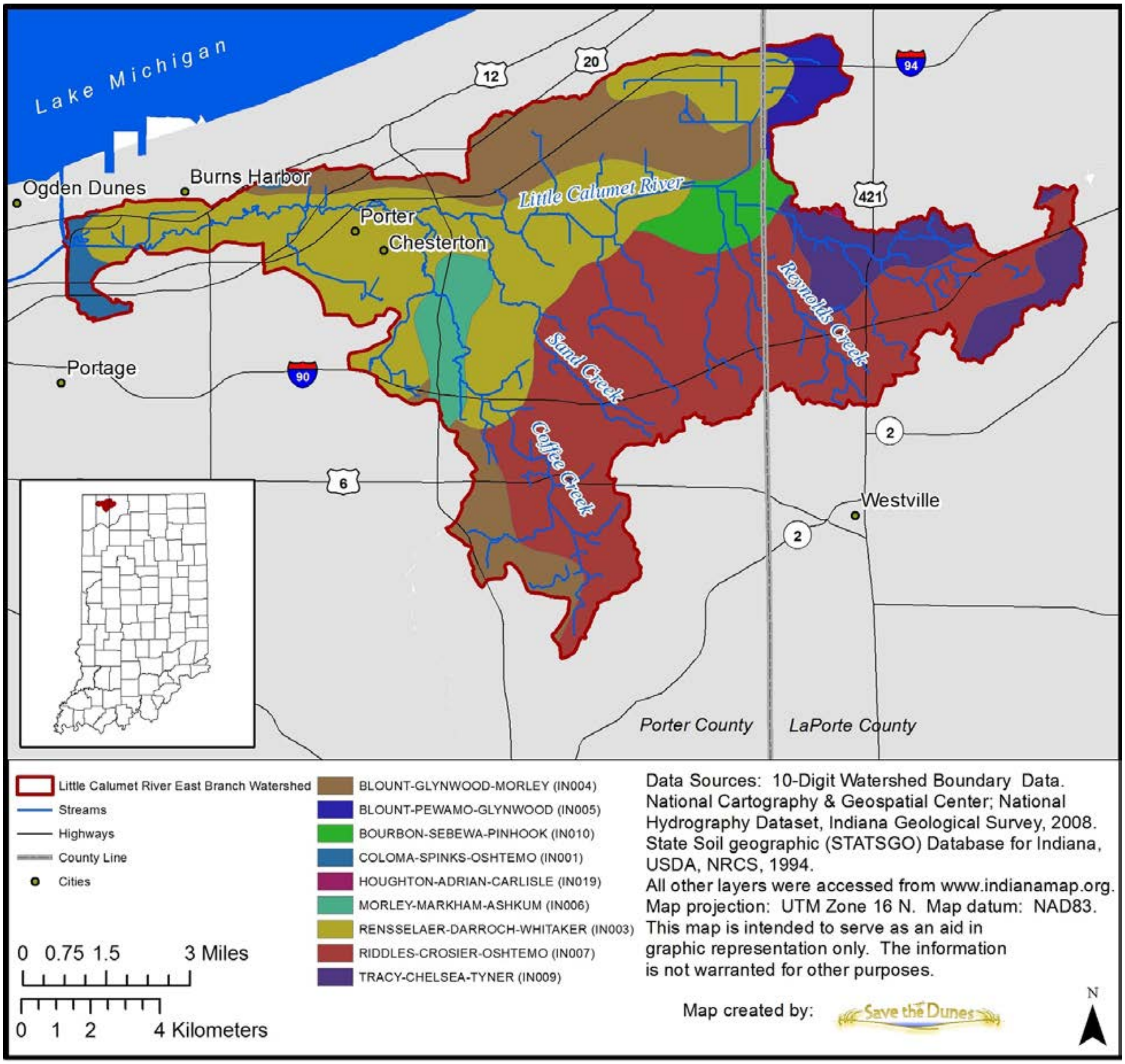

Figure 13. Major soil associations

Hydric Soils

Hydric soils are one of three characteristics used to identify wetlands. The National Technical Committee for Hydric Soils (NTCHS) defines hydric soil as soil that has been formed by saturation, flooding, or ponding for a portion of the growing season that is long enough to develop anaerobic soil conditions. These soils, under natural conditions, are either saturated or inundated long enough during the growing season to support the establishment of hydrophilic (water-loving) vegetation. Areas where hydric soils are present but wetlands no longer exist can be useful for identifying potential wetland restoration opportunities. Wetlands provide important ecosystem functions such as flood water storage, increased wildlife habitat, and sediment and nutrient removal. These wetland functions are in line with many stakeholder concerns including stormwater management and flood prevention, increased volume and flow due to altered hydrology, increased volume and flow causing erosion, sedimentation in streams, and failing to meet water quality standards (Figure 2). Hydric soils data from the Natural Resources Conservation Services (NRCS) are displayed for the LCEB watershed in Figure 14. Approximately 24% of the soils in the LCEB watershed are hydric.

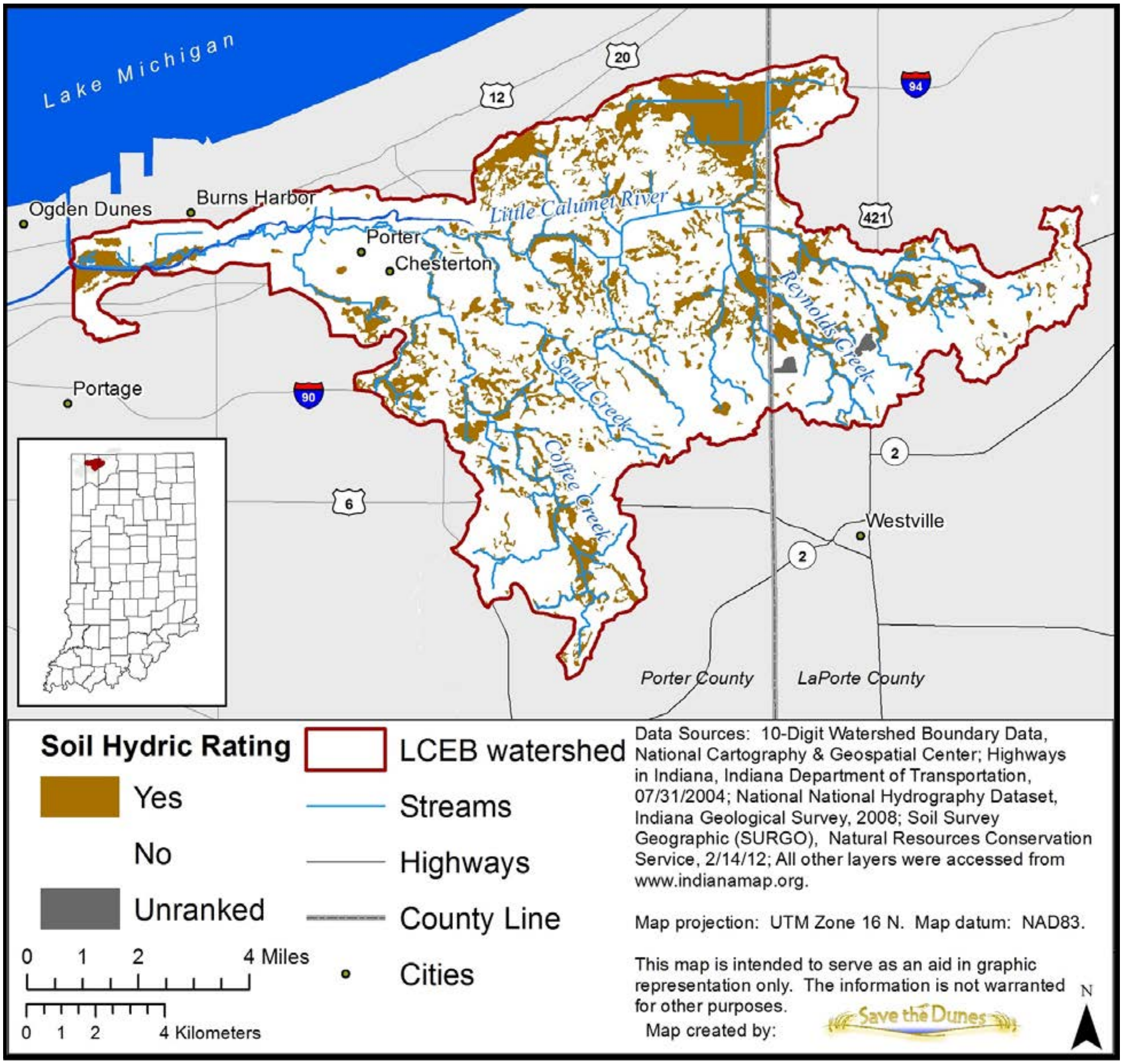

Figure 14. Hydric soils in the LCEB watershed

Soil Hydrologic Groups

A soil hydrologic group, as defined by the NRCS, is a group of soils that have similar runoff potential under similar storm and cover conditions. The influence of ground cover is treated independently and the slope of the soil surface is also not considered in assigning hydrologic soil groups. Changes in soil properties caused by land management or climate changes also cause the hydrologic soil group to change. Soils with higher runoff potential (groups C & D) will have increased stormwater flow and velocity, thus increasing stream bank erosion. Elevated concentrations of pollutants from the land are also common from soils with high runoff potential. This information is useful in identifying nonpoint source pollutant contribution areas coupled with land use and prioritizing implementation measures to reduce pollutant loading from runoff. Stakeholder concerns related to soil hydrologic group include: the need to understand watershed geology and hydrology, sedimentation in streams, and increased volume and flow causing erosion (Figure 2).

Of the soils found in the LCEB watershed 2% are of hydrologic group A, 7% are group A/D, 35% are group B, 19% are group B/D, 7% are group C, 24% are group C/D, and 6% are unranked. The hydrologic soil groups found in the LCEB are displayed in Figure 15 and described as follows:

Group A- Soils in this group have low runoff potential when thoroughly wet. Water is transmitted freely through the soil.

Group B- Soils in this group have moderately low runoff potential when thoroughly wet. Water transmission through the soil is unimpeded.

Group C- Soils in this group have moderately high runoff potential when thoroughly wet. Water transmission through the soil is somewhat restricted.

Group D- Soils in this group have high runoff potential when thoroughly wet. Water movement through the soil is restricted or very restricted.

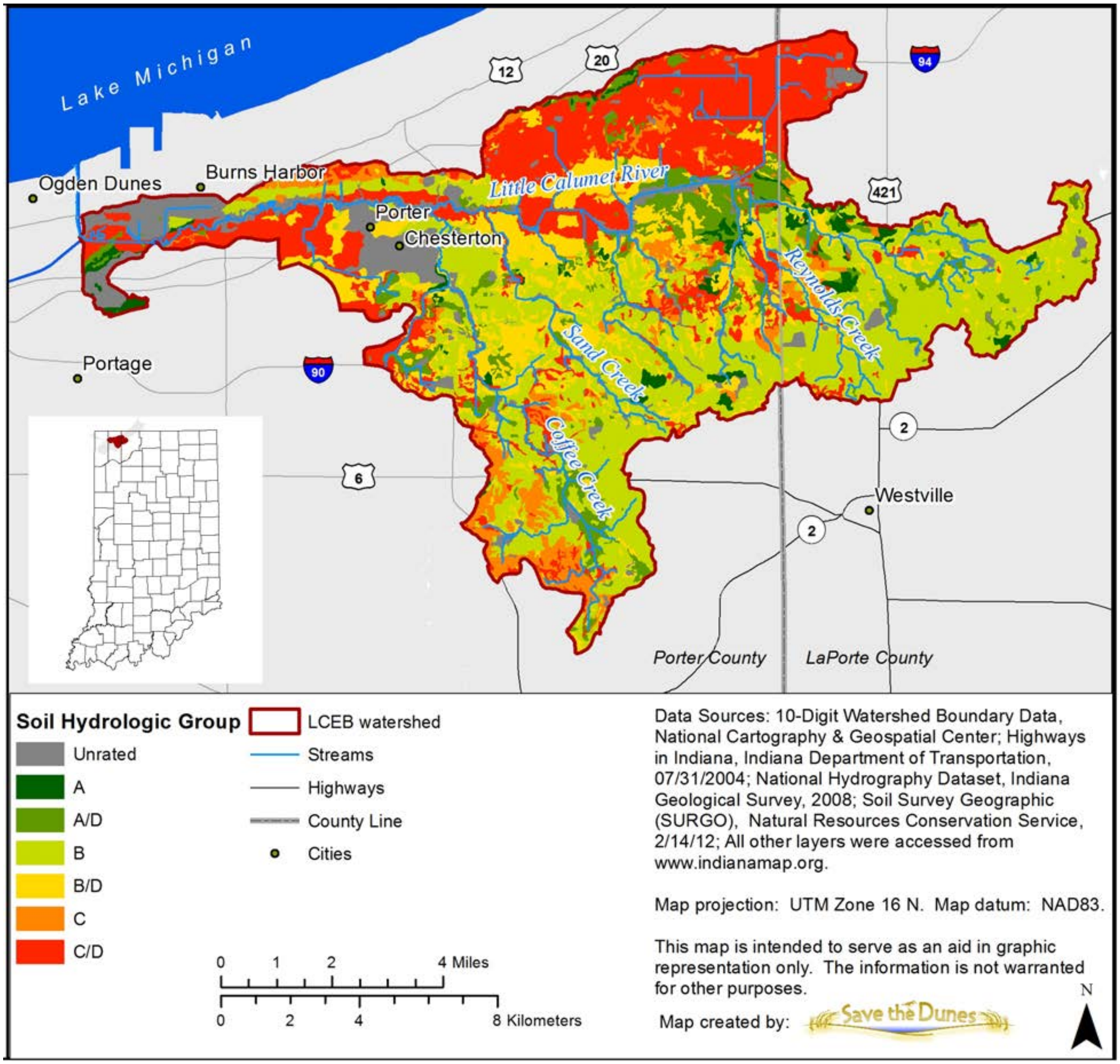

Figure 15. Soil hydrologic groups in the LCEB watershed

Soil Drainage Class

The soil drainage classes identify the natural drainage condition of the soil and refer to the frequency and duration of periods when the soil is free of saturation. Soils that drain poorly will encourage overland runoff, thus increasing the flow of stormwater and nutrients to streams. Likewise, more permeable soils that are well drained may be more susceptible to erosion, contributing to higher sedimentation rates and nutrient concentrations in streams. Stakeholder concerns related to soil drainage classes include: sedimentation in streams and increased volume and flow causing erosion.

Figure 16 displays drainage classes within the LCEB watershed. Of the soils in the LCEB watershed, 13% are very poorly drained, 7% are poorly drained, 30% are somewhat poorly drained, 7% are moderately well drained, 40% are well drained, 2% are excessively well drained, and 1% are unranked.

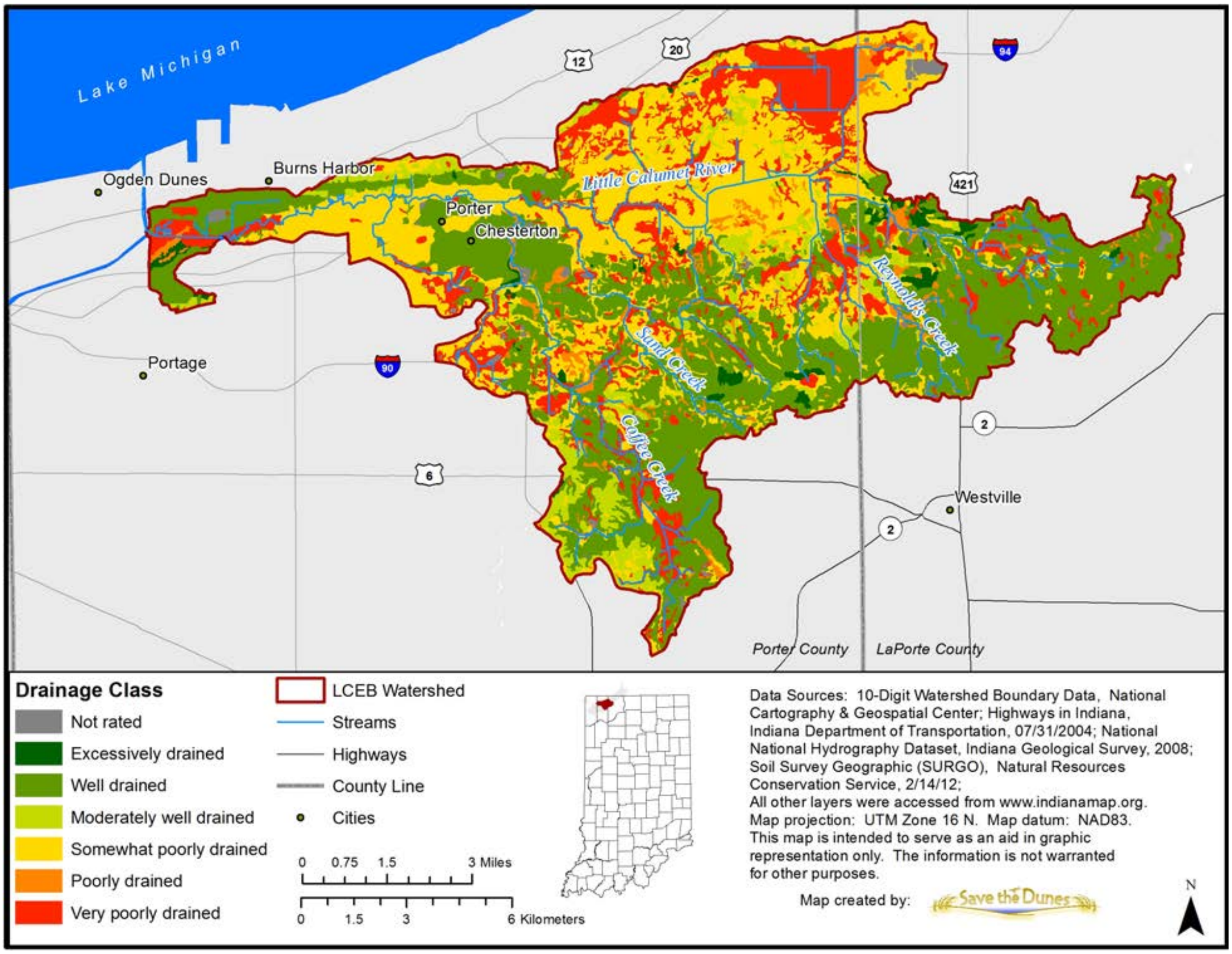

Figure 16. Soil drainage class in the LCEB watershed

Highly Erodible Land

Highly erodible land is a classification used by the NRCS to identify soils that are at highly susceptible to erosion through agricultural activities. The NRCS maintains a list of highly erodible soil units for each county based upon the potential of soil to erode from the land. The classification is based upon an erodibility index for a soil, which is determined by dividing the potential average annual rate of erosion by the soil unit's soil loss tolerance (T) value, the maximum annual rate of erosion that could occur without causing a decline in long-term productivity. The NRCS provided the list for Highly Erodible Land (HEL), which was used to generate a map of HEL in the watershed (Figure 17). Approximately 21,721 acres or 46% of the soils in the LCEB watershed are classified as highly erodible and potentially highly erodible. The LCEB stakeholders noted highly erodible soils on cropland as a concern (Figure 2).

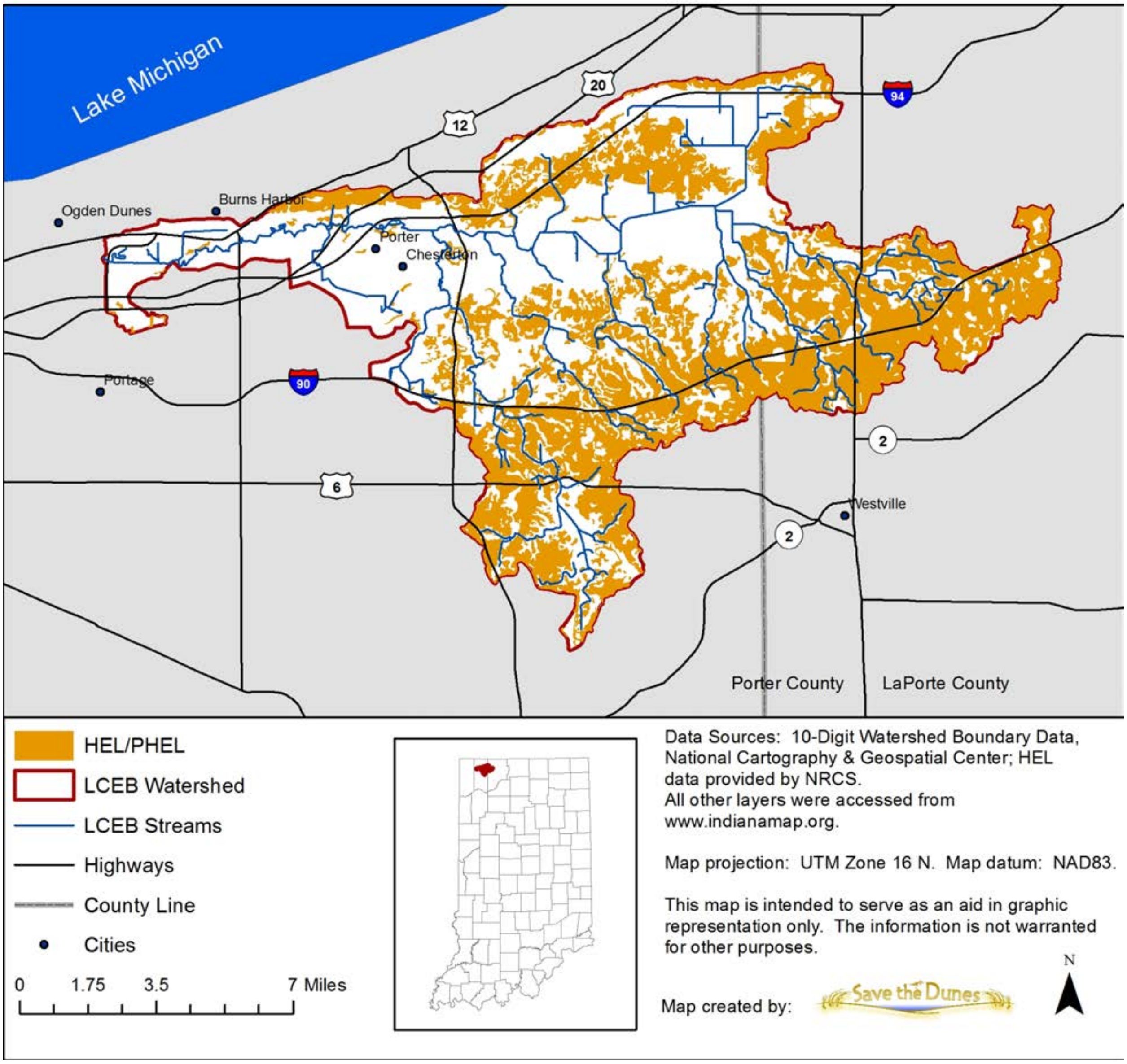

Figure 17. Highly erodible land (HEL) and potentially highly erodible land (PHEL)

Onsite Septic Systems

Conventional onsite sewage disposal systems (a.k.a. septic systems), while common, are not suitable for all areas. Among the limitations that might preclude installation of a conventional system are: high groundwater tables; shallow limiting layers of bedrock or fragipan; very slowly or rapidly permeable soils; topography; and lot size.

Figure 18 shows soil limitations within the LCEB for conventional septic systems that use absorption fields for treatment. Only part of the soil, between depths of 24 and 60 inches, is evaluated. The ratings are based on the soil properties that affect absorption of the effluent, construction and maintenance of the system, and public health. The data used to generate this figure was obtained from the NRCS Soil Survey Geographic Database (SSURGO). This information is not site specific and does not eliminate the need for onsite investigation. The rating class terms indicate the extent to which the soils are limited by all of the soil features that affect these uses. These include:

Not Rated- Soils are highly disturbed, such as in urban areas. These soils account for 6% of the watershed.

Not Limited- Soils have features that are very favorable for the specified use. Good performance and very low maintenance can be expected. This soil rating is not represented in this watershed.

Somewhat Limited - Soils have features that are moderately favorable for the specified use. Limitations can be overcome or minimized by special planning, design, or installation. Fair performance and moderate maintenance can be expected. These soils account for approximately 11% of the watershed.

Very Limited - Soils have one or more features that are unfavorable for the specified use. The limitations generally cannot be overcome without major soil reclamation, special design, or expensive installation procedures. Poor performance and high maintenance can be expected. This soil rating accounts for approximately 83% of the watershed.

Ninety four percent of LCEB soils are either somewhat limited or very limited for onsite septic systems. Likewise, approximately 80 percent of the LCEB is unsewered (Figure 19). The sewered portions of the LCEB are located in the Northwest portion of the watershed in the towns of Chesterton, Porter, Burns Harbor, and Portage. The remainder of the watershed is more sparsely populated and utilizing onsite septic systems. Due to the abundance of unsewered areas on soils that are either somewhat limited or very limited for onsite septic systems, it is likely that septic systems are a significant source of nonpoint source pollution (e.g. *E. coli*, nitrogen, and phosphorus) in the LCEB. Elevated *E. coli* concentration due to malfunctioning septic systems was identified as a stakeholder concern (Figure 2).

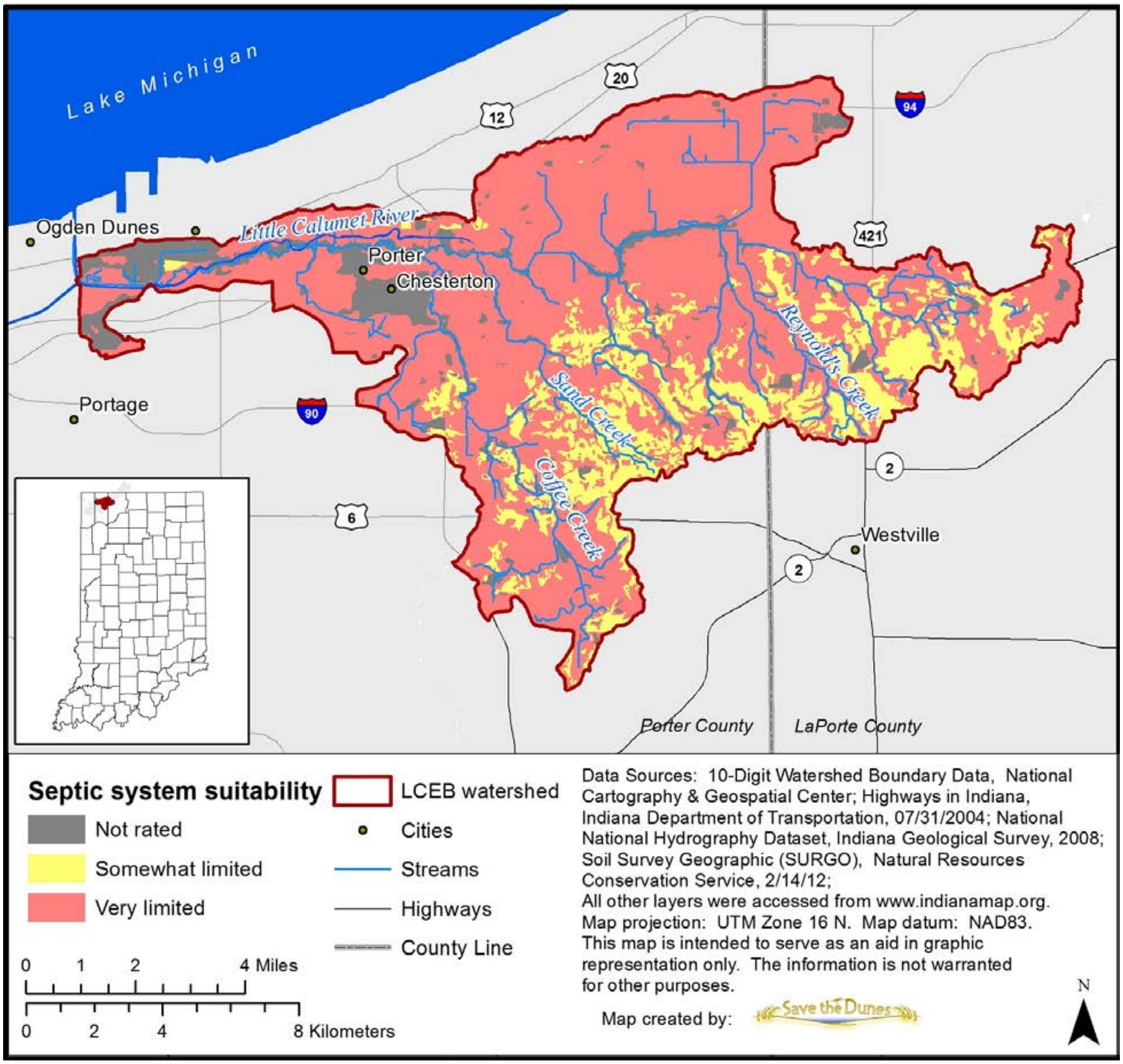

Figure 18. Soil septic system suitability in the LCEB watershed

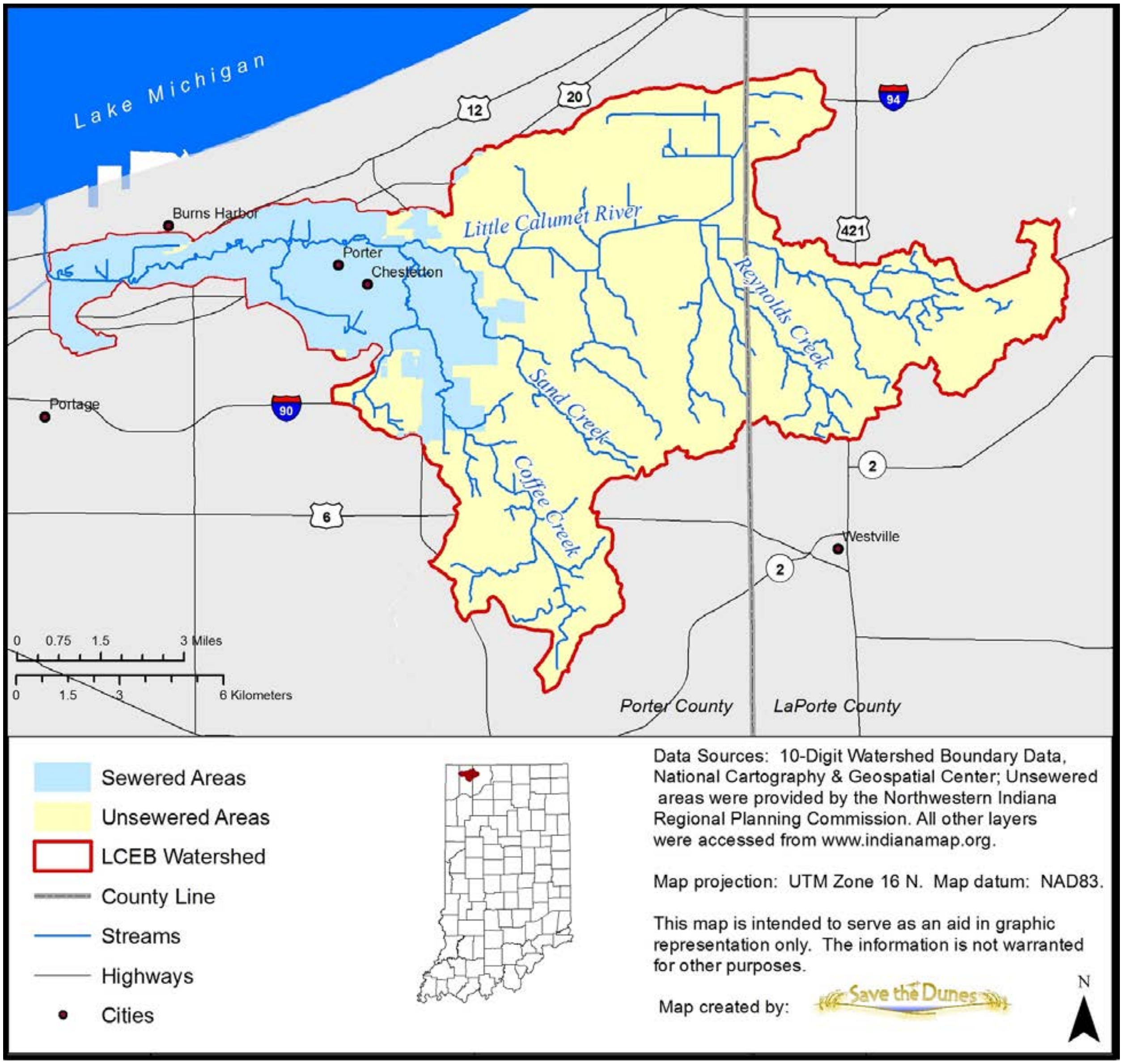

Figure 19. Sewered and unsewered areas

2.4 Land Use

Land use and cover within a watershed can have a profound impact on both water quality and habitat. Natural land cover such as forests, wetlands, and grasslands can protect or improve water quality and aquatic habitats. Alteration of natural land cover for human use typically leads to increased runoff, which can carry pollutants to nearby waterbodies. The pollutants generated are dependent on the land uses within the given watershed. Some of the common pollutants generated in urbanized areas include excess nutrients, sediment, metals, pathogens, and toxins. In agricultural areas common pollutants can include excess nutrients, sediment, pathogens, herbicides and pesticides. For this reason, having an understanding of what land uses are present in a watershed can help determine what factors may be contributing to water quality or habitat problems.

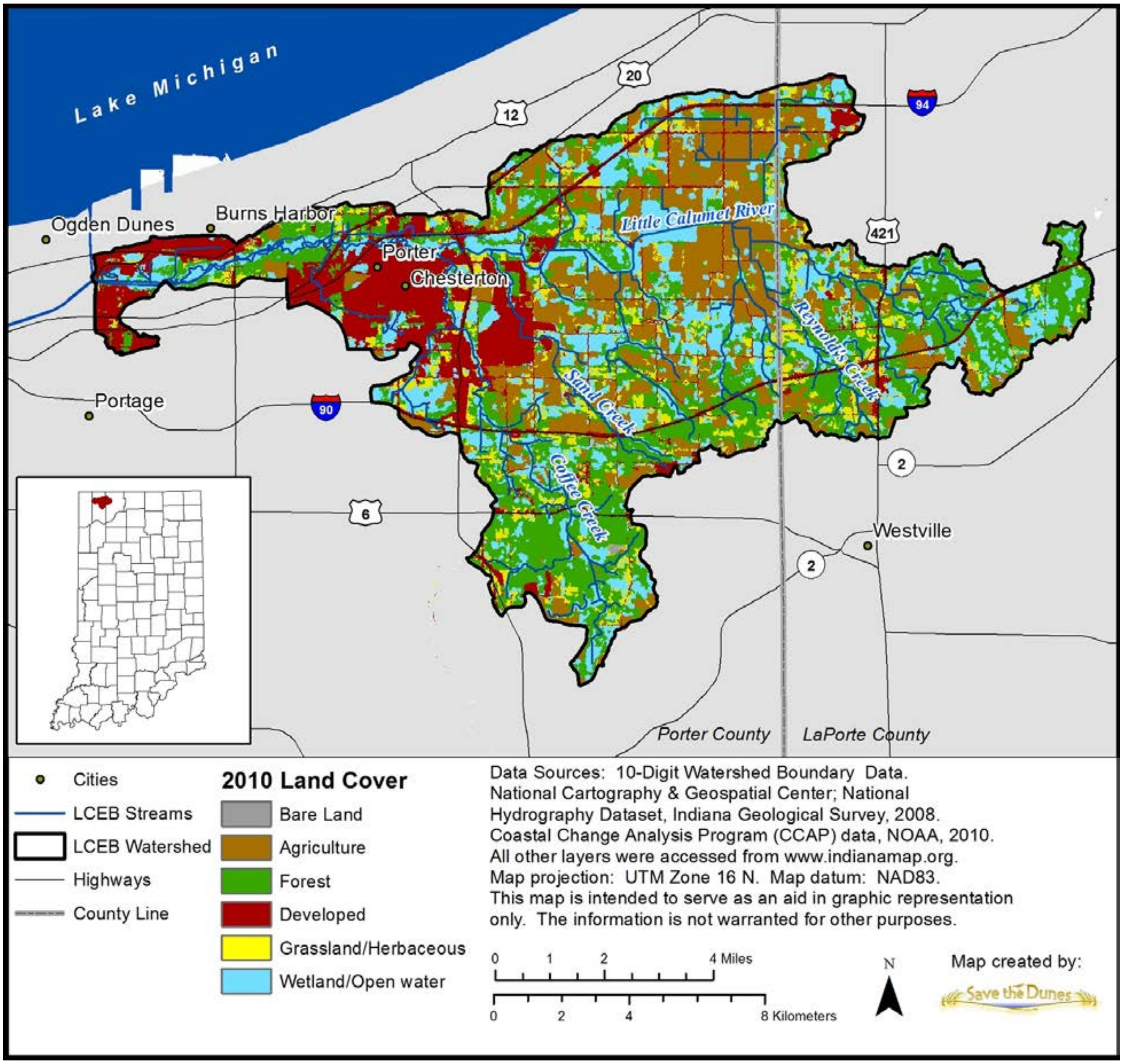

Figure 20. Land cover in the LCEB watershed

Figure 20, Table 6, Figure 21, and Figure 22 were generated using NOAA's Coastal Change Analysis Program (CCAP) data. CCAP produces a nationally standardized database of land cover and land change information for the coastal regions of the United States. It provides inventories of wetlands and adjacent uplands with the goal of monitoring these habitats by updating the land cover maps every five years. Data is developed using multiple dates of remotely sensed imagery and consist of land cover maps, as well as a changes that have occurred between these dates and where the changes were located. CCAP data for Indiana was available for 1996, 2001, 2006, and 2010.

Figure 21 displays the 2010 land cover data as a percentage of the LCEB watershed. Similar cover types have been grouped into generalized cover classes for display purposes. Forest (deciduous, evergreen, mixed, and shrub/scrub) is the dominant land cover type within the watershed, followed by agriculture (cultivated crops and pasture/hay) and developed (high, medium, low, open space). Generally, the greatest concentration of developed land occurs in the western half of the watershed along Coffee Creek and the downstream sections of the LCEB mainstem (Figure 20). Agricultural areas are primarily located in the northern portion of the watershed and forested areas are located in the southern and eastern areas of the watershed along the headwater tributaries.

Table 6. Land cover in the LCEB watershed

Land Cover	% of Watershed in 2010	Area in 2010 (Acres)	Change, 2006 to 2010 (Acres)
Developed, High Intensity	2%	962	+46
Developed, Medium Intensity	8%	4098	+83
Developed, Low Intensity	18%	8918	+446
Developed, Open Space	6%	2963	+196
Cultivated Crops	17%	8600	+63
Pasture/Hay	7%	3706	-212
Grassland/Herbaceous	9%	4243	-263
Deciduous Forest	15%	7363	-175
Evergreen Forest	1%	325	-9
Mixed Forest	<1%	128	-13
Scrub/Shrub	5%	2466	-93
Palustrine Forested Wetland	7%	3468	-26
Palustrine Scrub/Shrub Wetland	2%	478	-9
Palustrine Emergent Wetland	1%	316	-4
Bare Land	<1%	43	+2
Open Water	1%	303	+10

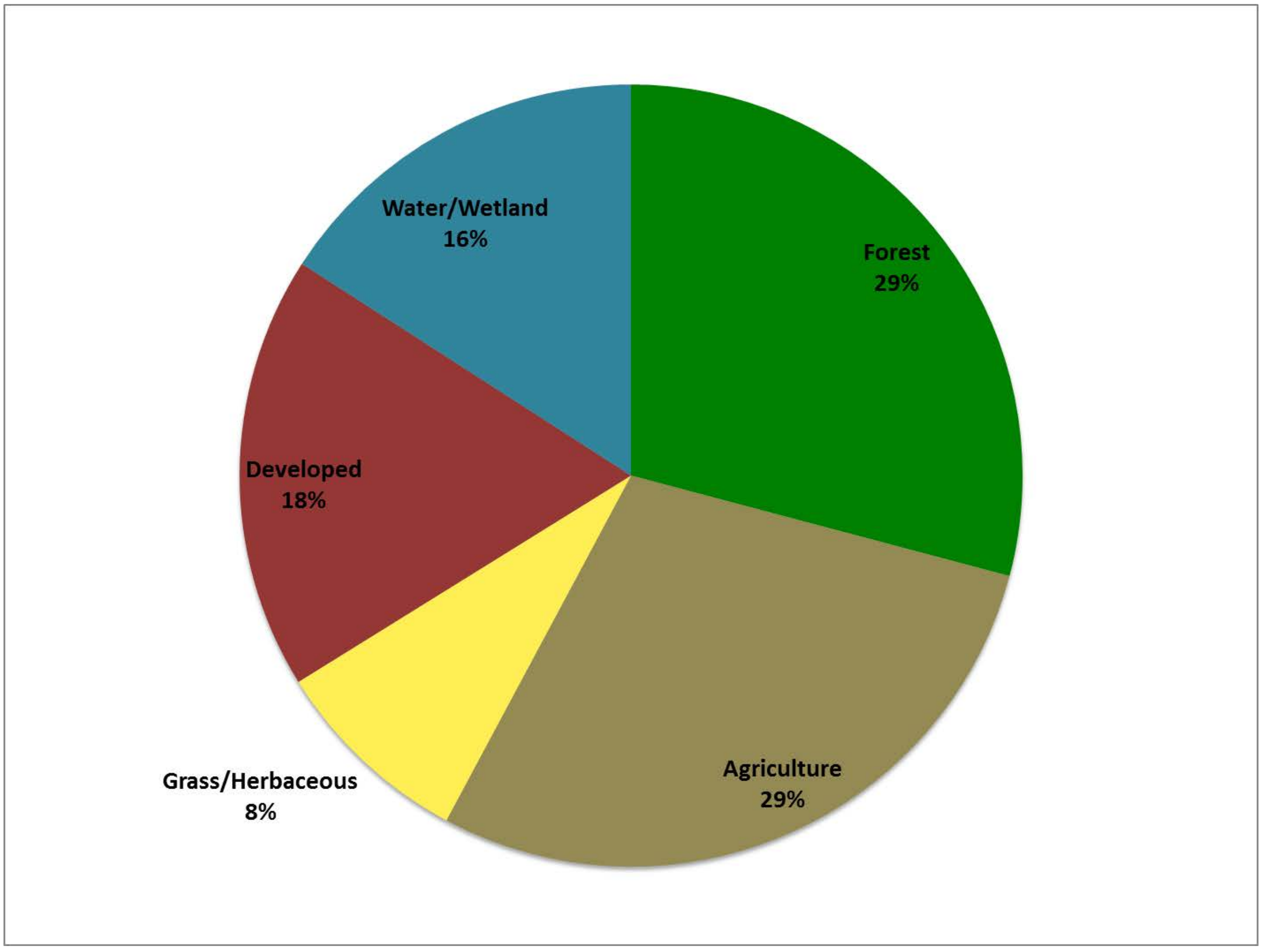

Figure 21. Land cover in the LCEB watershed by percent

Urban/Suburban

An extensive body of literature has been developed to examine the direct impact of urbanization on streams. Much of this research has focused on hydrologic, physical and biological indicators. In recent years, impervious cover (IC) has emerged as a way to explain and sometimes predict how severely these indicators change in response to varying levels of watershed development. The Center for Watershed Protection (CWP), located in Maryland, has integrated research findings into a general watershed-planning model, known as the impervious cover model (ICM). The ICM predicts that most stream quality indicators decline when watershed IC exceeds 10%, with severe degradation expected beyond 25% IC (CWP, 2003). Impervious cover was determined using the L-THIA (Long-Term Hydrologic Impact Assessment) model developed by Purdue University. L-THIA's estimation of impervious cover was based on land use, as determined by the USGS NLCD (National Land Characteristics Data) database and following methods develop by Cappiella and Brown (2001). Impervious cover for the Reynolds Creek and Kemper Ditch subwatersheds is well below 10% (Table 7), therefore, it is unlikely impervious cover plays a significant role in stream degradation of these subwatersheds. Coffee Creek subwatershed has approximately 14% impervious cover with the highest concentration in the northwestern portion of this subwatershed. Consequently, the urban areas of Chesterton, Porter and Burns Harbor may impact water quality in this subwatershed.

Table 7. Impervious cover for LCEB subwatersheds

LCEB Subwatershed	Impervious Cover (acres)	% of Subwatershed
Reynolds Creek	522	4
Kemper Ditch	1,326	5
Coffee Creek	2,905	14

Urban land in the watershed is generally concentrated in and adjacent to the incorporated areas, primarily located within the Coffee Creek subwatershed. According to Chesterton's comprehensive plan, growth of the city will likely take place to the south and southeast of the current city limits. In these urban areas, fertilizer may be over applied to lawns in residential and commercial areas and recreational areas such as golf courses. Pet waste may be contributing *E. coli* in urban areas.

Land cover changes between 1996 and 2006 were primarily due to the conversion of agricultural land to low-intensity developed land in and adjacent to the Town of Chesterton and the City of Portage. Land cover changes between 2006 and 2010 were primarily due to the conversion of pastureland, grassland, and forested land to low-intensity developed land in and adjacent to the Town of Chesterton and the City of Portage (Figure 22, Table 6). Some of this growth is happening in areas that are not connected to a municipal wastewater system, which could pose a risk for *E. coli* loading from septic systems that are on unsuitable soil and/or are not maintained, in addition to other nonpoint source runoff that does not pass through a WWTP. LCEB stakeholders have concerns with pathogen loading from malfunctioning septic systems and combined sewer overflows (Figure 2).

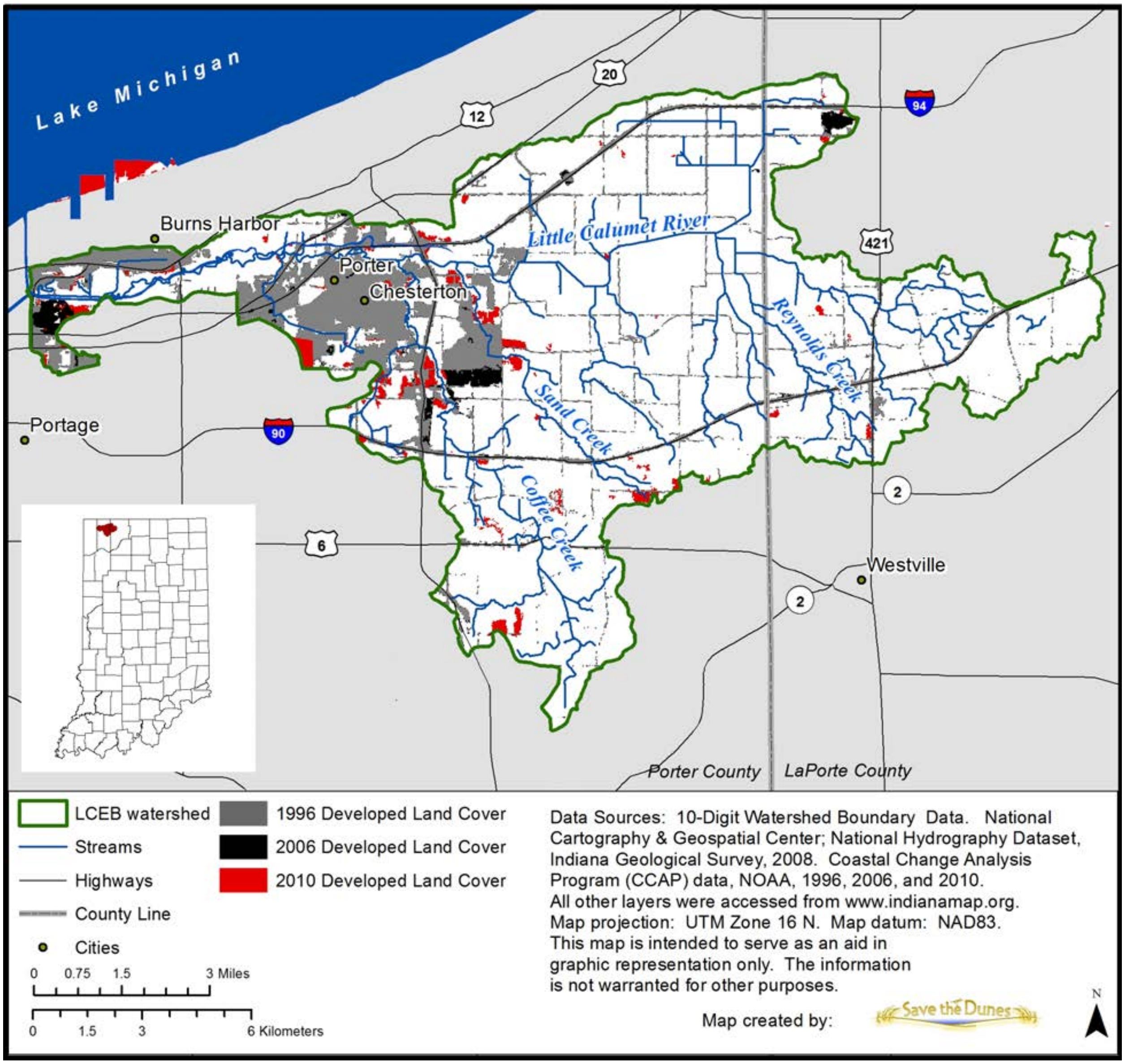

Figure 22. Change in developed land cover from 1996 to 2010.

Agriculture

In 2010, approximately 29% of the watershed was devoted to agriculture, which includes both hobby farms and conventional agriculture. The use of conventional fertilizer on agricultural lands is dominant due to the decreased popularity of animal husbandry in this watershed. Consequently, this reduces the availability of manure for fertilizer. No Confined Feeding Operations (CFOs) are located within the watershed. In cultivated areas, tillage practices can have a major effect on water quality. Conventional tillage leaves the soil surface bare and loosens soils particles making them susceptible to wind and water erosion. Conservation tillage reduces erosion by leaving at least 30% of the soil surface covered with crop residue after harvesting. Residues protect the soil surface from the impact of raindrops and act like a dam to slow water movement. Rainfall stays in the field allowing the soil to absorb it. With conservation tillage, less soil and water leave a field. While there is no data specifically available for conservation tillage practices by Hydrologic Unit Code, the Indiana State Department of Agriculture (ISDA) does provide data by county.

Cropland tillage data for 2011 for both corn and soybean are presented in Figure 23. In Porter County, agricultural management practices for corn are dominated by conventional tillage. However, management practices for corn in LaPorte County is predominantly mulch tillage. For soybeans, conservation tillage is common in both counties.

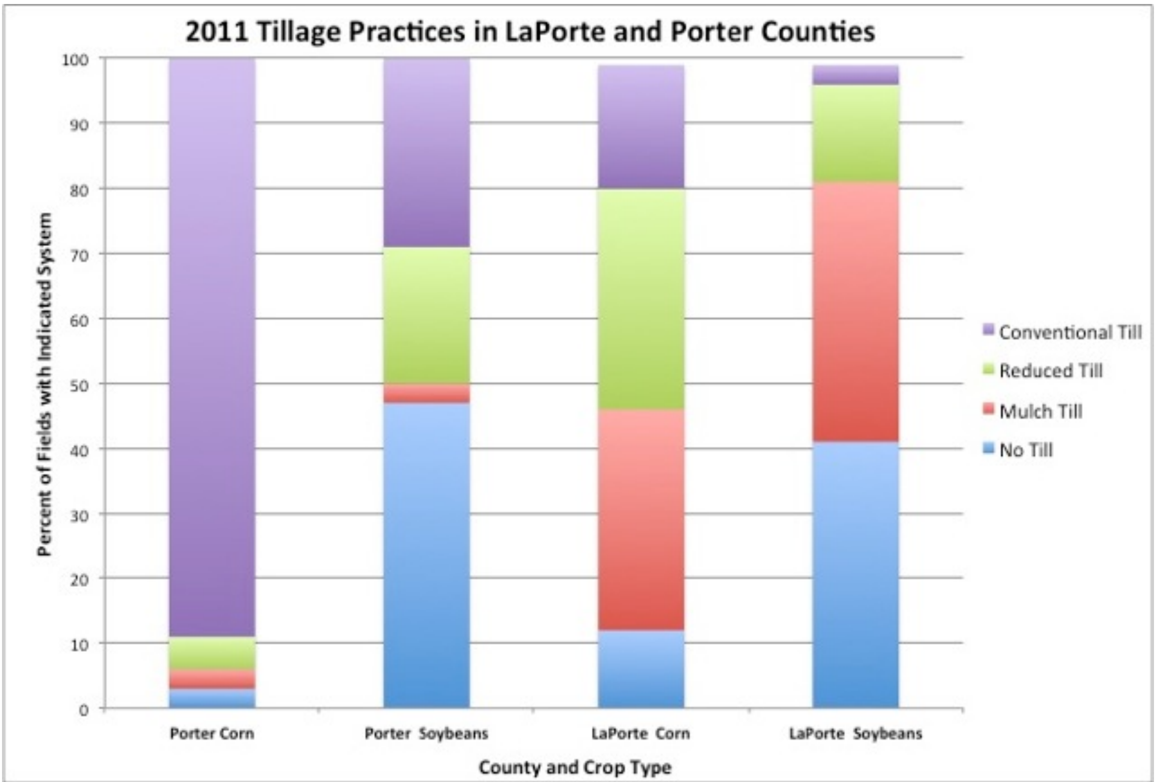

Figure 23. 2011 cropland tillage data for corn and soybeans

Forest and Undeveloped Land

Forests play a critical role in the health of a watershed. Forest cover reduces stormwater runoff and flooding by intercepting rainfall and promoting infiltration into the ground. Trees growing along streams help prevent erosion by stabilizing the soil with their root systems. They help improve water quality by filtering sediment and associated pollutants from runoff and they provide cover for both terrestrial and aquatic life. Forests also reduce summer air and water temperatures and improve regional air quality. Figure 24 shows managed lands in the LCEB watershed. The large amount of forest and undeveloped land in this watershed provides abundant open spaces and places for recreation.

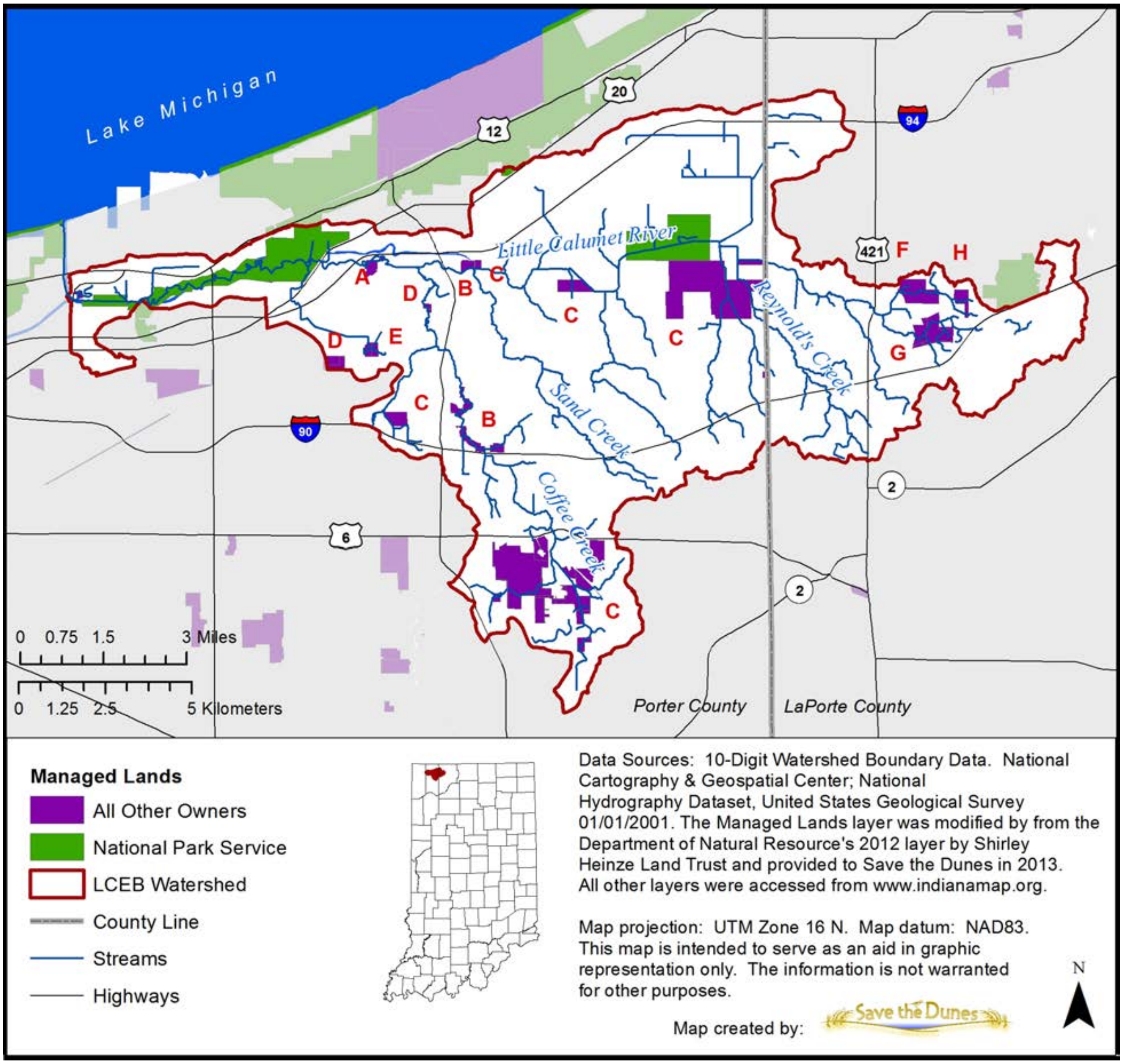

Figure 24. Managed lands in the LCEB watershed

Table 8. Other Land Owners of Managed Lands in the LCEB

Notation in Figure 24	Owner/Manager of Property
A	Town of Porter
B	Coffee Creek Conservancy
C	Indiana DNR
D	Town of Chesterton
E	Porter County Parks Foundation
F	Boy Scouts of America
G	LaPorte County Parks & Recreation
H	Izaak Walton League

The riparian zone refers to the area immediately adjacent to a stream, generally within the floodplain. The term riparian buffer implies a vegetated riparian zone that protects or buffers a stream, lake, wetland or other waterbody. Vegetated riparian buffers can provide many benefits to the water body, including slope and bank stabilization, reducing stormwater velocity, filtering and assimilating pollutants, and shading the waterbody. Riparian buffers vary in width, vegetation, soil type, hydrology, and other factors, all of which can impact the effectiveness of the buffer in protecting the waterbody. Restoring or establishing riparian buffers is a common best management practice (BMP) for controlling nonpoint source pollution; however, protecting existing, natural buffers is generally cheaper and more effective than creating or restoring degraded buffers. Streambank erosion and degraded riparian areas are concerns raised by stakeholders (Figure 2).

The Emerald Ash Borer (EAB) Beetle is an invasive insect from Asia that feeds exclusively on Ash trees. It was first confirmed in Indiana in 2004, and has since spread throughout most of the state. To date, the EAB has infected virtually all of the ash trees in the LCEB watershed. Since treatment of the infected Ash trees on a large scale is not economically feasible, these trees will perish within five years. This has negative implications for the river, since the death of over a thousand trees has the potential to increase temperatures through the removal of shade, to add to log jams that impair recreational access and enjoyment, and to add to the quantity of runoff that is making its way into the LCEB and its tributaries. The massive Ash die off will also remove a large amount riparian vegetation in some areas, which will reduce the abilities of riparian buffers to filter pollution from nonpoint sources. The LCEB watershed group listed the EAB as a concern for the watershed (Figure 2).

2.5 Planning Efforts in the Watershed

The LCEB watershed spans two counties and is within the Lake Michigan drainage basin. Consequently, there are many different planning efforts that may affect water quality in the watershed.

Indiana Coastal Nonpoint Pollution Control Program

The Coastal Zone Act Reauthorization Amendments of 1990 (CZARA) Section 6217 calls upon states with federally approved coastal zone management programs, such as the DNR's Lake Michigan Coastal Program, to develop and implement coastal nonpoint pollution control programs. Indiana's Lake Michigan Coastal Program area includes the LCEB watershed. The Coastal Nonpoint Source Pollution Control Program provides technical assistance to government, regional and nonprofit organizations to implement nonpoint source pollution best management practices. The 2005 Indiana Coastal Nonpoint Pollution Control Program was developed to address water quality issues in coastal waters with a goal to restore and protect coastal waters. Coastal Program Grants has funded several grants in the LCEB that support water quality improvements and public access. Funded projects include: a pedestrian bridge over the LCEB in Porter, the development of Coffee Creek Conservancy's Master Plan, and improved public access and restoration along the Little Calumet River in the City of Portage. Stakeholder concerns addressed by this planning effort include the reduction of nutrient and sediment loading and improved public access.

Watershed Management Plan requirements include compliance with 6217 program requirements from the Indiana Department of Natural Resources Coastal Program. This plan conforms to the needed requirements.

Coastal and Estuarine Land Conservation Program Plan

The Coastal and Estuarine Land Conservation Program (CELCP) Plan was developed by the IDNR Lake Michigan Coastal Program to prioritize land conservation needs and nominate potential projects for federal funding within Indiana's federally approved coastal program boundary. The purpose of the CELCP is to protect important coastal and estuarine areas that have significant conservation, recreation, ecological, historical, or aesthetic values, or that are threatened by conversion from their natural or recreational state to other uses. The plan develops a large scale framework for the protection of natural resources at a regional level. The plan also assists local communities with information to assist planning needs. The LCEB is a coastal watershed that lies within the area of interest for this program. As the greater Chicago area population continues to grow, the LCEB watershed will likely face increased development pressures. Conservation of natural lands may play a large role in protecting water quality in this watershed. Stakeholder concerns include the promotion of conservation easements in the LCEB (Figure 2).

Town of Chesterton Combined Sewer Overflow (CSO) Long Term Control Plan

Chesterton's Long Term Control Plan was designed to improve water quality and stream health in the LCEB watershed. Combined sewer systems are sewers that are designed to collect rainwater runoff, domestic sewage, and industrial wastewater in the same pipe. During periods of heavy rainfall or snowmelt the wastewater volume in a combined sewer system can exceed the capacity of the sewer system or treatment plant. For this reason, combined sewer systems are designed to overflow occasionally and discharge excess wastewater directly to nearby streams, rivers, or other water bodies. These overflows, called combined sewer overflows (CSOs), contain stormwater plus untreated human waste, industrial waste, potentially toxic materials, and debris. CSO communities are required to submit Long Term Control Plans to IDEM as a National Pollutant Discharge Elimination System (NPDES) permit requirement. The Chesterton Wastewater Treatment Plant (WWTP) has submitted a Long Term Control Plan (LTCP). The Chesterton LTCP states, "The town has been aggressive in the separation of combined sewers". The town recently constructed separate storm sewers and connected the older combined sewers to the newly constructed sewers. The town of Chesterton is also constructing a large overflow tank that will be able to hold 1.2 million gallons of wastewater, capturing up to a 10 year, 1 hour storm event. This will reduce the frequency of overflows, which should in turn reduce pathogen loads in the LCEB near the outfall and in downstream areas. The Chesterton WWTP currently processes all wastewater from Chesterton, Porter, and the Indian Boundary Conservancy District, which is a small group of subdivisions and other properties located just outside the Chesterton city limits. Figure 25 shows the service area for the Chesterton WWTP, which is more or less the city limits for Chesterton and Porter. Figure 1 shows the geographic relationship of these municipal areas with the watershed. The LCEB stakeholders noted pathogen loading from combined sewer and sanitary sewer overflows as a concern (Figure 2).

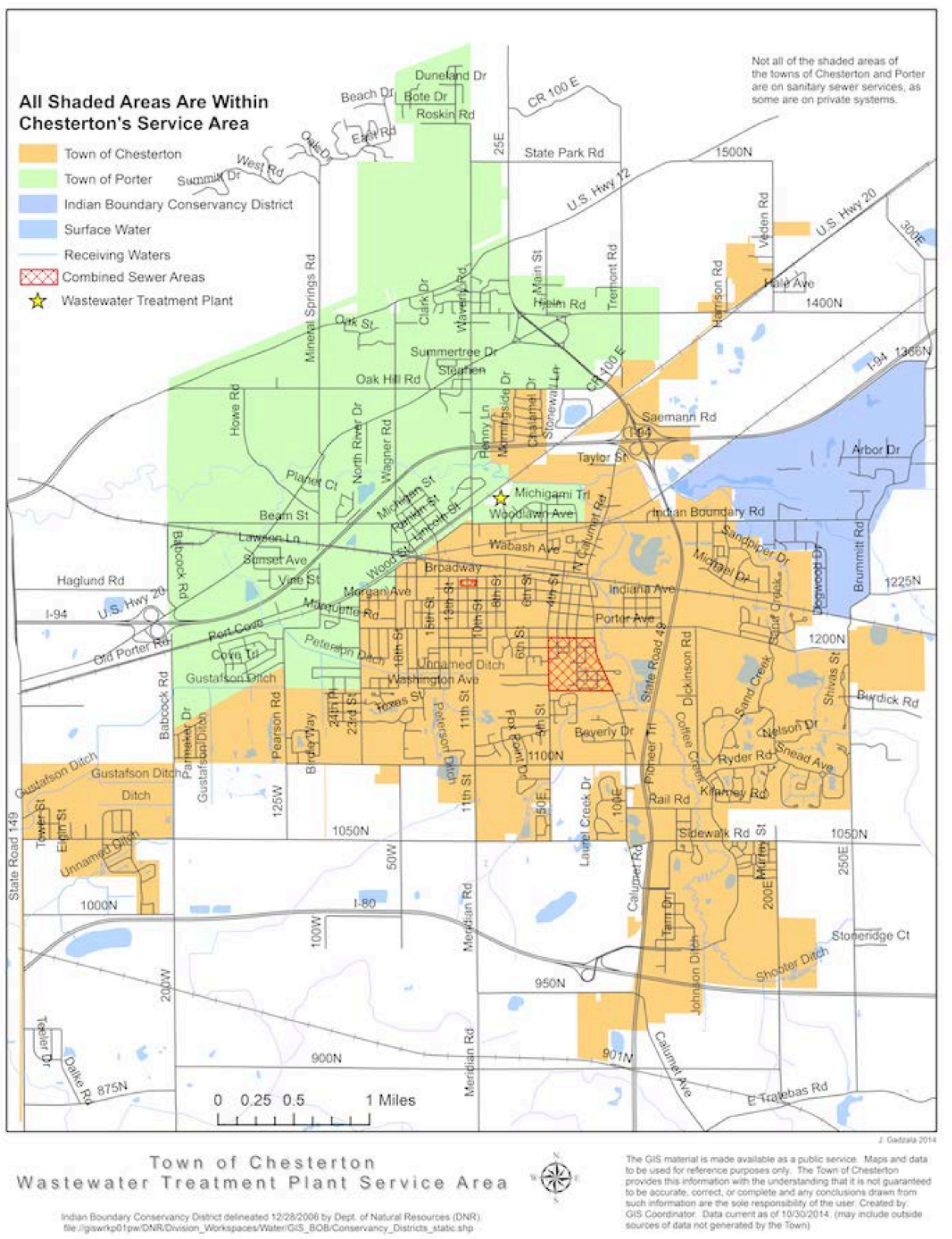

Figure 25. Service area for the Town of Chesterton Wastewater Treatment Plant

Coffee Creek Watershed Management Plan

The Coffee Creek Watershed Conservancy (CCWC), in collaboration with local stakeholders, completed the Coffee Creek WMP in 2003. While the Coffee Creek watershed is a subwatershed within the LCEB watershed, the project area for the Coffee Creek WMP is considerably smaller than the LCEB's Coffee Creek subwatershed (Figure 26). The Coffee Creek WMP serves as the community's road map to achieve the watershed stakeholders' vision for the watershed, which states that Coffee Creek supports a healthy cold-water biological community and provides an attractive resource for citizens. The CCWC has been an important stakeholder in developing the LCEB WMP and is represented on the Steering Committee. Save the Dunes worked closely with the CCWC to ensure that relevant information from the 2003 Coffee Creek WMP was incorporated into the LCEB WMP. The goals listed below played a role in the development of goals for the LCEB WMP.

Water quality improvement and protection goals identified in the Coffee Creek WMP

1. Establish/encourage vegetated streamside buffers along Coffee Creek and its tributaries
2. Encourage the conservation and improvement of forests in the headwater regions
3. Educate stakeholders of the value of Coffee Creek and ways to protect its water quality and aquatic life
4. Improve understanding of *E. coli* sources and improve education to stakeholders for the reduction of bacterial loads
5. Determine the contribution of sediment, nutrients and bacteria from surface and subsurface drains that were not monitored for the 2003 WMP
6. Reduce sediment loads from Pope O'Connor Ditch and Shooter Ditch by 65% and nutrients by 40%

Both the Pope O'Connor Ditch and Shooter Ditch drainage areas were selected as critical areas for the 2003 Coffee Creek WMP. Implementation efforts were conducted in Shooter Ditch. Drainage tiles were broken in a persistently wet agricultural field and a small dam/weir was built to manage the flow from this field. These implementation efforts likely improved water quality in Shooter Ditch.

Information from the Coffee Creek WMP among several other data sources was considered for the selection of critical and protection areas in the LCEB WMP. Ultimately, the Technical Committee decided that empirical data derived from the 2012 Baseline Study was the best indicator of water quality and water pollution. The Pope O'Connor Ditch and Shooter Ditch drainage areas were not selected as LCEB critical areas due to higher water quality than other parts of the LCEB watershed.

Chicago Wilderness Green Infrastructure Vision

This project provides a visionary, regional-scale map of the Chicago Wilderness region that reflects both existing green infrastructure, (forest preserve holdings, natural area sites, streams, wetlands, prairies, and woodlands) as well as opportunities for expansion, restoration, and connection. The broader goal of this effort is to bring the Chicago

Wilderness Biodiversity Recovery Plan to life in a more meaningful, visual, and accessible way for Chicago Wilderness members and outside audiences. For the purpose of this project, green infrastructure is: The interconnected network of land and water that supports biodiversity and provides habitat for diverse communities of native flora and fauna at the regional scale. The LCEB mainstem and Coffee Creek are included in the green infrastructure vision for Chicago Wilderness (Figure 26). To date, no projects for this regional plan have taken place in the LCEB. Stakeholder concerns addressed by this plan include acquisition of land and increased river access (Figure 2).

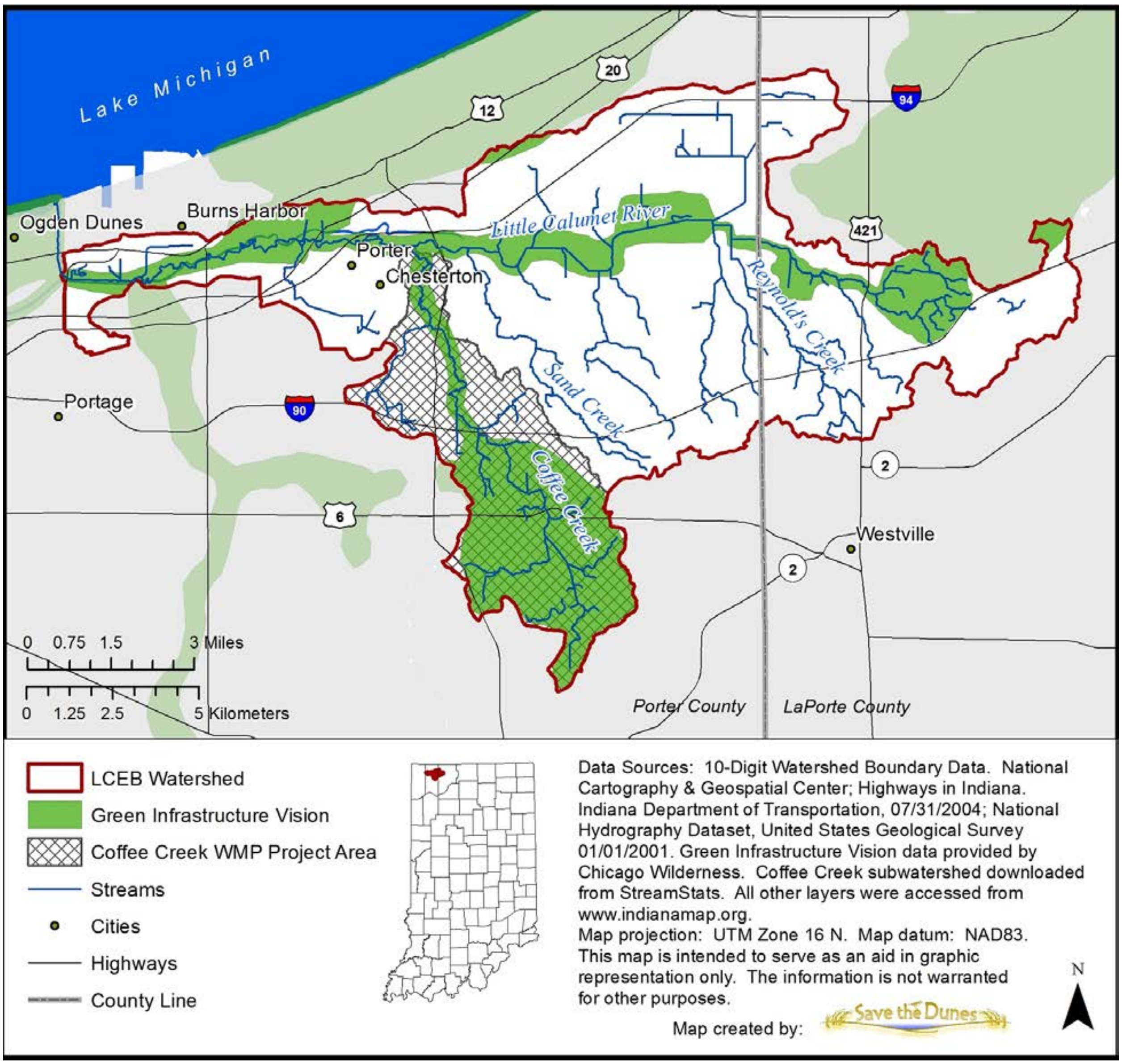

Figure 26. Green Infrastructure Vision and Coffee Creek Watershed Plan area

Indiana Comprehensive Wildlife Strategy

The Indiana Comprehensive Wildlife Strategy (CWS) was developed by the Indiana Department of Natural Resources (IDNR) in coordination with conservation partners across the state to protect and conserve habitats and associated wildlife at a landscape scale. It provides a comprehensive overview of conservation in Indiana and identifies needs and opportunities for helping prevent species from becoming threatened or endangered in the future. The Indiana Comprehensive Wildlife Strategy provides a framework for protecting species diversity (both on land and in water) for the LCEB watershed, which complements efforts to improve water quality in this watershed. Conservation recommendations are not made on a watershed scale, but rather on a regional and ecosystem basis. Recommendations include habitat protection, population management, population enhancement, disease/parasite management, and public education to reduce human disturbance. Due to a diversity of ecosystems in the LCEB and the noteworthy biodiversity of northwest Indiana, this program assists with the development of resources for the LCEB watershed. Information from this program was considered for the designation of protection areas.

Indiana Nonpoint Source Management Plan

The Indiana Nonpoint Source Management Plan, prepared by IDEM's Office of Water Quality, reflects the current goals and direction of Indiana's Nonpoint Source Management Program. It documents the methods Indiana will use to meet the state's long-term goal of measurable improvements in water quality through education, planning, and implementation while also meeting United States Environmental Protection Agency's (U.S. EPA's) criteria. As required by Section 319(h), each state's Nonpoint Source Management Program Plan describes the state program for nonpoint source management and serves as the basis for how funds are spent. The LCEB WMP is being drafted through an IDEM Section 319 grant.

Northwest Indiana Regional Greenways and Blueways Plan

The Greenways and Blueways Plan was developed jointly by NIRPC (Northwestern Indiana Regional Plan Commission) and Openlands. This effort represents a culmination of research, review, and analysis of local, regional, state, federal, and private endeavors that aim to preserve and restore linear open space corridors in the Northwest Indiana landscape. A 16-mile stretch of the LCEB is listed as a Blueway in the plan. NWIPA (Northwest Indiana Paddling Association) is working to implement the Greenways and Blueways plan by removing obstacles (woody debris) to paddling on the LCEB without harming important stream habitat. Increased walking trails, safe passage for recreational paddlers, and the acquisition of land are stakeholder concerns addressed by this plan (Figure 2). The LCEB watershed will benefit from this plan through the preservation of riparian areas, increased access and increased attention toward the restoration of aquatic resources. This plan may be used when assessing public access concerns.

Indiana Wellhead Protection Program

IDEM's Ground Water Section administers the Wellhead Protection Program, which is a strategy to protect ground water drinking supplies from pollution. The Safe Drinking Water Act and the Indiana Wellhead Protection Rule (327 IAC 8.4-1) mandates a wellhead program for all Community Public Water Systems. The Wellhead Protection Program involves the delineation of a Wellhead Protection Area (WHPA), identifying potential sources of contamination, and creating management and contingency plans for the WHPA. There is only one WHPA in the LCEB. Beechwood Mobile Home Park (Public Water Supply Identification Number 5246002) is located within the LCEB watershed in the headwaters of the Reynolds Creek subwatershed (10055 West 50 North, Michigan City, IN 46360). The Beechwood Mobile Home Park Wellhead Protection Plan was approved in October of 2006. Wellhead protection areas cannot be mapped for this WMP due to homeland security safety concerns.

Indiana Dunes National Lakeshore General Management Plan

The 1997 General Management Plan for INDU is a combination of the National Park Service's 1992 West Unit General Management Plan Amendment, 1991 Little Calumet River Corridor Plan, and 1997 East Unit General Management Plan Amendment. It defines the management philosophy and goals for making decisions and solving problems for the next 20 years. There are approximately 12,517 acres of INDU land within the LCEB watershed (Figure 24). This information was considered for the designation of protection and critical management areas, goals, and activities. This plan addresses several stakeholder concerns, including increased public access, continuous walking trails, and ADA compliant access (Figure 2).

Activities such as hiking, birding, and fishing are readily available on NPS lands in the LCEB. However, the 1997 plan does not include river clearing or facilities for paddling. The NPS, in collaboration with the National Forest Service and Urban Waters Initiative, has initiated the planning and environmental assessment (EA) process for a River Use Management Plan for the LCEB River. This plan and EA are currently in progress and will review all impacts and opportunities related to recreational use of the LCEB. The River Use Management Plan and the EA could greatly benefit the LCEB by drawing greater attention to the natural resources of the LCEB yet ensuring minimal harm to the environment.

Indiana Wetlands Conservation Plan

The purpose of the Indiana Wetlands Conservation Plan (IWCP) is to serve as a guide for wetland conservation efforts in the state. The IWCP serves as a framework for discussion and problem solving while establishing common ground on which progress of wetland conservation can be made. It also sets specific actions to achieve progress. While the IWCP does not specifically identify priority areas it does provide recommendations regarding prioritization. These recommendations are a framework of prioritization factors ranking various environmental conditions associated with water quality, flood control and groundwater benefits. This information may be used when designating priority protection areas. Stakeholder concerns addressed by this plan include acquisition of land and lack of cooperation between agencies (Figure 2).

Indiana Statewide Forest Assessment & Strategy

The Indiana Statewide Forest Strategy was developed by the IDNR in coordination with local stakeholders. It recognizes the most important issues that increasingly threaten the sustainability and ecological capacity of Indiana's forests to provide the benefits of clean air, carbon sequestration, soil protection, wildlife habitat, wood products and other values, goods and services. The plan addresses a limited forest base being fragmented or converted to other land uses, like subdivision housing, paved surfaces or row crop agriculture. The forest priority data displayed in Figure 27 was generated by the IDNR as part of the Indiana Statewide Forest Assessment to prioritize and reflect the relative importance of Indiana forest issues. The figure was generated by compositing forest issues and assigning a relative weighting score based on stakeholder feedback. This information was considered for the designation of protection areas.

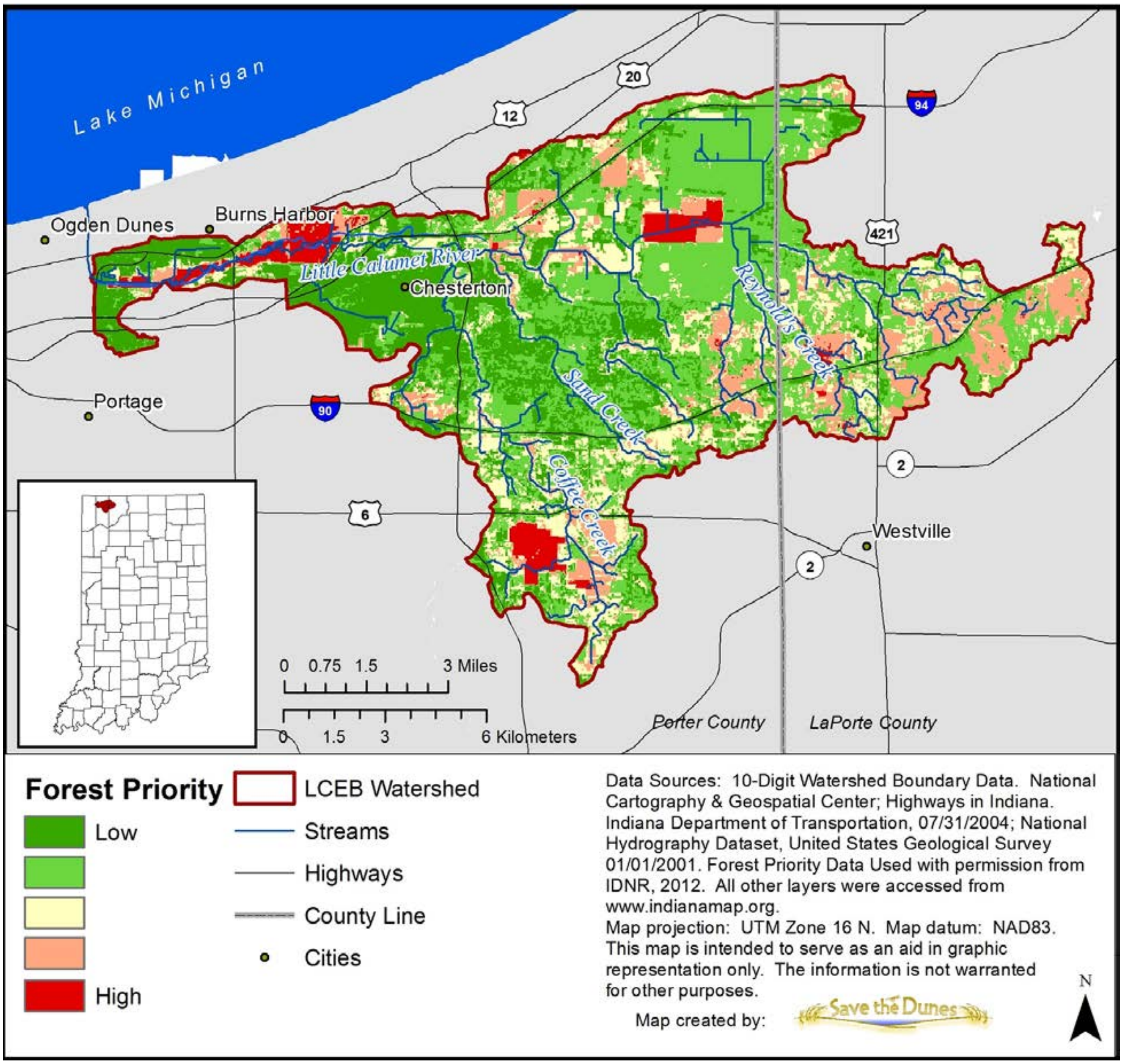

Figure 27. IDNR forest priority data

Little Calumet-Galien/Chicago Watershed Restoration Action Strategy

A Watershed Restoration Action Strategy (WRAS) is a large-scale coordination plan for an eight-digit hydrologic unit watershed. Each WRAS broadly covers an entire watershed; therefore, it is intended to be an overall strategy and does not dictate management and activities at the stream site or segment level. Water quality management decisions and activities for individual portions of the watershed are most effective and efficient when managed through sub-watershed plans, such as the LCEB Watershed Management Plan. Nonetheless, priority issues and management strategies were developed for the Little Calumet-Galien/Chicago watershed: data and information targeting, streambank erosion and stabilization, failing septic systems, water quality, fish consumption advisories, nonpoint source pollution (including an education and outreach component), and point sources. Larger scale efforts to improve water quality, such as this watershed restoration action strategy, play an important role for supporting local restoration activities in the LCEB.

Moraine Forest Conservation Planning Project

The objective and scope of the Moraine Forest Conservation Planning Project is to develop a large-scale comprehensive conservation planning effort for the moraine forest in the southern Lake Michigan watershed. This forested ecosystem is situated on the Valparaiso Moraine. It is characterized by rich mesic soils that support several species of hardwood trees and populations of spring ephemeral wildflowers. The headwaters of several streams that are tributaries of Lake Michigan, including the LCEB, are located within the moraine forest, which is vital to protecting water quality in these watersheds. Wetlands and streams punctuate the tree cover throughout the area and provide crucial habitat for wildlife. The project is a collaboration between four local land trusts (LaPorte County Conservation Trust, Save the Dunes, Woodland Savanna Land Conservancy, and SHLT) that will facilitate efforts to effectively preserve an unprecedented amount of this critical ecosystem in the southern Lake Michigan watershed. GIS data and models are being used to prioritize parcels located between Valparaiso in Porter County and the Michigan/Indiana state line in LaPorte County (Figure 28). Maps and brochures are being developed and used for landowner outreach, guided hikes, and public workshops aimed at protecting high-priority project areas. Three core areas identified through this project are entirely or partially within the LCEB watershed: the Red Mill County Park, the INDU Heron Rookery, and the Moraine Nature Preserve. This information was considered for the selection of protection areas.

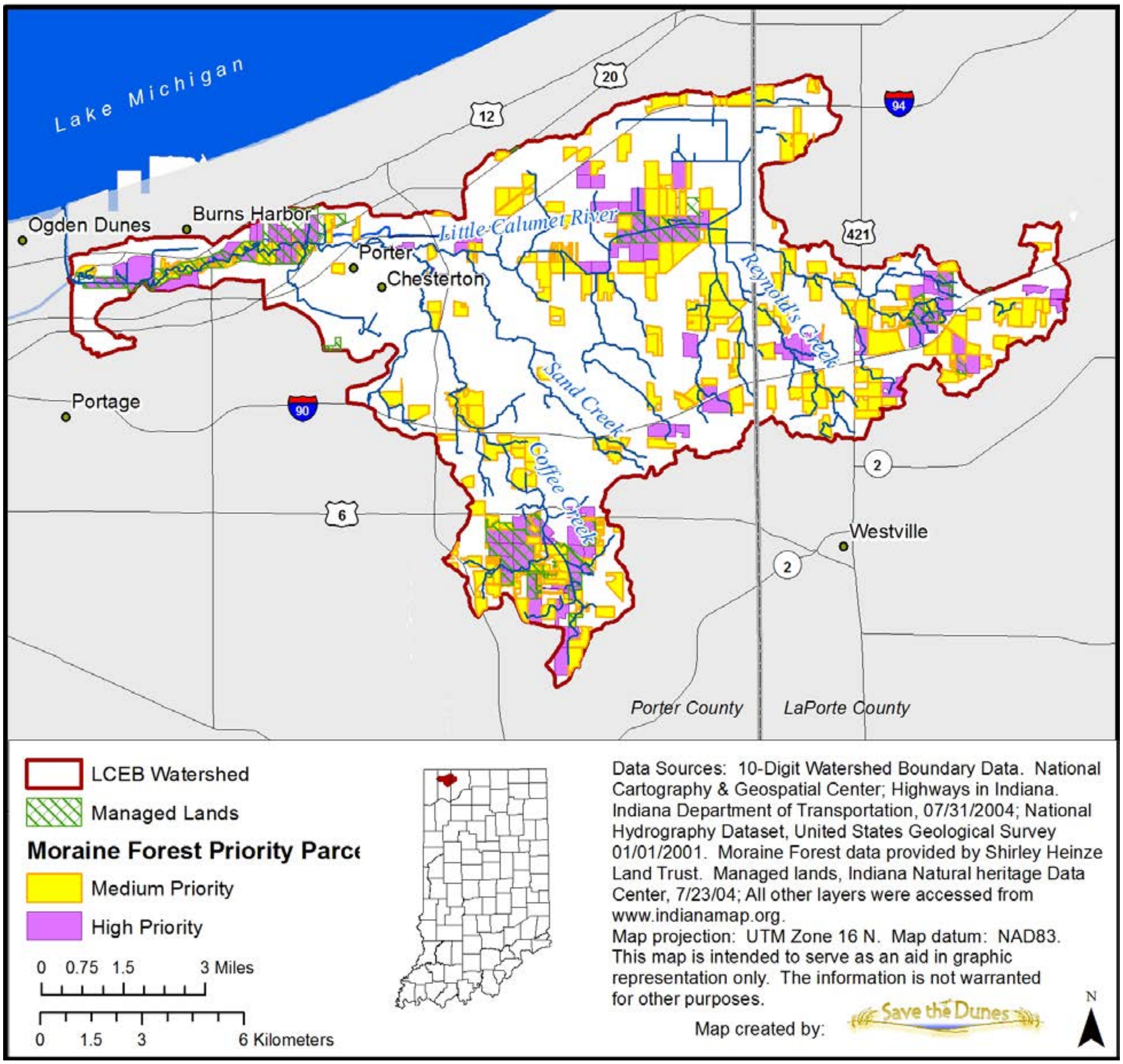

Figure 28. Shirley Heinze Land Trust moraine forest priority parcels

Municipal Separate Storm Sewer System (MS4)

The Clean Water Act requires storm water discharges from certain types of urbanized areas to be permitted under the National Pollutant Discharge Elimination System (NPDES) program. Under Phase II, 327 IAC 15-13 (Rule 13) was written to regulate most MS4 entities (cities, towns, universities, colleges, correctional facilities, hospitals, conservancy districts, homeowner's associations and military bases) located within mapped urbanized areas, as delineated by the United States Census Bureau, or, for those MS4 areas outside of urbanized areas, serving an urban population greater than 7,000 people. MS4s are required to develop and implement a Storm Water Quality Management Plan (SWQMP). One of the most important aspects of MS4 to watershed management practitioners is Part C of the SWQMP. Part C outlines the priorities, goals, and implementation strategies that the MS4 will utilize to improve water quality. LCEB stakeholders reported urban runoff to be a concern (Figure 2).

A review of MS4 entities data from IDEM shows the following designated MS4s partially within the LCEB watershed:

- LaPorte County (Permit Number INR0401070)
- Town of Chesterton (Permit Number INR040036)
- City of Portage (Permit Number INR040090)
- Town of Porter (Permit Number INR040115)
- Porter County (Permit Number INR040140)

The boundaries of each of these municipalities are shown in Figure 29. MS4 actions will improve water quality and address urban runoff to help to further the goals of this WMP.

IDEM has several water pollution reduction programs that appear to overlap. The MS4 Permit Program, the 319 Grant Program, and Rule 5 (Construction/Land Disturbance Storm Water Permitting) seem quite similar in that all programs seek to reduce pollutant loads from stormwater runoff but they actually fulfill quite different roles. The MS4 Permit Program is designed to regulate point source pollution from more populated urban and suburban areas. The 319 Grant Program provides guidance and financial assistance for watershed planning to reduce non-point source pollution. Rule 5 aims to reduce nonpoint source pollution from construction or land disturbing projects and pertains to anyone involved with a construction project that is one acre or larger.

Currently, there is one known development project in the watershed in need of Rule 5 enforcement. It is a 60+ acre home development project in the Chesterton area (Coffee Creek subwatershed) near sampling site 15 at CR 1050 N (see Figure 37). This site is currently in violation of Rule 5 and is being investigated by state and federal agencies. Private citizens are encouraged to report potential Rule 5 violations. Please contact the IDEM Complaint Coordinator at (800) 461-6027 ext. 24464 if a possible violation is identified.

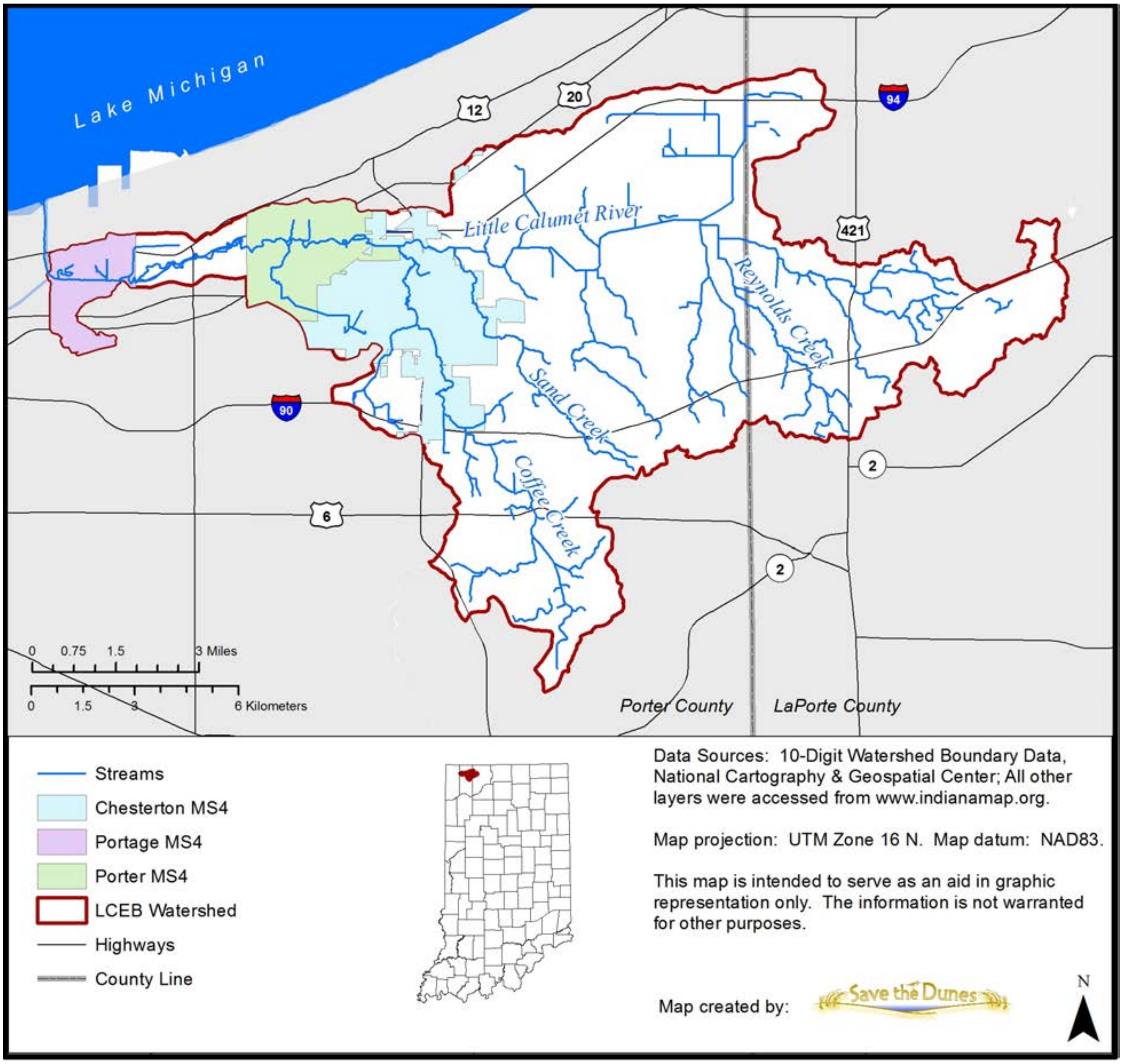

Figure 29. Municipal MS4 permit boundaries within the LCEB watershed

Total Maximum Daily Load (TMDL) Reports

A TMDL represents the maximum capacity of a waterbody to assimilate a pollutant while safely meeting the respective water quality standard. Section 303(d) of the Clean Water Act requires that TMDLs be established for each waterbody in a state that does not meet the water quality standards for the waterbody's designated use. The TMDL for a given waterbody and pollutant is the sum of individual waste load allocations (WLAs) for point sources and load allocations (LAs) for nonpoint sources and natural background levels (USEPA, 2001). The sum of the allocations must not result in the exceedance of the water quality standard. In addition, a margin of safety (MOS) must be included in the analysis, either implicitly or explicitly. The margin of safety accounts for any uncertainty in the relationship between loads and conditions in the receiving water and helps to ensure that the water quality standard is met.

The Little Calumet River and Portage Burns Waterway TMDL for *E. coli* was completed in 2004. The TMDL covers the LCEB watershed in addition to the Little Calumet River West Branch. Based on this report, the allowable TMDLs for the Little Calumet – Portage Burns Waterway will require reductions in nonpoint source loads from 34% to 97%. However, there is still uncertainty as to the magnitude that various nonpoint sources of *E. coli* play in the impairment of the Little Calumet and Portage Burns Waterway. Figure 30 was taken from the 2004 Little Calumet –Portage Burns Waterway TMDL.

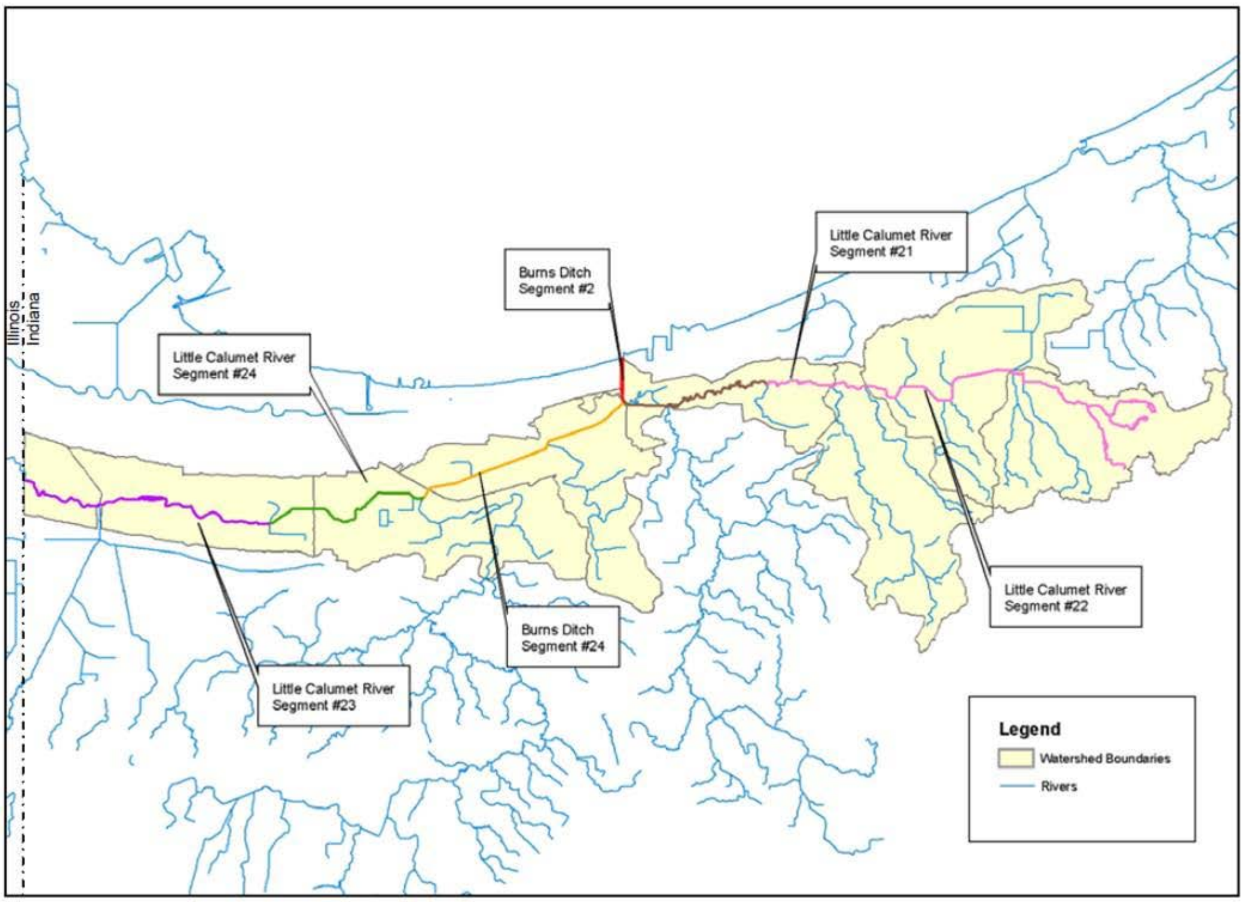

Figure 30. 2004 *E. coli* TMDL coverage area

2040 Comprehensive Regional Plan for Northwest Indiana

The 2040 Comprehensive Regional Plan (CRP) was developed as a comprehensive, citizen based regional vision that will guide the development of land use, transportation, local economies, green infrastructure, and social justice in Northwest Indiana. It is a policy program with strong coordination and implementation elements. The CRP deals largely with multijurisdictional needs and opportunities that no single agency can manage or effect on its own. Goals of the CRP that are in line with this WMP include:

- Protect natural resources
- Minimize impacts to environmental features and watershed
- Manage growth that protects farmland, environmentally sensitive areas, and important ecosystems
- Reduce flooding risks and improve water quality
- Improve green infrastructure

The CRP plays a strong role in the development and protection of the LCEB. Many stakeholder concerns are addressed by the CRP including, pollutant loading from combined sewer overflows and septic systems, stormwater management, and protection of fisheries and other natural habitats.

Local Comprehensive Plans

Indiana Code Section 36-7-4-500 through 512 enables local government to establish comprehensive plans and zoning ordinances. A comprehensive plan must contain at least the following elements:
(1) A statement of objectives for the future development of the jurisdiction.
(2) A statement of policy for the land use development of the jurisdiction.
(3) A statement of policy for the development of public ways, public places, public lands, public structures, and public utilities. The following comprehensive plans have the potential to impact water quality in the LCEB watershed:

- Burns Harbor Comprehensive Plan Place Making 20/20, 2009
- Town of Chesterton Comprehensive Plan, 2011
- LaPorte County Comprehensive Land Development Plan, 2008
- The City of Portage Comprehensive Plan, 2009
- Porter County Land Use and Thoroughfare Plan, 2001
- The Town of Porter Master Plan, 2003

Figure 31 shows the jurisdictions for all the comprehensive development plans in the LCEB.

Burns Harbor Comprehensive Plan Place Making 20/20

This plan provides a framework for the development and redevelopment of Burns Harbor. It outlines issues related to economic development, land use, transportation, and smart growth. The area of interest for this plan is the entire Burns Harbor city limits. Goals of the plan include:

- Preserve open space, natural beauty and critical environmental areas.
- Adopt ordinances to protect and preserve natural resources.
- Require new development to allow green corridors and protect natural resources.
- Remediate and redevelop brownfields.
- Encourage stormwater best management practices.
- Improve access to natural lands such as the Indiana Dunes National Lakeshore.

The Burns Harbor Comprehensive Plan addresses many stakeholder concerns including the remediation of brownfields, improved stormwater management, and improving public access to natural resources.

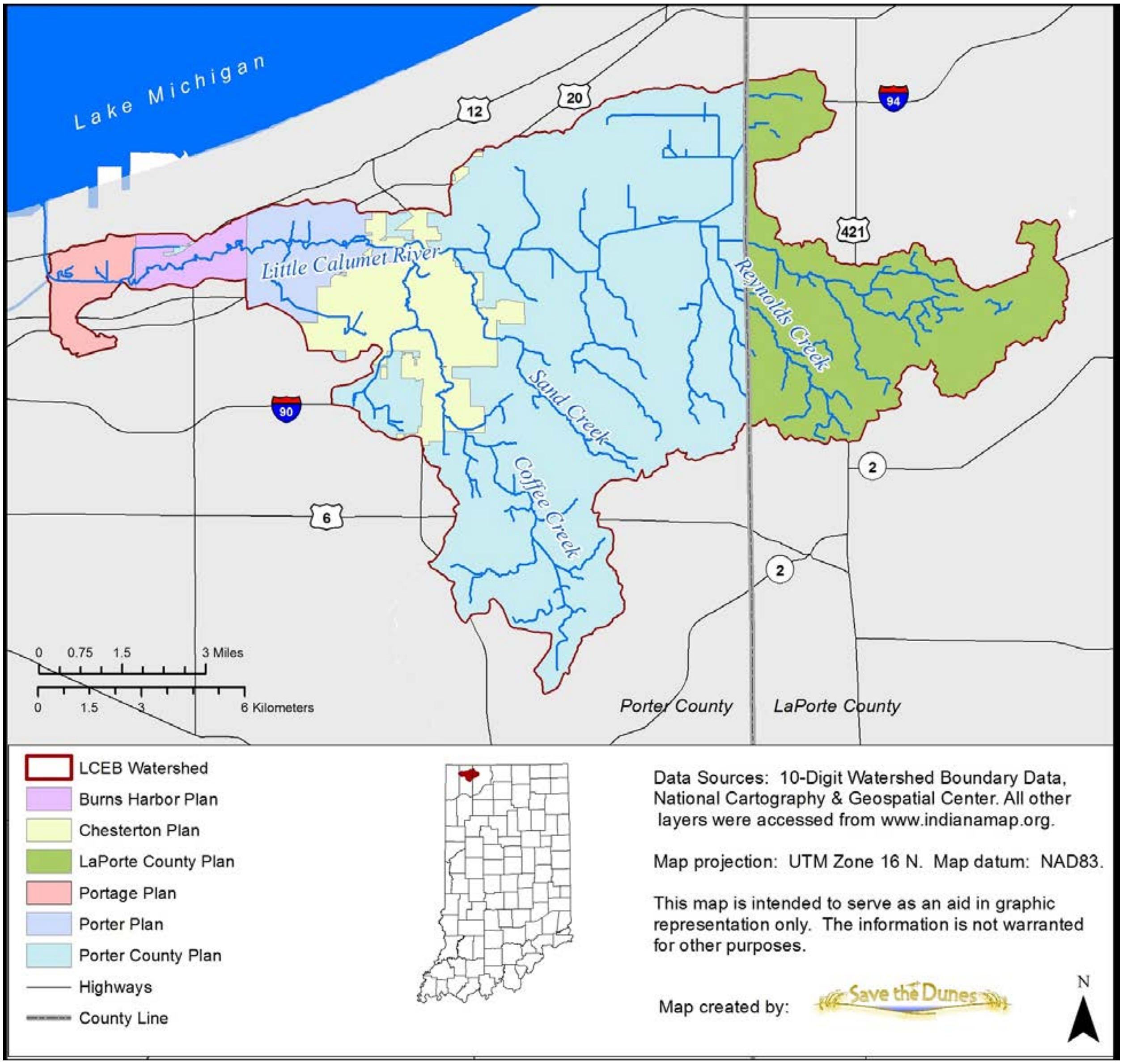

Figure 31. Jurisdictions for regional comprehensive plans

Chesterton, Indiana Comprehensive Plan 2010
The town of Chesterton Comprehensive Plan builds a detailed framework for future development in Chesterton. The plan includes the Chesterton municipal area. The plan's authors anticipate future development to extend approximately 1.5 miles to the south (CR 900 N) and 1 mile to the east (CR 350 E). Chesterton's comprehensive plan includes a detailed list of goals and priorities to guide development decisions. Many of these goals complement the goals for this watershed management plan. The comprehensive plan aims to encourage balanced land use partly by encouraging growth of parks and recreational opportunities. Preserving and enhancing natural resources will be accomplished by providing effective sewage collection, implementing stormwater BMPs and green infrastructure, protecting wetlands and floodplains, and increasing public awareness through education. Sustainable development will be promoted with appropriate zoning encouraging natural corridors, parks and open spaces. LCEB stakeholders have also expressed many of the goals outlined in Chesterton's Comprehensive Plan. Stakeholder concerns addressed by Chesterton's Comprehensive Plan include: improving stormwater management and flood prevention, nutrient and bacterial loading from combined sewers and septic systems, and the promotion of conservation easements and green infrastructure.

The Countywide Land Development Plan: Michigan City, City of LaPorte and All LaPorte County Communities
The LaPorte County comprehensive plan serves as a guide for land development decisions in LaPorte County. The plan covers the entire county, including the municipal areas of Michigan City, LaPorte, and others. The portion of the LCEB that is included in this development plan is very small (Figure 31). This plan addresses economic opportunities, transportation, public utilities, land uses, natural resources, and parks and recreational opportunities. Strategic goals and objectives were established for many topics addressed by this WMP. These goals included: encouraging the implementation of riparian buffers, urban and agricultural nonpoint source pollution BMPs, limiting the need for onsite septic systems, and reducing hydromodifications (stream channelization and stream bank erosion). These goals address several stakeholder concerns: need to restore tributary ditches, need to protect bottomlands and steep slopes, and reduce pollutant loadings from failing septic systems.

Portage, Indiana Comprehensive Plan
The comprehensive development plan for Portage provides a foundation based on existing conditions and guiding principles for future development. This plan covers the entire municipal area of Portage. The LCEB comprises a very small portion of this plan (Figure 31). Goals outlined in this plan that coordinate with the LCEB WMP include the development of trail systems to connect the city with the Indiana Dunes National Lakeshore and Indiana Dunes State Park, and the development and protection of parks and open spaces. This plan also expresses the intent to acquire land along the LCEB River and Salt Creek to establish riparian buffers for the protection of Lake Michigan water quality. The Portage development plan states the need for a comprehensive stormwater management plan. Unfortunately, it does not recommend any green stormwater best management practices or green infrastructure to help alleviate stormwater flow volumes. Stakeholder concerns addressed by this plan include: the need for walking trails and open

waterways along the LCEB, and the need to acquire land to improve connectivity and protect natural resources.

Porter County Land Use and Thoroughfare Plan
The Porter County Land Use and Thoroughfare Plan is a comprehensive plan designed to provide guiding principles and objectives toward future development (20 years) in Porter County. The plan addresses the whole county (all unincorporated areas), excluding municipal districts. Consequently, a large portion of the LCEB is covered by this comprehensive plan. Topics such as government, land use, parks and recreation, community services, economic development, natural resources, transportation, and infrastructure are covered by this planning effort. The plan seeks to promote intergovernmental coordination to manage the growth and development of Porter County. Many topics covered by this plan are also stakeholder concerns for the LCEB. The Porter County development plan seeks to preserve, maintain, and enhance natural resources including wetlands, wildlife, and water quality. By reducing pollution and preserving stream corridors, the plan aims to increase recreational opportunities and public access to countywide land and water trails.

The Town of Porter Master Plan
The comprehensive development plan for the Town of Porter is a framework to guide growth and development. This plan outlines development priorities for economic growth, transportation, land use and natural resources. The plan seeks to encourage tourism and the connectivity of downtown Porter to natural resources such as the Indiana Dunes National Lakeshore and the Indiana Dunes State Park. A stormwater management plan was developed that encouraged the use of green infrastructure to reduce the intensity of stormwater flows. The plan also encouraged the protection of open spaces to conserve natural resources and improve water quality. Many topics covered by the Town of Porter Master Plan are also concerns for LCEB stakeholders. These concerns included stormwater volumes creating degraded water quality, the need to protect natural habitats, and encouraging conservation of open spaces.

2.6 Flora and Fauna

2.6.a Endangered, Threatened, and Rare Species

The LCEB watershed is home to a large variety of endangered, threatened, and rare species. The watershed contains many natural areas and a diversity of ecosystems. The LCEB watershed is located just inland of the southern shoreline of Lake Michigan. “The Dunes” (Indiana Dunes National Lakeshore and Indiana Dunes State Park) are to the north and the Valparaiso Moraine is to the south. This places the watershed in an area where northern, eastern, southern, and western ecosystems come together, making for a rich diversity of native habitats. However, these native habitats have been modified, sometimes greatly so, since European settlement began in the 1830s. This has resulted in habitat fragmentation, with rare species distributed within the remaining pieces of natural areas.

The Indiana Natural Heritage Data Center, part of the Division of Nature Preserves (DNP), maintains information about federal and state endangered, threatened, rare, and special concern species, high quality natural communities, and significant natural areas in Indiana. This database assists in documenting the presence of special species and significant natural communities and serves as a tool for setting management priorities for these species and habitats. The database includes both historical and recent records and is based upon reported sightings from biologists and the general public, so it is not all-inclusive; therefore, there may be rare species present in the watershed but not documented.

There are three State Dedicated Nature Preserves in the watershed, all in headwaters areas on the Valparaiso Moraine. Little Calumet Headwaters Nature Preserve comprises 107 acres of wetlands and uplands within Red Mill County Park, LaPorte County. As indicated by the name, it is located within the headwaters of the East Branch Little Calumet River. The other two nature preserves are close together in the upper reaches of Coffee Creek; they are Moraine Nature Preserve and Suman Fen Nature Preserve. A third natural area is the Heron Rookery Unit of the INDU, which sits along both banks of the LCEB about three miles upstream of SR 49 at Chesterton. Most of the rare species are found in these natural areas, with Moraine Nature Preserve being the most important site. Pinhook Bog may also be considered part of the Little Calumet River East Branch watershed, although bogs do not actually drain to the river. It also does not drain to the adjacent Trail Creek Watershed. This bog and its adjacent uplands are a unit of INDU and support many unique species; this site is a National Natural Landmark.

The Coffee Creek Watershed Conservancy (CCWC) also maintains a 167-acre preserve along a middle section of Coffee Creek, south of Chesterton. This preserve contains over 5 miles of walking, hiking, and biking trails that are open to the public. Aside from Coffee Creek, Phillips Pond is also protected within the preserve boundaries, as well as numerous wetlands, upland prairie, and woodland habitats, which contain ecosystems unique to the moraine region in the southern portion of the watershed.

The federal and Indiana endangered Indiana bat (*Myotis sodalis*) has been documented in the watershed at the Heron Rookery Unit of INDU. It is currently the only known federally listed endangered species in the watershed**.** Appendix 2 contains the lists of endangered, threatened, rare, and special concern species known from the watershed. The oldest records are from Dr. Charles C. Deam in 1916 for areas that have since been developed. Some of the species in the database have not been reported for many years; they may or may not still be present, and current observers may not have provided their information to DNP. Because of the disparity in the dates of reported plant species, we have separated the information into historical (1950 and earlier) and current (1951 to present). However, wildlife species lists include both historical and current information because the differences are not as great as for the plants. The lists are for the entire watershed, not specific locations. Therefore, sites where various species were historically present may no longer exist because of development but the species may continue to persist within the watershed at other sites.

2.6.b Invasive Plant Species

Invasive plant species are plants that thrive in a given area, but are not native to the area. They may come from similar climates on other continents where natural predators keep them at non-nuisance levels, may be bred for landscaping purposes, or any number of other sources. These plants have the ability to spread out over large areas quickly and crowd out native plants, which can impact wetlands, floodplains, and other natural water treatment areas. Likewise, some invasive plants can contribute excess nutrients, such as nitrate, to streams, lowering water quality and feeding nuisance algae in waterbodies.

The Coffee Creek Invasive Species Assessment Tool was developed by Save the Dunes for The Nature Conservancy and in collaboration with IDNR (Indiana Department of Natural Resources), Coffee Creek Watershed Conservancy (CCWC), and Shirley Heinze Land Trust (SHLT). The project was developed to assist land managers and other stakeholders easily identify areas in the Coffee Creek subwatershed that are susceptible to invasive plant species. The list below summarizes some of the more common plant invaders in the LCEB watershed.

Reed Canary Grass (*Phalaris arundinacea*) is a highly competitive and aggressively spreading plant that can easily displace native plants and wildlife within wetland areas. It is capable if withstanding periods of flooding and droughts and spreads by seed and rhizome growth. Once established, it can be difficult to control. Early Detection/Rapid Response is critical for removal, along with cleaning equipment and clothing prior to entering wetland sites. The plant can be found throughout the Little Calumet Watershed within roadside ditches and degraded wetlands, with a particularly critical infestation in the headwaters of Coffee Creek.

Cattail (*Typha x glauca*; *Typha angustifolia*) is problematic within many wetlands, particularly those that have been disturbed. Cattails in the LCEB watershed are found in wet areas including the sides of ponds and lakes, ditches, wetlands, and stormwater detention ponds. They are generally not seen in open water like Common Reed and other wetland invaders. The hybridization of the exotic form (*Typha angustifolia*) has essentially eliminated the native cattail (*Typha latifolia*); as a result, management efforts often aim to control the spread of cattails in many wetland areas. Cattails are often controllable with current management techniques. However, large infestations often require several years of consistent treatment to reduce infestation to a manageable level due to a rapid growth rate. Cattails can out-compete native plants, eliminate habitats, and can result in closing of open waterways.

Common Reed (*Phragmites australis*) is an aggressive plant that appears to expanding throughout the LCEB watershed. This plant is found in many wet areas of the watershed, including the open water portion of some lakes and most wetlands, and has also been observed invading open upland areas with disturbed soils and a fair amount of sunlight. Common Reed prevents native plants from establishing, by growing in thick masses and exhibiting allelopathy. Older populations can take several years to remove. *Phragmites* is found mostly in sunlit areas with wet/moist soil conditions and along waterway edges. It can eliminate habitat for juvenile fish and waterfowl and is capable of lowering the water table allowing trees to become established in what would be wetland areas. There are native varieties of this plant, but these are relatively rare and non-invasive. At least one native population exists in the Suman Fen, part of the Moraine Nature Preserve.

Purple Loosestrife (*Lythrum salicaria*) is not terribly widespread in the LCEB watershed but is present in wetlands in the central portion of the watershed and in adjacent watersheds. This plant produces prolific amounts of seed that are easily dispersed by water and can also spread by rhizomes, resulting in vast, dense colonies. Purple Loosestrife can alter native plant communities and change drainage patterns by restricting the flow of water. It is possible to eradicate populations if detect early. However, large infestations can become costly to remove from sites. Large infestations are often treated with the use of *Galerucella spp.* beetles as a biological control.

Oriental Bittersweet (*Celastrus orbiculata*) is commonly found along edges of woodland communities in this watershed. This fast-growing vine prefers sunlit areas and can grow in several habitat types, including open woodlands and edges of streams. Birds consume the fruit and disperse it far from existing populations. Oriental Bittersweet rapidly climbs up trees, "choking" them out and ultimately shading out the understory, preventing any native vegetation from establishing. This vine prefers sunlit areas and can grow in several habitat types, including open woodlands and edges of streams.

Garlic Mustard (*Alliaria petiolata*) is a widespread exotic plant that can be hard to control without constant removal every year. This plant is a fast-growing biennial producing hundreds of seeds. It spreads mainly by either shooting out seeds from matured seed pods, adhering to humans and wildlife, or washing up on embankments from floodwaters. It exhibits allelopathy to inhibit the growth of mycorrhizal fungi, which many native plant species depend on during early stages of growth. This plant is mainly an edge species, but can also be found in floodplains, deciduous forests, and oak savannas. Early Detection/Rapid Response is critical to preventing further spread of this plant.

Canada Thistle (*Cirsium arvense*) is a noxious weed that occurs essentially in all sunlit areas of the watershed. It can produce prolific amount of seeds that are wind dispersed and can also spread by rhizome growth. Mechanical removal will increase spreading by rhizome growth, and would require consistent mowing over multiple times per year for several years to prevent seed dispersal. Chemical treatment can reduce infestation populations, but like mechanical removal it can be costly over time. This may lead to the need of bio-control to maintain more manageable populations. This plant can be found within a wide range of natural habitats, including savannas, sand dunes, wet prairies, and stream embankments. This plant can easily out-compete native plants and exhibits allelopathy chemical to prevent establishment of other plants.

Bush Honeysuckle (*Lonicera spp*.), Multiflora Rose (*Rosa multiflora*), and Autumn Olive (*Eleagnus umbellata*) were introduced simultaneously and historically planted as windbreakers, erosion control, and wildlife forage. Birds will consume the fruits from these shrubs, and disperse the seeds far beyond their existing populations. The shrubs can thrive in open areas and woodland edges, but can be found in forested ravines and woodland interior. They are found widespread throughout the Watershed and surrounding counties. These shrubs will grow in dense colonies preventing any native vegetation from establishing and can increase erosion on slopes and embankments.

Black Locust (*Robinia pseudoacacia*) is another species that was intentionally planted in the past. Black locust produces the highest heat value, fast-growing, and tolerates poor soil quality, which gives landowners a way to derive production from their land. This tree even though native to the United States has the tendency to be invasive to Northwest Indiana. It is particularly invasive in sandy soils within sunlit areas. It very seldom can invade areas with established tree cover, but tends to colonize woodland edges. It appears to occur predominately along the northern portion of the Watershed, especially across the main highways, but can be found throughout the rest of the Watershed. Removal of large mature trees can lead to several years of follow-up treatment of seedlings due to its fast growth rate. It can also fix nitrogen in the soil, even several years after removal, which could promote established of other exotic species.

Potential Expansion of Invasive Plants in Little Calumet Watershed

Japanese Barberry (*Berberis thunbergii*) is a popular shrub in residential landscapes, and has escaped from planting areas presumably by birds. While it has not reached the density of other commonly found invasive shrubs in the watershed, it may increase in expansion with continual use in landscaping and climate change. Its most commonly found within wooded areas.

Burning Bush (*Euonymus alatus*) and Privet (*Ligustrum* spp.) are other popular residential landscaping shrubs, which have also escaped from planting areas within surrounding counties. Continual use in landscaping and climate change may increase expansion.

The Buckthorns (*Frangula alnus, Rhamnu frangula,* and *Rhamnus cathartica*) were not detected in the LCEB. However, buckthorn species are present in the county and surrounding counties and can be expected to expand. The floodplains and mesic woodlands are the most threatened communities. Control is possible with Early Detection/Rapid Response to new populations.

Tree of Heaven (*Ailanthus altissima*) was not detected in the managed nature preserves in the watershed, but probably has sporadic populations since it is found within surrounding counties. This is a fast-growing tree with seeds that are wind dispersed. They can easily become established within any open areas and can be found on a variety of habitats.

Air Potato (*Diascorea bulbifera*) has been detected within one of the managed areas within this Watershed. This vine is a vigorous climber and often forms deep mats over low vegetation. Established populations have proven to be nearly unstoppable in southern Indiana, yet can be controlled with Early Detection/Rapid Response. Its method for dispersal seems to be by following moving water, but the explanation for isolated introductions is elusive.

Other species such as Kudzu, Japanese Knotweed, Black Swallowwort, Mugwort, and Giant Hogweed are also present in surrounding counties and are likely already moving into some parts of the LCEB watershed. These are extremely invasive and will likely spread into the watershed if existing populations are not controlled.

Future management of the invasive plants in the Little Calumet East Branch watershed should not only be direct efforts to limit the expansion of invasive species within protected nature preserves. It should also include requiring management crews, such as highways, railroads, and parks to receive training in the identification and control methods for these plants, proper equipment cleaning techniques, along with preventing use of invasive plants in landscaping.

2.7 Watershed Summary

The LCEB watershed is a diverse watershed with variable soils, land use, and ecosystems supporting both rural, agricultural areas and developed urban areas.

Due to diverse surficial geology developed by glacial deposits and lake development, the LCEB watershed contains a rich diversity of soils ranging from nutrient rich, poorly draining soils to nutrient poor, highly permeable sandy soils. Agricultural lands and forests are the two dominant land uses on these diverse soils. These contrasting soil types nonetheless have a similar defining characteristic. Both soil types are poorly suited to fairly poorly suited for onsite septic systems. One drains too quickly while the other drains too slowly. The majority of the watershed is not serviced by sewer infrastructure; consequently malfunctioning onsite septic systems could produce widespread nonpoint source pollution. Plans for improving water quality will need to consider soil type, adjusting methods or techniques based on the existing soil characteristics.

The diversity of ecosystems in the LCEB have led to an abundance of endangered, threatened or rare (ETR) and invasive species in the watershed. This provides a unique opportunity for management in the watershed because both protection and restoration measures may be needed.

Water quality sampling over time has shown increased impairments throughout the watershed. Nearly every stream in the watershed has been listed on IDEM's 303(d) listing of impaired waters for *E. coli*, nutrients, impaired biotic communities, chloride, and/or PCBs in fish tissue.

Municipalities and other jurisdictions within the LCEB watershed have developed plans for protecting and improving water quality, wildlife, and natural habitats. Some plans identify higher quality lands in need of protection that will increase connectivity of natural landscapes. Other plans encourage the protection of wetlands or the reduction of nonpoint source pollution. Increasing public access to natural lands is common goal that many of the plans share.

3.0 Watershed Inventory 2 – Water Quality

To better understand the LCEB watershed, an assessment of existing water quality sampling studies was conducted. Reviewing past and current water quality is fundamental to developing a more complete understanding of the watershed. Because the LCEB is within the Great Lakes system, water quality standards under Indiana Administrative Code (IAC) 327 IAC 2-1.5 apply. The main stem of the LCEB and its tributaries, downstream to Lake Michigan via Burns Waterway, are designated as salmonid streams (327 IAC 2-1.5-5) for which more stringent water quality standards apply for some parameters.

3.1 Historic Water Quality Sampling Campaigns

Several water quality-sampling campaigns have been conducted in the LCEB watershed in recent history.

Impaired Waterbodies – 303(d)
As required by Chapter 305(b) of the Clean Water Act, the Indiana Department of Environmental Management is charged with assessing water quality in the state. Each water body is assigned a rating based on its ability to meet Indiana's Water Quality Standards, which were developed in an effort to make all Indiana waters swimmable, fishable and drinkable. Waterways that fail designated standards are declared impaired and put on the 303(d) listing.

Nearly all the stream segments within the LCEB watershed have been found to be impaired for *E. coli*, nutrients, biotic communities, dissolved oxygen, chloride and/or PCBs in fish tissue. In 2005, U.S. EPA approved a TMDL completed by IDEM to address the *E. coli* impairments in the Little Calumet River mainstem. Table 9 shows the impaired stream segments within the LCEB that were addressed by this TMDL. These segments continue to be impaired and remain on subsequent versions of the 303(d) list with an updated AUID under Category 4A. Additional impairments have been found in the watershed (using the updated AUIDs), but no new TMDLs have been completed (Table 10).

Table 10 shows the 303(d) listed stream segments within the LCEB watershed from the 2008 and 2010 approved listings, as well as the 2012 draft listing (see Figure 32). As of the writing of this report, the 2012 and 2014 impaired streams listings are in draft form and have not yet been approved by EPA.

In 2012, a baseline study of water chemistry and biotic communities in the watershed was performed by IDEM and National Parks Service (NPS) staff on a monthly basis at the 48 LCEB baseline sampling sites. As a result of this comprehensive sampling program, IDEM reassessed the stream segments in February 2013 and found additional impairments (Table 11 and Figure 33). Figures 34, 35 and 36 highlight the specific 2014 draft 303(d) impairments for stream reaches throughout the watershed.

Table 9. Impaired water bodies from the 2004 Little Calumet and Portage Burns Waterway TMDL for *E. coli* Bacteria

Subwatershed	Old AUID	New AUID	Assessment Unit Name	Cause of Impairment	Category	Year Listed
REYNOLDS	INC0161_T1023	INC0141_T1002	LITTLE CALUMET RIVER, EAST ARM, UNNAMED TRIBUTARY	E. COLI	4A	2006
REYNOLDS	INC0161_T1023	INC0141_01	LITTLE CALUMET RIVER, EAST ARM	E. COLI	4A	2006
KEMPER	INC0162_T1060	INC0142_01	LITTLE CALUMET RIVER, EAST ARM	E. COLI	4A	2006
KEMPER	INC0162_T1082	INC0142_01	LITTLE CALUMET RIVER, EAST ARM	E. COLI	4A	2006
COFFEE	INC0163_T1061	INC0143_04	LITTLE CALUMET RIVER, EAST ARM	E. COLI	4A	2006
COFFEE	INC0164_T1018	INC0143_04	LITTLE CALUMET RIVER, EAST ARM	E. COLI	4A	2006
COFFEE	INC0164_T1086	INC0143_04	LITTLE CALUMET RIVER, EAST ARM	E. COLI	4A	2006
COFFEE	INC0164_T1108	INC0143_04	LITTLE CALUMET RIVER, EAST ARM	E. COLI	4A	2006

Table 10. 2008, 2010, and 2012 (draft) 303(d) listed streams

Subwatershed	AUID	Assessment Unit Name	Cause of Impairment	Category	Year Listed
KEMPER	INC0142_T1003	LITTLE CALUMET RIVER, EAST ARM, UNNAMED TRIBUTARY	E. COLI	5A	2008, 2010, 2012
COFFEE	INC0143_04	LITTLE CALUMET RIVER, EAST ARM	IMPAIRED BIOTIC COMMUNITIES	5A	2008, 2010, 2012
COFFEE	INC0143_04	LITTLE CALUMET RIVER, EAST ARM	E. COLI	5A	2008
COFFEE	INC0143_04	LITTLE CALUMET RIVER, EAST ARM	PCBs (FISH TISSUE)	5B	2008, 2010, 2012
COFFEE	INC0143_T1006	COFFEE CREEK	E. COLI	5A	2008, 2010, 2012
COFFEE	INC0143_T1007	COFFEE CREEK, UNNAMED TRIBUTARY	E. COLI	5A	2010, 2012

Table 11. 2014 (draft) 303(d) listed streams

Subwatershed	AUID	AUID Name	Cause of Impairment	Category	Year Listed
REYNOLDS	INC0141_01	LITTLE CALUMET RIVER, EAST ARM	DISSOLVED OXYGEN	5A	2014
REYNOLDS	INC0141_01	LITTLE CALUMET RIVER, EAST ARM	IMPAIRED BIOTIC COMMUNITIES	5A	2014
REYNOLDS	INC0141_T1001	LITTLE CALUMET RIVER, EAST ARM - UNNAMED TRIBUTARY	DISSOLVED OXYGEN	5A	2014
REYNOLDS	INC0141_T1002	LITTLE CALUMET RIVER, EAST ARM - UNNAMED TRIBUTARY	IMPAIRED BIOTIC COMMUNITIES	5A	2014
REYNOLDS	INC0141_T1003	REYNOLDS CREEK	IMPAIRED BIOTIC COMMUNITIES	5A	2014
REYNOLDS	INC0141_T1004	LITTLE CALUMET RIVER, EAST ARM - UNNAMED TRIBUTARY	IMPAIRED BIOTIC COMMUNITIES	5A	2014
REYNOLDS	INC0141_T1004	LITTLE CALUMET RIVER, EAST ARM - UNNAMED TRIBUTARY	E. COLI	5A	2014
COFFEE	INC0142_01	LITTLE CALUMET RIVER, EAST ARM	DISSOLVED OXYGEN	5A	2014
COFFEE	INC0142_01	LITTLE CALUMET RIVER, EAST ARM	IMPAIRED BIOTIC COMMUNITIES	5A	2014
COFFEE	INC0142_01	LITTLE CALUMET RIVER, EAST ARM	NUTRIENTS	5A	2014
COFFEE	INC0142_T1001	LITTLE CALUMET RIVER, EAST ARM - UNNAMED TRIBUTARY	IMPAIRED BIOTIC COMMUNITIES	5A	2014
COFFEE	INC0142_T1001	LITTLE CALUMET RIVER, EAST ARM - UNNAMED TRIBUTARY	NUTRIENTS	5A	2014
COFFEE	INC0142_T1001	LITTLE CALUMET RIVER, EAST ARM - UNNAMED TRIBUTARY	E. COLI	5A	2014
COFFEE	INC0142_T1001	LITTLE CALUMET RIVER, EAST ARM - UNNAMED TRIBUTARY	DISSOLVED OXYGEN	5A	2014
COFFEE	INC0142_T1002	LITTLE CALUMET RIVER, EAST ARM - UNNAMED TRIBUTARY	IMPAIRED BIOTIC COMMUNITIES	5A	2014
COFFEE	INC0142_T1002	LITTLE CALUMET RIVER, EAST ARM - UNNAMED TRIBUTARY	E. COLI	5A	2014
KEMPER	INC0142_T1003	LITTLE CALUMET RIVER, EAST ARM - UNNAMED TRIBUTARY	E. COLI	5A	2014
KEMPER	INC0142_T1003	LITTLE CALUMET RIVER, EAST ARM - UNNAMED TRIBUTARY	IMPAIRED BIOTIC COMMUNITIES	5A	2014

Subwatershed	AUID	AUID Name	Cause of Impairment	Category	Year Listed
KEMPER	INC0142 _T1004	LITTLE CALUMET RIVER, EAST ARM - UNNAMED TRIBUTARY	NUTRIENTS	5A	2014
KEMPER	INC0142 _T1004	LITTLE CALUMET RIVER, EAST ARM - UNNAMED TRIBUTARY	DISSOLVED OXYGEN	5A	2014
KEMPER	INC0142 _T1004	LITTLE CALUMET RIVER, EAST ARM - UNNAMED TRIBUTARY	E. COLI	5A	2014
KEMPER	INC0142 _T1004	LITTLE CALUMET RIVER, EAST ARM - UNNAMED TRIBUTARY	IMPAIRED BIOTIC COMMUNITIES	5A	2014
COFFEE	INC0143 _04	LITTLE CALUMET RIVER, EAST ARM	PCBS (FISH TISSUE)	5B	2014
COFFEE	INC0143 _04	LITTLE CALUMET RIVER, EAST ARM	IMPAIRED BIOTIC COMMUNITIES	5A	2014
COFFEE	INC0143 _T1002	WILLOW CREEK (UPSTREAM F CHRISMAN DITCH)	DISSOLVED OXYGEN	5A	2014
COFFEE	INC0143 _T1005	LITTLE CALUMET RIVER, EAST ARM - UNNAMED TRIBUTARY	CHLORIDE	5A	2014
COFFEE	INC0143 _T1005	LITTLE CALUMET RIVER, EAST ARM - UNNAMED TRIBUTARY	E. COLI	5A	2014
COFFEE	INC0143 _T1005	LITTLE CALUMET RIVER, EAST ARM - UNNAMED TRIBUTARY	IMPAIRED BIOTIC COMMUNITIES	5A	2014
COFFEE	INC0143 _T1006	COFFEE CREEK	IMPAIRED BIOTIC COMMUNITIES	5A	2014
COFFEE	INC0143 _T1006	COFFEE CREEK	DISSOLVED OXYGEN	5A	2014
COFFEE	INC0143 _T1006	COFFEE CREEK	E. COLI	5A	2014
COFFEE	INC0143 _T1007	COFFEE CREEK - UNNAMED TRIBUTARY	NUTRIENTS	5A	2014
COFFEE	INC0143 _T1007	COFFEE CREEK - UNNAMED TRIBUTARY	IMPAIRED BIOTIC COMMUNITIES	5A	2014
COFFEE	INC0143 _T1007	COFFEE CREEK - UNNAMED TRIBUTARY	DISSOLVED OXYGEN	5A	2014
COFFEE	INC0143 _T1007	COFFEE CREEK - UNNAMED TRIBUTARY	E. COLI	5A	2014
COFFEE	INC0143 _T1008	PETERSON DITCH	DISSOLVED OXYGEN	5A	2014
COFFEE	INC0143 _T1008	PETERSON DITCH	E. COLI	5A	2014
COFFEE	INC0143 _T1008	PETERSON DITCH	IMPAIRED BIOTIC COMMUNITIES	5A	2014

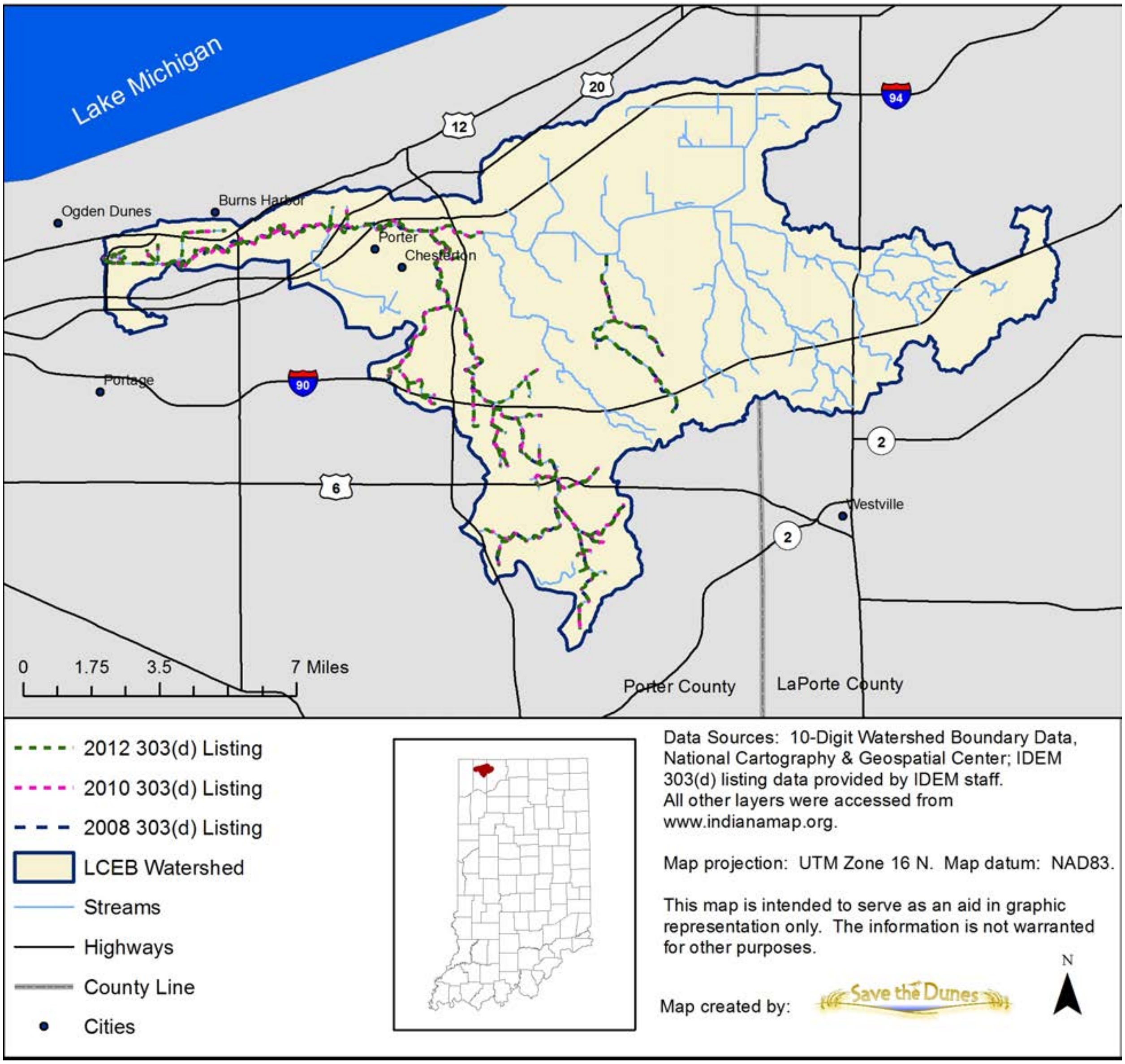

Figure 32. 2008, 2010, and 2012 303(d) listings

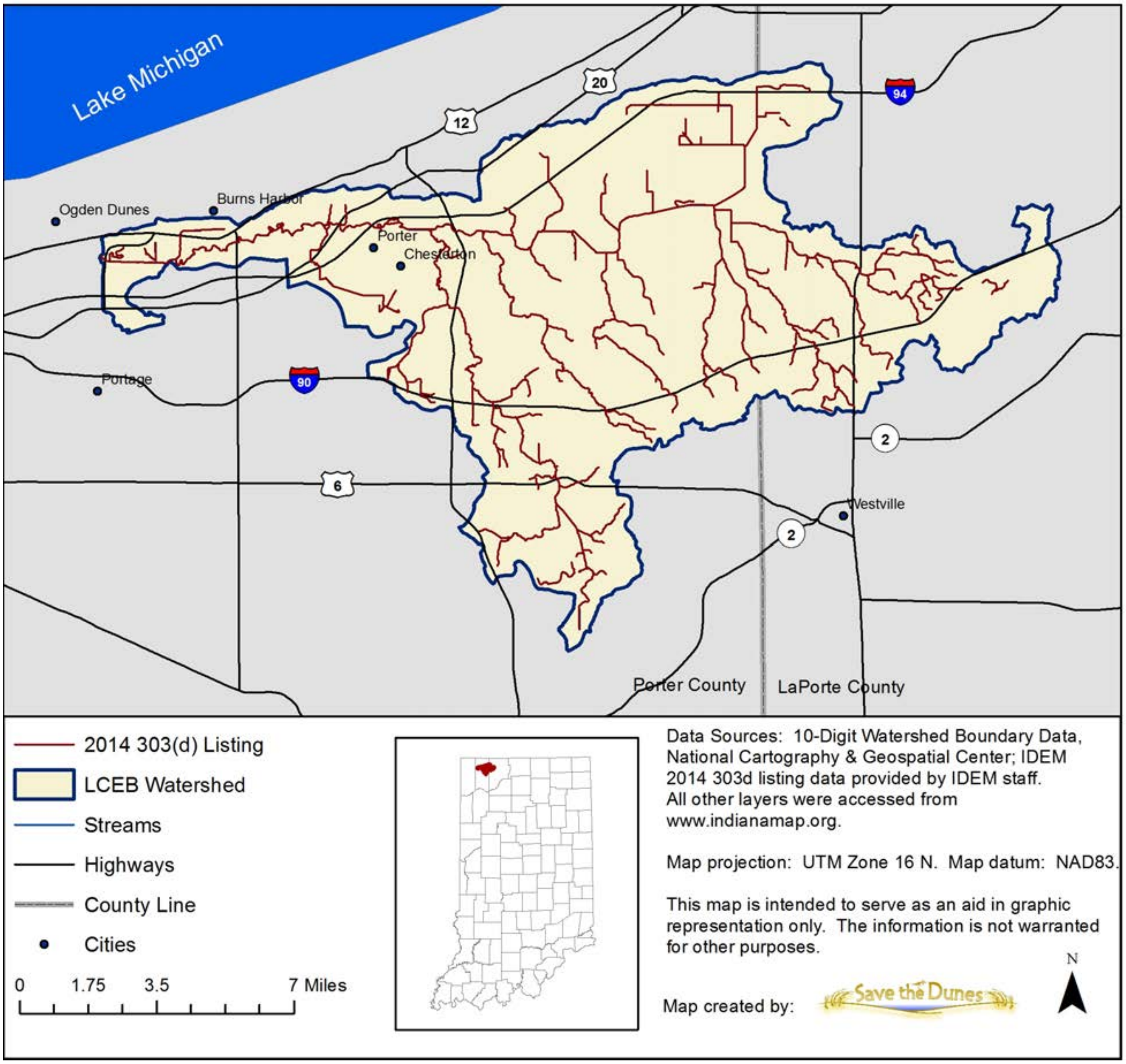

Figure 33. 2014 draft 303(d) listing

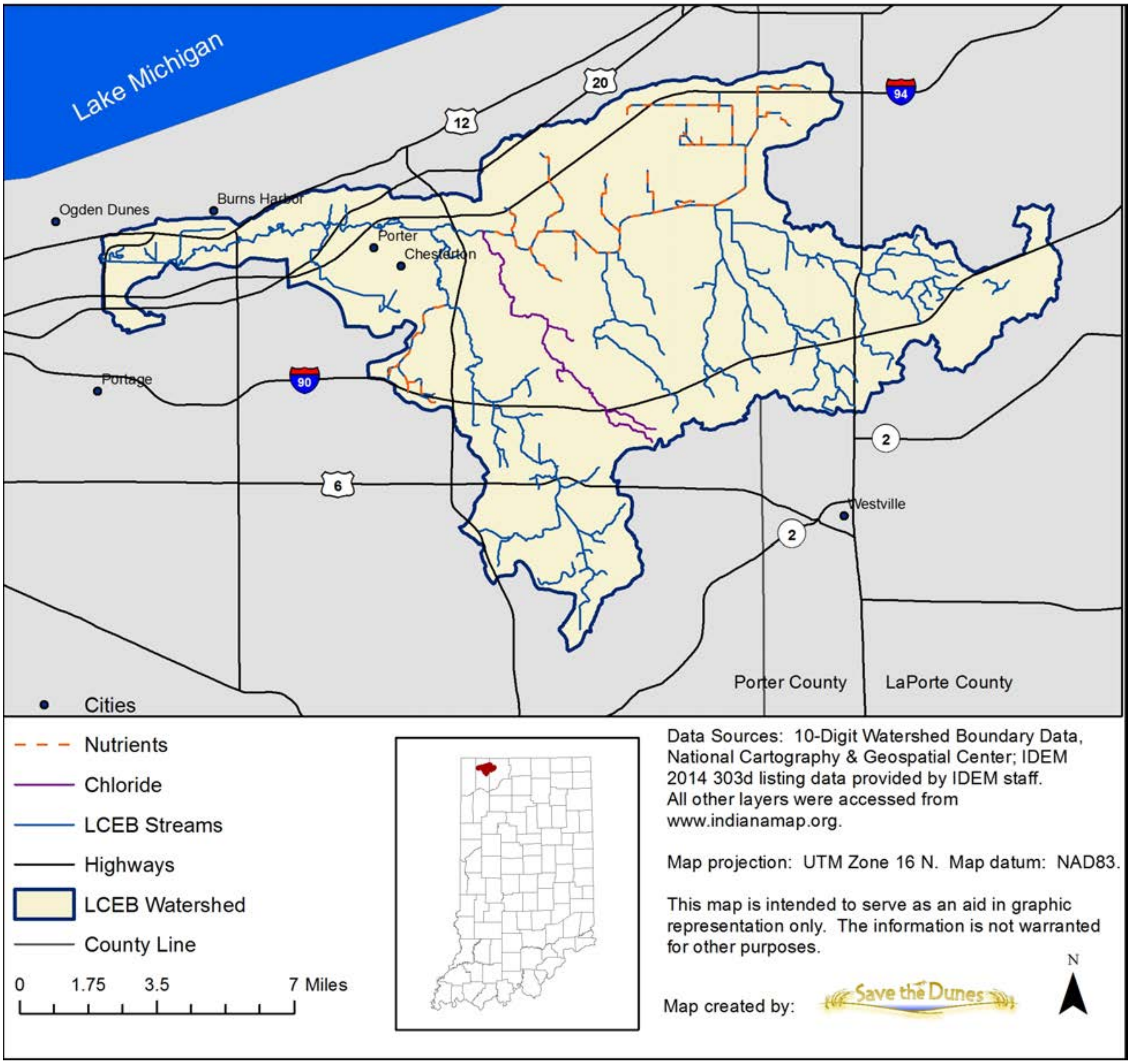

Figure 34. 2014 draft 303(d) listing for nutrients and chloride

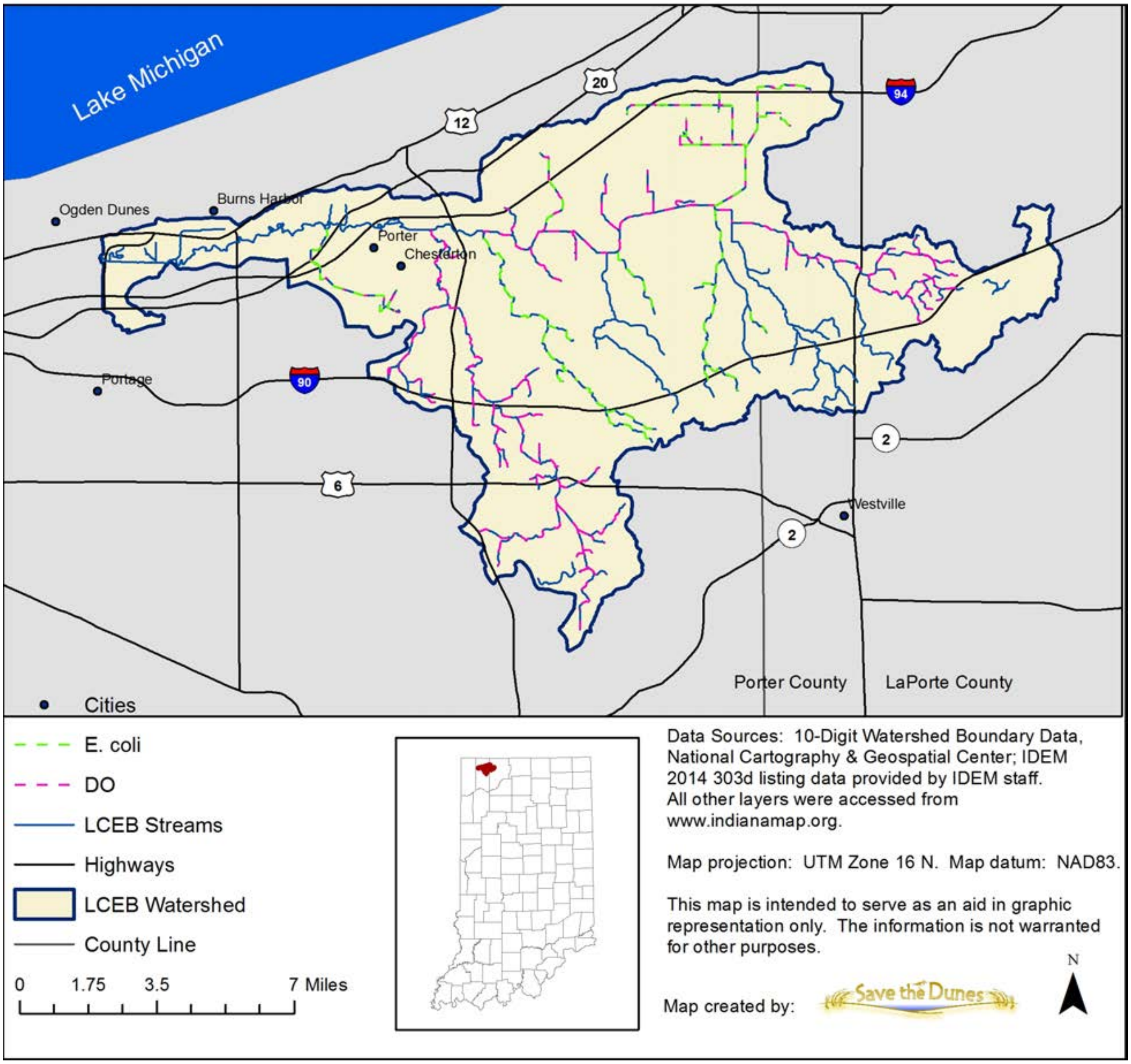

Figure 35. 2014 draft 303(d) listings for *E. coli* and dissolved oxygen (DO)

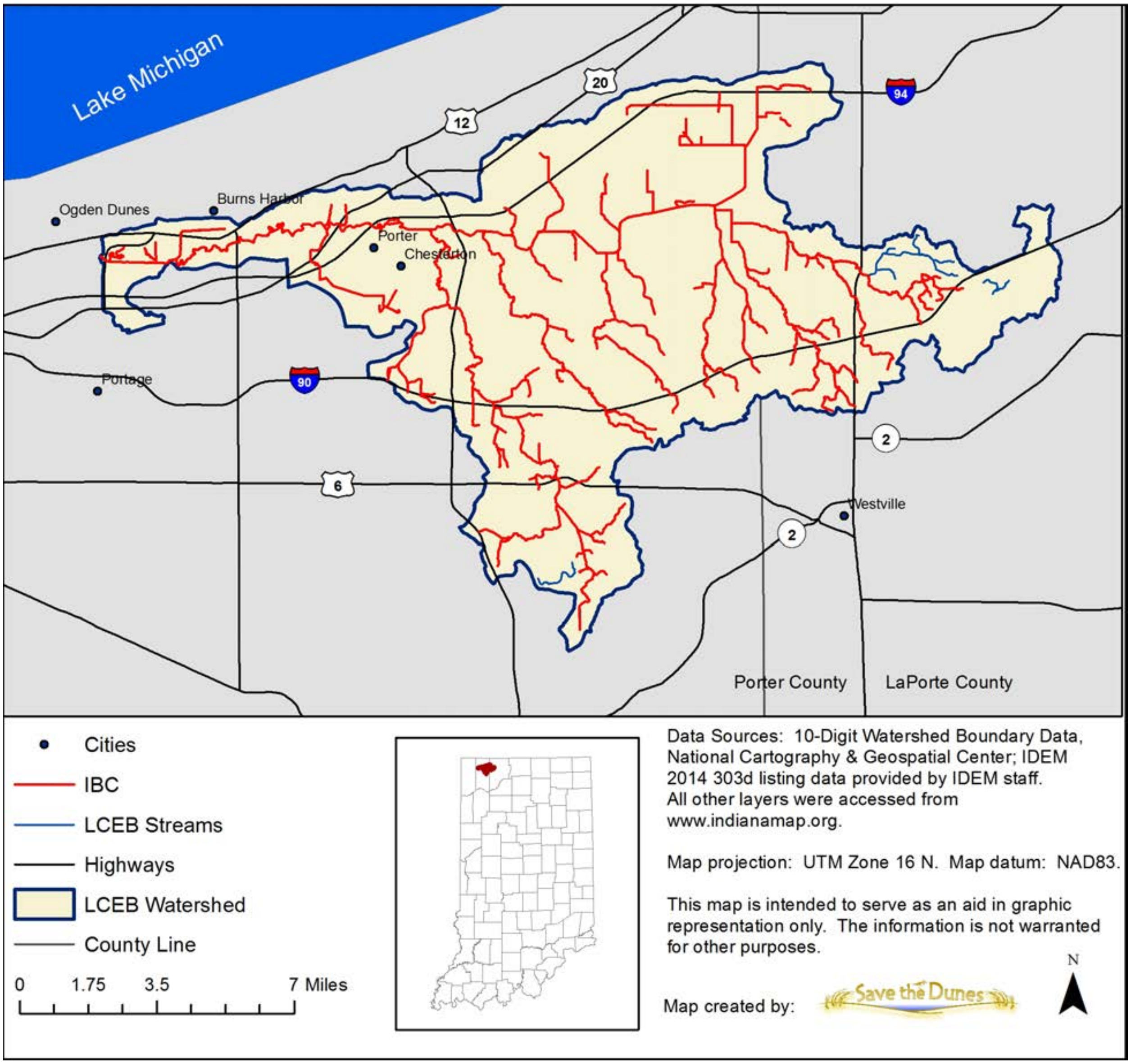

Figure 36. 2014 draft 303(d) listings for impaired biotic communities (IBC)

Fish Consumption Advisory

The Fish Consumption Advisory (FCA) is produced through collaboration with Indiana Department of Environmental Management, Indiana Department of Natural Resources, and Indiana State Department of Health. Fish tissue samples are collected on a rotating basin methodology and analyzed for PCBs, pesticides and heavy metals. The Fish Consumption Advisory listing in Table 12 is for the LCEB River in Porter and LaPorte Counties.

Advisory Groups for the Indiana Fish Consumption Advisory:

- Group 1: Unrestricted consumption for adult males and females. One meal per week for women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15.
- Group 2: Limit to one meal per week (52 meals per year) for adult males and females. One meal per month for women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15.
- Group 3: Limit to one meal per month (12 meals per year) for adult males and females. Women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15-Do Not Eat.
- Group 4: Limit to one meal every two months (6 meals per year) for adult males and females. Women who are pregnant or breastfeeding, women who plan to have children, and children under the age of 15-Do Not Eat.
- Group 5: No consumption (Do Not Eat).

Table 12. Fish Consumption Advisory listing for the LCEB watershed

Fish Species	Fish Size (inches)	Advisory Group
Black Buffalo	All	3
Bluegill	Up to 7	1
Channel Catfish	All	4
Common Carp	Up to 22	3
Common Carp	22 and higher	4
Flathead Catfish	All	4
Largemouth Bass	Up to 13	1

Little Calumet River E. coli Total Maximum Daily Load (TMDL) Study

Portions of the Little Calumet River East Branch mainstem have been sampled for many years. Certain sections of the river have failed to comply with the state's water quality standards. Consequently, the state must conduct a TMDL study to address the impairments. The only TMDL study conducted for the LCEB watershed is the "Little Calumet and Portage Burns Waterway TMDL for *E. coli* Bacteria" in 2004 (see Figure 30). The TMDL concluded the dominant source of *E. coli* to be nonpoint source pollution. This TMDL indicates the need for a 90% reduction of *E. coli* bacteria.

IDEM Fixed Station Assessments

Water quality samples have been collected for the IDEM fixed station water quality monitoring program monthly at two sites for the LCEB watershed. These two sites were duplicated for the LCEB baseline study: Site 1 and Site 5. Both sites are on the LCEB mainstem in the Coffee Creek subwatershed. Water quality data has been collected at these sites since 1990.

Site 1 is located on the LCEB mainstem just before the confluence with Burns Waterway on Crisman Road and after the confluence with Salt Creek. Due to its location at the base of the LCEB watershed and receiving flow from the Salt Creek watershed, this sampling site has a high flow rate that can carry high pollutant loadings with relatively low pollutant concentrations. The mean *E. coli* concentration at Site 1 was 398 CFU/100ml. Nearly a third of the samples collected exceeded the target concentration of 235 CFU/100ml. Mean nitrate concentrations were 1.24 mg/l with 36% of the samples exceeding the target (1.0 mg/l). Eighteen percent of phosphorus samples exceeded the target (0.08 mg/l). The mean phosphorus concentration was 0.04 mg/l. Total suspended solids (TSS) exceeded the state target with only 10% of all samples collected. The mean TSS concentration (19 mg/l) was well below the 30 mg/l target.

Site 5 is located on the LCEB mainstem in Burns Harbor off SR 149. *E. coli* concentrations (mean=747 CFU/100ml) exceeded the target in 60% of samples. Mean nitrate concentrations (1.45 mg/l) were above the target concentration of 1.0 mg/l. Seventy percent of nitrate samples exceeded this target. Mean phosphorus concentrations were 0.04mg/l with 34% of samples exceeding the target. Only 15% of TSS samples exceeded the target. Mean TSS concentrations (15 mg/l) were well below the 30 mg/l target.

1990 Macroinvertebrate Study

The 1990 macroinvertebrate study examined two sites in the LCEB: site 16 (Coffee Creek mainstem) and in the Heron Rookery (Kemper Ditch subwatershed). Site 16 reported an mIBI score of 3.6 (moderately impaired) and a QHEI of 65 (good). The Heron Rookery site was also moderately impaired for macroinvertebrates (mIBI = 2.8) and received an excellent rating for habitat (QHEI = 82).

IDEM 2000 & 2010 Probabilistic/Rotating Basin Monitoring Study

IDEM conducted the 2000 Corvallis study at one LCEB mainstem location near site 9 (off Wagner road). This study assessed general chemistry and metals with 4 sampling dates from June through October in 2000. The fish community (IBI) and habitat (QHEI) were also assessed on one date for this study. State standards were exceeded for many parameters, including turbidity, temperature, nitrate, TSS, phosphorus, and dissolved oxygen. The 2010 Corvallis study was conducted at two LCEB locations: near site 16 and 32. The study was conducted from June through September and examined similar parameters as the 2000 study. State water quality standards were exceeded for temperature, *E. coli*, sediment, and phosphorus. Fish and macroinvertebrate communities were also assessed at site 32.

IDEM 2000 Pesticide Study

IDEM tested for over 143 different pesticides on one LCEB mainstem site near the crossing of US 20 (near site 9). Six pesticides: atrazine, acetoclor, cyanazine, desethylatrazine, metolachlor, and simazine were detected during May and June of that year, corresponding to the seasonality of pesticide use. Pesticides, when present in surface waterways, can contribute to the impairment of biotic communities, because they kill many of the plants or animals. Of the six pesticides detected, only metolachlor is classified as an EPA class C pesticide and carcinogen. Metolachlor had two violations of the benchmark (1 µg/l).

Burns Waterway TMDL 2000 Study

The Burns Waterway TMDL study was conducted at site 1. Samples were collected from July through August for limited water chemistry, *E. coli*, environmental variables, and a few pesticides. Over 40% of E. coli samples exceeded the target concentration. All temperature readings for this assessment violated the standard for cold water fisheries. Although DO was low (7.0 mg/l), there were no violations for this parameter.

2000 E. coli Study

IDEM's 2000 *E. coli* study was conducted at 4 sites in the LCEB (near sites 1, 5, 13, and 32) and included 5 sampling dates in July and August of 2000. All sites consistently violated the IAC standard of 125 CFU/100ml.

2000 LCEB Study

The 2000 East Branch Little Calumet River IDEM study examined 11 sites in the LCEB: near 1, 5, 9, 10, 23, 32, 33, 44, 45, 46, and 48. These sites were sampled in August 2000 for limited water chemistry*, E. coli*, environmental variables and pesticides. E. coli exceeded targets at most sites and 42% of all samples were above the target concentration. Likewise, most sites had temperature violations and 42% of all samples exceeded the target temperature. There were no dissolved oxygen violations, Nutrients and total suspended solids were not evaluated.

USGS Gage

There are two USGS gages associated with the LCEB watershed. One gage is located at site 1 (gage# 04095090). This gage has recorded discharge since 1994. Since 2011, the gage at site 1 has recorded water temperature, specific conductance, pH, turbidity and dissolved oxygen. A second gage is located at site 9 (gage# 04094000). This gage has recorded stream discharge since 1945.

Summary of Historic Water Quality Sampling Efforts

Several short term water quality studies have been conducted throughout the LCEB watershed in addition to the one long-term study (fixed stations). These studies provide useful historical data and benchmarks for comparing future water quality. These studies also show that water pollution has been degrading the LCEB tributaries for many years and is getting worse over time.

3.2 Current Water Quality Assessment

In 2012, a baseline study of water chemistry and biotic communities in the watershed was performed by IDEM and National Parks Service (NPS) staff on a monthly basis at 48 sampling sites in the watershed (Figure 37). See Appendix 3 for a more detailed description of study sites. This study was conducted monthly for one year between November of 2011 and November of 2012. All study sites were assessed for a variety water chemistry parameters including temperature, dissolved oxygen (DO), DO percent saturation, pH, conductivity, *E. coli* bacteria, nitrogen, phosphorus, sediment, ammonia, chloride, fluoride, sulfate, metals, chemical oxygen demand, and total organic carbon. Flow (discharge) data was also collected at the two tributary outlet sites and on one LCEB main stem site (38, 41, and 43, respectively).

With the assistance of the Great Lakes Innovative Stewardship through Education Network (GLISTEN), Save the Dunes was able to provide additional sampling efforts to the IDEM baseline study. The GLISTEN research assistants, under the direction and supervision of Save the Dunes, performed additional weekly water chemistry sampling at a subset of LCEB sampling locations (sites 9, 12, 20, 22, 32, 34, 38, 43, 44, and 48) during the summer of 2012 (Figure 38). Due to GLISTEN sampling efforts, 11 additional sampling dates occurred between June and August of 2012. Four of these GLISTEN sampling locations (sites 27, 28, 49 and 50) were privately funded by a private donor for inclusion in the LCEB baseline study. These sites were chosen to assess water quality for the tributaries feeding and draining two small lakes in the Kemper Ditch subwatershed: Mar Mac Lake and Rice Lake. Sites 27 and 28 were existing IDEM sampling locations, and sites 49 and 50 were selected to examine the inlet and outlet for Mar Mac Lake. This data is summarized in Section 4.0 Watershed Inventory 3 – Subwatersheds.

The two sampling studies provided a wealth of water quality data, but due a variety of complex issues, basic data analysis was challenging. IDEM, the National Park Service, and Save the Dunes with GLISTEN interns all used different laboratories with differing reporting limits during the sampling campaign. To further complicate things, there was a historic drought during 2012 that made it difficult to detect nonpoint source pollution in many tributaries. When a pollutant is at a level that is too low for the laboratory to detect with their equipment, that parameter is reported back to IDEM or Save the Dunes as a nondetect. The reported value comes back as less than the analytical laboratory's reporting limit. Historically, watershed groups nationwide have substituted zero for these (usually) few and far between non-detect values. This method skews means and other statistics towards lower values than they likely are in reality. This method is typically justified because all data is skewed in the same way, allowing it to be comparable. However, our data (that was collected in 2012) contained a substantial amount of nondetect values. Our dataset also contained differing detection limits for many parameters due to IDEM's use of different analytical laboratories. Consequently, the substitution of zero for nondetect values was statistically inappropriate for the LCEB baseline study. Andrea Bolks, a research fellow at USEPA Region 5, and Jon Harcum, a statistician from TetraTech, assisted Save the Dunes with data analysis. Their statistical expertise allowed us to get a more realistic picture of water quality in the watershed.
See
http://www.bae.ncsu.edu/programs/extension/wqg/319monitoring/tech_notes.htm
for more information on the procedure they used.

LCEB Technical Committee members and Save the Dunes staff conducted windshield surveys in 2012. The LCEB watershed was divided into 12 sections based on the drainage area of major tributary outlets. Each technical committee member chose one or more sections of the watershed to evaluate. Each surveyor identified land use and land cover throughout the watershed. The windshield surveys provided photographs combined with GPS coordinates. However, due to a lack of GPS equipment, not all surveyors were able to collect GPS coordinates. For these circumstances, a detailed description of the location was provided. The information from these surveys was reported out to the LCEB steering committee and additional input on these areas was sought at that time from the rest of the watershed group. The windshield surveys are summarized in Section 4 of this plan, where the subwatersheds' land use and land cover are discussed.

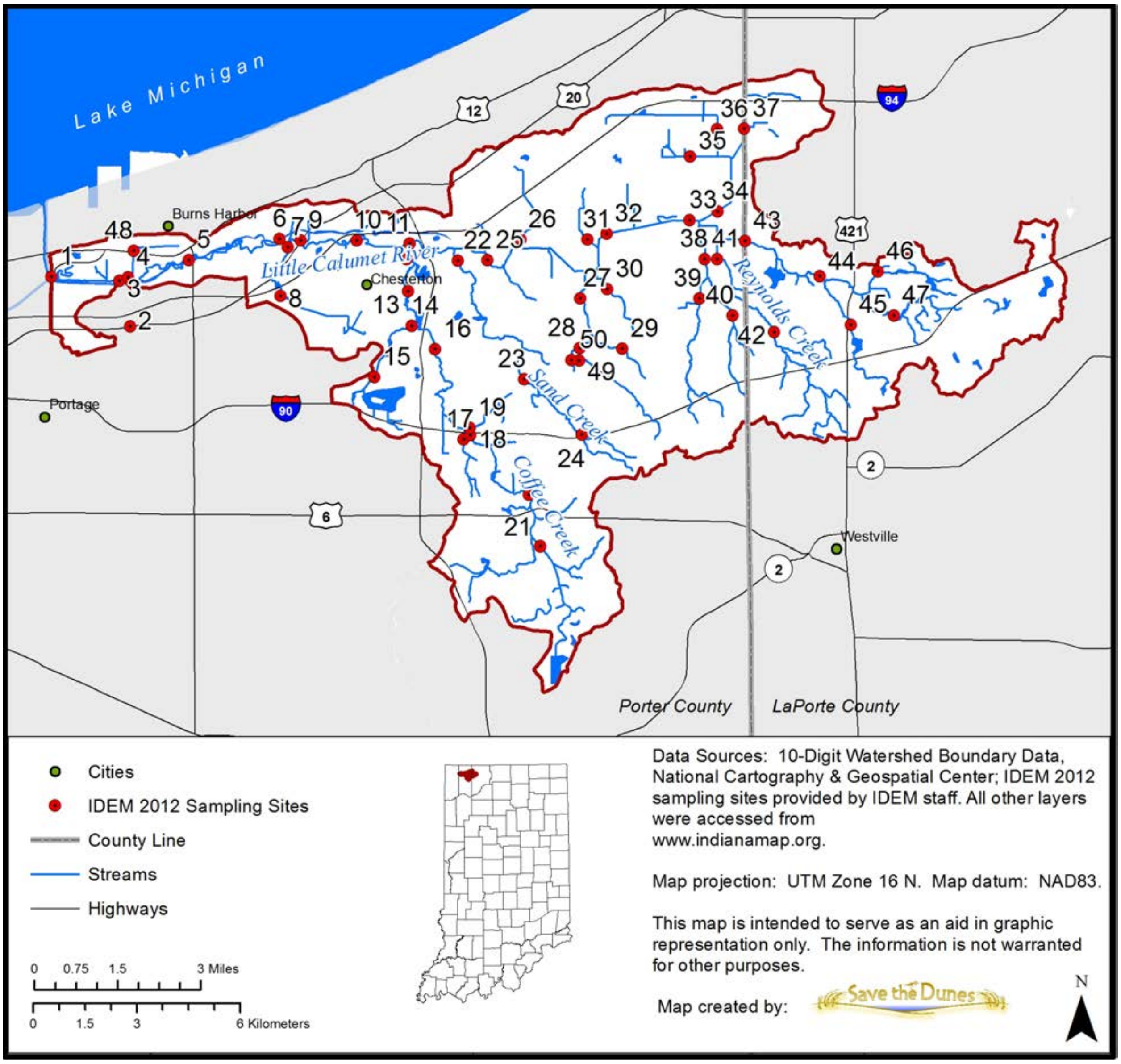

Figure 37. Sampling sites for IDEM's 2012 Baseline study

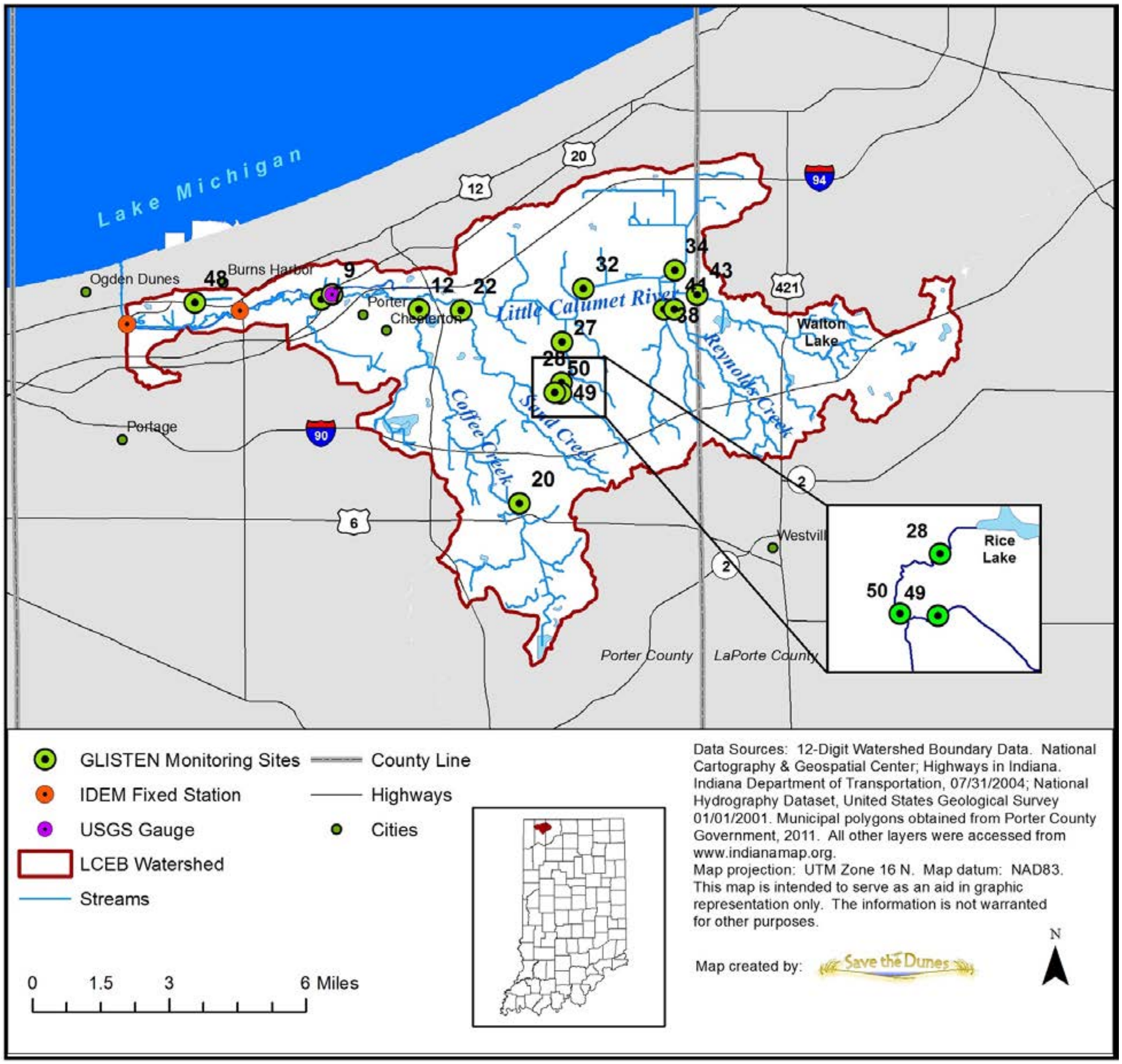

Figure 38. Additional 2012 sampling sites

The following is a detailed description of the parameters analyzed during the stream sampling efforts:

Temperature

Temperature can determine the form, solubility, and toxicity of a broad range of aqueous compounds. For example, water temperature affects the amount of oxygen dissolved in the water column. Water temperature also governs species composition and activity of aquatic biological communities. Since essentially all aquatic organisms are cold-blooded, the temperature of the water regulates their metabolism and ability to survive and reproduce effectively. The IAC (327 IAC 2-1.5-8) sets maximum temperatures to protect aquatic life for Indiana streams in the Great Lakes system according to the time of year. Since the mainstem of the LCEB and its tributaries downstream of Lake Michigan via Burns Waterway are designated as coldwater salmonid streams, the temperature should not exceed 70 °F (21.1 °C) at any time or 65 °F (18.3 °C) during spawning or imprinting periods. The LCEB watershed group has selected the IAC coldwater standard as the target for stream temperature in the LCEB watershed.

Conductivity

Conductivity is a measure of the ability of an aqueous solution to carry an electric current. This ability depends on the presence of ions, on their total concentration, mobility, and valence (APHA, 1998). During low discharge, conductivity is higher than during high discharge because the water moves more slowly across or through ion containing soils and substrates during base flow. Carbonates and other charged particles (ions) dissolve into the slow-moving water, thereby increasing conductivity measurements. Rather than setting a conductivity standard, the IAC sets a standard for dissolved solids (750 mg/L), which can be converted to a specific conductance range of approximately 1,000 to 1,360 µmhos/cm. The LCEB group chose to not include conductivity in the LCEB targets.

Dissolved Oxygen (DO)

Dissolved oxygen (DO) is the dissolved gaseous form of oxygen. It is essential for respiration of fish and other aquatic organisms. Fish need at least three to five mg/L of DO. Coldwater fish such as trout generally require higher concentrations of DO than warmwater fish such as bass or bluegill. The IAC (327 IAC 2-1.5-8) sets the minimum average DO concentrations at five mg/L per calendar day and no less than four mg/L at any time for Indiana streams in the Great Lakes system. Since the LCEB is recognized as a coldwater fishery stream, DO should not fall below six mg/L at any time or below seven mg/L in areas where spawning occurs during the spawning season and in areas used for imprinting during the time salmonids are being imprinted. DO enters water by diffusion from the atmosphere and as a byproduct of photosynthesis by algae and plants. Excessive algae growth can over-saturate (greater than 100% saturation) the water with DO. IDEM considers DO values over 12 mg/L to be indicative of an algae or nutrient problem, and sites high DO violations (>12mg/L) for 303(d) assessments if there is a corresponding nutrient, pH, or temperature violation that occurred during the same sampling event for that site. Conversely, DO is consumed by respiration of aquatic organisms, such as fish, and during bacterial decomposition of plant and animal matter. The LCEB watershed group has chosen to use the same benchmarks: 6 mg/L as a lower threshold and 12mg/L as an upper threshold. Using a similar method to IDEM's CALM 303(d) assessment methodology, the upper DO violations will only be considered as such if they correspond to another aquatic life use parameter violation: a violation of the target for nutrients, temperature, or pH at the same site during the same sampling event. None of the upper limit violations corresponding to these other parameters occurred during the baseline sampling in 2012.

pH

The pH of water describes the concentration of acidic ions (specifically H+) present in water. Water's pH determines the form, solubility, and toxicity of a wide range of other aqueous compounds. The IAC (327 IAC 2-1.5-8) establishes a range of six to nine pH units for the protection of aquatic life. Concentrations in excess of nine are considered acceptable when the concentration occurs as daily fluctuations associated with photosynthetic activity. The LCEB group has chosen to use the IAC recommendations for pH as the interim and long term targets for the LCEB watershed. There were no samples showing pH readings outside of the IAC range during the baseline sampling study that was conducted in 2012.

Nutrients

Nutrient concentrations can estimate the amount of algae growth and/or rooted plant (macrophyte) growth that is possible in a stream. Algae and other plants are a natural and necessary part of aquatic ecosystems. Both will always occur in a healthy stream. Algal and rooted plant growth can, however, reach nuisance levels and interfere with the aesthetic and recreational uses of a stream. Nutrients themselves, as well as the primary producers (algae and plants) they feed, can also affect the composition of secondary producer communities such as macroinvertebrates and fish. Changes in secondary producer communities can, in turn, impact the way chemical constituents in the water are processed. Common sources of nutrients are fertilizers from lawns and agricultural fields, leaking septic systems, and manure or other animal wastes.

Phosphorus and nitrogen have several chemical forms in water. Two common forms of phosphorus are soluble reactive phosphorus (SRP) and total phosphorus (TP). SRP is a measure of orthophosphate and is a dissolved form of phosphorus. It is a form that is directly usable by plants. Algae cannot directly digest and use particulate phosphorus. Total phosphorus is a measure of both dissolved and particulate forms of phosphorus. IDEM and Save the Dunes both sampled total phosphorus during the baseline study that occurred in 2012. The LCEB watershed group has chosen 0.08mg/L, the Ohio EPA recommendation, as the target for streams in the watershed.

The most commonly measured nitrogen forms are nitrate-nitrogen (NO_3) and ammonia-nitrogen (NH_3). Nitrate is a common form of nitrogen that can be found in a moving stream or anywhere that oxygen is readily available. Because oxygen is typically available in stream systems, nitrate-nitrogen is the dominant dissolved form of nitrogen in stream systems. In contrast, ammonia-nitrogen is present where oxygen is lacking. Ammonia is a byproduct of decomposition generated by bacteria as they decompose organic material. It can be extremely harmful to fish and other aquatic organisms. The target chosen for nitrate is 1.0 mg/L **(**OEPA, 1999**)**. The IAC does have a drinking water standard for nitrate, 10 mg/L, but the LCEB technical committee decided this was too high to protect aquatic life. The IAC has two different recommendations for ammonia concentrations in Indiana streams and rivers. One recommendation is for the Great Lakes region and the other pertains to the rest of the state. Both IAC recommendations for ammonia are based on pH and temperature, yielding a range of values due to current conditions. The IAC's Great Lakes region ammonia standard ranges from 0.8254-28.47 mg/L, while the standard for the rest of the state is 0.0075-0.2137 mg/L. Standards for the Great Lakes region do apply to the LCEB watershed however, the technical committee decided to use the more stringent IAC ammonia standard (0.0075-0.2137 mg/L).

Total Suspended Solids (TSS)

A TSS measurement quantifies all particles suspended and dissolved in water. Closely related to turbidity, which is a measure of the cloudiness of water caused by particles that can be seen with the human eye, TSS quantifies sediment particles and other solid compounds typically found in water, including those too small to see without a microscope. In general, the concentration of suspended solids is greater in streams during high flow events due to increased overland flow and resuspension of previously settled or attached material. The increased overland flow can erode hillsides and streambanks carrying more soil and other particulates to the stream. The sediment in water originates from many sources, but a large portion of sediment entering streams can come from active construction sites or other disturbed areas such as unvegetated stream banks and poorly managed farm fields.

Suspended solids impact streams in a variety of ways. When suspended in the water column, solids can clog the gills of fish and some macroinvertebrates. As the sediment settles to the stream bottom, it covers spawning and resting habitat for aquatic fauna, reducing the animals' reproductive success. Suspended sediments also impair the aesthetic and recreational value of a waterbody. Pollutants, such as phosphorus, attach to sediment and also degrade water quality. In general, TSS concentrations greater than 80 mg/L have been found to be deleterious to aquatic life, although TSS concentrations between 25 and 80 mg/L have been known to reduce fish concentrations (Waters, 1995). IDEM does not have a water quality standard for TSS, however it does have a draft target for TMDLs of 30 mg/L, which is what the LCEB watershed group has chosen for the TSS target.

Escherichia coli (E. coli) Bacteria

E. coli is one member of a group of bacteria that comprise the fecal coliform bacteria and is used as an indicator organism to identify the potential for the presence of pathogenic organisms in a water sample. Pathogenic organisms can present a threat to human health by causing a variety of serious diseases, including infectious hepatitis, typhoid, gastroenteritis, and other gastrointestinal illnesses. *E. coli* can come from the feces of any warm-blooded animal. Wildlife, livestock, and/or domestic animal defecation, manure fertilizers, previously contaminated sediments, and failing or improperly sited septic systems are common sources of the bacteria. The IAC sets the maximum concentration of *E. coli* at 235 colony forming units (CFU)/ 100 ml in any one sample within a 30-day period. For data sets consisting of five equally spaced samples over a 30-day period, the geometric mean must not exceed 125 CFU/ 100mL and not more than one sample shall exceed 576 CFU/ 100 ml. For data sets consisting of 10 or more grab samples where no five of which are equally spaced over a 30-day period not more than 10% of measurements shall exceed 576 CFU/ 100mL and not more than one sample shall exceed 2,400 CFU/ml. The LCEB has chosen to use 235 CFU/100 ml as the target for LCEB streams. *E. coli* was analyzed using the Colilert® method by both IDEM and Save the Dunes, which yields results in terms of most probable number (MPN) per 100 ml. These units are virtually identical to CFU, and so the targets are applicable to *E. coli* analyzed with this method.

Metals

While the presence of small amounts of some metals in drinking water can be beneficial to human health, their presence in surface waters can be toxic to aquatic life. When metals are found in surface waterways in a dissolved form, they can be taken up through the gills of aquatic organisms and cause death. While total metal concentrations were analyzed the most before 1993, and are currently analyzed for surface waterways in Indiana as of the writing of this plan, they can show a value that is higher than the actual amount available to biological living creatures. Heavy metals, such as Copper (Cu), Iron (Fe), Cadmium (Cd), Zinc (Zn), Mercury (Hg), and Lead (Pb) are considered the most harmful to aquatic organisms (USEPA 1996) The toxicity of metals in surface waterways can be influenced by several other parameters, including temperature, pH, hardness (usually as Calcium carbonate [$CaCO_3$] concentration), alkalinity, suspended solids concentration, redox potential and dissolved organic carbon. Metals can also bind to other inorganic compounds, which can result in a lower toxicity. Water quality criteria for metals in the IAC are in terms of dissolved metals. Many rivers in the LCEB watershed are fed by fens, a type of natural spring, which can result in naturally high concentrations of metals and minerals, such as iron, magnesium, and calcium, to surface waterways.

The 2012 baseline study performed by IDEM utilized analysis methods for a wide variety of total recoverable metals, including antimony, arsenic, beryllium, cadmium, calcium, copper, chromium, lead, magnesium, nickel, selenium, silver, thallium and zinc. These data could not be compared to applicable numeric aquatic life standards for dissolved metals without other parameters. For example, using EPA's Biotic Ligand Model to determine the aquatic life criteria for copper, one would need concentrations for ten other parameters, including dissolved organic carbon, which was not sampled by IDEM in 2012. The LCEB watershed group set no targets for metals.

Pesticides

The term pesticide covers a broad category that includes herbicides, insecticides, fungicides, rodenticides, and any other poisons meant to kill unwanted plants, insects, fungi, or rodents that are considered harmful to cultivated crops or animals. The presence and concentration of pesticides in surface waterways tends to correspond to the agricultural and recreational season, when farmers, homeowners, or commercial companies apply them to the land. Over 1 billion pounds of pesticides are applied in the United States every year (Gillom et al. 2006). There are numerous varieties and metabolites of currently used pesticides, but currently Maximum Contaminant Loads (MCLs) for surface waters only exist for 9 of them. The LCEB watershed group selected no targets for pesticides, because no current data exists.

Benthic Macroinvertebrates

Benthic macroinvertebrates are aquatic invertebrates that live in the bottom portions of our waters. They make good indicators of watershed health because they live in the water for all or most of their lives, are easy to collect, differ in their tolerance to amount and types of pollution, are easy to identify in a laboratory, often live for more than one year, have limited mobility, and are integrators of environmental condition. The benthic macroinvertebrate community in the LCEB watershed was evaluated using IDEM's macroinvertebrate Index of Biotic Integrity (mIBI). The mIBI is a multi-metric index that combines several aspects of the benthic community composition. As such, it is designed to provide a complete assessment of a creek's biological integrity. Karr and Dudley (1981) define biological integrity as *the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to the best natural habitats within a region.* The mIBI is calculated by averaging the classification scores for associated metrics, based on the multi-habitat macroinvertebrate collection procedure (mHAB) methodology utilized by IDEM for the CALM assessment. Using this method, mIBI scores that are greater than 36 are said to be fully supportive of benthic macroinvertebrate communities. If an mIBI score shows that a river is not supporting macroinvertebrate communities, a qualitative habitat evaluation index (QHEI) is calculated for the stream reach to help determine if the nonsupporting status is caused by poor water quality or poor habitat.

Although the IAC does not include mIBI scores as numeric criteria for establishing whether streams meet their aquatic life use designation, IDEM will be using mIBI scores as well as other information (temperature, dissolved oxygen, nutrients, sediment, and pH) to make this determination. Under state law, all waters of the state, except for those noted as Limited Use in the IAC, must be capable of supporting recreational and aquatic life uses. In the 2010 303(d) consolidated assessment and listing methodology (CALM), IDEM suggests that those waterbodies with mIBI scores less than 36 when using the multi-habitat approach are considered non-supporting for aquatic life use. Under federal law, waters that do not meet their designated uses must be placed on the 303(d) list and remediation/restoration plans (total maximum daily load (TMDL) plans) must be developed for these waters in order to take action to reduce pollution levels. The LCEB Watershed Group selected 36 mIBI score as the target for streams in this watershed.

Fish Communities

Fish communities are assessed using the multi-metric index of biotic integrity (IBI). The 12 metrics associated with this index include the number of fish and species, as well as the species' varied tolerances to pollution, among other metrics. Site-specific results will be discussed in further detail in Section 4.

In the event that an IBI score shows a river is not supportive of fish communities, a QHEI was calculated by IDEM to assess the adjacent habitat, to see if the fish communities are struggling due to water quality or habitat degradation. If the QHEI score shows that the habitat should support fish populations, water pollution is the most likely stressor.

Although the IAC does not include IBI scores as numeric criteria for establishing whether streams meet their aquatic life use designation, IDEM may be using IBI scores to make this determination. (Under state law, all waters of the state, except for those noted as Limited Use in the IAC, must be capable of supporting recreational and aquatic life uses.) In the 2010 303(d) consolidated assessment and listing methodology (CALM), IDEM states that waterbodies with IBI scores less than 36 are considered non-supporting for aquatic life use. Under federal law, waters that do not meet their designated uses must be placed on the 303(d) list and remediation/restoration plans (TMDL plans) must be developed for these waters. The LCEB Watershed Group selected 36 IBI score as the target for streams in this watershed.

Habitat

The physical habitat at the sampling sites where streams were found to have scores that are non-supporting for the mIBI or IBI indices was evaluated using the QHEI. The Ohio EPA developed the QHEI for streams and rivers in Ohio (Rankin 1989, 1995). The QHEI is a physical habitat index designed to provide an empirical, quantified evaluation of the general lotic (flowing water) habitat (OEPA, 1989). While the Ohio EPA originally developed the QHEI to evaluate fish habitat in streams, IDEM and other agencies routinely utilize the QHEI as a measure of general "habitat" health. The QHEI is composed of six metrics including substrate composition, in-stream cover, channel morphology, riparian zone and bank erosion, pool/glide and riffle-run quality, and map gradient. Observations of stream conditions along a 200-foot (61 meter) reach are recorded on the QHEI datasheet. Each metric is then scored individually then summed to provide the total QHEI score. The habitat assessed at each reach may not be representative of habitat present throughout the stream system or subwatershed. Rather the QHEI score represents the habitat present within that 200-foot (61 meter) reach of the sampling site where non-supporting indices were calculated.

Substrate type and quality are important factors of habitat quality and the QHEI score is partially based on these characteristics. Sites that have greater substrate diversity receive higher scores as they can provide greater habitat diversity for benthic organisms. The quality of substrate refers to the embeddedness of the benthic zone. Because the rocks (gravel, cobble, and boulder) that comprise a stream's substrate do not fit together perfectly like pieces in a jigsaw puzzle, small pores and crevices exist between the rocks in the stream's substrate. Many stream organisms can colonize these pores and crevices, or microhabitats. In streams that carry high silt loads, the pores and crevices between rock substrate become clogged over time. This clogging, or embedding, of the stream's substrate eliminates habitat for the stream's biota. Thus, sites with heavy embeddedness and siltation receive lower QHEI scores for the substrate metric.

In-stream cover, another metric of the QHEI, refers to the type(s) and quantity of habitat provided within the stream itself. Examples of in-stream cover include woody logs and debris, aquatic and overhanging vegetation, and root wads extending from the stream banks. The channel morphology metric evaluates the stream's physical development with respect to habitat diversity. Pool and riffle development within the stream reach, the channel sinuosity, and other factors that represent the stability and direct modification of the site comprise this metric score.

A stream's buffer, which includes the riparian zone and floodplain zone, is a vital functional component of riverine ecosystems. It is instrumental in the detention, removal, and assimilation of nutrients. Riparian zones govern the quality of goods and services provided by riverine ecosystems (Ohio EPA, 1999). Riparian zone (the area immediately adjacent to the stream), floodplain zone (the area beyond the riparian zone that may influence the stream though runoff), and bank erosion were examined at each site to evaluate the quality of the buffer zone of the stream, the land use within the floodplain that affects inputs to the waterway, and the extent of erosion in the stream, which can reflect insufficient vegetative stabilization of the stream banks. For the purposes of the QHEI, a riparian zone consists only of forest, shrub, swamp, or woody vegetation. Typically, weedy, herbaceous vegetation has higher runoff potential than woody components and does not represent an acceptable riparian zone type for the QHEI (OEPA, 1989). Streams with grass or other herbaceous vegetation growing in the riparian zone receive low QHEI scores for this metric.

Metric 5 of the QHEI evaluates the quality of pool/glide and riffle/run habitats in the stream. These zones in a stream, when present, provide diverse habitat and, in turn, can increase habitat quality. The depth of pools within a reach and the stability of riffle substrate are some factors that affect the QHEI score in this metric.

The final QHEI metric evaluates the topographic gradient in a stream reach. This is calculated using topographic data. The score for this metric is based on the premise that both very low and very high gradient streams will have negative effects on habitat quality. Moderate gradient streams receive the highest score, 10, for this metric. The gradient ranges for scoring take into account the varying influence of gradient with stream size.

The QHEI evaluates the characteristics of a stream segment as opposed to the characteristics of the entire stream. Therefore, it must be noted that the segment is in some cases only representative of a small fraction of the streams/headwaters within the sampling site's subwatershed. QHEI scores from hundreds of stream segments in Ohio have indicated that values greater than 60 are generally conducive to the existence of warmwater faunas. Scores greater than 75 typify habitat conditions that have the ability to support exceptional warmwater faunas (OEPA, 1999). IDEM indicates that higher QHEI scores represents more diverse habitat for colonization by macroinvertebrates. Scores below 51 suggest that poor habitat may be limiting biota within the association stream. The LCEB Watershed Group selected 51 QHEI score as the target for streams in this watershed.

3.3 Water Quality Targets

Water quality standards, or targets, were selected for water chemistry parameters in the baseline study. These water quality targets are based on applicable Indiana Administrative Code and other standards accepted by the Indiana Department of Environmental Management. IDEM also collected additional water chemistry parameters, such as metals and pesticides. Unfortunately, the samples collected by IDEM for this study were analyzed for total metals, while the IAC only has targets for dissolved metals.

Table 13. Water quality targets

Parameter	Target	Source
Benthic Macroinvertebrate Community	mIBI $\geq$ 36 indicates full support (scores range from 12-60)	Indiana Administrative Code [327 IAC 2-1-3(2), 327 IAC 2-1-9(49)]
Dissolved Oxygen (DO)	Minimum: 6 mg/L Minimum: 7 mg/L in areas where spawning and imprinting occurs Maximum: 12 mg/L during the growing season	Indiana Administrative Code (327 IAC 2-1.5-8)
E. coli	Maximum: 235 CFU/100 mL in a single sample Maximum: geometric mean of 125 CFU/100 mL from 5 equally spaced samples over a 30-day period	Indiana Administrative Code (327 IAC 2-1.5-8)
Fish Community (IBI)	IBI $\geq$ 36 indicates full support (scores range from 0-60)	Indiana Administrative Code [327 IAC 2-1-3(2), 327 IAC 2-1-9(49)]
Nitrate-Nitrogen (NO_3)	Maximum: 1 mg/L	Ohio EPA recommended criteria for Warm Water Habitat (WWH) headwater streams
pH	No pH values below six (6) or above nine (9)	Indiana Administrative Code (327 IAC 2-1.5-8)
Habitat (QHEI)	QHEI > 51 indicates fair quality (scores range from 0-100)	IDEM CALM: The Qualitative Habitat Evaluation Index (QHEI) is not used to determine aquatic life use support. The QHEI is an index designed to evaluate the lotic habitat quality important to aquatic communities and is used in conjunction with mIBI or IBI data, or both to evaluate the role that habitat plays in waterbodies where impaired biotic communities have been identified
Temperature	Maximum: 70°F or 21.1°C Maximum: 65°F or 18.3°C during spawning or imprinting periods	Indiana Administrative Code (327 IAC 2-1.5-8)
Total Ammonia (NH_4)	Range between 0.0 and 0.21 mg/L depending upon temperature and pH	Indiana Administrative Code (327 IAC 2-1-6)
Total Phosphorus (TP)	Maximum: 0.08 mg/L	Ohio EPA recommended criteria for Warm Water Habitat (WWH) headwater streams
Total Suspended Solids	Maximum: 30 mg/L	IDEM draft TMDL target from NPDES rule for lake dischargers in 327 IAC 5-10-4 re: monthly average for winter limits for small sanitary treatment plants

4.0 Watershed Inventory 3 – Subwatersheds

The LCEB watershed contains three 12-digit HUC subwatersheds: Reynolds Creek (040400010401), Kemper Ditch (040400010402), and Coffee Creek (040400010403) (Figure 6). Land use, which is a driver for nonpoint source pollution, differs among these subwatersheds. Figure 39 highlights the differences in dominant land uses among the three subwatersheds in the LCEB watershed. Understanding differences in land use can be a starting point to help to explain differences in water quality or potential sources for water pollution.

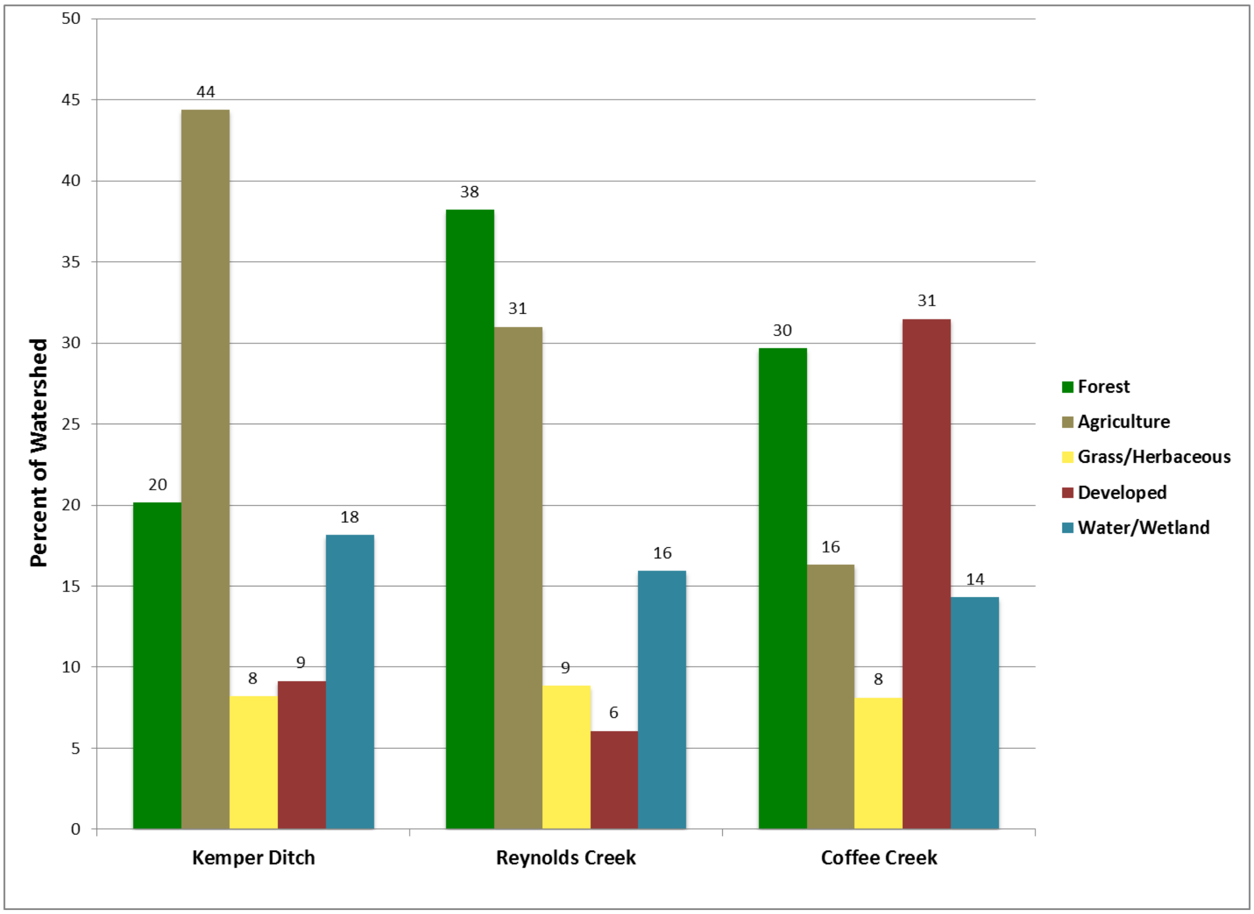

Figure 39. 2010 Land Cover by subwatershed

4.1 Reynolds Creek Subwatershed (HUC12- 040400010401)

The Reynolds Creek subwatershed contains the headwaters of the LCEB. This watershed is 12,780 acres, which is 27% of the entire watershed. Named waterbodies include the LCEB mainstem, Reynolds Creek, Lake Lee, Massauga Creek, Spring Branch, Hildebrandt Lake, Round Lake, Ryden Lakes, Swede Lake, and Walton Lake. There are no National Pollutant Discharge Elimination System (NPDES) permit program facilities in the Reynolds Creek watershed. Purdue University's North Central (PNC) Campus was a NPDES facility from 1974 through 2007. The university's wastewater was then added to Westville's water treatment system, which led to the termination of the university's wastewater permit. There is no indication of legacy water quality problems related to this permitted discharge.

Sampling Sites 38, 39, 40, 41, 42, 43, 44, 45, 46 and 47 are within the Reynolds Creek subwatershed.

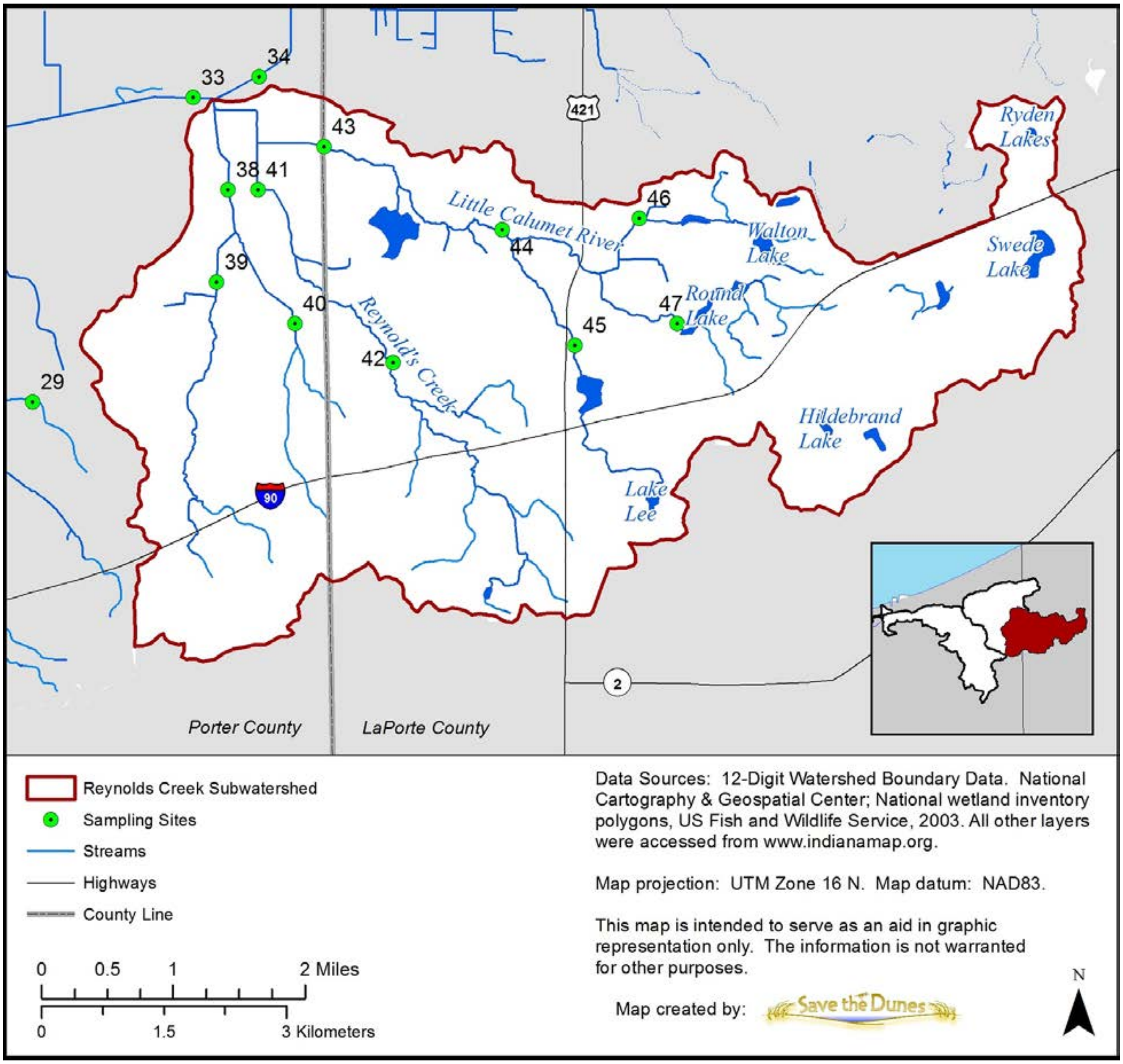

Figure 40. Reynolds Creek subwatershed sampling sites

4.1.a Water Quality Information

Past Studies

Sites in the Reynolds Creek subwatershed were included in two older studies conducted by IDEM: the 2000 Little Calumet East Branch River study, and the 2000 Pesticide study. Two sites on the mainstem (site 44 and at the crossing of Highway 421) and an unnamed tributary (site 45) were included in IDEM's 2000 LCEB Assessment. The geometric mean for *E. coli* exceeded the IAC standard (125 CFU/ 100mL) at site 44 (180 CFU/100mL) and at site 45 (330 CFU/100mL), but not where the mainstem crosses US-Highway 421 (106 CFU/100mL). It should be noted that this data is over 14 years old, as of the writing of this plan, and indicates historic trends as opposed to current conditions. IDEM also conducted a pesticide study in the year 2000 that included sites 44 and 45. No pesticides were detected at either site during that study.

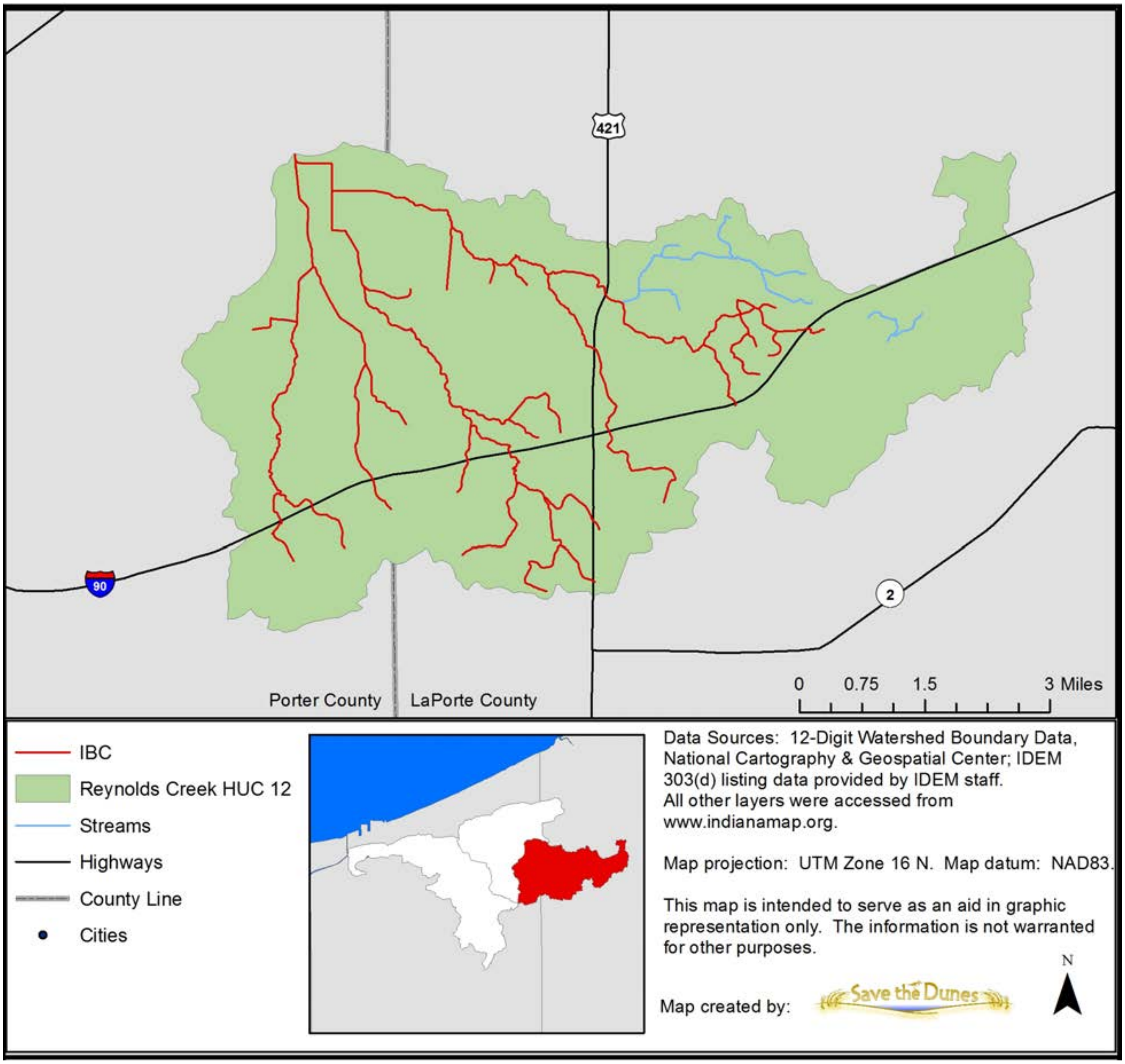

Figure 41. Reynolds Creek subwatershed 2014 draft 303(d) listing for impaired biotic communities

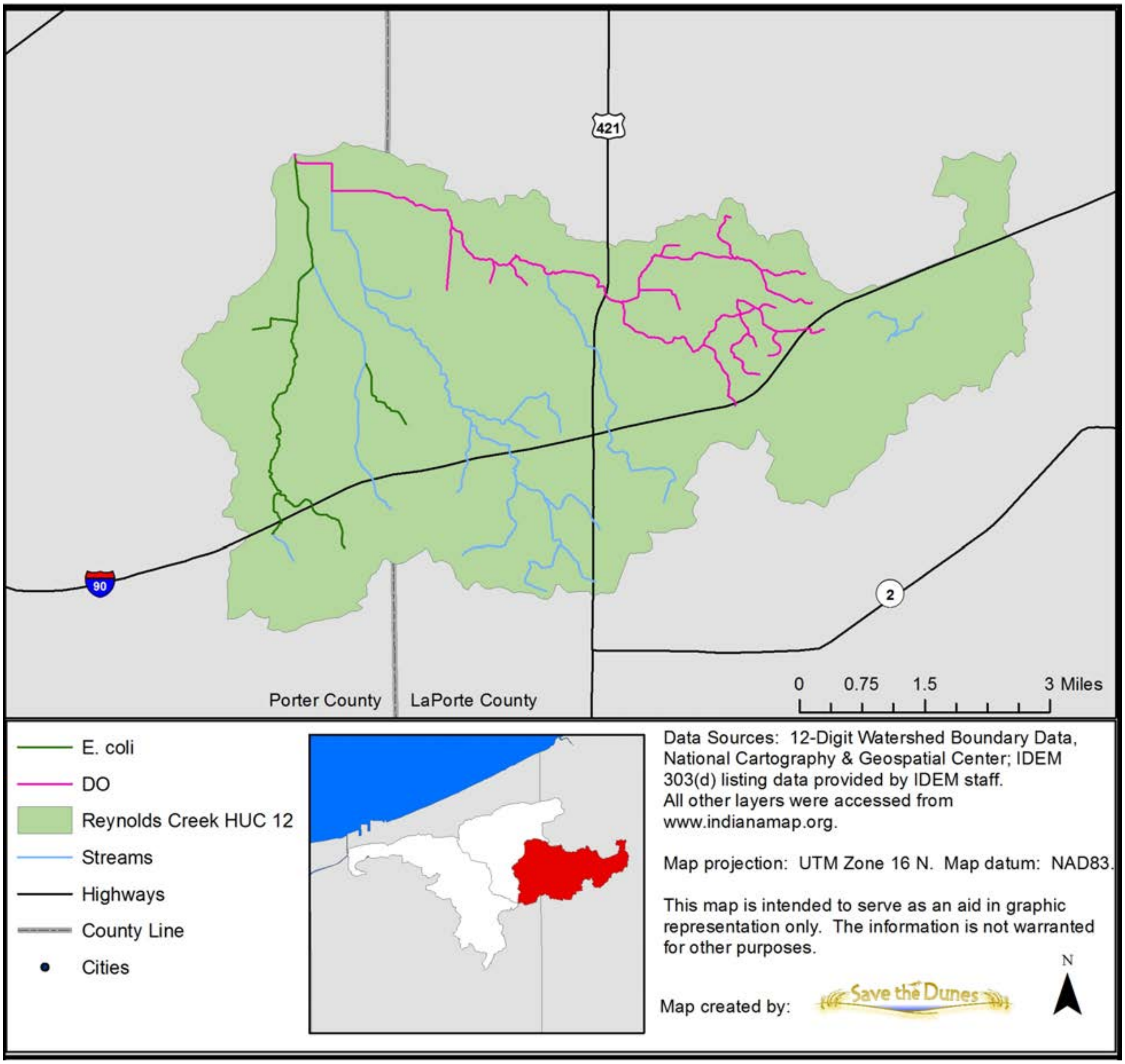

Figure 42. Reynolds Creek subwatershed 2014 draft 303(d) listings for E. coli and dissolved oxygen

Current Studies

All stream segments within the Reynolds Creek subwatershed are included on the 2014 (draft) 303(d) listing. For impaired biotic communities (Figure 41), nearly the entire subwatershed is listed, except the headwater tributary monitored by site 46 (Walton Lake Outlet). The headwater tributaries of the LCEB (sites 43, 45, 46 and 47) are also listed for dissolved oxygen (Figure 42). The Spring Branch tributary (including sites 38 and 39) and Massauga Creek Upstream (site 40) are listed for *E. coli* (Figure 42).

Temperatures in Reynolds Creek and its tributaries were generally low in 2012. Only 8% of samples exceeded the target temperature (21.1° C) Site 39 (Spring Branch), site 40

(Massauga Creek Upstream), site 42 (Reynolds Creek Upstream), and Site 44 (Little Calumet River East Branch 1), all had zero exceedances of the temperature standard for cold water aquatic communities (21.1° C). Site 40 (Massauga Creek Upstream) had the second lowest temperature mean in the LCEB watershed. Site 45 (Lake Lee Outlet) had the third lowest temperature mean in the LCEB. However, site 47 had the highest individual temperature of 23.3˚ C with 43% of samples exceeding the target.

Two sites had dissolved oxygen (DO) exceedances for the Reynolds Creek subwatershed during the 2012 sampling period (sites 46 and 47). Site 46 also had the lowest mean for DO concentrations (8.32 mg/l). The highest mean concentration for dissolved oxygen was 11.44 mg/l at site 45(Lake Lee Outlet). There was no evidence of oversaturation because DO readings greater than 12 mg/L always occurred when the water was very cold, which allows the water column to hold more oxygen than under warmer conditions. There were no pH violations at any site in the Reynolds Creek subwatershed during the 2012 baseline sampling events: all samples fell within the six to nine pH units range from the IAC.

Nitrate + nitrite levels were generally low in the Reynolds Creek subwatershed. Sites 39, 41, 42, 46 and 47 had the lowest nitrate means in the LCEB watershed. Site 41 had the lowest calculated mean for the LCEB (0.074 mg/l), and sites 39, 42, 46, and 47 had values that were consistently low such that they could not be detected over 90% of the time. Because of this, means could not be calculated. Consequently, nitrate levels at these sites were very low during the sampling period. Data was available to calculate loads for only 3 sites in this subwatershed (sites 38, 43, and 45). Annual and areal loads require at least twelve monthly water quality data with detected values and corresponding flow data. Site 45 (Lake Lee Outlet) had the lowest nitrate annual load (562 lb/yr) for the entire LCEB.

Twenty-nine percent of all phosphorus samples collected in the Reynolds Creek subwatershed exceeded the target of 0.08 mg/l. Fifty percent of all samples were below the analytical detection limit. Every site had exceedances. Means for each site ranged from 0.06 to 1.0 mg/l. Six sites had enough data to calculate loads (38, 39, 41, 43, 45, and 46). Site 41 (Reynolds Creek Downstream) had the lowest load (414 lb/yr), while site 43 (LCEB mainstem) had the highest phosphorus load (1,964 lb/yr) in the Reynolds Creek subwatershed.

TSS was relatively low for Reynolds Creek sites. Only 8% of samples exceeded target concentrations (30 mg/l). Several sites (39, 40, 42, 46 and 47) had no TSS exceedances during 2012 sampling events. Over 26% of samples were below the analytical detection limit. The lowest mean for TSS was 4.4 mg/l at site 42 (Reynolds Creek upstream) and the highest mean was 35 mg/l at site 43 (LCEB mainstem). Loads and areal loads for TSS were calculated for five sites in this subwatershed (38, 39, 41, 43, and 47). Of these, the lowest annual TSS load (15,229 lb/year) was site 47 (Round Lake Outlet). The highest annual load was 340,180 lb/yr at site 43.

E. coli concentrations exceeded the target for 47% of samples in the Reynolds Creek subwatershed. Every site had exceedances. Sites 38 (Massauga Creek Downstream), 41 (Reynolds Creek Downstream), and 43 (mainstem) had the highest number of violations

(17, 16, and 15, respectively). The lowest mean concentration was 69 CFU/100 ml at site 47, while the highest mean was 1,506 CFU/100 ml at site 43. Annual loads were not calculated for *E. coli* in the LCEB watershed based on this data.

4.1.b Habitat/Biological Information

Red Mill County Park, located in the headwaters of the LCEB, was the site of a Great Lakes Fishery and Ecosystem Restoration (GLFER) ecosystem restoration project. The site encompasses a 108-acre Indiana Nature Preserve and is considered to be a high quality ecosystem. In 1833, an earthen dam was built that created a large native pond and wetland community. The GLFER restoration project preserved and restored over 120 acres of wetland habitat by maintaining existing water levels, restoring native plant species and improving fish habitat. Removing a section of the dam and creating a new stream channel restored natural hydrology and stream connectivity. The project, which was completed in 2011, protects the hydrology of this high quality ecosystem for the plants and animals that rely on it.

Benthic macroinvertebrates were analyzed using IDEM's mIBI metric, and fish communities were assessed using the IDEM's IBI methodology. Benthic macroinvertebrates were not supported at any Reynolds Creek site. All sites scored less than 36 for the mIBI. Site 40 was the only sampling location that was supporting for fish communities in the subwatershed (IBI=36). All other sites scored less than 36 for the IBI. QHEI scores for habitat were calculated for each site to help determine the cause of impaired biotic communities. Sites 41 and 44 yielded habitat scores that were not supportive of aquatic life. This suggests that in-stream habitat could be the reason aquatic communities are not healthy at sites 41 and 44. However, sites 38, 39, 42, 43, 45, 46 and 47 had QHEI scores indicating the habitat should be suitable for fish and macroinvertebrate communities. These findings indicate that water pollution is the most likely stressor affecting these populations. Site 42 had the best habitat rating in the LCEB watershed. There were no biological assessments performed by IDEM at site 46 for the baseline study due to drought conditions.

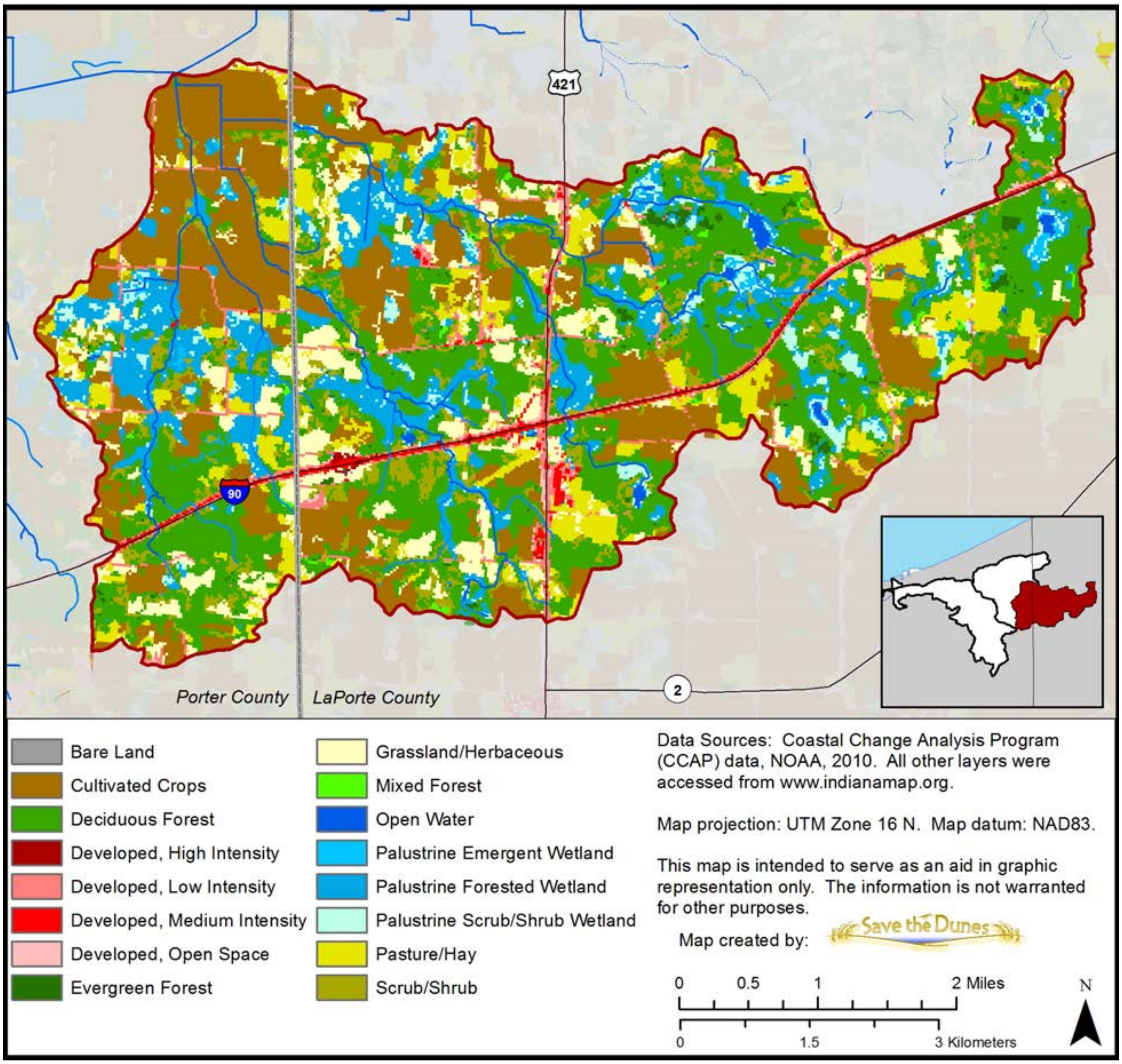

Figure 43. Land cover in the Reynolds Creek subwatershed

4.1.c Land Use Information

Land cover in the Reynolds Creek subwatershed is predominantly forested (38%) and agriculture (31%). Developed land cover is limited (6% of the subwatershed) with the exception of Purdue North Central Campus and adjacent development along Highway 421. Proposed zoning maps for LaPorte County indicate that the majority of the watershed in LaPorte County is zoned agricultural. The area surrounding the highway 421 and I-80 interchange is zoned for general commercial, low-density rural residential, and light industrial. ***

The Indiana Toll Road (I-80) runs through this subwatershed. Protected areas in the Reynolds Creek subwatershed include an Izaak Walton League property around Walton Lake, the LaPorte County Little Calumet Headwaters Nature Preserve, several LaPorte County Parks, and The Nature Conservancy's Hildebrandt Lake. Izaak Walton League's local chapter also owns several protected natural properties in the LCEB headwaters. These are located along County Line Road. The older of the two is the Massauga acquisition. The Little Calumet River enters the 10-acre property at the north end, just south of the railroad tracks. Land cover on this property is primarily wet woods, with Massauga Creek entering the parcel underneath CR 1100 North. The Frame Conservation Area is a parcel of 19.5 acres that lies along the LCEB mainstem. It extends to both sides of the river, but the majority of the parcel is on its south side. The Frame Conservation Area also includes part of the east side of Reynolds Creek up to its terminus with the Little Calumet River. The Izaak Walton League recently purchased another 40 acres adjacent to the Frame Conservation Area. This property includes 660 feet of Reynolds Creek and ½ mile of the Little Calumet River. These properties are adjacent to the new DNR Reynolds Creek Wildlife Area, which is a 1,250-acre game bird preserve. Due to the recent acquisition of this property and its recent conversion from cropland to prairie grassland habitat (post 2012 IDEM baseline study), these acres have been added to the list of BMPs in section 9.

There is no large industry or plans for major development in this subwatershed. There are no fairgrounds or kennels. Low-density rural residential homes and agriculture are scattered throughout this watershed. Agriculture accounts for approximately 31% of land use. There are six hobby farms located in the Reynolds Creek subwatershed (five with horses and one with buffalo) (Figure 44). The combined acreage of these farms is ~148 acres with a sum of approximately 85 horses and 20 buffalo. Conventional fertilizer is the dominant form of fertilizer applied to agricultural fields in the Reynolds Creek subwatershed. Manure is generally not applied to agricultural fields in this subwatershed.

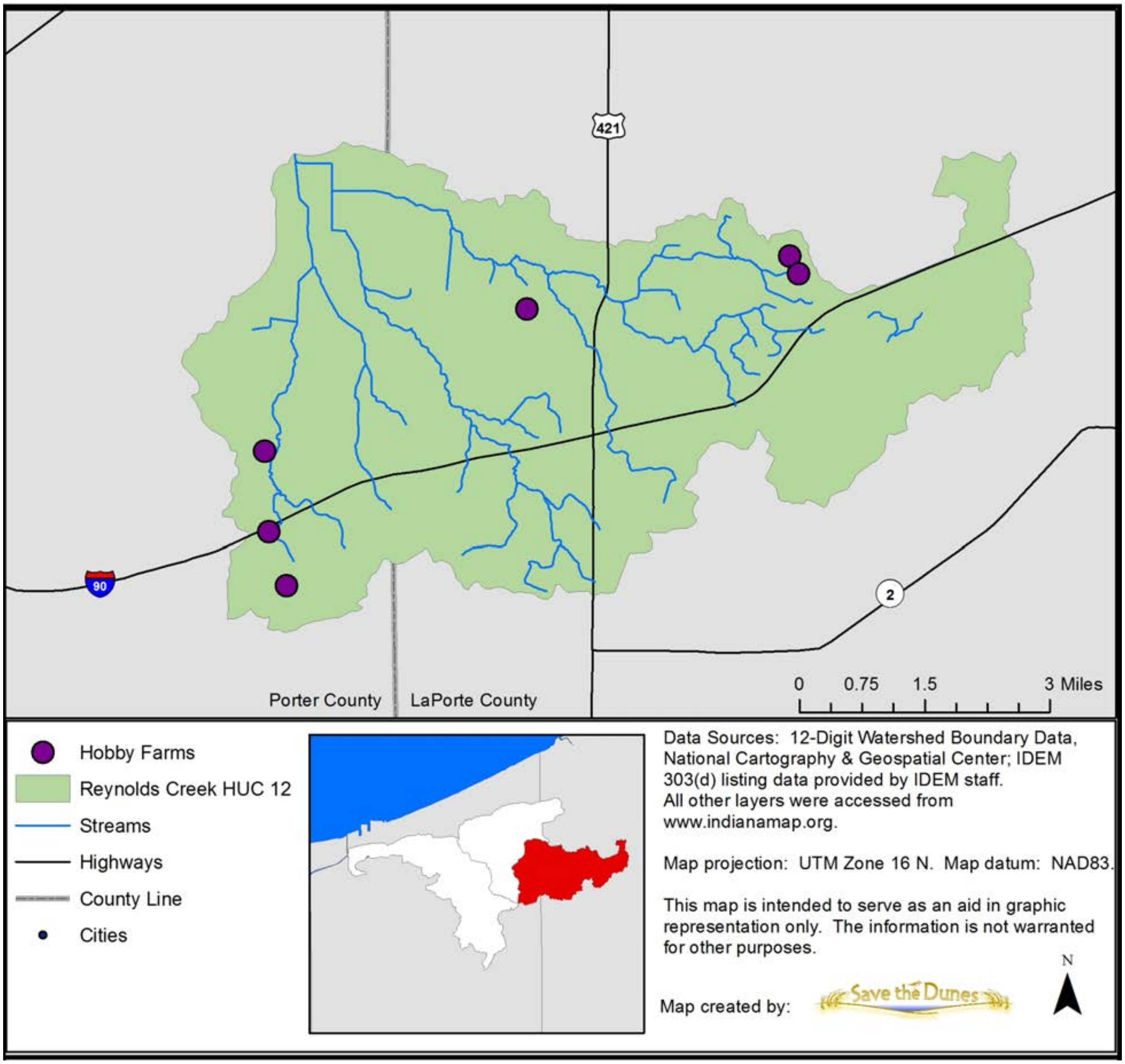

Figure 44. Hobby farms in the Reynolds Creek subwatershed

Windshield surveys in the Reynolds Creek subwatershed highlighted land uses due to their potential effect on water quality. Beneficial land uses noted by the surveyors included the presence of a fen, protected natural areas including classified habitat, and 2 wildlife preserves, at least 5 wetlands, 2 rain gardens, 2 stormwater detention ponds, and several in-stream lakes. Other land uses reported by surveyors included two construction sites, the presence of the toll road, livestock, Canadian geese and other waterfowl in ponds, several large turf grass areas, lawns maintained up to stream or lake edges, homes and lawns in close proximity to rivers, several large impervious areas, occasional steep banks, and conventional farming practices. The windshield survey combined with desktop analysis reported 1.67 miles of absent or insufficient riparian buffers (Figure 45). Utilizing both the QHEI (habitat) analysis and the windshield survey, approximately 266 ft. of stream bank are eroding throughout in the Reynolds Creek subwatershed (Figure 45). Moderate to heavy siltation was also reported for 340 ft. of streambed.

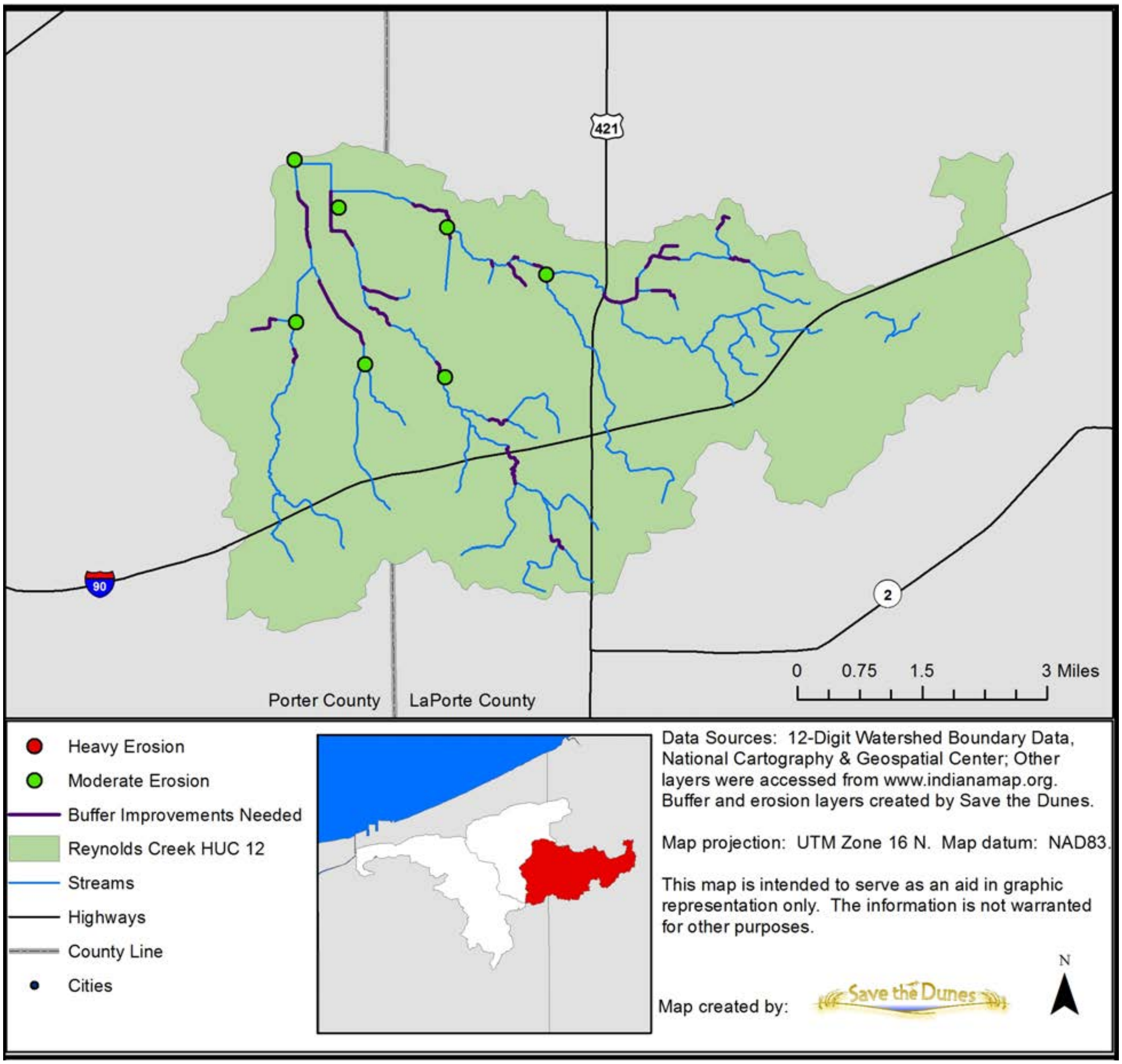

Figure 45. Streambank erosion and buffers needed for the Reynolds Creek subwatershed

4.1.d Summary

The Reynolds Creek subwatershed is somewhat sparsely developed and contains abundant high quality natural lands. However, this subwatershed also contains a notable amount of agriculture (conventional agriculture and hobby farms) that may be exporting nutrients and sediment. This rural landscape may also be contributing large amounts of *E. coli* through poorly functioning onsite septic systems from the abundant low-density rural residential homes checkered throughout this subwatershed's landscape. Most of the streams in this subwatershed are 303(d) listed for biotic communities, while others are listed for dissolved oxygen and *E. coli*. Due to the drought, the 2012 baseline study might under-report water quality impairments such as nutrients and sediment. However, the impairment of biological communities may demonstrate established water quality issues in this subwatershed.

4.2 Kemper Ditch Subwatershed (HUC12- 040400010402)

The Kemper Ditch subwatershed is 14,157 acres, which is nearly 30% of LCEB watershed. Named waterbodies within the Kemper Ditch subwatershed include the LCEB mainstem, Carver Ditch, Kemper Ditch, Rice Lake, and Mar Mac Lake. There are no NPDES permitted facilities in the subwatershed.

Sampling Sites 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 49 and 50 are within the Kemper Ditch subwatershed.

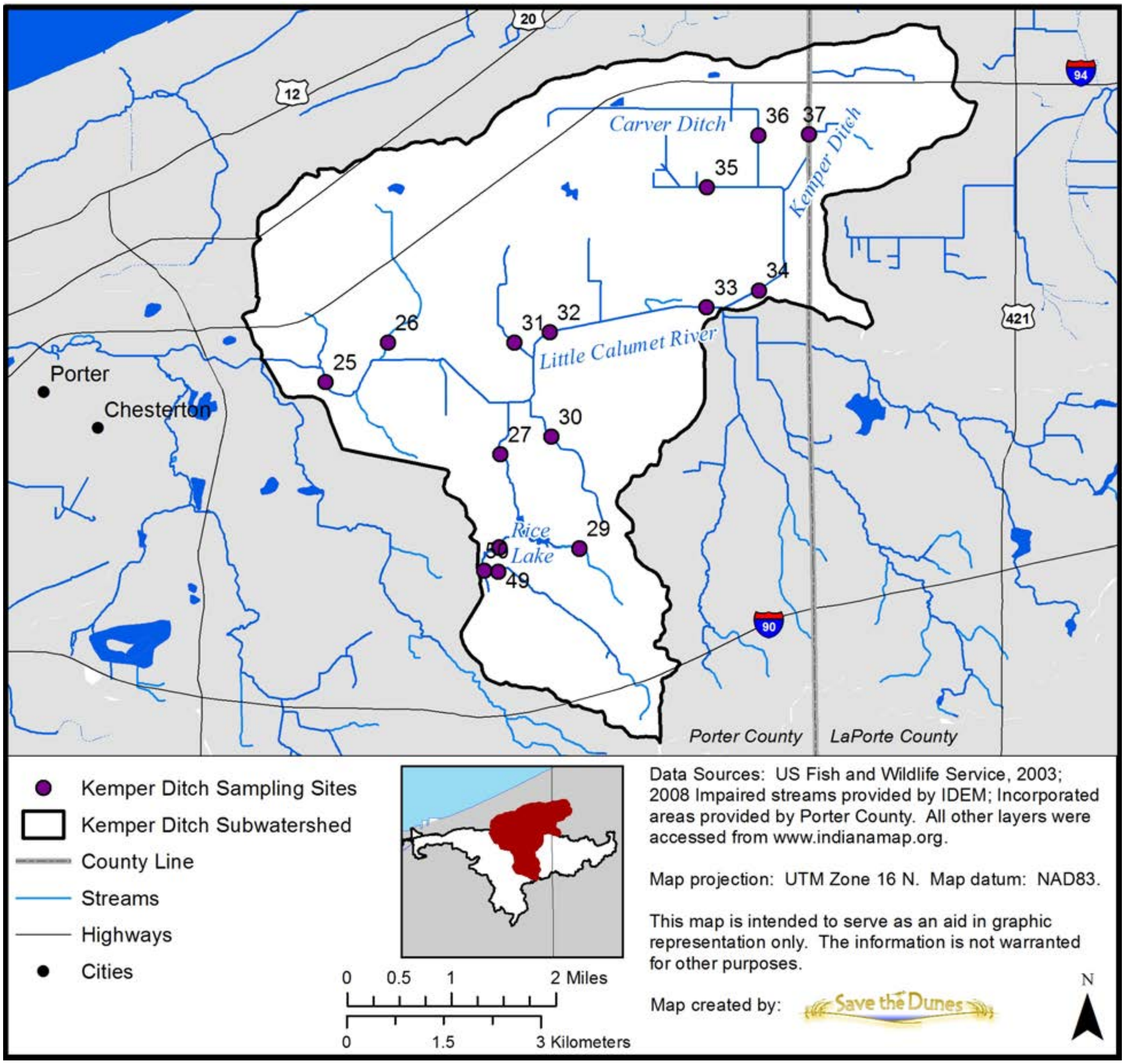

Figure 46. Kemper Ditch subwatershed sampling sites

4.2.a Water Quality Information

Past Studies

Three studies have been conducted in the Kemper Ditch subwatershed: IDEM's 2000 Little Calumet River East Branch study, the 2000 LCEB *E. coli* study, and the 2010 Corvallis Probabilistic Monitoring study. The 2000 LCEB study included two mainstem sites: 32 and 33. Site 32 exceeded the *E. coli* target for 50% of the samples. Temperature and DO had no violations. Site 33 had one temperature violation and exceeded the *E. coli* target for 80% of the samples taken. There were no DO violations. It should be noted that this data is over 14 years old, as of the writing of this plan, and indicates historic trends, not current conditions. Only one site from the Kemper Ditch subwatershed was examined for the 2000 *E. coli* study: a location near site 32. *E. coli* concentrations exceeded target concentrations with 80% of samples collected. The 2010 Corvallis study included one location in the Kemper Ditch subwatershed: site 32 (LCEB mainstem). All *E. coli* samples exceeded the target concentration, however, there were no violations for temperature or dissolved oxygen. A third of samples taken for TSS, phosphorus and nitrate exceeded target concentrations.

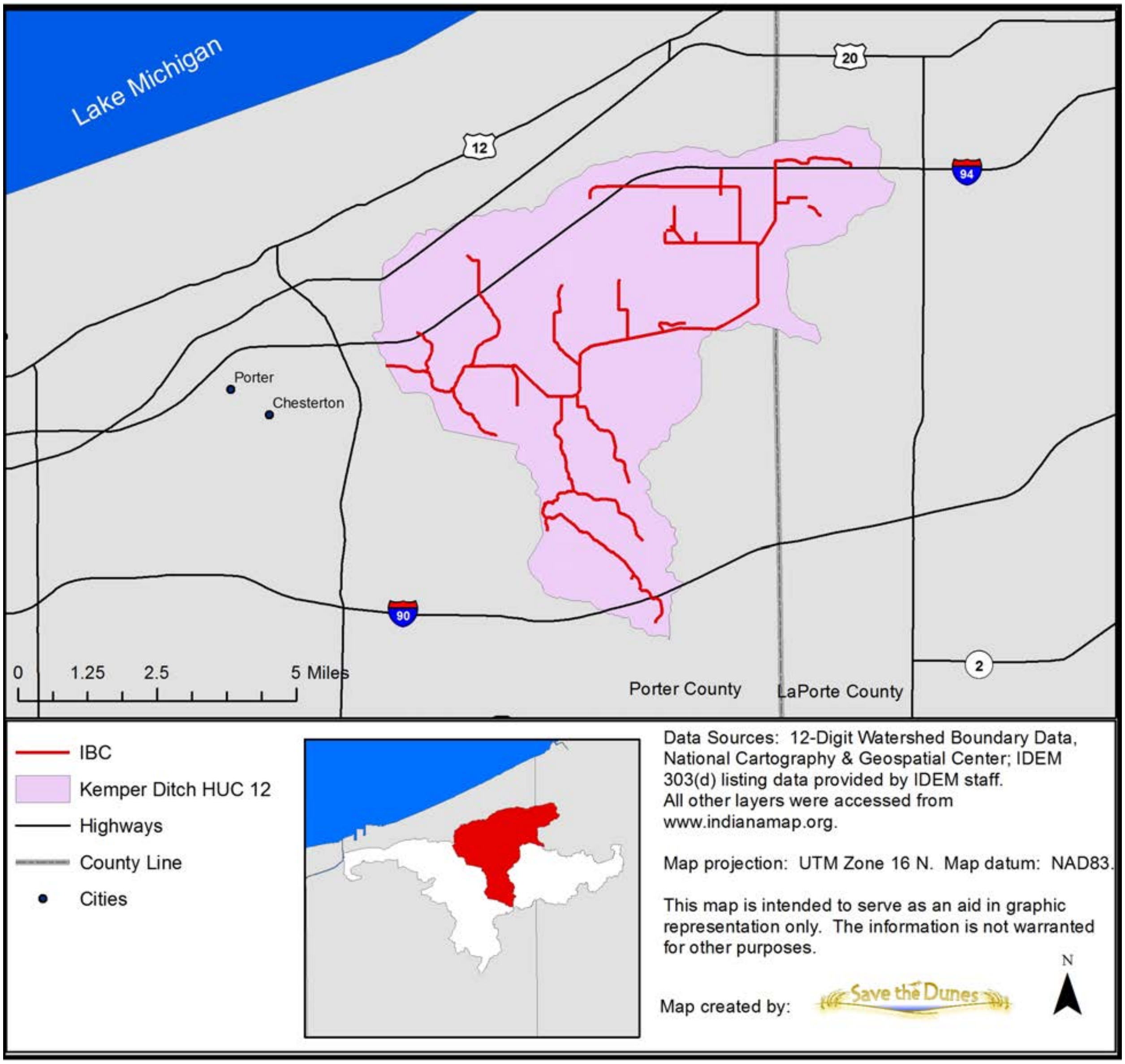

Figure 47. Kemper Ditch subwatershed 2014 draft 303(d) listing for impaired biotic communities

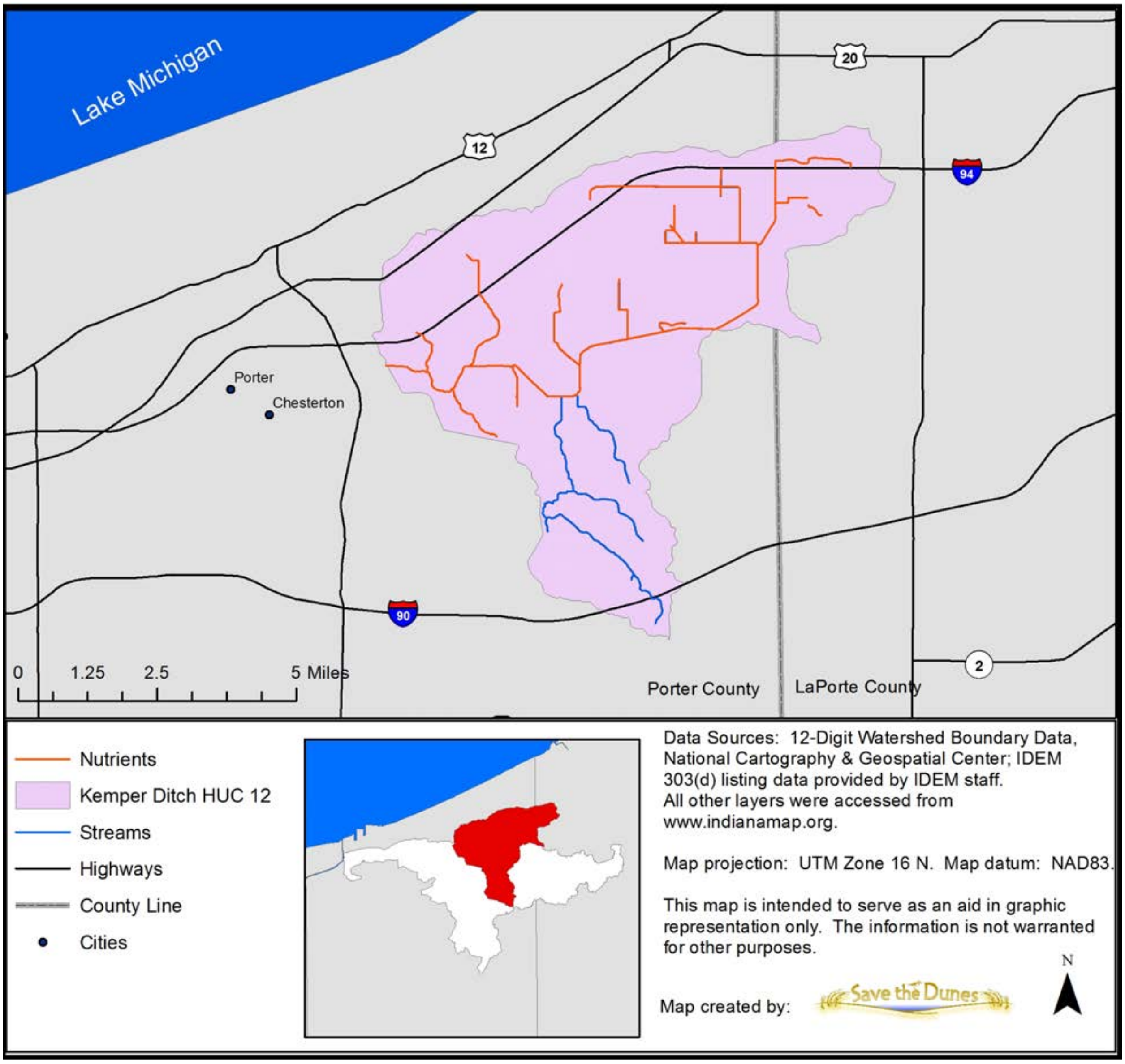

Figure 48. Kemper Ditch subwatershed 2014 draft 303(d) listings for nutrients

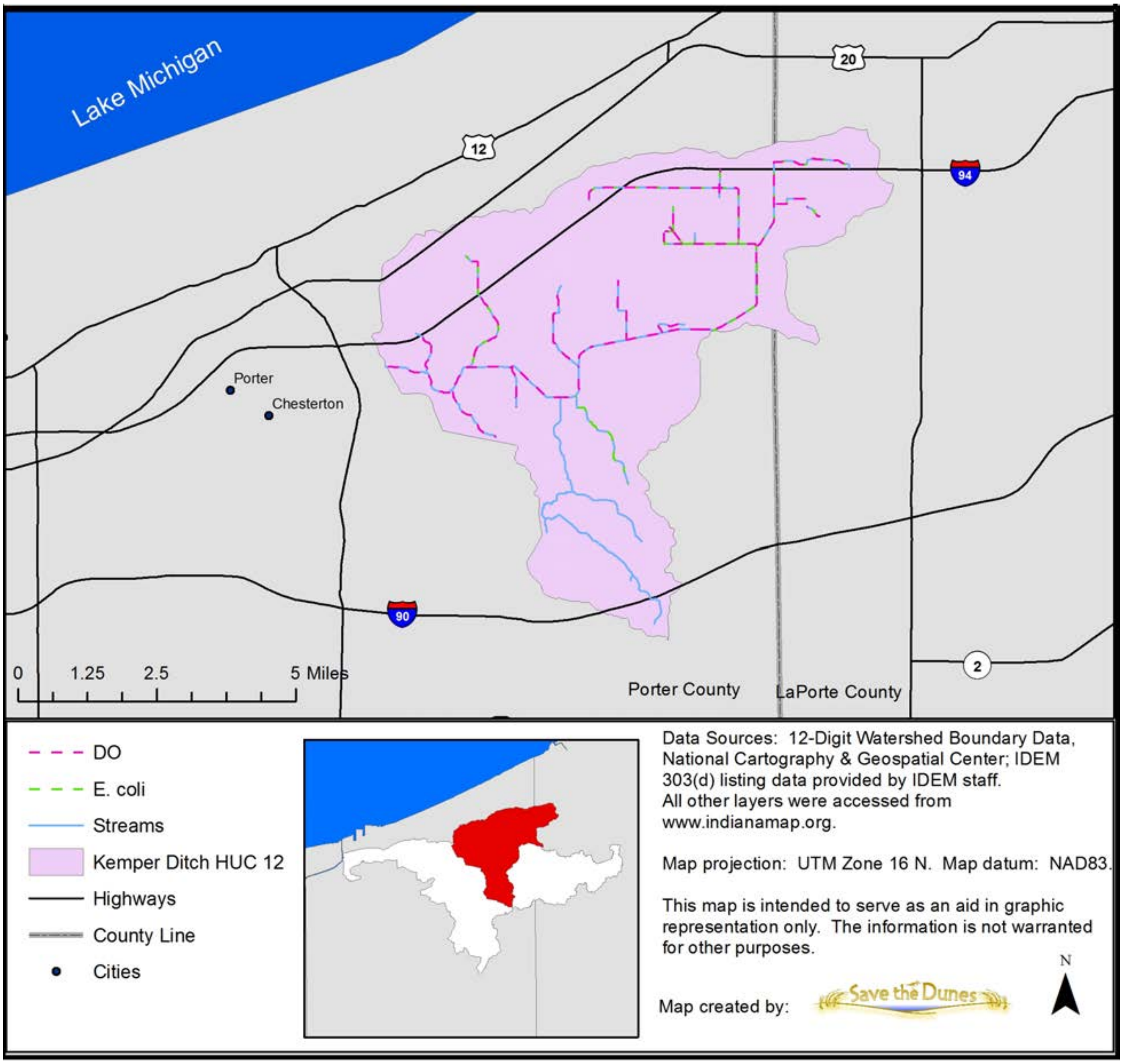

Figure 49. Kemper Ditch subwatershed 2014 303(d) listing for *E. coli* and dissolved oxygen

Current Studies

All stream segments within the Kemper Ditch subwatershed are included on the 2014 (draft) 303(d) listing. For impaired biotic communities (Figure 47), the entire subwatershed is listed. The Carver Ditch (sites 35 and 36) and Kemper Ditch (sites 34 and 37) tributaries, mainstem locations (sites 25, 32 and 33), and other tributaries (sites 26 and 31) are also listed for nutrient impairment (Figure 48). Tributaries listed for *E. coli* (Figure 49) include: the Carver Ditch (sites 35 and 36) and Kemper Ditch (sites 34 and 37) tributaries and other tributaries (sites 26 and 30). Sites impaired by dissolved oxygen (DO) (Figure 49) include: the Carver Ditch (sites 35 and 36) and Kemper Ditch (sites 34 and 37) tributaries, mainstem locations (sites 25, 32 and 33), and other tributaries (sites 26 and 31).

Water temperature in the Kemper Ditch subwatershed was variable depending on location. Overall, only 15% of samples collected in this watershed exceeded the target. All of the means were below the temperature standard (21.1° C), but there were very high temperatures measured during the recreational period at a few sites. Sites 31 (unnamed tributary) and 33 (mainstem) had zero temperature violations. Sites 26 (Tributary West), 30 (tributary), 32 (mainstem) and 35(Kelleys Ditch) all had one temperature exceedance. The highest summertime temperature was 25.8° C at site 27(Rice Lake Outlet). This site also had the highest number of target violations (10), followed by site 28 (Mar Mac Lake Creek) with 8 exceedances. Sites 34(Carver Ditch Downstream) and 37(Kemper Ditch) also had temperature violations (4 and 3, respectively) with higher summertime values.

Dissolved oxygen (DO) concentrations in the Kemper Ditch subwatershed varied based on location. The mean concentration was 8.8 mg/l but means for each site were typically higher. Several sites had zero exceedances of the target concentration (6 mg/l): sites 25 (mainstem), 27 (Rice Lake Outlet), 29 (Rice Lake Inlet), 30 (unnamed tributary), 32 (mainstem) and 33 (mainstem). Site 28 (Mar Mac Lake Creek) only had one low DO violation. This indicates that the mainstem and the Rice Lake tributaries maintained relatively good DO concentrations. The Carver Ditch and Kemper Ditch tributaries had more target concentration violations. Sites 34 (Carver Ditch Downstream) and 36 (Carver Ditch Upstream) both had 6 DO violations, while sites 37 (Kemper Ditch) and 35 (Kelleys Ditch) had 4 and 2 violations, respectively. The lowest mean was at site 28 (Mar Mac Lake Creek, 9.1 mg/l). Site 37 (Kemper Ditch) had the highest mean in this subwatershed (12.8 mg/l). The high DO readings typically corresponded with extremely low water temperatures during the winter months, which allowed the water to hold more oxygen than it would under warmer temperatures. These samples were not designated as oversaturated, even though some values were as high as 15.8 mg/l (corresponding with 2.3°C water temperature.) This site also had extreme low values of DO in 2012- the lowest was 1.78 mg/l, which corresponded to a very warm water temperature (24.1° C). Site 37 also had the only high DO violations for the subwatershed (18.4 mg/l at 24.8° C and 14.3 mg/l at 13.2° C). The extreme DO values at this site should be examined further. There were no pH violations for the Kemper Ditch subwatershed during the 2012 baseline sampling events: all samples fell within the six to nine pH units range from the IAC.

Nitrate + nitrite levels were relatively low in the Kemper Ditch subwatershed in 2012. Only 3% of samples exceeded the target concentration of 1.0 mg/l, while nearly 34% of samples were below the analytical detection limit. The model used to generate annual loads requires at least twelve data points with associated stream flow. Consequently, nitrate loads were calculated at only 4 sites in this subwatershed (sites 25, 27, 28, and 32). The highest load was 16,178 lb/yr at site 25 (mainstem), while the lowest calculated load was 678 lb/yr at site 27 (Rice Lake Outlet). The highest sample concentration was 4.8 mg/l (at site 34, Carver Ditch Outlet) during a storm event. However, nitrate concentrations were below the analytical detection limit (censored) at this site for more than half of the 2012 sampling events. Because of this, no total annual load was calculated for sites on or draining from Carver Ditch. The one time high value after the storm event suggests that nitrate may have accumulated on the landscape during the historic 2012 drought. The baseline data that has been reported for this parameter may underestimate normal pollution levels for this watershed.

Phosphorus concentrations were variable for this subwatershed. Over 50% of samples exceeded the target concentration of 0.08 mg/l, yet 32% of samples collected were below the analytical detection limit. Six sites had calculated annual loads (sites 25, 27, 28, 32, 33, and 34). The highest annual load was 7,387 lb/yr at site 25 (mainstem) and the lowest annual load was 184 lb/yr at site 28 (Mar Mac Lake Creek). The highest mean phosphorus concentration was 0.46 mg/l at site 35 (Kelleys Ditch). This site also had the highest concentration for a single sample (1.3 mg/l). The lowest mean was 0.07 mg/l at site 28 (Mar Mac Lake Creek).

Total suspended solids (TSS) concentrations were low on the mainstem and high in the agricultural area of the Kemper Ditch subwatershed. Nearly 18% of samples exceeded the target concentration (30 mg/l), and 30% of samples were below the analytical detection limit. Only four sites had enough data to calculate annual loads: sites 25 (mainstem), 27 (Rice Lake Outlet), 32 (mainstem), and 33 (mainstem). The highest sediment load was 1,066,138 lb/yr at site 25 and the lowest load was 31,086 lb/yr. The highest mean was 116.5 mg/l at site 35 (Kelleys Ditch) and the lowest mean was 3.7 mg/l at site 28 (Mar Mac Lake Creek). The agricultural areas drained by Carver Ditch (sites 34, 35, and 36) had the highest number of samples exceed target concentrations (6, 5, and 6, respectively). Three sites had zero violations of the target TSS concentration (site 25, 26, and 28).

E. coli concentrations for the Kemper Ditch subwatershed were generally high. Eighty-six samples (48%) exceeded the target concentration of 235 CFU/100 ml. All sites had multiple exceedances. Sites 32 (mainstem) and 28 (Mar Mac Lake Creek) had the most exceedances. The agricultural sites of 35 (Kelleys Ditch) and 37 (Kemper Ditch) had the fewest *E. coli* violations. Site 34 (Carver Ditch Outlet) had the highest mean of 1,905 CFU/100 ml, while the lowest mean was at site 27 (218 CFU/100 ml, Rice Lake Outlet).

Mar Mac Lake and Rice Lake Study

As part of the 2012 GLISTEN study, four study sites were privately funded to assess the tributaries for Mar Mac Lake and Rice Lake. Sites 27 and 28 (the inlet and outlet tributaries for Rice Lake) are also IDEM sampling locations for the 2012 LCEB baseline study. The data collected for these sites and the other GLISTEN collected sites was added to the IDEM baseline study, except sites 49 and 50 (the inlet and outlet tributaries for Mar Mac Lake). Sites 49 and 50 do no overlap with any IDEM sampling locations and were only collected during the summer of 2012. Consequently, these two sites were not included in the baseline study.

Temperatures were relatively high for sites 49 and 50. Eighty-six percent and 90% of samples collected for sites 49 and 50 (respectively) exceeded the target temperature. However, it should be noted that water quality data for these sites was only collected during the summer months. The mean temperature was 24.6˚ C and 26.0˚ C for sites 49 and 50, respectively. There were zero violations for dissolved oxygen for these two sites. However, their mean DO concentrations were fairly low (7.1 and 7.8 mg/l, respectively).

Nitrate concentrations were fairly low. There were zero exceedances and the mean concentration was 0.08 and 0.01 mg/l for sites 49 and 50, respectively. Site 49 had 3 samples exceed the target concentration for phosphorus (0.08 mg/l). Nonetheless, the mean concentration for both sites was below the target (0.03 and 0.00 mg/l, respectively). Total suspended solids and *E. coli* concentrations followed a similar pattern for the inlet (site 49) and outlet (site 50) for Mar Mac Lake. Both pollutant concentrations were higher upon entering the lake and are largely reduced at the outlet. The mean TSS concentration was 8.0 mg/l at the inlet and reduced to 3.6 mg/l at the outlet. Similarly, the mean *E. coli* concentration was 545 CFU/100 ml upon entering Mar Mac Lake and reduced to 95 CFU/100 ml at the outlet. Site 49 exceeded the *E. coli* target concentration for over 78% of samples collected, while site 50 had zero violations.

4.2.b Habitat/Biological Information

IDEM assessed habitat and biotic communities in 1990 at the Heron Rookery and in 2010 at site 32, just downstream of the Heron Rookery. In 1990, the Heron Rookery site rated a mIBI score of 2.8 (moderately impaired using KICK metric) and a QHEI of 82 (excellent). The 2010 Corvallis study (site 32) rated a mIBI score of 20 (very poor using multihabitat metric) and a QHEI of 50 (fair). Site 32 received an IBI score of 34 (poor) and a QHEI score of 58 (good).

IDEM utilized two biotic indices during the recreational period in 2012 to analyze two aquatic communities. Benthic macroinvertebrates were analyzed using IDEM's mIBI methodology, and fish communities were assessed using IDEM's IBI methodology. All sites in the Kemper Ditch subwatershed received a not supporting rating for macroinvertebrates. Site 35 (Kelleys Ditch) was not assessed due to drought conditions. For fish communities, only two sites were found to support this community: sites 32 (mainstem) and site 33 (mainstem). QHEI scores were calculated for each site to determine if the lack of aquatic communities support was due to water pollution or habitat degradation. Four sites were found to have supporting habitat: sites 25 (mainstem), 27 (Rice Lake Outlet), 28 (Mar Mac Lake Creek), and 32 (mainstem).

4.2.c Land Use Information

Land cover in the subwatershed is predominantly agricultural (44%), followed by forested (20%). Developed land cover is limited (9% of the subwatershed), yet many low-density residential homes are scattered throughout the rural/agricultural areas. Urban land cover is primarily comprised of Interstate 94 and the landfill (located south of I-94 and near site 37) Proposed zoning maps for LaPorte County indicate that the area surrounding the highway 421 and I-94 interchange is zoned for general commercial and highway commercial. Protected areas include the INDU Heron Rookery, which protects a significant (~ 543-acre) wetland complex along the LCEB mainstem. A large (~ 4,700 acres) agricultural area of hydric soils is present along Carver and Kemper ditches. This area is also a floodplain. This area of hydric soils is being examined as a potential wetland mitigation area. Kemper Ditch, Carver Ditch, and the mainstem of the LCEB are regulated drains within the Kemper Ditch subwatershed. The LCEB is also designated as a legal drain within the Heron Rookery. Save the Dunes, NPS, and the Porter County Surveyor have met to begin discussing strategies to ensure that adequate drainage is maintained while also protecting the Heron Rookery.

There is no large industry or plans for major development in this subwatershed. There are no fairgrounds or kennels. Conventional agriculture is the dominant land use (44%) in this subwatershed. Low-density rural residential homes are also abundant throughout this landscape. There are no hobby farms in this subwatershed. Conventional fertilizer is the dominant form of fertilizer applied to agricultural fields. Manure is not used as a fertilizer for conventional agriculture in this subwatershed.

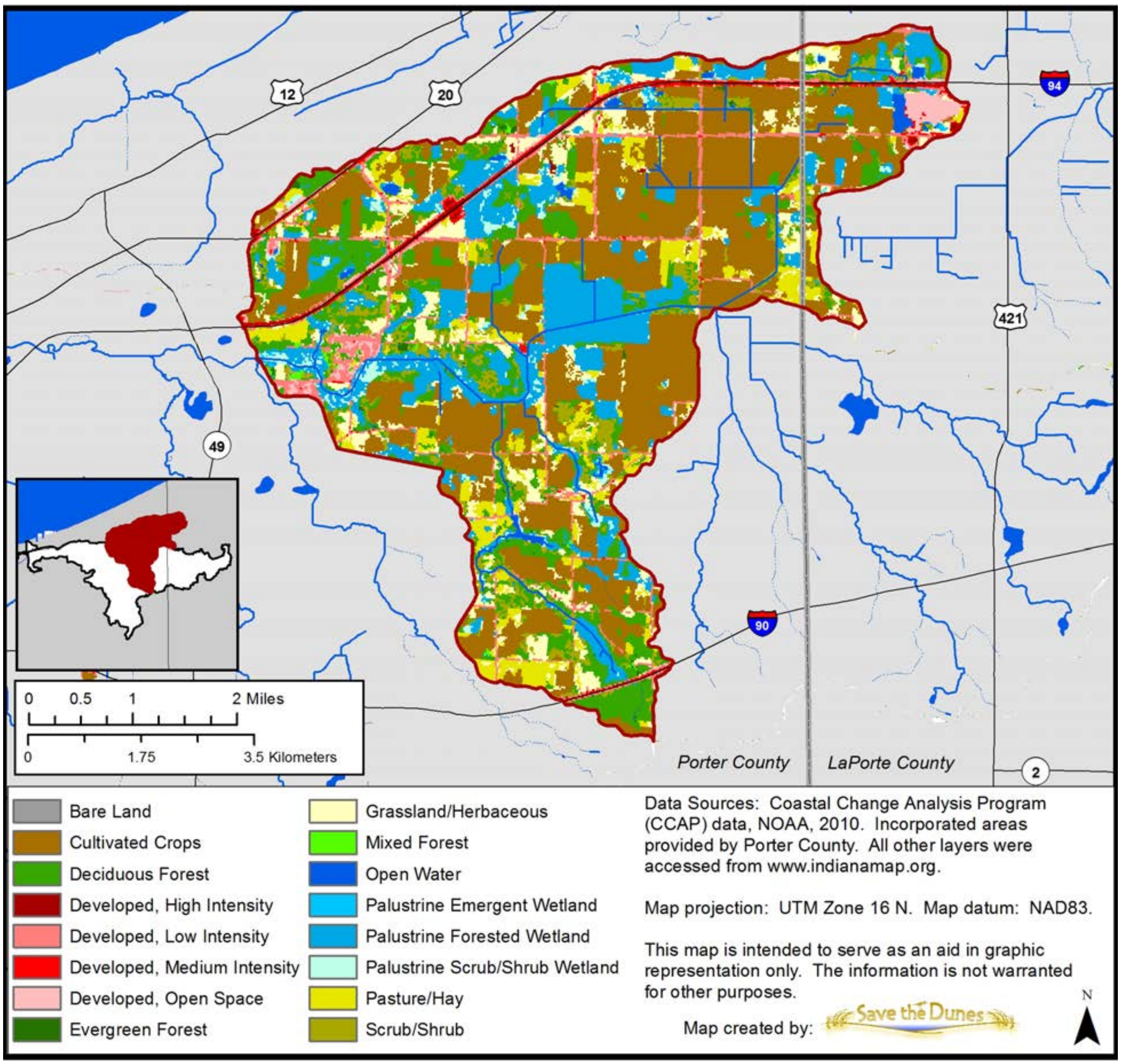

Figure 50. Land cover in the Kemper Ditch subwatershed.

Windshield surveys in the Kemper Ditch subwatershed highlighted land uses due to their potential effect on water quality. Beneficial land uses noted by the surveyors included INDU land, several small forest preserves, several wooded wetlands, buffer strips along several agricultural ditches, a natural prairie area, and at least 3 wetlands. Other land uses observed by surveyors included 2 sites with piles of loose fill material, 4 steep streambanks, three suspected eutrophic waterbodies, 2 demolition activities, turbid ditch water at 4 sites, 2 home construction sites, the presence of duckweed at 4 sites, numerous discharging pipes, ditch-side plowing of a crop at one site, large turf lawns up to stream edges at more than 6 sites, livestock close to rivers, Canadian geese and other water fowl in ponds, conventional agriculture at many sites, dredging, 2 illegal dump sites, and a landfill. Nearly 8 miles of absent or insufficient riparian buffers were identified from the windshield survey combined with desktop analysis (Figure 51). Utilizing both the QHEI (habitat) measurements and the windshield survey, approximately 456 ft. of stream bank are eroding throughout in the Kemper Ditch subwatershed (Figure 51). Moderate to heavy siltation was also reported for 835 ft. of streambed.

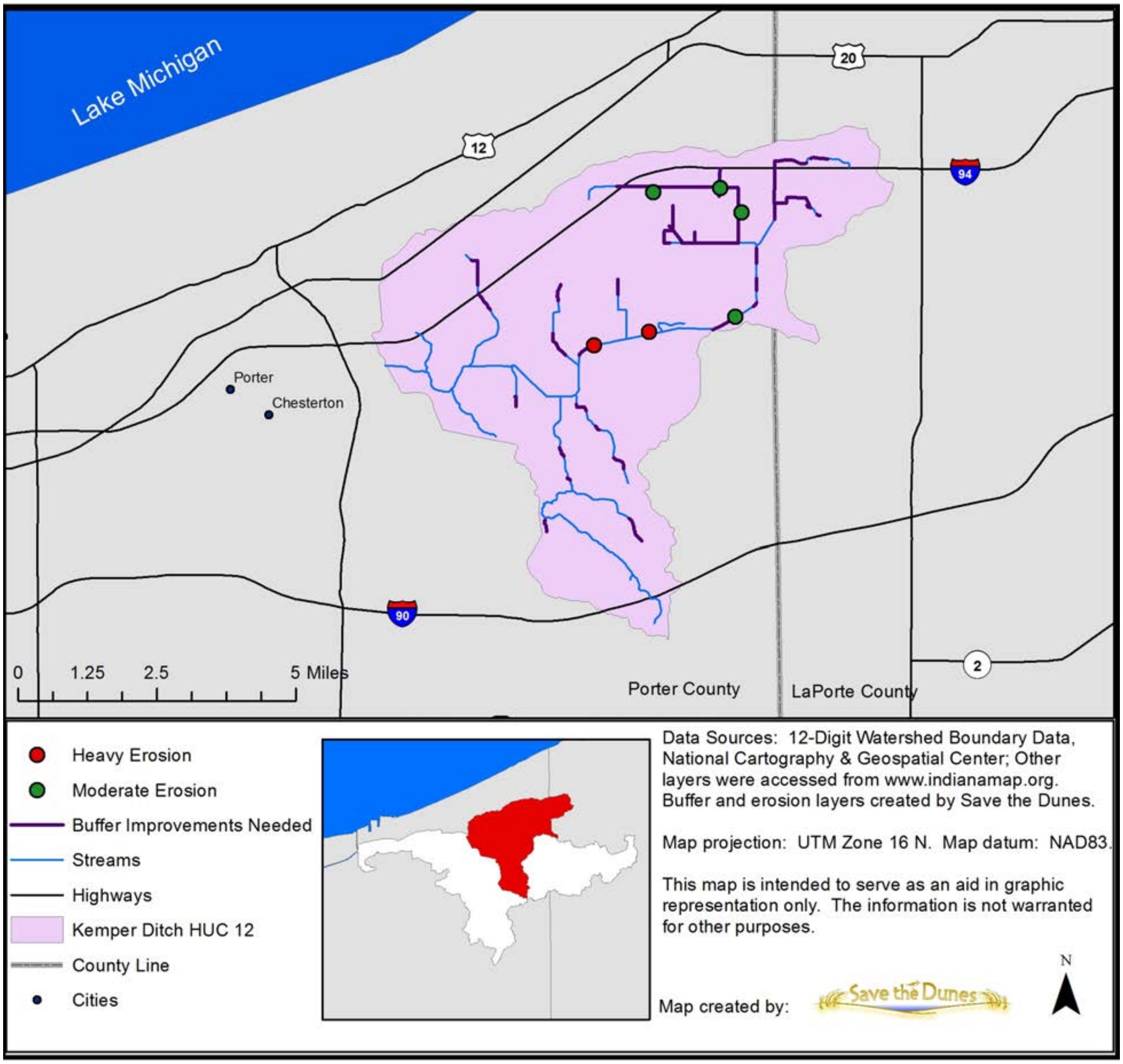

Figure 51. Streambank erosion and buffers needed in the Kemper Ditch subwatershed

4.2.d Summary

The Kemper Ditch subwatershed is sparsely developed and contains the most agricultural land in the LCEB. However, this subwatershed also contains high quality natural lands, such as the Heron Rookery. The agricultural lands in this subwatershed are contributing abundant nutrients and sediment to streams and rivers in the Kemper ditch subwatershed. This rural landscape may also be contributing large amounts of *E. coli* through poorly functioning onsite septic systems from the many low-density rural residential homes checkered throughout this subwatershed's landscape. All the streams in this subwatershed are 303(d) listed for biotic communities, while others are listed for nutrients, dissolved oxygen, and *E. coli*. Due to the drought, the 2012 baseline study may underestimate water quality parameters such as nutrients and sediment. However, the impairment of the biological communities may demonstrate established water quality problems in this subwatershed.

4.3 Coffee Creek Subwatershed (HUC 12: 040400010403)

The Coffee Creek subwatershed is 20,393 acres, which is approximately 43% of the LCEB watershed. Named waterbodies within the Coffee Creek subwatershed include the LCEB mainstem, Coffee Creek, Peterson Ditch, Pope O'Connor Ditch, Shooter Ditch, Johnson Ditch, Suman Tributary, Chubb Lake, Morgan Lake, Chestnut Lakes, Mud Lake, Carlson Pond, and Moore Swamp. There are several NPDES permits in the Coffee Creek subwatershed: The Chesterton Wastewater Treatment Plant main outfall and additional overflow outlets (INM022578), the Town of Porter lift station overflow (INJ046949), and the outlets for the Burns Harbor WWTP and ArcelorMittal (IN0000175).

Sites 1, 3, 4, 48, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, and 24 are in the Coffee Creek Subwatershed.

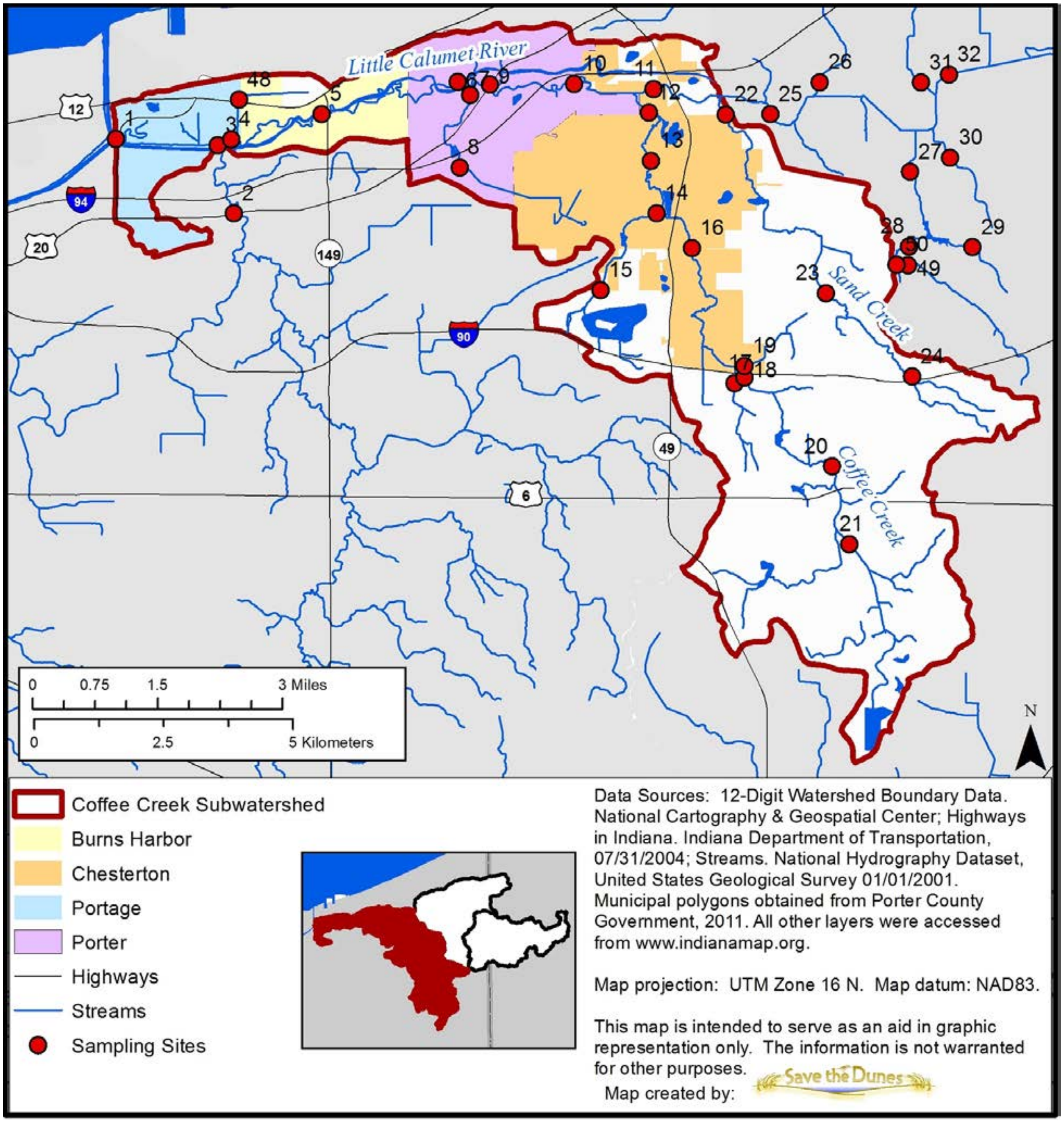

Figure 52. Coffee Creek subwatershed sampling sites

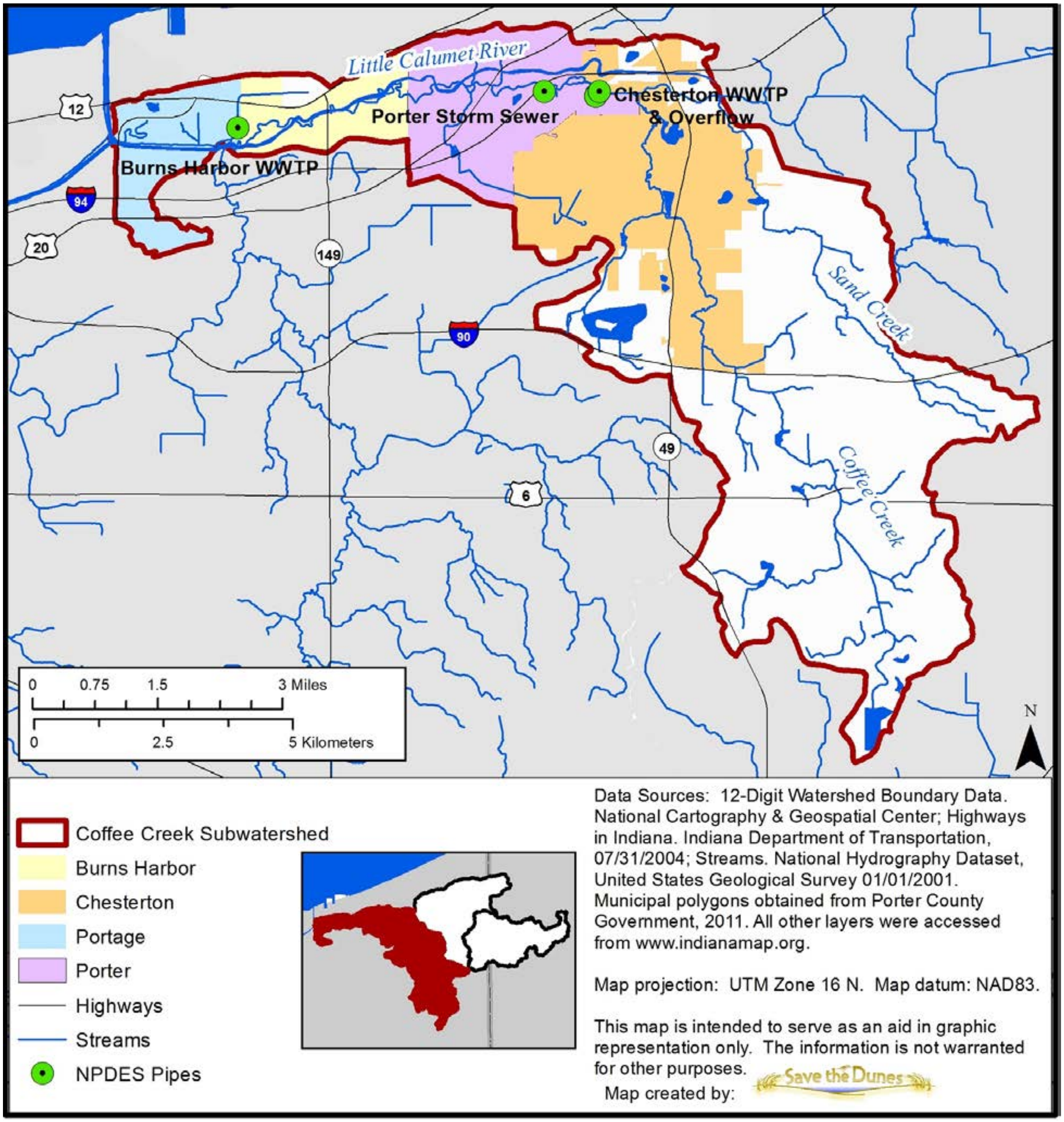

Figure 53. NPDES permits in the Coffee Creek subwatershed

4.3.a Water Quality Information

Past Studies

Several water quality studies have been conducted in the Coffee Creek subwatershed. From 1990 to present, IDEM has maintained fixed stations at sites 1 and 5 on the LCEB mainstem. The fixed stations have examined metals, basic water chemistry, and other environmental variables. IDEM also performed the Burns Waterway TMDL assessment in 2000, which measured chemistry, environmental variables, and organics at Site 1. Brief summaries for these studies are located in Section 3.1 Historic Water Quality Sampling Campaigns.

IDEM's 2000 *E. coli* study included sites 1, 5, and 13 in the Coffee Creek subwatershed. Sixty-two percent of samples collected at these sites exceeded the target concentration (235 CFU/100 ml). The 2000 Corvallis study examined a location near site 9. Target concentrations were exceeded for phosphorus, temperature, nitrate, sediment, and dissolved oxygen. The 2010 Corvallis study examined site 16 in the Coffee Creek subwatershed. State water quality standards were exceeded for temperature, *E. coli*, sediment, and total phosphorus. The 2000 East Branch Little Calumet River study examined six sites in the Coffee Creek subwatershed (1, 5, 9, 10, 23, and 48). Forty-four percent of samples exceeded the IAC standard for *E. coli a*nd 61% exceeded the target for temperature. There were no dissolved oxygen violations.

In 2000, IDEM tested for 103 different pesticides on one LCEB mainstem location (near site 9). Six pesticides: Atrazine, Acetoclor, Cyanazine, Desethylatrazine, Metolachlor, and Simazine were detected during May and June of that year. This corresponds to the seasonality of pesticide use. Pesticides, when present in surface waterways, can contribute to the impairment of biotic communities, since they can kill aquatic plants and animals. Of the six pesticides detected in the study from 2000, only Metolachlor, classified as an EPA class C pesticide and carcinogen, has an EPA aquatic life benchmark. Metolachlor had two violations of IAC criteria.

The Coffee Creek Watershed Management Plan (2003) examined water quality at 8 sites within the Coffee Creek subwatershed. Overall, water quality in the tributaries was more degraded than the mainstem. High temperatures and elevated *E. coli* concentrations, combined with high nutrient and sediment loads were cited as problems for water quality and biological communities. Shooter Ditch and Pope O'Connor Ditch were selected as critical areas.

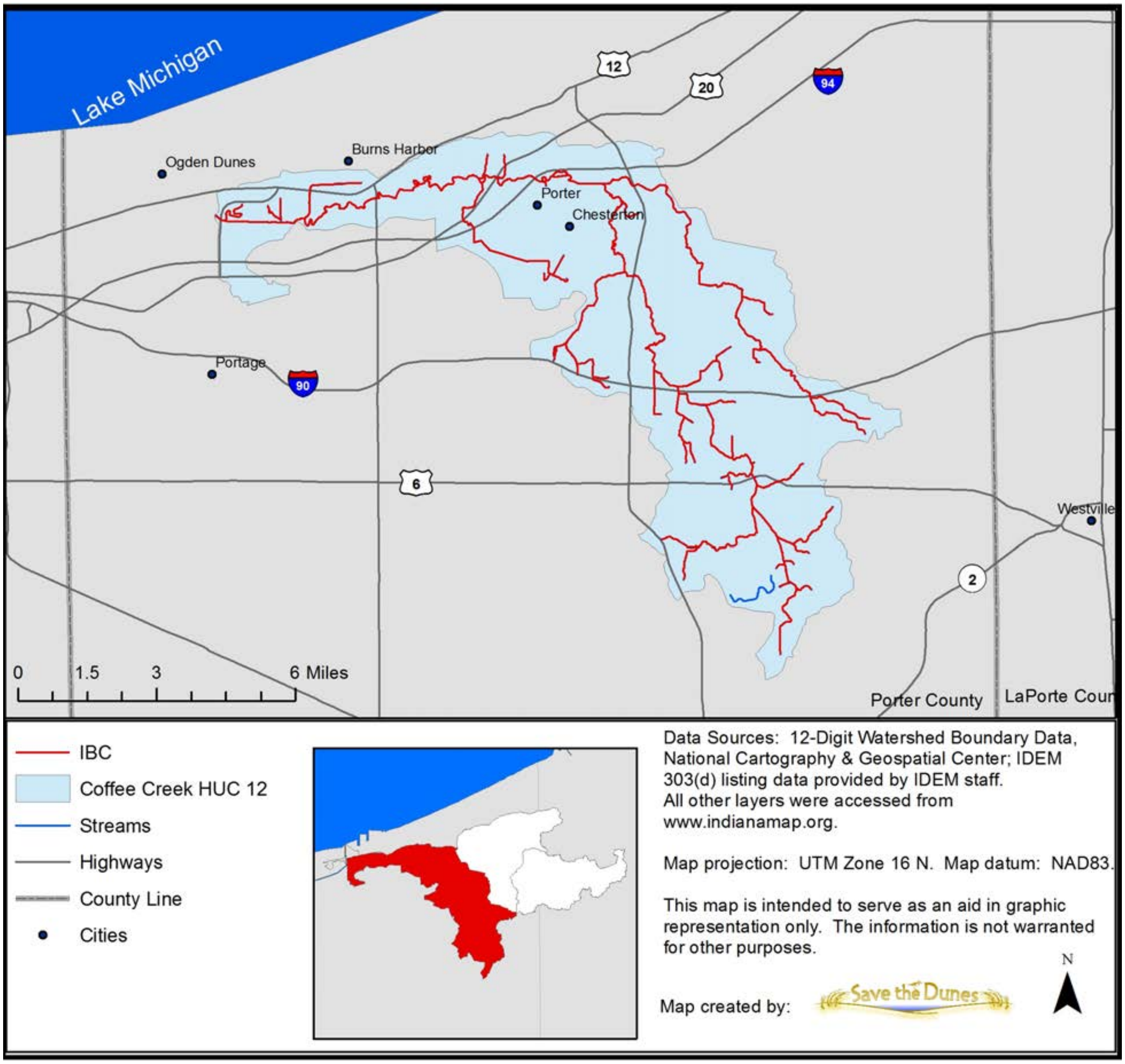

Figure 54. Coffee Creek subwatershed 2014 draft 303(d) listing for impaired biotic communities

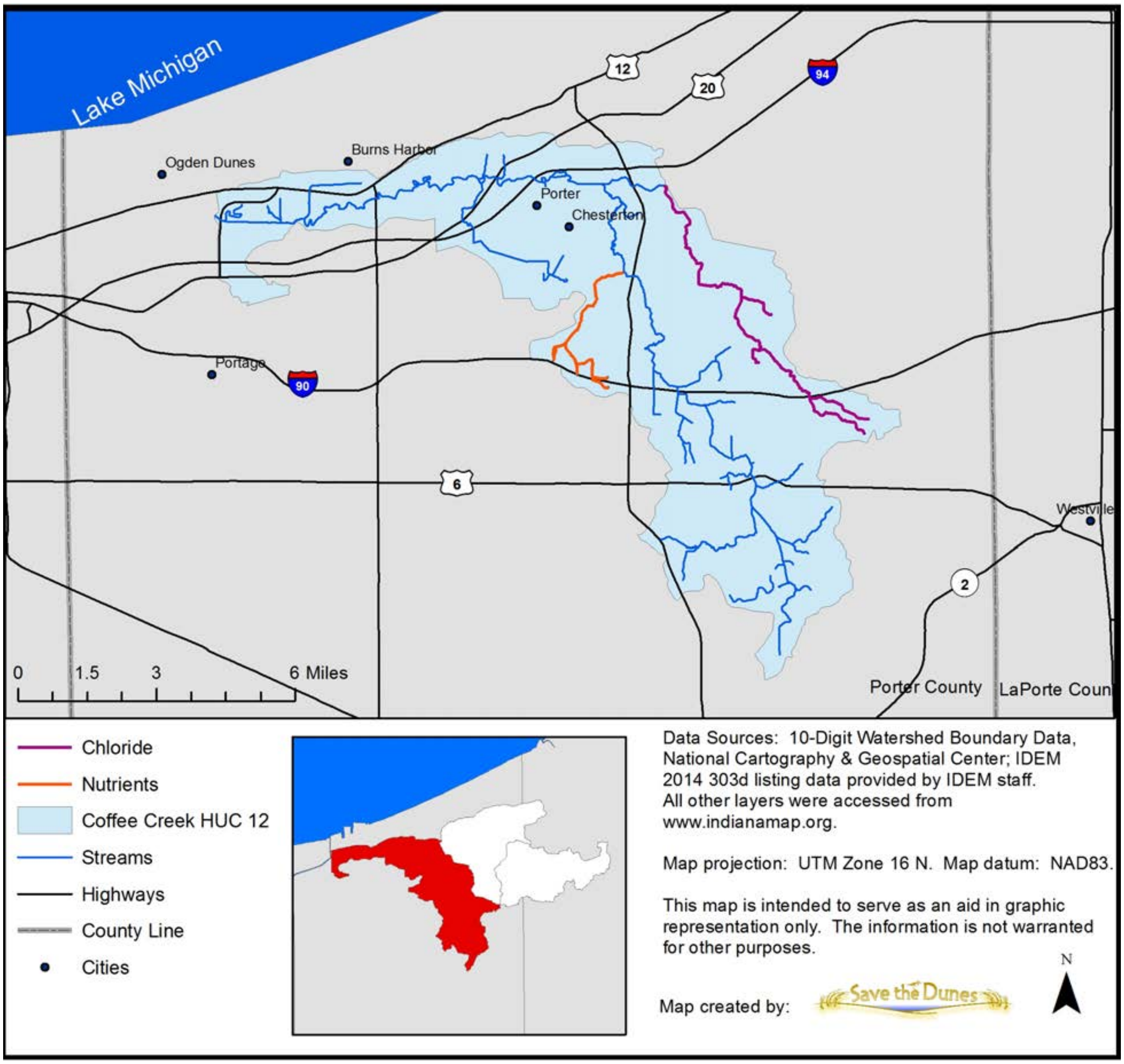

Figure 55. Coffee Creek subwatershed 2014 draft 303(d) listings for nutrients and chloride

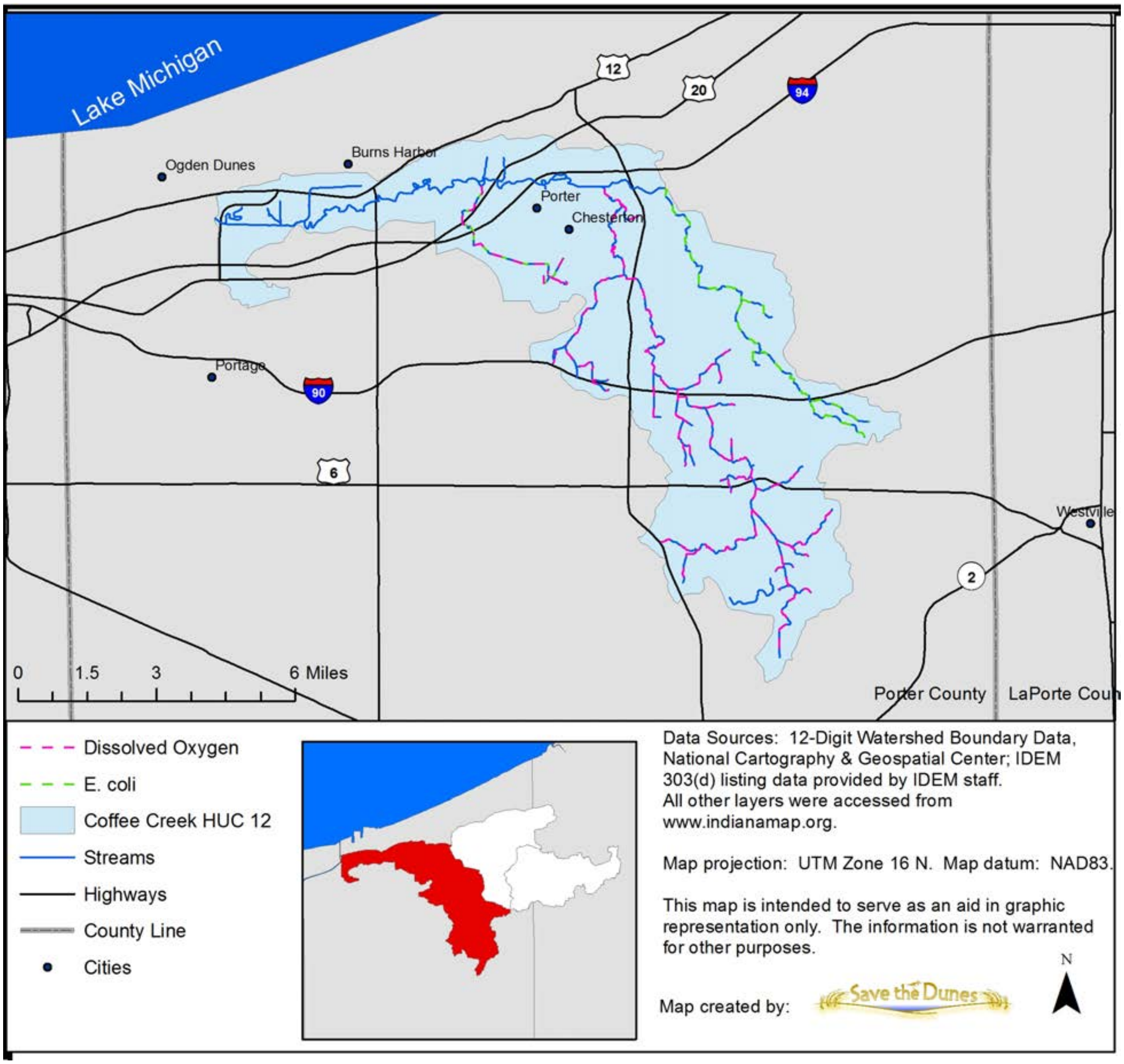

Figure 56. Coffee Creek subwatershed 2014 draft 303(d) listings for *E. coli* and dissolved oxygen

Current Studies

All stream segments within the Coffee Creek subwatershed are included on the 2014 (draft) 303(d) listing. For impaired biotic communities (Figure 54), the entire subwatershed is listed. The entire length of the Pope O'Connor Ditch (sites 14 and 15) is impaired for excessive nutrients (Figure 55). The entire length of Sand Creek (sites 22, 23, and 24) is impaired for chloride and *E. coli*. Peterson Ditch (sites 7 and 8) is impaired for *E. coli* and dissolved oxygen (Figure 56). The entire Coffee Creek (sites 12, 13, 16, 18, 20, and 21) and its tributaries, Johnson Ditch and Shooter Ditch (sites 17 and 19, respectively), are also listed for dissolved oxygen (Figure 56) on the 2014 (draft) 303(d) listing.

For the purpose of this data summary, Sites 1 and 2 were not included for data analysis. Site 2 is at the base of the Salt Creek watershed, which is entirely out of the LCEB watershed. Site 1 includes discharge from the Salt Creek watershed in addition to discharge from the entire LCEB watershed. Consequently, site 1 is not an appropriate comparison for the rest of the LCEB stream sites.

Temperatures in the Coffee Creek subwatershed were highest at the base of the watershed and lower in the tributaries. Most sites had few samples exceed the designated target temperature (21.1° C) during baseline sampling in 2012. Four sites had zero temperature violations (site 8, Peterson Ditch Upstream; site 15, Pope O'Connor Ditch Upstream; site 23, Middle Sand Creek; and site 24, Upper Sand Creek). Overall, 28% of samples in the Coffee Creek subwatershed exceeded the temperature target. The highest measurement was 27.9° C at site 14 (Pope O'Connor Ditch Downstream). The highest mean was 23.6° C at site 4 (Samuelson Ditch Downstream). Sites 4, 3, and 48 had the three highest temperature means in the LCEB watershed (23.6° C, 22.1° C, and 20.9° C, respectively). Site 24 had the lowest mean in the LCEB watershed (and the Coffee Creek subwatershed), however this upstream part of Sand Creek was not flowing during much of the recreational period in 2012, so temperature data for this site likely underestimates normal average temperatures for a given year.

There were relatively few dissolved oxygen (DO) violations for the Coffee Creek subwatershed, except for three sites that frequently exceeded the target concentration (6 mg/l). Sites 8, 19, and 22 had 6, 6, and 8 violations, respectively. The highest mean was 17.2 mg/l at site 15 (Pope O'Connor Ditch Upstream), but the high DO readings always corresponded with extremely low water temperatures during the winter months, which allowed the water in Coffee Creek to hold more oxygen than it would under warmer temperatures. Because of this, the samples were not labeled as oversaturated, even though some values were as high as 19.9 mg/l (corresponding with 13.5° C water temperature). At Site 15 the lowest concentration was 3.1 mg/l, which corresponded to a very warm water temperature (27.9° C). The lowest mean in the Coffee Creek subwatershed was 9.4 mg/l at site 22 (Lower Sand Creek), which is still well above the target concentration of 6 mg/l. Overall, only 8% of samples collected in the Coffee Creek subwatershed exceeded the target concentration. There were no pH violations in the Coffee Creek subwatershed in 2012: all samples fell within the six to nine pH units range from the IAC.

Nitrate and nitrite concentrations in the Coffee Creek subwatershed were generally low in 2012. Only 15% of samples collected exceeded the target concentration of 1.0 mg/l and 25% of samples were below the analytical detection limit. Sites 5 (mainstem), 9 (mainstem), and 10 (mainstem) had the highest percentage of samples exceed the target concentration (83%, 75% and 82%, respectively). Site 10 (mainstem) also had the highest mean (1.8 mg/l). The lowest mean of 0.1 mg/l was at site 17 (Johnson Ditch). This site was also the second lowest nitrate mean in the LCEB watershed. Seven sites in the Coffee Creek subwatershed had enough data to calculate annual loads: sites 3 (mainstem), 7 (Peterson Ditch Downstream), 9 (mainstem), 11 (mainstem), 12 (Coffee Creek), 20 (Coffee Creek) and 22 (Lower Sand Creek). The Purdue load tool requires at least 12 uncensored data points with associated flow to generate loads, and several sites in this subwatershed had too little data to calculate loads and areal loads. Site 9 (mainstem) had the highest annual nitrate-loading rate (138,394 lb/yr) and site 3 (mainstem) within the National Lakeshore had the second highest annual load (100,015 lb/yr) for nitrate in the LCEB watershed in 2012. It is important to note that due to the historic 2012 drought, the baseline data that has been reported for nitrate may underestimate normal pollution levels for this watershed.

Phosphorus in the Coffee Creek subwatershed was somewhat high. Thirty-seven percent of samples collected exceeded the target concentration of 0.08 mg/l and 36% of samples were below the analytical detection limit. Every site, except sites 4 and 48 (Samuelson Ditch) had exceedances for phosphorus. Sites 10 (mainstem) and 19 (Shooter Ditch) had the highest percentage of samples exceed the phosphorus target. Ten sites had enough data to calculate annual loads: sites 3, 7, 9, 11, 12, 13, 17, 18, 20, and 22. Site 9 (mainstem) had the highest phosphorus load of any site in the LCEB watershed (10,160 lb/yr), while site 17 (Johnson Ditch) had the smallest phosphorus load (154 lb/yr) in the Coffee Creek subwatershed. The smallest phosphorus means were 0.03 and 0.05 mg/l at sites 48 and 4, respectively. It is important to note that Samuelson Ditch (sites 4 and 48) is comprised only of treated steel mill effluent, and is therefore not a true river like the rest of the sites in the LCEB watershed. The largest mean in this subwatershed was 0.14 mg/l at site 22 (Lower Sand Creek).

Total suspended solids (TSS) were relatively low in the Coffee Creek subwatershed. Overall, only 5% of samples collected exceeded the target concentration (30 mg/l) and 40% of samples were below the analytical detection limit. Fourteen sites had no TSS violations (sites 3, 4, 6, 7, 8 10, 11, 13, 14, 15, 16, 18, 20 and 24), while six more had only one violation (sites 9, 17, 19, 21, 23, and 48). Site 12 (Coffee Creek) had the largest percentage of exceedances (24%). The lowest mean for TSS was 4 mg/l at site 14 (Pope O'Connor Ditch downstream). This was the second lowest mean in the LCEB watershed in 2012. The lowest annual TSS load (36,965 lb/yr) was site 7(Peterson Ditch Upstream). However, site 9 had the highest annual load of those calculated for the LCEB watershed at 1,548,644 lb/yr.

Concentrations of *E. coli* in the Coffee Creek Outlet showed a wide range of bacterial levels. Over 47% of samples collected exceeded the target concentration of 235 CFU/100 ml. Only two sites (4 and 48) had zero *E. coli* violations. Sites 4 and 48 (Samuelson Ditch Downstream and Upstream) had the lowest *E. coli* means in the entire LCEB watershed (12 and 18 CFU/100 ml, respectively). This waterway was created to drain and cool treated steel mill effluent and is not a natural waterway. It is important to note that several of the smaller tributary sites were not flowing or totally dry during the growing season, so some of the baseline values at these sites may underestimate normal conditions in these streams. Site 7 (Peterson Ditch Downstream) had the largest mean (2,277 CFU/100 ml). The largest percentage of samples exceeding the target concentration was at Site 12 (Coffee Creek, 81%). Sites 7 (Peterson Ditch), 9 (mainstem), and 22 (Lower Sand Creek) also had large percentages of exceedances (75%, 70%, and 70%, respectively).

4.3.b Habitat/Biological Information

The 1990 macroinvertebrate study sampled site 16 in the Coffee Creek subwatershed. This site rated a QHEI score of 65 (good) and a mIBI score of 3.6 (moderately impaired). The 2000 Corvallis study examined a mainstem site near site 9. A QHEI score of 35 (non-supporting) and an IBI score of 34 (poor) were reported.

The Coffee Creek Watershed Management Plan (2003) evaluated macroinvertebrates in the spring and fall at the 7 sampling sites. The fall sampling reported higher mIBI scores (5 sites supporting, 2 sites not supporting) than the spring sample (3 sites supporting and 4 sites not supporting). Only one site received a supporting score for the QHEI (habitat).

IDEM utilized two biotic indices during the recreational period in 2012 to analyze two main aquatic communities. Benthic macroinvertebrates were analyzed using the mIBI methodology, and fish communities were assessed using the IBI methodology. Both communities were assessed at all the Coffee Creek subwatershed sites except for site 15 (Pope O'Connor Ditch Upstream) where IDEM assessed neither of the biotic communities in 2012 and site 24 (Upper Sand Creek) where the fish community was not assessed due to drought conditions.

Two sites received supporting scores (>36) for macroinvertebrates (mIBI): sites 5 (mainstem) and 23 (Middle Sand Creek). Sites 5 (mainstem), 6 (mainstem), 9 (mainstem), 13 (Coffee Creek), and 16 (Coffee Creek) received supporting scores for fish communities (>36). To evaluate the cause of failing biotic communities, in-stream habitat is assessed using the QHEI. Habitat was found to be not supporting at sites 8 (Peterson Ditch Upstream), 14 (Pope O'Connor Ditch Downstream), 19 (Shooter Ditch), 21 (Coffee Creek), 22 (Lower Sand Creek), and 48 (Samuelson Ditch Upstream). It is important to note that 2012 was a historic drought year, and many of these sites showed habitat ratings that were potentially lower than what may be considered normal conditions for these sites, due to low water levels that could have put root wads, overhanging vegetation, and other fish and macroinvertebrate habitats above the waterline.

4.3.c Land Use Information

Land cover in the subwatershed is predominantly developed land/urban (31%) followed by forest (30%) and agriculture (16%) (Figure 39 and Figure 57). With 31% developed land, the Coffee Creek subwatershed is by far the most urban in the LCEB watershed. Developed land is primarily in and around the incorporated areas along the mainstem and near the confluence of Coffee Creek with the mainstem. The rural areas in the Coffee Creek subwatershed have abundant low-density rural residential homes combined with agriculture. The headwaters of Coffee Creek are largely forested and protected within the Moraine Nature Preserve, which provides a large amount of open space. Much of the LCEB mainstem, downstream of Coffee Creek, is protected within INDU. Sections of Shooter Ditch, Pope O'Connor Ditch, Johnson Ditch, Peterson Ditch, and some reaches of the LCEB mainstem are regulated drains within the Coffee Creek subwatershed.

Chesterton is likely to expand to the south and southwest, in areas that are currently agriculture or low-density rural residential homes. Large industry, such as ArcelorMittal, is not anticipated to expand in to this watershed. There are no fairgrounds located in the Coffee Creek subwatershed at this time. There are only two small animal kennels located in Chesterton and Porter: Ark of the Dunes Animal Hospital in Chesterton and Dog Kennels Runs and More in Porter. Two small hobby farms are located in the Coffee Creek subwatershed (Figure 58). The acreage of these farms is approximately 18 acres with 6 horses and 10 cattle.

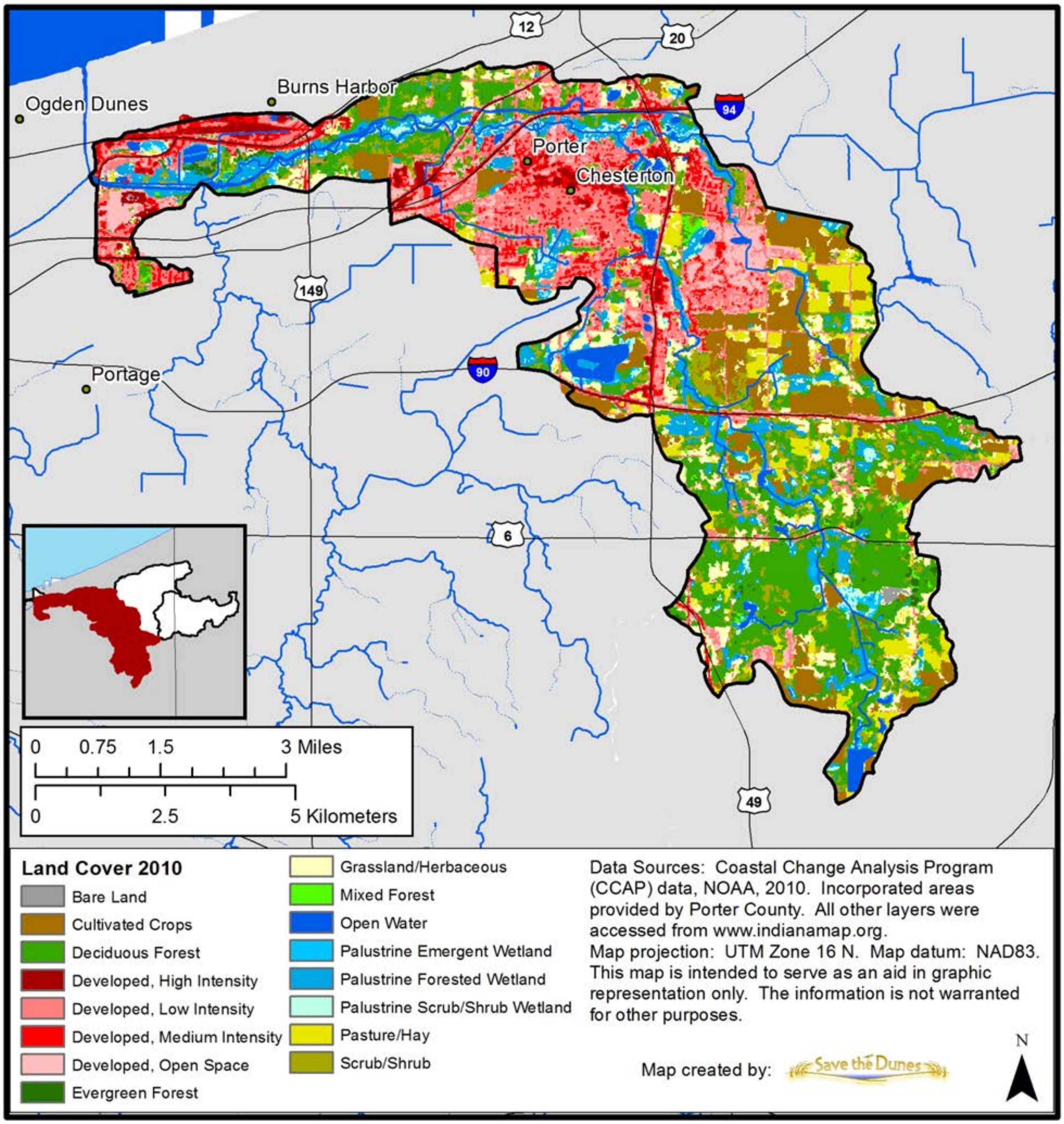

Figure 57. Land cover in the Coffee Creek subwatershed

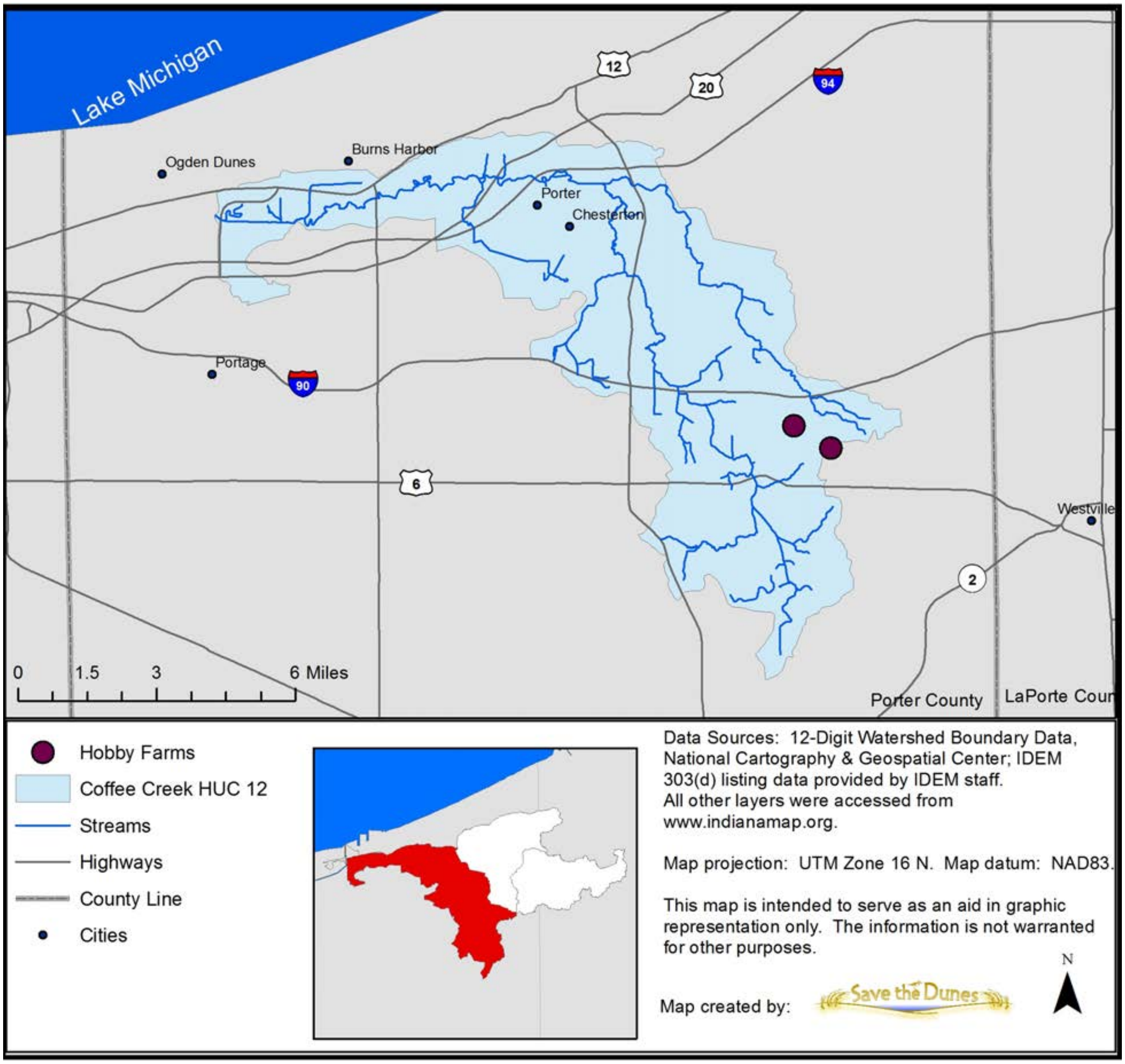

Figure 58. Hobby farms in the Coffee Creek subwatershed

Windshield surveys in the Coffee Creek subwatershed highlighted land uses due to their potential effect on water quality. Beneficial land uses noted by the surveyors included INDU forest preserves, a fen, many wetlands, ponds and lakes, two stormwater detention basins, a classified forest, and three preservation areas. Other land uses reported by surveyors included: severe bank erosion associated with the Praxair dam, an armored streambank near the confluence with Deep River, 4 sites with steep streambanks, industrial effluent at one site on the mainstem, dense residential areas within Chesterton, 4 large impervious surfaces/parking lots, large strip mall development, several large lawn turf areas up to stream edges, 4 yard waste dump sites, 2 sites where trash has been dumped near the stream, green and grey color of the LCEB mainstem at two different sites, exposed pipes at two sites, Canadian geese and other water fowl in ponds, rusty discoloration of curbs and trees in a neighborhood with sprinkler systems, a road salt storage facility, disturbed soils at two locations, two sites with loose fill material, a large neighborhoods' ditches draining to nearby creek, a channelized river at one site, a sand mine, and numerous log jams. Over 3.4 miles of absent or insufficient riparian buffers were identified from the windshield survey combined with desktop analysis (Figure 59). Utilizing both the QHEI (habitat) analysis and the windshield survey, approximately 1,206 ft. of stream bank are eroding throughout in the Coffee Creek subwatershed (Figure 59). Moderate to heavy siltation was also reported for over 1,775 ft. of streambed.

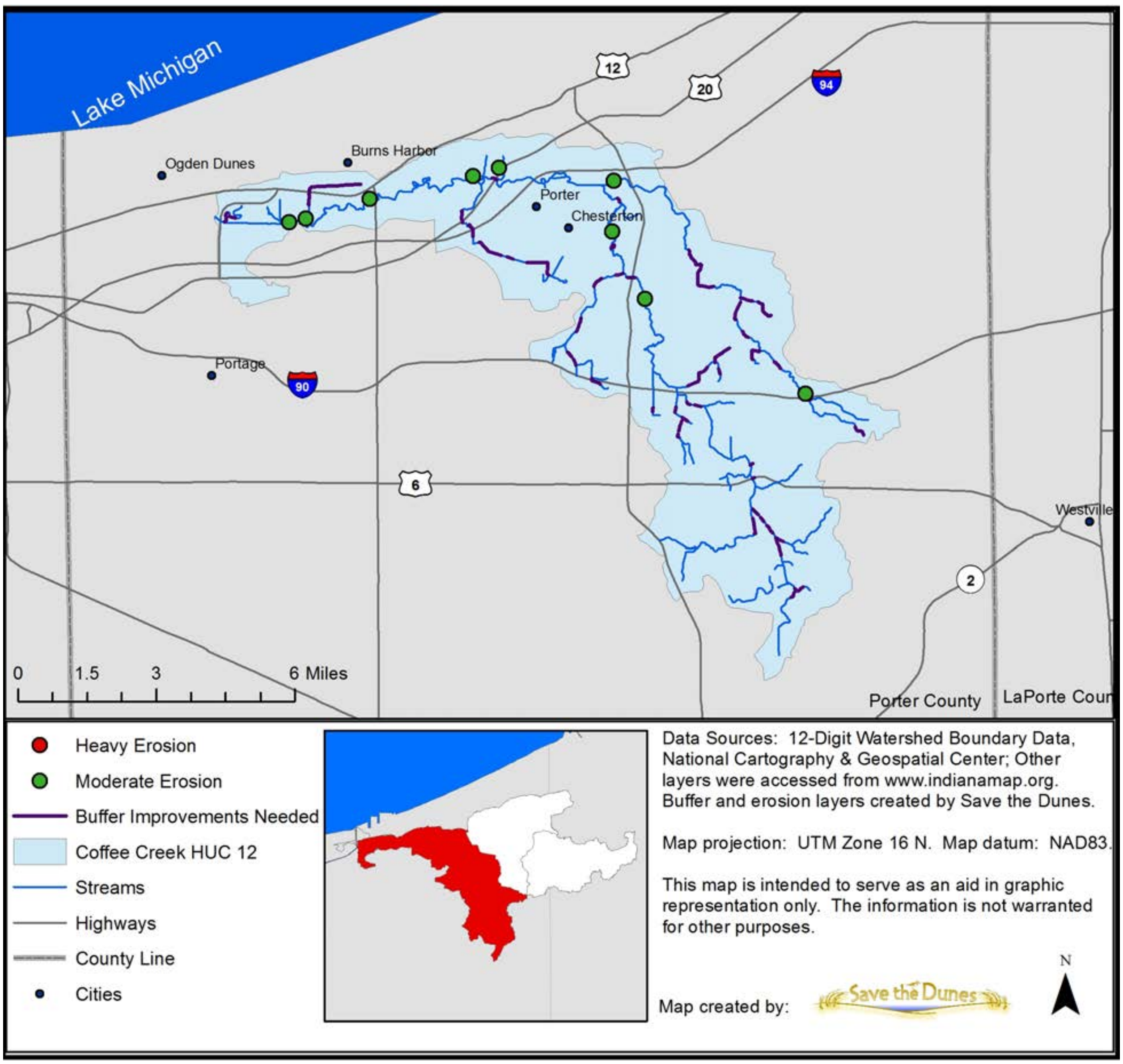

Figure 59. Streambank erosion and buffers needed in the Coffee Creek subwatershed

4.3.d Summary

The Coffee Creek subwatershed has the largest amount of urban land use in the LCEB. Impervious surfaces in urban landscapes tend to degrade water quality and scour stream banks. Commercial development areas in the Coffee Creek subwatershed generally lack green infrastructure to reduce impacts of large impervious surfaces. However, this urban area is also the only part of the LCEB serviced by sanitary sewers. The southern and eastern portion of the Coffee Creek subwatershed is not serviced by sewers and may be contributing *E. coli* from malfunctioning onsite septic systems. The rural areas of this watershed contain many large residential homes on wooded lots or in agricultural settings. Approximately 16% of the Coffee Creek subwatershed is agricultural. Therefore, sediment and nutrients are likely exported to local streams and rivers. This subwatershed also contains a large portion of forested protected lands, such as the Moraine Nature Preserve and the Coffee Creek Watershed Preserve. All streams in this subwatershed are 303(d) listed for biotic communities, while others are listed for nutrients, dissolved oxygen, chloride, and *E. coli*. Due to the drought, the 2012 baseline study may underestimate water quality parameters such as nutrients and sediment. However, the impairment of the biological communities may demonstrate established water quality problems in this subwatershed.

4.4. Watershed Inventory Summary

The LCEB watershed is a diverse landscape containing high quality natural lands, conventional agriculture, and urban areas with extensive impervious surfaces. Soils in this watershed are also diverse; ranging from very poorly draining and nutrient rich to quickly draining and nutrient poor sandy soils. Historic water quality sampling shows that water quality impairments and impaired biological communities are increasing throughout the watershed. The 2012 baseline study was affected by a historic multi-year drought. Pollutant loads could not be calculated for many sampling sites due to data restrictions. However, the 2014 (draft) 303(d) impairment listings clearly demonstrate the current level of water quality impairments in the LCEB. Numerous sampling sites exceeded the IAC target for over 50% of samples collected for nitrogen (nitrate+nitrite), phosphorus (total phosphorus), *E. coli*, and sediment (total suspended solids) (Figure 60). Only 11 sites (4, 15, 16, 20, 24, 39, 40, 42, 45, 46, and 47) are not represented in Figure 60. This means only 11 sites consistently had fairly good water quality.

The widespread impairment of biological communities demonstrates a well-established condition of impairment throughout the watershed. The health of stream biological communities helps to interpret long-term conditions, while a grab sample for water chemistry can only assess current conditions. Nearly every stream in the LCEB has been listed for impaired biological communities. Figure 61 depicts the sampling sites that rated unsupporting for fish (IBI) and macroinvertebrates (mIBI), or poor for habitat (QHEI). Site

5 was the only sampling site evaluated that rated satisfactory scores for biology and habitat.

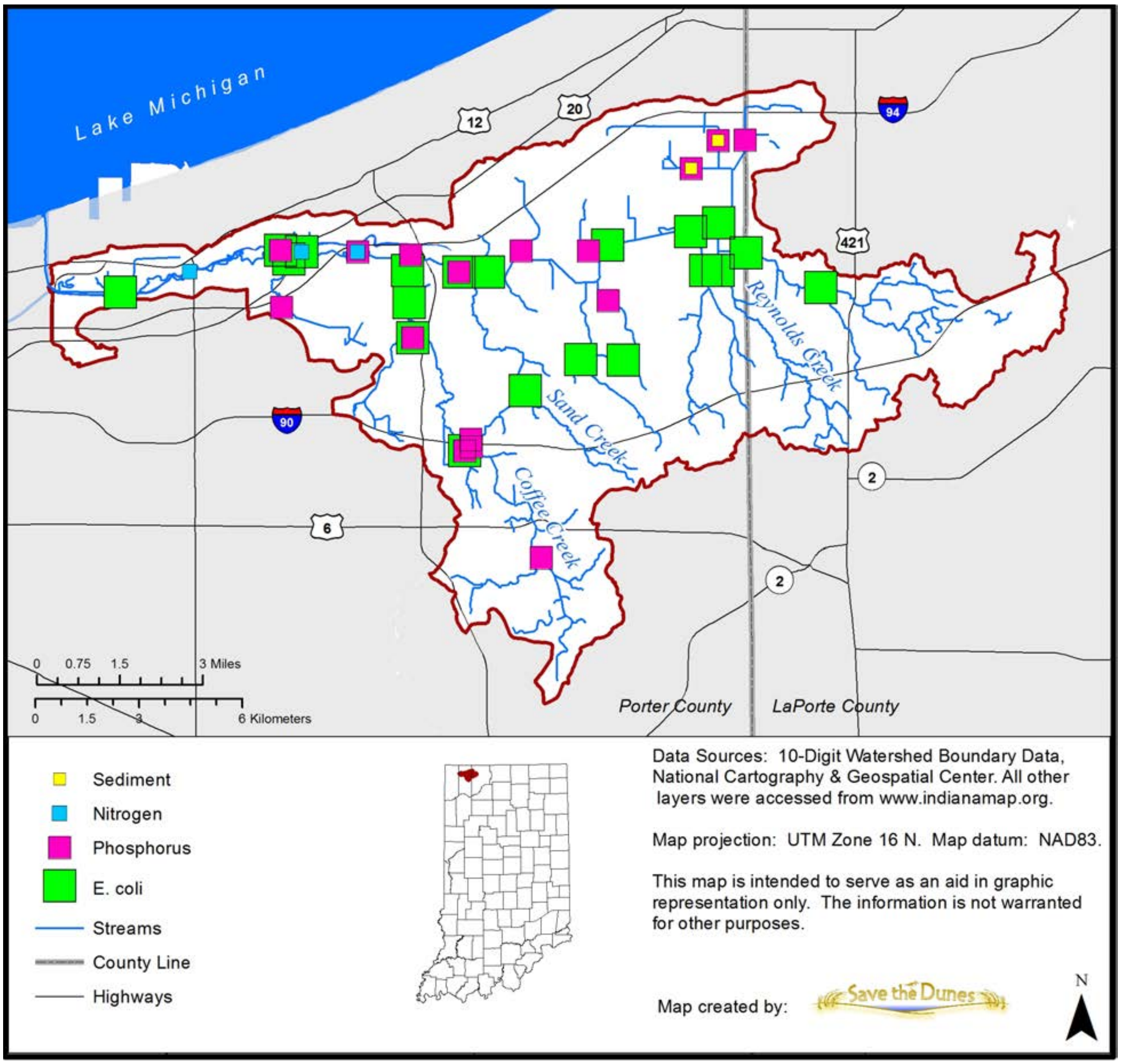

Figure 60. LCEB sampling sites that exceeded IAC targets for over 50% of samples collected in 2012 Baseline Study.

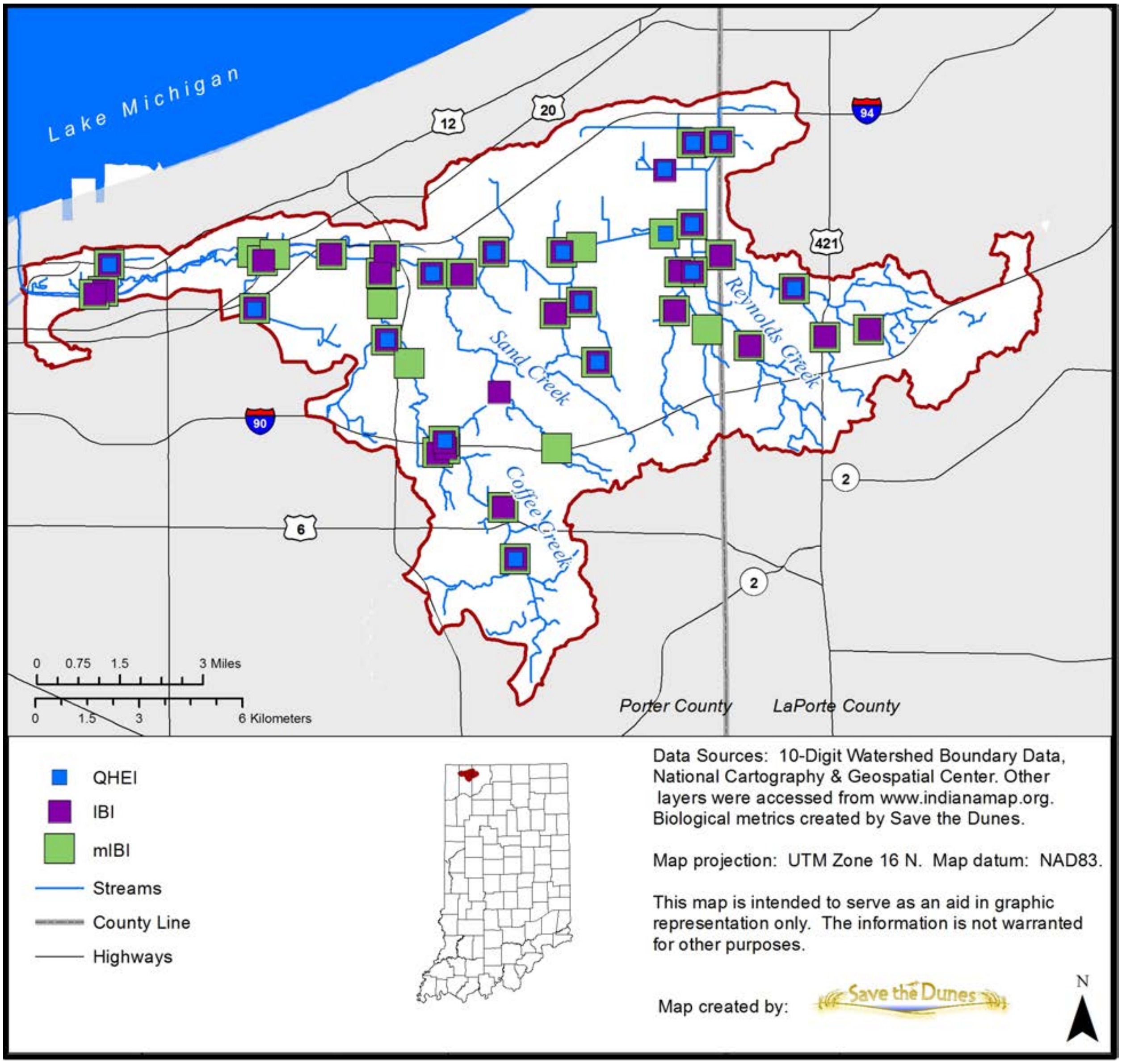

Figure 61.LCEB sampling sites that did not meet targets for 2012 Baseline Study

5.0 Review of Watershed Problems and Causes

5.1 Stakeholder Concerns

The following stakeholder concerns were developed from stakeholder input and the watershed inventory analysis. The LCEB steering committee evaluated the concerns and available data to determine the group's focus.

Table 14. Stakeholder concerns, evidence, and analysis

Stakeholder Concern	Evidence	Within Project Scope?	Data-Supported?	Able to Quantify?	Group Wants to Focus On?
Elevated Pathogens					
Pathogen loading from combined sewer and sanitary sewer overflows	Over the past 5 years, there have been 10 CSOs totaling over 9 million gallons and 26 SSOs totaling over 2 million gallons. Long-term control plans are in currently being implemented; consequently, significantly reduced CSOs and SSOs are expected for the future.	No	Yes	Yes	Yes, to support municipal efforts
Public health effects from high *E. coli* concentrations	During a drought (2012 baseline), over 80% of sampling sites exceeded the target and 20 sites exceeded the target in over 50% of samples collected.	Yes	Yes	Yes	Yes
High *E. coli* concentrations due to failing septic systems	During a drought (2012 baseline), over 80% of sampling sites exceeded the IAC target and 20 sites exceeded the target in over 50% of samples collected. 94% of the soils are classified as limited or very limited for on-site septic systems and 80% of the watershed is unsewered.	Yes	No	No	Yes
Pathogen loading polluting groundwater	Suggested by unsewered areas with low soil septic suitability, but there is no groundwater data to quantify this concern.	No	No	No	No
Not meeting water quality standards	2014 draft 303(d) assessment shows over 32 miles of LCEB streams are impaired for *E. coli*. 2012 baseline data shows many target exceedances for *E. coli*.	Yes	Yes	Yes	Yes
Integrate 2004 *E. coli* TMDL	The 2004 TMDL for *E. coli* has been incorporated in to this plan.	Yes	Yes	Yes	Yes
Excessive Sediment and Nutrient Loading					
Streambank erosion and sedimentation	Streambank erosion occurs along approximately 1.6 miles of watershed streams according to the windshield survey and the QHEI.	Yes	Yes	Yes	Yes

Stakeholder Concern	Evidence	Within Project Scope?	Data-Supported?	Able to Quantify?	Group Wants to Focus On?
Degraded riparian corridors allow sediment and nutrient loading from runoff	Insufficient or limited buffers are present along approximately 13 miles of streambank.	Yes	Yes	Yes	Yes
Highly erodible soils on cropland may contribute sediment	There are 27,721 acres of highly and potentially highly erodible soils in this watershed.	Yes	No	No	Yes
Nutrient loading from combined sewer and sanitary sewer overflows	Over the past 5 years, there have been 10 CSOs totaling over 9 million gallons and 26 SSOs totaling over 2 million gallons. Long-term control plans are in currently being implemented; consequently, significantly reduced CSOs and SSOs are expected for the future.	No	Yes	Yes	Yes, to support municipal efforts
Increased volume and flow causing stream bank and channel erosion	Changes in land use can increase the flashiness of streams. However, data is not available to support this claim.	Yes	No	No	Yes
Erosion caused by woody debris	NPS is currently studying the effects of woody debris in this watershed; however, no data is currently available.	Yes	No	No	No
Habitat, Biotic Communities and Hydrology					
Need to protect fisheries and habitat	35 sites (or 1.7 miles of stream) scored un-supporting (<36) for IBI, 41 sites (or 2.2 miles of stream) scored un-supporting (<36) for mIBI, and 17 sites (or 0.6 miles of stream) scored poor for habitat (51 or less) for the QHEI.	Yes	Yes	Yes	Yes
Fish habitat and passage for native non jumping fish	17 sites (or 0.6 miles of stream) scored (51 or less) poor habitat with the QHEI and 10 dams restrict fish passage.	Yes	Yes	Yes	Yes
Sedimentation in streams has a negative impact on fish habitat	The QHEI reported approximately 1.8 miles of streambed to have moderate to heavy silt.	Yes	Yes	Yes	Yes

Stakeholder Concern	Evidence	Within Project Scope?	Data-Supported?	Able to Quantify?	Group Wants to Focus On?
Failing to meet water standards	35 sites (or 1.7 miles of stream) scored un-supporting (<36) for IBI and 41 sites or 2.2 miles of stream) scored un-supporting (<36) for mIB and 17 sites (or 0.6 miles of stream) scored poor for habitat (51 or less) for QHEI. Nearly all stream segments are listed as impaired on the 2014 draft 303(d) reassessment.	Yes	Yes	Yes	Yes
Methods of dredging ditches are having multiple negative impacts on the LCEB	There is no data showing the environmental impacts of dredging on this watershed.	Yes	No	No	Yes
Emerald ash borer (EAB) killing trees, source of debris	EAB was studied for Coffee Creek Watershed Conservancy report. All ash in the region is expected to die within 5 years.	Yes	Yes	Yes	Yes
Invasive plants impact biodiversity and have impact on water quality/wetlands	There is currently no data quantifying the impact of invasive plants on water quality and wetlands in the LCEB.	Yes	No	No	Yes
Increased volume and flow due to altered hydrology (regulated drains, ditches)	Altered hydrology tends to increase stream flows and velocity; however, there is no data to confirm this claim. Stream gages are only located at the base of the watershed.	Yes	No	No	Yes
LaPorte County Waste Management landfill, is closed but may have impact	There is no data to support environmental impacts from the landfill.	No	No	No	No
Fish Consumption	The Fish Consumption Advisory listing provides data for fish consumption. Three fish species are listed under Advisory Group 4 and 2 fish species are listed under Advisory Group 3.	No	Yes	No	No, this is outside the scope of the project
Need to understand geology and hydrology. Several habitat types in watershed	Geology and hydrology have been described in this project. Habitats have also been described.	Yes	Yes	Yes	Yes
Need permits for woody debris management and fisheries and habitat protections	Permit acquisition is not within the scope of this plan. Fisheries and habitat protections will be explored for this plan.	No	No	No	No

Stakeholder Concern	Evidence	Within Project Scope?	Data-Supported?	Able to Quantify?	Group Wants to Focus On?
Promote conservation easements	Conservation easements can help improve water quality, but no data exists to support this claim in the LCEB.	Yes	No	No	Yes
Need more environmentally friendly methods for ditch maintenance	Environmentally friendly methods for ditch maintenance are encouraged by this project.	No	No	No	No
Need to protect bottomland, slopes, and highland	The protection of natural ecosystems is encouraged by this project.	Yes	No	No	Yes
Need to fix tributary ditches environmentally or remove them	The maintenance of regulated drains is not within the scope of this plan.	No	No	No	No
Stormwater management, flood prevention efforts need improvement	Stormwater best management practices are encouraged by this plan. Education on this topic is also encouraged.	Yes	No	No	Yes
Public Education, Involvement, and Access					
Public does not have enough access to information about LCEB or water quality	The social indicators study and this plan will help to improve public information available on the LCEB. Improved education on water quality and this watershed is a goal for this plan.	Yes	No	No	Yes
Lack of press coverage for LCEB management efforts and water quality	Four articles were published in 2012 and 5 in 2013.	Yes	Yes	Yes	Yes
Not enough private property owners are directly involved in WMP process	Public attendance of meetings is low.	Yes	Yes	Yes	Yes
Environmental assessment should have public component	A public meeting was held for the EA, but this is not within the scope of this plan.	No	No	No	No
Dumping of trash	Dumping was reported in the windshield survey.	Yes	Yes	Yes	Yes

Stakeholder Concern	Evidence	Within Project Scope?	Data-Supported?	Able to Quantify?	Group Wants to Focus On?
Lack of safe passage for paddlers due to log jams/woody debris, culverts, bridges, beaver dams, and physical features	Concerns have been documented by paddlers with pictures and GPS.	Yes	Yes	Yes	Yes
No continuous walking trail along LCEB	While many trails exist, there is no continuous trail along the LCEB.	Yes	Yes	Yes	Yes
Need to respect private property rights, locate access points in easements	Improved access is being explored by this plan.	Yes	No	No	No
Lack of river access sites – river and tributaries are out of public sight	Improved access is being explored by this plan.	Yes	No	No	Yes
Advocating for full body contact despite *E. coli* and contaminants	22% of samples collected for the baseline study exceeded IAC target for *E. coli*.	Yes	No	No	No
Need environmental assessment to evaluate paddling assess in INDU	The EA is currently in progress.	Yes	No	No	Yes
Two major branches flow under Highway 421	This statement is true.	No	No	No	No
Culverts, bridges, beaver dams, and physical features to be addressed	Culverts, bridges, and beaver dams are outside the scope of this plan.	No	No	No	No
ADA compliance at existing and future access sites	ADA access is being examined for this plan.	Yes	Yes	Yes	Yes
Create incentives and diminish disincentives for private property owners	Several state and federal programs currently exist to incentivize landowners to implement BMPs. This plan seeks to improve incentives for landowners.	Yes	No	No	Yes
Need data and information on positive impact of trails for property owners	There is currently no local data available on the impact of trails for landowners.	No	No	No	No
Inventory and identify land owners	This is outside the scope of this project	No	No	No	No

Stakeholder Concern	Evidence	Within Project Scope?	Data-Supported?	Able to Quantify?	Group Wants to Focus On?
Engage land owners in WMP process and increase communication	Press releases, public educational events, and the social indicators study helped to engage land owners.	Yes	No	No	Yes
Acquisition of land from farmers	Land conservation is a goal for this plan.	Yes	Yes	Yes	Yes
Fisherman may be eating fish, despite 303(d) impairment for PCBs in fish tissue	The Fish Consumption Advisory Listing provides data for fish consumption. Three fish species are listed under Advisory Group 4 and two species are listed under Advisory Group 3. However, there is no data on personal consumption.	Yes	No	No	No
Lack of Multijurisdictional Coordination					
Lack of funding to achieve all watershed goals	Stakeholder observation or perception	Yes	No	Yes	Yes
Lack of septic system inspection and operation and maintenance programs	Stakeholder observation or perception	Yes	No	No	Yes
Lack of cooperation between agencies to achieve watershed goals	Stakeholder observation or perception	Yes	No	No	Yes
Conflicting missions between agencies and organizations	Stakeholder observation or perception	Yes	No	No	No
Local government adoption of the plan once complete	Stakeholder observation or perception	Yes	No	No	Yes
Aging culverts and infrastructure	Stakeholder observation or perception	Yes	No	No	No
Varied waterway use for owners and municipalities creates lack of mutual respect	Stakeholder observation or perception	Yes	No	No	Yes

Stakeholder Concern	Evidence	Within Project Scope?	Data-Supported?	Able to Quantify?	Group Wants to Focus On?
Need industry and land owners at the table	Stakeholder observation or perception	Yes	No	No	Yes
Respect for each perspective. Find mutual benefit through process.	Stakeholder observation or perception	Yes	No	No	Yes
Need robust, long-term, sustained, meaningful monitoring	Stakeholder observation or perception	Yes	No	No	Yes

5.2 Problems That Reflect LCEB Concerns

Table 15. Problems that reflect the concerns of the LCEB Watershed

Stakeholder Concerns	Problem
Elevated Pathogens	
Pathogen loading from combined sewer and sanitary sewer overflows	The LCEB and its tributaries have high pathogen loads, as indicated by high *E. coli*. This causes the river to fail to meet its designated use for recreational contact and poses a health risk for public access.
Public health effects from high *E. coli* concentrations	
High *E. coli* concentrations due to failing septic systems	
Not meeting water standards	
Pathogen loading from pasture and manure application	
Pathogen loading from pet waste and wildlife	
Excessive Sediment and Nutrient Loading	
Streambank erosion and sedimentation	Excessive sediment and nutrient loading to the LCEB and its tributaries degrades uses, such as biotic communities, aesthetics, and recreation.
Degraded riparian corridors allow sediment and nutrient loading from runoff	
Highly erodible soils on cropland may contribute sediment	
Nutrient loading from combined sewer and sanitary sewer overflows	
Increased flow volume causing stream bank and channel erosion	
Fertilizer application to urban lands contributes nutrients	
Habitat, Biotic Communities, and Hydrology	
Need to protect fisheries and habitat	Biotic communities in the LCEB and its tributaries are impaired due to poor water quality, poor habitat, and altered hydrology. This causes the river to fail to meet its designated use for aquatic life use support.
Habitat and passage for native non-jumping fish threatened or lacking	
Sedimentation in streams has a negative impact on fish habitat	
Failing to meet water standards	
Methods of dredging ditches have negative impacts on the LCEB	
Emerald ash borer killing trees, source of debris	
Invasive plants impact biodiversity and have impact on water quality/wetlands	
Increased volume and flow due to altered hydrology (regulated drains, ditches)	
Poor water quality leads to impaired biotic communities	
Habitat, Biotic Communities, and Hydrology	
Public does not have enough access to information about LCEB or water quality	The public is not taking actions to protect and improve the LCEB and is not engaged in the LCEB watershed management effort.
Lack of press coverage for LCEB management efforts and water quality	
Not enough private property owners are directly	

Stakeholder Concerns	Problem
involved in WMP process	
Environmental assessment should have a public component	
Dumping of trash	
Lack of safe passage for paddlers due to log jams/woody debris, culverts, bridges, beaver dams, and physical features	Limited public access to the LCEB and its corridor limits recreational opportunities and public value of the LCEB.
No continuous walking trail along LCEB	
Need to respect private property rights, locate access points in easements	
Lack of river access sites and public visibility of streams	
Advocating for full body contact despite *E. coli* and contaminants	
Need environmental assessment to evaluate paddling in INDU	
Lack of Multijurisdictional Coordination	
Lack of funding to achieve all watershed goals	A lack of multijurisdictional coordination could limit the ability of the LCEB watershed group and partners to achieve watershed goals to protect and improve water quality
Lack of septic system inspection, operation, and maintenance programs	
Lack of cooperation between agencies to achieve watershed goals	
Local government adoption of the plan once complete	
Varied waterway use for owners and municipalities creates lack of mutual respect	
Need industry and land owners at the table	
Respect for each perspective. Find mutual benefit through process.	
Need robust, long-term, sustained, meaningful monitoring	

5.3 Potential Causes and Sources for LCEB Problems

Table 16 was generated using water quality data, windshield surveys, GIS, and local knowledge. This data can be useful for identifying water quality problems.

Table 16. Potential cause(s) and source(s) for each identified problem

Problem	Potential Cause(s)	Potential Source(s)
The LCEB and its tributaries have high pathogen concentrations, as indicated by high *E. coli*. This causes the river to fail to meet its designated use for recreational contact and poses a health risk for public access	High pathogen levels as indicated by *E. coli* concentrations that exceed state standards	Pathogen loading from combined sewer and sanitary sewer overflows and aging infrastructure in the Coffee Creek subwatershed. Over the past 5 years, there have been 10 CSOs totaling over 9 million gallons and 26 SSOs totaling over 2 million gallons. However, long-term control plans are in currently being implemented and significantly reduced CSOs and SSOs are expected for the future.
		Pathogen loading from malfunctioning septic systems in all three subwatersheds: Coffee Creek, Kemper Ditch, and Reynolds Creek. During a drought (2012 baseline), over 80% of sampling sites exceeded the IAC target for *E. coli* and 20 sites exceeded the target for over 50% of samples collected. 94% of the soils are classified as limited or very limited for on-site septic systems and 80% of the watershed is unsewered. Kemper Ditch and Reynolds Creek subwatersheds have no sewers and are entirely serviced by onsite septic systems.
		Pathogen loading from pasture runoff. There are 8 hobby farms in the Coffee Creek and Reynolds Creek subwatersheds with horses, cattle, and buffalo. Hobby farms comprise ~160 acres with approximately 91 horses, 10 cattle and 20 buffalo.
		Pathogen loading from pet waste originating from parks and residences primarily in the Coffee Creek subwatershed. Roughly 20% of the LCEB is developed and may generate elevated *E. coli* concentrations from pet waste.
		Pathogen loading from wildlife.
Excessive sediment and nutrient loading to the LCEB and its tributaries degrades uses, such as biotic communities, aesthetics, and recreation	TSS levels exceed the target set by the LCEB watershed group	Sediment loading from in stream and stream bank erosion. Streambank erosion occurs along approximately 1.2 miles of LCEB streams according to the windshield survey and the QHEI. The QHEI reported approximately 1.8 miles of streambed to have moderate to heavy silt. The heaviest streambank erosion sites are located in the Kemper Ditch subwatershed on the mainstem

Problem	Potential Cause(s)	Potential Source(s)
		near Heron Rookery.
		Sediment loading from insufficient or limited buffers, which are present along approximately 13 miles of streambank. The Kemper Ditch subwatershed has ~8.0 miles of streambank needing improvements. The Coffee Creek and Reynolds Creek subwatersheds have 3.4 and 1.7 miles respectively of streambank needing improvements.
		Sediment loading from cropland, particularly on HEL soils. There are 27,721 acres of highly and potentially highly erodible soils in this watershed. HEL soils are fairly evenly divided among the subwatersheds but are most abundant throughout the southern portion of the LCEB.
		Sediment loading from roads and parking lots, including the strip mall parking lots along Indian Boundary Rd. in the Coffee Creek subwatershed.
		Sediment loading from construction sites located in all three subwatersheds.
	Nutrient (TP and nitrate) levels exceed the target set by the LCEB watershed group	Nutrient loading from combined sewer and sanitary sewer overflows in the Coffee Creek subwatershed. Over the past 5 years, there have been 10 CSOs totaling over 9 million gallons and 26 SSOs totaling over 2 million gallons. However, long-term control plans are in currently being implemented and significantly reduced CSOs and SSOs are expected for the future.
		Nutrient loading from insufficient or limited buffers, which are present along approximately 13 miles of streambank. The Kemper Ditch subwatershed has ~8.0 miles of streambank needing improvements. The Coffee Creek and Reynolds Creek subwatersheds have 3.4 and 1.7 miles respectively of streambank needing improvements.
		Nutrient loading from fertilizer application on urban lands and residential lawns (both urban and rural homes). Residential turfgrass lawns are prevalent throughout all three subwatersheds: Reynolds Creek, Kemper Ditch, and Coffee Creek.
		Nutrient loading from fertilizer application on cropland. Approximately 17% (8,600 acres) of the LCEB is conventional agriculture. The Kemper Ditch subwatershed is 44%

Problem	Potential Cause(s)	Potential Source(s)
		agriculture and the Reynolds Creek subwatershed is 31% agriculture.
		Nutrient loading from malfunctioning septic systems in all three subwatersheds: Coffee Creek, Kemper Ditch, and Reynolds Creek. During a drought (2012 baseline), over 80% of sampling sites exceeded the IAC *E. coli* target and 20 sites exceeded the target in over 50% of samples collected. For phosphorus, 91% of sampling sites exceeded the target with 30% of sites exceeding the target in more than 50% of samples collected. 94% of the soils are classified as limited or very limited for on-site septic systems and 80% of the watershed is unsewered. Kemper Ditch and Reynolds Creek subwatersheds are entirely serviced by onsite septic systems.
Biotic communities in the LCEB and its tributaries are impaired due to poor water quality, poor habitat, and altered hydrology. This causes the river to fail to meet its designated use for aquatic life use support	Macroinvertebrate and fish communities (as measured by mIBI and IBI) do not meet state standards	Nutrient and sediment loading from the sources described above in all three subwatersheds. CSOs & SSOs, malfunctioning septic systems, fertilizer application from cropland & urban lands are sources of nutrients. Instream & bank erosion, cropland, roads & parking lots, and construction sites are sources of sediment.
		High temperatures from lack of riparian cover and high levels of impervious surfaces in all three subwatersheds. Insufficient or limited buffers are present along 8 miles of the Kemper Ditch subwatershed and 3.4 miles in the Coffee Creek subwatershed. There are approximately 4,753 acres of impervious surfaces in the LCEB, primarily in the Coffee Creek subwatershed.
		Low DO due to high temperatures and high nutrient concentrations. 12 sites exceeded the low DO target at least once. 10 sites exceeded the low DO target in 25% of samples taken. Most DO exceedances are located in the Kemper Ditch subwatershed. 80% of sampling sites exceeded temperature targets at least once. 10 sampling sites exceeded the temperature target in 40% of samples collected. Most temperature exceedances are located in the Coffee Creek subwatershed. Limited tree canopy due to insufficient or limited buffers are present along 8 miles of Kemper Ditch and 3.4 miles of Coffee Creek subwatersheds can increase temperatures and reduce DO.
		Ammonia concentrations exceed state standards in localized tributaries. 17

Problem	Potential Cause(s)	Potential Source(s)
		sampling sites exceeded the IAC target at least once (10 of these sites are located in the Coffee Creek Subwatershed). 7 sampling sites exceeded the target in 25% of samples collected.
		Inadequate habitat exists to support biotic communities. 17 sampling sites (or 0.6 miles of stream) scored poor for habitat (51 or less) for the QHEI (9 sites in Kemper Ditch and 6 sites in Coffee Creek subwateresheds).
	Habitat as measured by QHEI does not meet state standards and limits biotic communities	Sedimentation in streams has a negative impact on fish habitat. The QHEI reported approximately 1.8 miles of streambed to have moderate to heavy silt.
		Direct alteration of in stream habitat occurs when streams are channelized and ditches are dredged. At least 45 stream miles are designated regulated drains and most of these miles are located in the Kemper Ditch and Coffee Creek subwatersheds.
		Indirect alteration of in stream habitat (low base flow, streambank and in stream erosion) due to altered hydrology (impervious cover, altered drainage, wetland loss, etc.) has occurred in all three subwatersheds: Coffee Creek, Kemper Ditch, and Reynolds Creek.
		Lack of riparian buffers. Insufficient or limited buffers are present along approximately 13 miles of streambank. The Kemper Ditch subwatershed has ~8.0 miles of streambank needing improvements. The Coffee Creek and Reynolds Creek subwatersheds have 3.4 and 1.7 miles respectively of streambank needing improvements.
		Death of ash trees due to EAB, resulting in altered hydrology, reduced riparian buffers, and decreased stream cover. All ash trees in the region (and all three subwatersheds) are expected to die within 5 years.
The public is not taking actions to protect and improve the LCEB and is not engaged in the LCEB watershed management effort	The public lacks adequate knowledge about the LCEB and water quality	Public does not have adequate access to information about LCEB or water quality.
		Lack of press coverage for LCEB management efforts and water quality.
	The public is uninvolved in LCEB watershed management efforts	Public does not have adequate access to information about LCEB or water quality.
		Lack of press coverage for LCEB management efforts and water quality.
		Not enough private property owners are directly involved in WMP process.
	Limited public	No continuous walking trail along LCEB.

Problem	Potential Cause(s)	Potential Source(s)
	access to the LCEB and its corridor limits recreational opportunities and public value of the LCEB	Lack of funds for environmental assessment to evaluate paddling in INDU, including public input.
		Private property owners may be distrustful of public access and watershed efforts.
		Lack of river access sites and public visibility of streams in all three subwatersheds.
		Lack of safe passage for paddlers due to log jams/woody debris, culverts, bridges, beaver dams, and physical features.
		LCEB does not meet recreational use standard.
A lack of multijurisdictional coordination could limit the ability of the LCEB watershed group and partners to achieve watershed goals to protect and improve water quality	Lack of funding to achieve all watershed goals	No funding for full time watershed coordinator to facilitate implementation of the LCEB WMP after June of 2014.
		Limited resources at county, municipal, state, and federal levels.
	Fear failure of local government and agencies to adopt WMP and achieve watershed goals	Lack of cooperation between agencies to achieve watershed goals
		Varied waterway use creates lack of mutual respect and cooperation.
		Lack of septic system inspection, operation, and maintenance programs in both Porter and LaPorte Counties.

6.0. Load Estimates

Nonpoint source pollution can be generated from varied sources including urban/suburban runoff, agricultural runoff, construction activities, stream bank erosion, and solid waste disposal, among others. Pollutant loading rates caused by these activities can be determined using many different methods, models and techniques. Two methods have been utilized to interpret nutrient, sediment and pathogen loading in the surface waters of the LCEB watershed: empirical data (measured results from the 2012 baseline sampling campaign) and modeled data using the Long-Term Hydrologic Impact Analysis (L-THIA), a nonpoint source pollutant loading model. Both methods provide advantages and disadvantages for understanding water quality in this watershed. The LCEB steering committee considered both modeled and empirical data when making decisions for water quality goals and critical areas.

6.1 Monitoring Results

Water quality data collected from sampling campaigns is typically used to estimate pollutant loads. Measured flow data combined with nutrient, sediment and pathogen concentrations is used to determine pollutant loads. This is often performed using Loadest, a commonly used modeling tool approved by IDEM for working with watershed management.

As discussed in section 3, 48 sampling sites located throughout the LCEB watershed were monitored once a month from November 2011 through November 2012. Unfortunately, this water sampling campaign occurred during a historic drought. This multi-year drought peaked during the growing season of 2012 and ended later in the same the year. Due to the extreme drought conditions, stream flow was low and some streams were dry at the time of sampling. Consequently, there was not enough data collected from many sampling sites to accurately calculate annual water quality loads using Loadest. There are obvious benefits for using empirical data to determine pollutant loads. However, drought-related problems with the 2012 dataset created limitations. Table 17 provides the loads for total phosphorus, nitrate-nitrite, and total suspended solids for the 2012 sampling sites. *E. coli* loads were not calculated due to limited amount of data.

Table 17. Pollutant Loads for 2012 monitoring data using Loadest

Site	HUC 12	Nitrogen		Phosphorus		TSS	
		lbs/yr	lbs/yr/ac	lbs/yr	lbs/yr/ac	lbs/yr	lbs/yr/ac
3	Coffee	100,015	2.2	8,933	0.2	*	*
4	Coffee	*	*	*	*	*	*
5	Coffee	*	*	*	*	*	*
6	Coffee	*	*	*	*	*	*
7	Coffee	2,972	1.4	429	0.2	36,964	18.0
8	Coffee	*	*	*	*	*	*
9	Coffee	138,394	3.3	10,159	0.2	1,548,644	36.7
10	Coffee	*	*	*	*	*	*
11	Coffee	15,944	0.5	9,292	0.3	1,262,995	40.9
12	Coffee	8,560	0.9	1,627	0.2	292,918	29.6
13	Coffee	*	*	*	*	*	*
14	Coffee	*	*	*	*	*	*
15	Coffee	*	*	*	*	*	*
16	Coffee	*	*	*	*	*	*
17	Coffee	*	*	153	0.2	*	*
18	Coffee	*	*	871	0.2	*	*
19	Coffee	*	*	*	*	*	*
20	Coffee	2,619	0.6	740	0.2	89,278	21.0
21	Coffee	*	*	*	*	*	*
22	Coffee	4,189	1.2	995	0.3	175,493	50.0
23	Coffee	*	*	*	*	*	*
24	Coffee	*	*	*	*	*	*
25	Kemper	16,178	0.6	7,387	0.3	1,066,138	40.6
26	Kemper	*	*	*	*	*	*
27	Kemper	678	0.4	409	0.2	31,087	17.4
28	Kemper	834	0.7	185	0.2	*	*
29	Kemper	*	*	*	*	*	*
30	Kemper	*	*	*	*	*	*
31	Kemper	*	*	*	*	*	*
32	Kemper	11,609	0.6	5,922	0.3	894,995	47.4
33	Kemper	*	*	6,092	0.3	998,796	56.0
34	Kemper	*	*	2,723	0.6	*	*

Site	HUC 12	Nitrogen		Phosphorus		TSS	
35	Kemper	*	*	*	*	*	*
36	Kemper	*	*	*	*	*	*
37	Kemper	*	*	*	*	*	*
38	Reynolds	1,857	0.6	765	0.2	168,910	51.8
39	Reynolds	*	*	435	0.2	62,097	32.0
40	Reynolds	*	*	*	*	*	*
41	Reynolds	*	*	415	0.2	93,799	38.7
42	Reynolds	*	*	*	*	*	*
43	Reynolds	3,224	0.5	1,964	0.3	340,180	51.7
44	Reynolds	*	*	*	*	*	*
45	Reynolds	562	0.8	120	0.2	*	*
46	Reynolds	*	*	77	0.1	15,229	29.4
47	Reynolds	*	*	*	*	*	*
48	Coffee	*	*	*	*	*	*

* denotes inadequate data to calculate loads using Loadest

6.2 L-THIA Model Results

The Long-Term Hydrologic Impact Analysis (L-THIA) model is a tool to estimate runoff, recharge and nonpoint source pollution resulting from land use changes. It provides a long-term average pollutant load based on historical (30 year) precipitation data, land use, and soil type. This hydrological simulation model is an additional tool for the estimation of pollution loads, especially nonpoint source pollution. L-THIA is calibrated to the Great Lakes region of Indiana, including the LCEB watershed. Using current land use and historical precipitation data, L-THIA models pollutant transport as surface runoff to streams.

Like all models and methodologies, L-THIA has limitations. One noteworthy limitation is that L-THIA estimates only runoff volumes. Pollutant loadings from tile drainage, streambank erosion, livestock access, nutrient application, or point source pollution will not be represented by L-THIA. Another limitation is the inability of L-THIA to model *E. coli*, a common nonpoint source pollutant. Nonetheless, this model provides a useful estimation of watershed loadings for nonpoint source pollution.

6.3 Annual Load Estimates and Reductions

Due to the extreme and atypical hydrological conditions of 2012, the LCEB Technical Committee could not use the 2012 baseline study data to calculate watershed pollutant loadings (Table 17). Numerous sites did not have enough data to calculate a pollutant load. The technical committee concluded that the empirical data did not accurately represent typical loads resulting from nonpoint source pollution. Consequently, the committee opted to utilize modeled loads calculated with the L-THIA model. Water quality loads calculated from the 2012 baseline study were utilized for critical area designation.

To estimate subwatershed loads from the 2012 monitoring data, sampling sites near the base (or pour point) of each subwatershed were used. For the Reynolds Creek subwatershed, data from sites 38, 41, and 43 were combined to estimate pollutant loads. Site 25 represents the Kemper Ditch subwatershed and site 3 represents the Coffee Creek subwatershed.

Table 18. L-THIA modeled annual load estimates for subwatersheds

Subwatershed	Nitrogen		Phosphorus		TSS	
	(lb/yr)	(lb/ac/yr)	(lb/yr)	(lb/ac/yr)	(lb/yr)	(lb/ac/yr)
Reynolds Creek	18,229	1.6	4,694	0.4	404,314	35
Kemper Ditch	40,433	2.8	11,081	0.8	949,900	66
Coffee Creek	47,926	2.3	12,496	0.6	1,257,209	61
Total LCEB Watershed	**106,588**	**6.7**	**28,271**	**1.8**	**2,611,423**	**162**

Table 19. Comparison of measured vs. modeled loads

Subwatershed	Nitrogen (lb/yr)		Phosphorus (lb/yr)		TSS (lb/yr)	
	Measured	Modeled	Measured	Modeled	Measured	Modeled
Reynolds Creek	NA	18,229	3,144	4,694	602,889	404,314
Kemper Ditch	16,178	40,433	7,387	11,081	1,066,138	949,900
Coffee Creek	100,015	47,926	8,933	12,496	NA	1,257,209

Table 20. Comparison measured vs. modeled areal loads

Subwatershed	Nitrogen (lb/ac/yr)		Phosphorus (lb/ac/yr)		TSS (lb/ac/yr)	
	Measured	Modeled	Measured	Modeled	Measured	Modeled
Reynolds Creek	NA	1.6	0.7	0.4	142.2	35.2
Kemper Ditch	0.6	2.8	0.3	0.8	40.6	65.8
Coffee Creek	2.2	2.3	0.2	0.6	NA	60.9

Conclusions based on the comparison of measured and modeled data did not reveal consistent trends. The reader should note that the comparison is inherently unequal as the measured data was collected for one year during a historic drought compared to the L-THIA model, which incorporates 30 years of regional hydrological and land use data. Measured nitrogen loads were not available for Reynolds Creek due to the limited amount of data. L-THIA overestimated (~2x) nitrogen loads for Kemper Ditch, but underestimated (~2x) nitrogen loads for Coffee Creek. Measured phosphorus loads were available for all three subwatersheds. L-THIA underestimated phosphorus loads (~4x) the Reynolds Creek subwatershed, but overestimated phosphorus loads for both the Kemper Ditch and Coffee Creek subwatersheds. Measured data was not available for total suspended solids from the Coffee Creek subwatershed. TSS loads estimated by L-THIA were fairly similar to measured loads (within the same order of magnitude).

Target loads were calculated using the load duration curve (LDC) method. For this method, we utilized over 20 years of stream flow data from the USGS gage (#04095090 located on Burns Ditch) and adjusted flow rates based on watershed area to estimate flow for each subwatershed. Target pollutant loads were estimated by using the target pollutant concentrations At the 50% (average) flow and multiplying that by 365.

Table 21. Target annual loads for LCEB subwatersheds

Subwatershed	Nitrogen (lb/yr)	Phosphorus (lb/yr)	TSS (lb/yr)
Reynolds Creek	6,814	543	204,483
Kemper Ditch	14,738	1,178	442,179
Coffee Creek	24,739	1,978	742,158

Table 22. Load reductions for LCEB subwatersheds (lb/yr)

Subwatershed	Nitrogen (% Reduction)	Phosphorus (% Reduction)	TSS (% Reduction)
Reynolds Creek	11,415 (63%)	4,151 (88%)	199,831 (49%)
Kemper Ditch	25,695 (64%)	9,903 (89%)	507,721 (53%)
Coffee Creek	23,187 (48%)	10,518 (84%)	515,051 (41%)

The technical committee decided to use the *E. coli* loads and recommended reductions from the Little Calumet Portage Burns Waterway TMDL for *E. coli* Bacteria (2004). The TMDL sampling sites did not match up well with the subwatersheds but were close enough to estimate. The TMDL's sampling sites were called Junctions.

Junction 20 captures the entire Reynolds Creek subwatershed, as well as most of the eastern portion of the Kemper Ditch subwatershed. For this report, Junction 20 represents the Reynolds Creek subwatershed. AUIDs represented by this sampling site include: INC0141_01 (Little Calumet River, East Arm), INC0141_01A (unnamed), INC0141_T1001 (unnamed tributary near Walton Lake), INC0141_T1002 (unnamed tributary near Lake Lee), INC0141_T1003 (Reynolds Creek), INC142_T1001 (Carver and Kemper Ditch). Since Junction 20 includes more drainage area than only the Reynolds Creek subwatershed, the WASP6 model used in the TMDL was not able to determine loads specifically for this subwatershed. However, water quality data was collected in 2000 during wet and dry conditions and was used in the TMDL to determine that a 70% and 34% reduction, respectively, are needed in this subwatershed. These reductions seem to be consistent with our *E. coli* data that was collected in the Reynolds Creek subwatershed (80% of our mean values exceed the water quality standard during a drought year and we had a maximum value of 9,900 cfu/100 ml at Site 38. There was also one stream segment added to the 2014 303(d) list of impaired waters for *E. coli* in addition to two segments already listed in this subwatershed.).

Junction 15 captures the western portion of the Kemper Ditch subwatershed as well as the Sand Creek drainage area, which is part of the Coffee Creek subwatershed. For this report, Junction 15 represents the Kemper Ditch subwatershed. AUIDs represented by this sampling site include: INC0142_01 (Little Calumet River, East Arm), INC0142_T1002 (unnamed), INC0142_T1003 (unnamed tributary near Rice Lake), INC0142_T1004 (unnamed), INC0143_T1005 (Sand Creek), INC0143_04 (Little Calumet River, East Arm). The calculated load for this junction was 1.99×10^{10} cfu/yr. The target load was 2.02×10^{10} cfu/yr. The WASP6 model used in the TMDL calculated that the target load is higher than the actual load, indicating that no reduction is needed. However, water quality data was collected in 2000 during wet and dry conditions and was used in the TMDL to determine that an 81% and 59% reduction, respectively, are needed in this subwatershed. These reductions seem to be consistent with our *E. coli* data that was collected in the Kemper Ditch subwatershed (100% of our mean values exceed the water quality standard during a drought year and we had a maximum value of 17,000 cfu/100 ml at Site 34. There were also two stream segments added to the 2014 303(d) list of impaired waters for *E. coli* in addition to three segments previously listed in this subwatershed.).

Junctions 13 and 14 capture the remaining portion of the Coffee Creek subwatershed, just before the confluence with Salt Creek at site 3. For this report, Junctions 13 and 14 represent the Coffee Creek subwatershed. AUIDs represented by this sampling site include: INC0143_04 (Little Calumet River, East Arm), INC0143_T1006 (Coffee Creek), INC0143_T1006A (Coffee Creek), INC0143_T1007 (unnamed tributary near Mud Lake), INC0143_T1008 (Peterson Ditch). The calculated load for Junction 13 was 9.14×10^{10} CFU/yr. The target load was 5.24×10^{10} CFU/yr. The calculated load for Junction 14 was 9.14×10^{10} CFU/yr. The target load was 5.28×10^{10} CFU/yr. The WASP6 model used in the TMDL does indicate that load reductions are needed in this subwatershed, but the results are much lower than what the water quality data shows. The water quality data was collected in 2000 during wet and dry conditions and was used in the TMDL to determine that a 97% and 50% reduction, respectively, are needed in this subwatershed. These reductions seem to be consistent with our *E. coli* data that was collected in the Coffee Creek subwatershed (88% of our mean values exceed the water quality standard during a drought year and we had a maximum value of 11,000 cfu/100 ml at Site 7. There were also six stream segments added to the 2014 303(d) list of impaired waters for *E. coli* in addition to three segments previously listed in this subwatershed.).

Junction 12 captures the rest of the Little Calumet East Branch River just before the confluence with Burns Ditch and after the confluence with Salt Creek. AUIDs represented by this sampling site include: INC0143_04 (Little Calumet River, East Arm), INC0159_01 (Little Calumet River, West Branch), INC0159_02 (Burns Ditch). The calculated load for this junction was 1.45×10^{12} CFU/yr. The target load was 6.23×10^{10} CFU/yr. The WASP6 model used in the TMDL indicates that load reductions are needed in this subwatershed, but the results are much higher than what the water quality data shows. The water quality data was collected in 2000 during wet and dry conditions and was used in the TMDL to determine that a 46% reduction is needed at the outlet of the LCEB watershed. These reductions seem to be consistent with historical *E. coli* data that was collected at IDEM's fixed station, LMG060-0005 (Nearly 30% of the values exceed the water quality standard.

In 2012, the maximum value recorded was 2,400 cfu/100 ml. This stream segment has been impaired for *E. coli* since 1998.).

Table 23. *E. coli* loads, targets, and load reductions from the Little Calumet Portage Burns Waterway TMDL for *E. coli* Bacteria

Sub-Watershed	Junction	Total Average Loads From All Sources (CFU/day)	Estimated Average Loads From Nonpoint Sources (CFU/day)	Total Target Loads From All Sources (CFU/day)	Nonpoint Source Load Allocation (Wet)	Nonpoint Source Load Allocation (Dry)
Reynolds Creek	20	NA	NA	NA	70%	34%
Kemper Ditch	15	1.99×10^{10}	1.99×10^{10}	2.02×10^{10}	81%	59%
Coffee Creek	13	9.14×10^{10}	9.14×10^{10}	5.24×10^{10}	97%	50%
Coffee Creek	14	5.79×10^{10}	5.54×10^{10}	5.28×10^{10}		
LCEB + Salt Creek	12	1.45×10^{12}	7.60×10^{11}	6.23×10^{10}	46%	46%

7.0 Water Quality Goals and Indicators

Water quality impairments were shown throughout the LCEB watershed. The dominant impairments include nitrogen, phosphorus, sediment and *E. coli* bacteria. To address these impairments, goals were created to help focus implementation efforts. Goals for improving water quality in the LCEB watershed were based on baseline water quality sampling efforts, modeled pollutant loadings, the watershed inventory efforts (including the windshield survey), and stakeholder inputs (concerns, problems, sources).

The Spreadsheet Tool for the Estimation of Pollutant Loads (STEPL) was used to model potential load reductions based on established BMPs and to develop scaled goals. This method is further described in Section 9.3 Load Reduction by Best Management Practice. The long-term goals of 25 years were chosen to provide a reasonable time period to meet the desired load reductions from Table 22. Two scaled (or short-term) goals for 5 and 15 years were selected to provide easier to reach benchmarks. Save the Dunes worked with the county Soil and Water Conservation Districts and LCEB Steering Committee members to determine appropriate best management practices and acreages for each subwatershed and critical area. The 5-year goals are focused entirely on the critical areas, per EPA requirements. The 15-year goals apply to the three HUC-12 subwatersheds. The STEPL modeling program utilized the selected BMPs and acreages to produce nutrient and sediment reductions.

7.1 Reduce Nutrient Loading

The overall goal for this project is for all waters in the LCEB watershed to meet the stated water quality standards of 1.0 mg/L for nitrogen and 0.08 mg/L for phosphorus. To achieve these goals, the following load reductions will be sought.

Reynolds Creek subwatershed
Long-term (25 year) goal: Reduce nitrogen loading by 11,415 lb/yr, which is a 63% reduction. Reduce phosphorus loading by 4,151 lb/yr, which is an 88% reduction.

5-year goal for critical areas only (drainage area 43): Reduce nitrogen loading by 114.4 lb/yr, which is 0.3% of the long-term goal. Reduce phosphorus by 24 lb/yr, which is 0.2% of the long-term goal.

15-year goal: Reduce nitrogen loading by 5,411 lb/yr, which is 47% of the long-term goal. Reduce phosphorus loading by 1,320 lb/yr, which is 32% of the long-term goal.

Kemper Ditch subwatershed
Long-term (25 year) goal: Reduce nitrogen loading by 25,695 lb/yr, which is a 63% reduction. Reduce phosphorus loading by 9,903 lb/yr, which is an 89% reduction.

5-year goal for critical areas only (drainage areas 30, 31, 34, 35, and 36): Reduce nitrogen loading by 2,076 lb/yr, which is 8% of the long-term goal. Reduce phosphorus loading by 412 lb/yr, which is 4% of the long-term goal.

15-year goal: Reduce nitrogen loading by 8,338 lb/yr, which is 32% of the long-term goal. Reduce phosphorus loading by 1,961 lb/yr, which is 20% of the long-term goal.

Coffee Creek subwatershed
Long-term (25 year) goal: Reduce nitrogen loading by 23,187 lb/yr, which is a 48% reduction. Reduce phosphorus loading by 10,518 lb/yr, which is an 84% reduction.

5-year goal for critical areas only (drainage areas 12 and 22): Reduce nitrogen loading by 250 lb/yr, which is 1% of the long-term goal. Reduce phosphorus loading by 34 lb/yr, which is 0.3% of the long-term goal.

15-year goal: Reduce nitrogen loading by 4,104 lb/yr, which is 18% of the long-term goal. Reduce phosphorus loading by 844 lb/yr, which is 8% of the long-term goal.

Indicators for Success
Water quality and social data will be used to demonstrate progress toward these stated goals.

The Hoosier Riverwatch volunteer program will be utilized to monitor water quality improvements. Water quality sampling for nitrogen and phosphorus will occur (at minimum) at each of the three subwatershed's pour points. Samples will be collected monthly, except when surface waters are frozen. Pollutant loadings will be calculated from the water quality sampling to determine if goals are being met. Sampling will occur (at minimum) after 5, 15 and 25-years following implementation to assess progress made toward each interim goal. This post-implementation sampling will provide the necessary information needed to assess progress toward the stated goals and the effectiveness of BMPs implemented.

A social indicators survey will be conducted no less than five years after the start of implementation. The survey will be compared with the baseline survey to demonstrate progress.

7.2 Reduce Sediment Loading

The overall goal for this project is for all waters in the LCEB watershed to meet the stated water quality standard of 30 mg/L for suspended solids. To achieve this goal, the following load reductions will be sought.

Reynolds Creek subwatershed
Long-term (25 year) goal: Reduce sediment loading by 199,831 lb/yr, which is a 49% reduction.

5-year goal for critical areas only (drainage area 43): Reduce sediment loading by 19,758 lb/yr, which is 10% of the long-term goal.

15-year goal: Reduce sediment loading by 199,831 lb/yr, which is 100% of the long-term goal.

Kemper Ditch subwatershed
Long-term (25 year) goal: Reduce sediment loading by 507,721 lb/yr, which is a 53% reduction.

5-year goal for critical areas only (drainage areas 30, 31, 34, 35, and 36): Reduce sediment loading by 344,596 lb/yr, which is 68% of the long-term goal.

15-year goal: Reduce sediment loading by 507,721 lb/yr, which is 100% of the long-term goal.

Coffee Creek subwatershed
Long-term (25 year) goal: Reduce sediment loading by 515,051 lb/yr, which is a 41% reduction.

5-year goal for critical areas only (drainage areas 12 and 22): Reduce sediment loading by 11,158 lb/yr, which is 2% of the long-term goal.

15-year goal: Reduce sediment loading by 515,051 lb/yr, which is 100% of the long-term goal.

Indicators for Success

Water quality and social data will be used to demonstrate progress toward these stated goals.

The Hoosier Riverwatch volunteer program will be utilized to monitor water quality improvements. Water quality sampling for sediment will occur (at minimum) at each of the three subwatershed's pour points. Samples will be collected monthly, except when surface waters are frozen. Pollutant loadings will be calculated from the water quality sampling to determine if goals are being met. Sampling will occur (at minimum) after 5, 15 and 25-years following implementation to assess progress made toward each interim goal. This post-implementation sampling will provide the necessary information needed to assess progress toward the stated goals and the effectiveness of BMPs implemented.

A social indicators survey will be conducted no less than five years after the start of implementation. The survey will be compared with the baseline survey to demonstrate progress.

7.3 Reduce *E. coli* Loading

The overall goal for this project is for all waters in the LCEB watershed to meet the stated water quality standard of 235 CFU/100 mL for *E. coli*. To achieve this goal, the following load reductions will be sought.

Reynolds Creek subwatershed

Long-term (25 year) goal: Reduce *E. coli* loadings so that all streams meet the water quality standard, which is 70% reduction in wet conditions and 34% reduction in dry conditions.

5-year goal for critical areas only (drainage area 43): Reduce *E. coli* loadings 18% in wet conditions and 9% in dry conditions.

15-year goal: Reduce *E. coli* loadings 35% in wet conditions and 17% in dry conditions.

Kemper Ditch subwatershed

Long-term (25 year) goal: Reduce *E. coli* loadings so that all streams meet the water quality standard, which is 81% reduction in wet conditions and 59% reduction in dry conditions.

5-year goal for critical areas only (drainage areas 30, 31, 34, 35, and 36): Reduce *E. coli* loadings 20% in wet conditions and 15% in dry conditions.

15-year goal: Reduce *E. coli* loading 41% in wet conditions and 30% in dry conditions.

Coffee Creek subwatershed
Long-term (25 year) goal: Reduce *E. coli* loadings so that all streams meet the water quality standard, which is 97% reduction in wet conditions and 50% reduction in dry conditions.

5-year goal for critical areas only (drainage areas 12 and 22): Reduce E. coli loadings 24% in wet conditions and 13% in dry conditions.

15-year goal: Reduce E. coli loadings 49% in wet conditions and 25% in dry conditions.

Indicators for Success
Water quality and social data will be used to demonstrate progress toward these stated goals.

The Hoosier Riverwatch volunteer program will be utilized to monitor water quality improvements. Water quality sampling for *E. coli* will occur (at minimum) at each of the three subwatershed's pour points. Samples will be collected monthly, except when surface waters are frozen. *E. coli* concentrations will be calculated from the water quality sampling to determine if goals are being met. Sampling will occur (at minimum) after 5, 15 and 25-years following implementation to assess progress made toward each interim goal. This post-implementation sampling will provide the necessary information needed to assess progress toward the stated goals and the effectiveness of BMPs implemented.

A social indicators survey will be conducted no less than five years after the start of implementation. The survey will be compared with the baseline survey to demonstrate progress.

7.4 Improve Biological Communities

The overall goal for this project is for all waters in the LCEB watershed to meet the stated water quality standards for biological communities (IBI and mIBI scores ≥ 36). To achieve these goals, the following water quality improvements will be sought.

Reynolds Creek subwatershed
Long-term (25 year) goal: Restore the natural biological stream community (mainly fish and macroinvertebrates) so that all streams score higher than a 36 on the IBI and the mIBI. Restore stream habitats so that they fully support their aquatic biological communities (all streams score higher than 51 on the QHEI).

5-year goal for critical areas only (drainage area 43): Restore the natural biological stream community so that site 43 scores higher than a 36 on the IBI and mIBI.

15-year goal: Restore the natural biological stream community so that 60% of stream sampling sites score higher than a 36 on the IBI and mIBI.

Kemper Ditch subwatershed

Long-term (25 year) goal: Restore the natural biological stream community (mainly fish and macroinvertebrates) so that all streams score higher than a 36 on the IBI and the mIBI. Restore stream habitats so that they fully support their aquatic biological communities (all streams score higher than 51 on the QHEI).

5-year goal for critical areas only (drainage areas 30, 31, 34, 35, and 36): Restore the natural biological stream community so that these 5 sampling sites score higher than a 36 on the IBI and mIBI.

15-year goal: Restore the natural biological stream community so that 60% of stream sampling sites score higher than a 36 on the IBI and mIBI.

Coffee Creek subwatershed

Long-term (25 year) goal: Restore the natural biological stream community (mainly fish and macroinvertebrates) so that all streams score higher than a 36 on the IBI and the mIBI. Restore stream habitats so that they fully support their aquatic biological communities (all streams score higher than 51 on the QHEI).

5-year goal for critical areas only (drainage areas 12 and 22): Restore the natural biological stream community so that these two sampling sites score higher than a 36 on the IBI and mIBI.

15-year goal: Restore the natural biological stream community so that 60% of stream sampling sites score higher than a 36 on the IBI and mIBI.

Indicators for Success

Water quality and social data will be used to demonstrate progress toward these stated goals.

The Hoosier Riverwatch volunteer program will be utilized to monitor water quality improvements. Water quality sampling for biological communities will occur (at minimum) at each of the three subwatershed's pour points. Samples will be collected annually. Biological community metrics will be calculated from the water quality sampling to determine if goals are being met. Sampling will occur (at minimum) after 5, 15 and 25-years following implementation to assess progress made toward each interim goal. This post-implementation sampling will provide the necessary information needed to assess progress toward the stated goals and the effectiveness of BMPs implemented.

A social indicators survey will be conducted no less than five years after the start of implementation. The survey will be compared with the baseline survey to demonstrate progress.

7.5 Increase Public Awareness and Participation

The goals for Increased Public Awareness and Participation are the same for all subwatersheds.

Long-term (25 year) goal: Increase public awareness and knowledge of watershed processes, including sources of pollution and methods for reducing nonpoint source pollution. Using the social indicators study, increasing public understanding of the consequences of poor water quality by reducing the response ‘I don’t know’ to zero percent for topics such as contaminated drinking water and excessive aquatic plants and algae. Increase public understanding of the existence and severity of common water pollutants by decreasing the response ‘I don’t know’ to zero percent.

5-year goal: Improve community participation in watershed group meetings and educational events. Using the social indicators study, increasing public understanding of the consequences of poor water quality by reducing the response ‘I don’t know’ to 10% for topics such as contaminated drinking water and excessive aquatic plants and algae. Increase public understanding of the existence and severity of common water pollutants by decreasing the response ‘I don’t know’ to 10%.

15-year goal: Increase community involvement with BMP efforts, natural area protection, and participation in educational activities. Using the social indicators study, increasing public understanding of the consequences by reducing the response ‘I don’t know’ to 5% for topics such as contaminated drinking water and excessive aquatic plants and algae. Increase public understanding of the existence and severity of common water pollutants by decreasing the response ‘I don’t know’ to 5%.

Indicators for Success

A social indicators survey will be conducted no less than five years after the start of implementation. The survey will be compared with the baseline survey to demonstrate progress.

7.6 Lack of Jurisdictional Coordination

Long-term (25 year) goal: Increase cooperation among agencies to fund and achieve all long-term goals.

5-year goal: All applicable municipalities adopt the LCEB Watershed Management Plan.

15-year goal: Increase cooperation among agencies to fund and achieve all scaled goals.

8.0 Critical and Protection Areas

To prioritize future implementation efforts, critical areas and protection areas were established. Critical and priority areas were based on the 2012 baseline water quality sampling study. Several different parameters and datasets (such as the windshield survey, impervious surfaces map, 303(d) impairment listing, land use, potentially erodible soils map, and information from the Coffee Creek WMP) were considered for the selection of critical and protection areas. Ultimately, the Technical Committee decided that empirical data derived from the 2012 Baseline Study was the best indicator of water quality and water pollution. The sampling sites with the worst water quality have land use problems upstream and/or in the sampling site's drainage area. Further examination of land use within the drainage areas will lead to the source or cause of water pollution for the sampling site.

The Coffee Creek Watershed Management Plan (2003) designated two drainage areas as critical: Pope O'Connor Ditch (LCEB drainage areas 14 & 15) and Shooter Ditch (LCEB drainage area 19). The LCEB WMP did not select these areas as critical. Additionally, the upper Pope O'Connor Ditch (drainage area 15) has been selected as a protection area due to comparatively higher water quality. The areal watershed size for the 2003 Coffee Creek Watershed Management Plan is only approximately 21% of the LCEB watershed (10,048 acres compared to 47,293 acres). LCEB critical and protection areas were selected based on empirical data from the entire, much larger watershed. Consequently, the perceived severity of a degraded water body may vary when compared against water bodies with more significant water pollution. Pope O'Connor Ditch and Shooter Ditch were considered for inclusion in the LCEB critical areas but ultimately were not added.

Critical areas are locations with the most degraded water quality. These areas have been given highest priority for the implementation of restoration funds and activities. The designated critical areas are likely the largest contributors of pollutant loads in the watershed.

Conversely, protection areas have the highest water quality in the watershed. These areas are crucial for the long-term environmental health of the watershed and require protective measures to maintain or enhance existing water quality. The protection of these areas will prevent future degradation to promote higher water quality throughout the watershed.

Critical areas and protection areas were calculated using a numeric ranking system to score all 48 IDEM Baseline study sample sites. The 2012 water quality data was used as the basis for this ranking metric. Each site was individually ranked for *E. coli*, total suspended solids (TSS), nitrogen, phosphorus, ammonium, dissolved oxygen (DO), temperature, and the biotic community (IBI & mIBI) (See Appendix 6). The site with poorest (or worst) value for the water quality parameter was given a ranking score of 1. Increasing water quality scored incrementally higher values. Identical values were given the same rank; consequently, the highest rank possible varied among each water quality parameter. Unique metrics were developed for each parameter depending upon the available data.

For nitrogen, phosphorus, and TSS, the following parameters were individually ranked for each of the 48 sampling sites:

- mean
- percent of samples that exceeded the concentration target
- single highest sample
- 2012 annual load
- 2012 annual load per acre

For *E.coli*, temperature, and ammonia, the following parameters were individually ranked for each of the 48 sampling sites:

- mean
- percent of samples that exceeded the concentration target
- single highest sample

For dissolved oxygen, the following parameters were ranked for each of the 48 sampling sites:

- mean
- percent of samples that exceeded the concentration target
- single lowest sample

For the biotic communities (fish and macroinvertebrates), the values for the IBI and mIBI were ranked with the final scores combined.

For each parameter (e.g. nitrogen), the ranked scores (mean, % exceed, highest sample, load, and areal load) were summed across the row for each site and divided by the total possible score (the sum of the highest ranks). The result of this step was a Percent Score. This procedure was conducted separately for each water quality parameter: nitrogen, phosphorus, TSS, E. coli, temperature, ammonia, dissolved oxygen, and biological communities. Table 24 is the worksheet for the nitrogen metric, an example of how this metric works. All worksheets for this step are located in Appendix 6.

A water quality summary score was then created (see Table 25). The final percentage score for each parameter was averaged for each site, providing a final percentage score that can be interpreted as a grade for each particular site (see Table 25 and Figure 61)

The mean (across all sites) of these final water quality scores was 0.56 with a standard deviation of 0.12. Critical areas (as determined by the Technical Committee) were designated at one standard deviation below the mean (all sites scoring 44% and below). Protection areas were designated at one standard deviation above the mean (all sites scoring 67% and above).

Consequently, eight sampling sites (or drainage areas) were selected as critical areas. The area of land that drains to each sampling site was calculated using the U.S. Geological Survey's StreamStats website (www.water. usgs. gov/osw/streamstats/).

Selected critical drainage areas originate from sampling sites:

- 12-Coffee Creek Mainstem (upstream from site 12 until site 13 and bounded approximately by I-94, SR 49, and Morgan Ave.)
- 22-Lower Sand Creek (upstream from site 22 until site 23 and bounded approximately by Indian Boundary Rd., N 350 E, and SR 49)
- 30-Unnamed Tributary (everything upstream from site 30 and bounded approximately by N 450 E, N 550 E, E 1050 N, and N 475 E)
- 31-Unnamed Tributary (everything upstream from site 31 and bounded approximately by I 94, N 500 E, E 1300 N, 375 E, and E 1400 N)
- 34-Carver Ditch Downstream (upstream from site 34 until sites 35, 36, & 37 and bounded approximately by 1500 N, W 300 N, County Line Rd., 1350 N, and 600 E)
- 35-Kelleys Ditch (everything upstream from site 35 and bounded approximately by I 94, County line Rd., 600 E, E 1400 N, and N 500 E)
- 36-Carver Ditch Upstream (everything upstream from site 36 and bounded approximately by 400 N, Old Chicago Rd., County Line Rd., E 1400 N, and E 1500 N)
- 43-LCEB Mainstem (upstream from site 43 until site 44 and bounded approximately by County Line Rd., Otis Rd., and Snyder Rd.)

These critical areas (or drainage areas) have the poorest water quality in the LCEB. While the final score was based on ranked water quality parameters, biological communities, and habitat, the most influential low scoring parameters varied for each site.

- Drainage Area 12 (Coffee Creek subwatershed) scored low based on sediment, temperature, dissolved oxygen, and *E. coli.* This drainage area is located in downtown Chesterton. The proximity of large roads and highways in addition to abundant stores and other businesses likely plays a large role in the degraded water quality of this area. Large strip malls drain directly to this stream and Chubb Lake, which affects water quality in this drainage area. `
- Site 22 (Coffee Creek subwatershed) scored low based on phosphorus, temperature, dissolved oxygen, ammonia, biotic communities, and *E. coli.* This drainage area is located near the base of Sand Creek and the LCEB mainstem, which is mainly within the City Limits of Chesterton and contains the Sand Creek Country Club. The golf course and large home developments are likely sources for water quality impairments.
- Site 30 (Kemper Ditch subwatershed) scored low based on phosphorus, sediment, biotic communities, and *E. coli.* This drainage area is located in a rural/low density residential setting. The combination of agricultural drainage with modern lawn care practices, and septic systems placed in poorly suited soils are the suspected sources of degraded water quality.
- Site 31 (Kemper Ditch subwatershed) scored low based on phosphorus, sediment, dissolved oxygen, and biotic communities. This drainage area is located in a rural

setting, checkered with low-density housing. The combination of agricultural management practices with septic systems placed in poorly suited soils is the suspected source of degraded water quality.

- Site 34 (Kemper Ditch subwatershed) scored low based on nitrogen, phosphorus, sediment, temperature, dissolved oxygen, and *E. coli.* This drainage area is located in a predominantly agricultural setting. The combination of agricultural management practices with septic systems placed in poorly suited soils is the suspected source of degraded water quality.
- Site 35 (Kemper Ditch subwatershed) scored low based on phosphorus, sediment, dissolved oxygen, ammonia, and biotic communities. This drainage area is located in a predominantly agricultural setting. The combination of agricultural management practices with septic systems placed in poorly suited soils is the suspected source of degraded water quality.
- Site 36 (Kemper Ditch subwatershed) scored low based on phosphorus, sediment, temperature, and dissolved oxygen. This drainage area is located in a predominantly agricultural setting. The combination of agricultural management practices with septic systems placed in poorly suited soils is the suspected source of degraded water quality.
- Site 43 (Reynolds Creek subwatershed) scored low based on phosphorus, sediment, biotic communities, and *E. coli.* This drainage area is located in a rural setting, checkered with low-density housing. The combination of agricultural management practices with septic systems placed in poorly suited soils is the suspected source of degraded water quality.

To determine which variables were driving the selection of critical areas, a principal component analysis (PCA) was run. The data for this analysis included all water quality data, QHEI data, and land use. First, a nonparametric t-test was run to determine which variables differed between the critical and priority sites (see Appendix 7). After deleting all non-significant variables, the principle components analysis (PCA) was run to see which variables contributed to explaining the cumulative variance. Step one was to run a scree plot to see how many factors to include (see Appendix 7). A two-factor solution was then run for the PCA (see Appendix 7). All loadings greater than 0.8 (+or-) were included for Factor 1 and those greater than 0.6 (+or-) for Factor 2. The two factor solution explains 80% of the cumulative variance.

Factor 1 explains 62% of the cumulative variance and has a strong habitat component with positive loadings on QHEI substrate, cover, and channel score as well as QHEI total score. On the chemical side there were strong positive loading on both DO (dissolved oxygen) and hardness with strong negative loadings on TP (total phosphorus), TOC (total organic carbon), and turbidity. Factor 2 explained an additional 18% of the cumulative variance negatively loading on ammonia, alkalinity, calcium, and agriculture.

The results from this statistical analysis will help to inform implementation decisions. The BMPs selected for each critical area will consider effects on stream habitat, dissolved oxygen, hardness, total phosphorus, total organic carbon, turbidity, and the other indicated drivers of critical area selection.

Eight sites (or drainage areas) were also selected as protection areas. Selected protection areas originated from sites: 13 (Coffee Creek Mainstem), 15 (Pope O'Connor Ditch Upstream), 16 (Coffee Creek Mainstem), 18 (Coffee Creek Mainstem), 23 (Middle Sand Creek), 40 (Massagua Creek Upstream), 42 (Reynolds Creek Upstream), and 45 (Lake Lee Outlet) (Figure 62). These sites have the highest water quality in the LCEB and will be monitored to maintain and improve conditions in these areas.

Table 24. Nitrogen critical/protection area metric

Nitrogen Critical/Protection Area Metric													
Site ID	Mean	Mean Rank	% Exceed	% Exceed Rank	Single Highest Sample	Highest Sample Rank	Load (lb/yr)	Load Rank	Load/Acre (lb/ac/yr)	Load/acre Rank	Rank Total	Total Possible	Percent Score (Grade)
3	0.74	6	0%	11	1.0	10	100015	2	2.2	2	31	93	33%
4	0.41	11	0%	11	0.5	15					37	67	55%
5	1.62	2	83%	1	2.6	4					7	67	10%
6	1.18	4	45%	4	2.9	3					11	67	16%
7	0.59	7	5%	9	1.3	8	2972	9	1.5	3	36	93	39%
8	0.79	5	36%	5	1.6	7					17	67	25%
9	1.22	3	75%	3	2.3	5	138394	1	3.3	1	13	93	14%
10	1.82	1	82%	2	3.1	2					5	67	7%
11	0.13	33	0%	11	0.3	17	15944	4	0.5	10	75	93	81%
12	0.18	22	0%	11	0.5	15	8560	6	0.9	5	59	93	63%
13	0.13	33	0%	11	0.4	16					60	67	90%
14	0.29	14	0%	11	0.8	12					37	67	55%
15	0.52	9	0%	11	0.9	11					31	67	46%
16	0.14	30	0%	11	0.3	17					58	67	87%
17	0.11	37	0%	11	0.2	18					66	67	99%
18	0.11	36	0%	11	0.2	18					65	67	97%
19	0.14	30	0%	11	0.3	17					58	67	87%
20	0.11	35	0%	11	0.5	15	2619	10	0.6	8	79	89	89%
21	0.16	27	0%	11	0.5	15					53	67	79%
22	0.50	10	0%	11	0.7	13	4189	7	1.2	4	45	93	48%
23	0.33	12	0%	11	0.5	15					38	67	57%
24	0.17	25	0%	11	0.2	18					54	67	81%
25	0.17	24	0%	11	0.4	16	16178	3	0.6	8	62	93	67%
26	0.26	17	10%	7	1.8	6					30	67	45%
27	0.26	16	5%	10	1.1	9	678	13	0.4	12	60	93	65%
28	0.18	23	0%	11	0.3	17	834	12	0.7	7	70	93	75%

Nitrogen Critical/Protection Area Metric													
Site ID	Mean	Mean Rank	% Exceed	% Exceed Rank	Single Highest Sample	Highest Sample Rank	Load (lb/yr)	Load Rank	Load/Acre (lb/ac/yr)	Load/acre Rank	Rank Total	Total Possible	Percent Score (Grade)
29	0.20	19	0%	11	0.4	16					46	67	69%
30	0.20	18	0%	11	0.6	14					43	67	64%
31	0.26	17	0%	11	0.7	13					41	67	61%
32	0.17	26	0%	11	0.5	15	11609	5	0.6	8	65	93	70%
33	0.15	29	0%	11	0.3	17					57	67	85%
34	0.59	8	15%	6	4.8	1					15	67	22%
35	0.19	21	0%	11	0.6	14					46	67	69%
36	0.15	29	9%	8	1.1	9					46	67	69%
37	0.12	34	0%	11	0.3	17					62	67	93%
38	0.15	28	0%	11	0.4	16	1857	11	0.6	9	75	93	81%
39													NA
40	0.14	31	0%	11	0.3	17					59	67	88%
41	0.07	38	0%	11	0.5	15					64	67	96%
42													NA
43	0.19	20	0%	11	0.3	17	3224	8	0.5	11	67	93	72%
44	0.13	32	0%	11	0.2	18					61	67	91%
45	0.28	15	0%	11	0.4	16	562	14	0.8	6	62	93	67%
46													NA
47													NA
48	0.32	13	0%	11	0.4	16					40	67	60%

Table 25. Critical areas and priority protection areas water quality summary

Site ID	Sub-Watershed	Nitrogen	Phosphorus	TSS	Temp	DO	Ammonia	Biotic Communities	*E. coli*	Average
3	Coffee	33%	69%	84%	8%	58%	28%	44%	93%	52%
4	Coffee	55%	98%	93%	8%	53%	19%	59%	100%	61%
5	Coffee	10%	87%	46%	66%	52%	NA	85%	49%	57%
6	Coffee	16%	40%	78%	58%	68%	NA	67%	79%	58%
7	Coffee	39%	63%	90%	23%	51%	65%	37%	9%	47%
8	Coffee	25%	35%	NA	88%	42%	63%	59%	53%	52%
9	Coffee	14%	45%	49%	15%	44%	76%	89%	28%	45%
10	Coffee	7%	38%	69%	64%	76%	NA	52%	75%	54%
11	Coffee	81%	34%	55%	71%	84%	NA	56%	85%	66%
12	Coffee	63%	61%	32%	25%	37%	61%	56%	17%	44%
13	Coffee	90%	53%	97%	53%	86%	NA	74%	65%	74%
14	Coffee	55%	24%	94%	38%	59%	26%	11%	70%	47%
15	Coffee	46%	58%	NA	73%	87%	NA	NA	93%	72%
16	Coffee	87%	82%	94%	26%	91%	NA	67%	81%	75%
17	Coffee	99%	56%	67%	51%	82%	NA	26%	25%	58%
18	Coffee	97%	81%	93%	49%	82%	NA	56%	83%	77%
19	Coffee	87%	31%	53%	61%	18%	26%	22%	77%	47%
20	Coffee	89%	81%	84%	14%	48%	91%	56%	58%	65%
21	Coffee	79%	55%	51%	28%	67%	NA	22%	48%	50%
22	Coffee	48%	31%	45%	41%	24%	44%	44%	10%	36%
23	Coffee	57%	70%	73%	83%	96%	NA	78%	34%	70%
24	Coffee	81%	56%	61%	100%	99%	NA	9%	43%	64%
25	Kemper	67%	49%	55%	73%	53%	NA	41%	58%	56%
26	Kemper	45%	21%	80%	89%	24%	31%	70%	52%	52%
27	Kemper	65%	41%	76%	16%	38%	56%	41%	73%	50%

Site ID	Sub-Watershed	Nitrogen	Phosphorus	TSS	Temp	DO	Ammonia	Biotic Communities	*E. coli*	Average
28	Kemper	75%	72%	99%	40%	21%	78%	52%	45%	60%
29	Kemper	69%	41%	26%	70%	66%	NA	22%	28%	46%
30	Kemper	64%	23%	13%	78%	66%	NA	33%	26%	43%
31	Kemper	61%	12%	19%	93%	37%	59%	11%	54%	43%
32	Kemper	70%	45%	31%	63%	43%	91%	78%	17%	55%
33	Kemper	85%	41%	38%	62%	81%	NA	67%	44%	60%
34	Kemper	22%	14%	18%	36%	16%	67%	63%	10%	31%
35	Kemper	69%	3%	4%	50%	36%	35%	19%	74%	36%
36	Kemper	69%	6%	10%	38%	12%	61%	56%	68%	40%
37	Kemper	93%	13%	34%	36%	59%	NA	48%	68%	50%
38	Reynolds	81%	54%	40%	67%	43%	96%	67%	12%	58%
39	Reynolds	NA	62%	72%	89%	73%	NA	48%	33%	63%
40	Reynolds	88%	75%	71%	98%	81%	NA	78%	73%	81%
41	Reynolds	96%	65%	39%	71%	60%	56%	67%	34%	61%
42	Reynolds	NA	90%	98%	95%	88%	NA	67%	91%	88%
43	Reynolds	72%	43%	26%	51%	52%	98%	26%	10%	47%
44	Reynolds	91%	73%	63%	60%	69%	NA	48%	36%	63%
45	Reynolds	67%	79%	69%	96%	83%	NA	70%	71%	76%
46	Reynolds	NA	68%	81%	65%	6%	NA	NA	86%	61%
47	Reynolds	NA	88%	96%	27%	28%	96%	15%	93%	63%
48	Coffee	60%	100%	48%	15%	91%	11%	48%	98%	59%

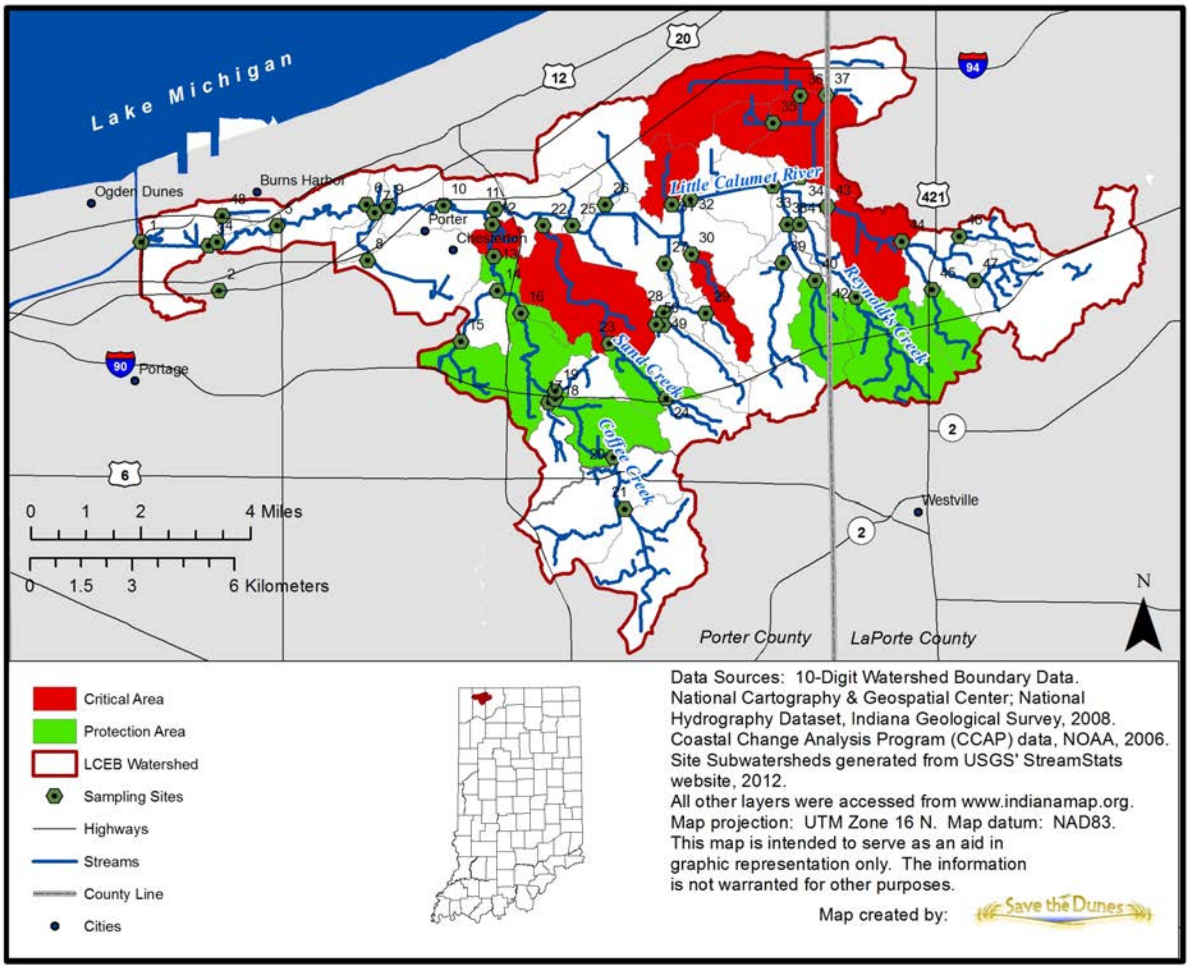

Figure 62. Critical and priority areas in the LCEB

8.4 Critical and Protection Areas Summary

Eight sites in the LCEB were selected as critical areas based on primarily on poor water quality, fish communities, macroinvertebrate communities, stream habitat quality, and land use issues. Due to the unusual conditions created by the historic drought of 2012, a unique metric was created to rank the LCEB sampling sites based on poorest quality to highest quality. Eight sites were also selected for protection using the same metric. The LCEB Technical Committee considered all available data and other sources of information including other planning initiatives, the windshield survey, 303(d) listings, habitat preserves, and personal knowledge of LCEB Steering Committee members.

9.0 Implementation Strategies

Best management practices (BMPs) have been developed to reduce nonpoint source pollution. The most common BMPs available are useful for reducing nutrients, sediment, and/or *E. coli*, which are the dominant pollutants in the LCEB. The following list of BMPs was compiled by the Technical Committee and is intended to identify the most common and most likely BMPs available in this region. Due to the diversity of land uses in the LCEB, this list includes agricultural BMPs as well as BMPs that are more effective in urban and suburban areas.

9.1 Best Management Practices

Nonpoint source best management practices (BMPs) are operational techniques implemented to reduce or prevent nonpoint source pollution. These practices control nonpoint source pollutants by reducing pollutant loads and often reducing stormwater flow volumes to nearby streams. BMPs that were considered by the LCEB Steering Committee for implementation include:

Cover Crops

Cover crops are the use of legumes (e.g. clover, hairy vetch, and alfalfa) or grasses, including cereals, (planted or volunteered vegetation) that are established following a harvested crop primarily for seasonal soil protection and the retention of nutrients. Cover crops protect soil from erosion and retain nitrogen and phosphorus in the root zone. They are grown for one year or less.

Biomass and Forage Crops

Biomass crops or forage crops are typically hay, pasture, or bioenergy grasses. They can be established and maintained for many years. These harvested perennial crops reduce the loss of nutrients and sediment from agricultural fields. These crops also typically reduce the quantity of stormwater runoff.

Extended Wet Detention Ponds

Extended wet detention ponds are large basins constructed with a permanent pool of water and additional storage room to hold stormwater flow. The pool is designed to release stormwater slowly. Pollutants are removed through settling, and biological and chemical processes.

Filter Strips: urban & agricultural

Filter strips are grassed strips of land that help to reduce sediment and nutrients in overland flow from reaching a receiving water body. Filter strips are placed perpendicular to flow thus reducing flow velocity and removing sediment and nutrients.

Grade Stabilization Structures

A grade stabilization structure is designed to control soil erosion in either natural or artificial waterways. Grade stabilization structures can prevent the formation or growth of gullies, enhance environmental quality, and improve or maintain habitat for fish and other wildlife.

Land Conversion: Cropland to Grassland
Land conversion to grassland is the practice of taking agricultural lands out of production to promote a grassland or prairie.

Land Conversion: Cropland to Wetland
Land conversion to wetland is the practice of taking agricultural lands out of production to allow or construct a wetland habitat.

Manure Management
Manure management involves the managing and/or considering the volume and type of manure produced, crop rotations, the quantity of nutrients needed for each crop, field slope, soil type, and manure collection, transportation, storage, and distribution methods. Manure management uses similar techniques to nutrient management with regard to nutrient budgets. Specific practices can include waste storage facilities and waste utilization programs.

Nutrient Management
Nutrient management involves the strategic application of fertilizer to crops. The goal is to apply no more fertilizer than the crop requires for optimal growth. Different parts of a field may require different rates of fertilizer. Nutrient management seeks to supply adequate nutrients for optimum crop yield, while helping to sustain the physical, biological, and chemical properties of the soil.

Pervious Pavement
Pervious pavement is any type of pavement that allows the infiltration of stormwater runoff. Pervious pavement reduces sediment and nutrient flow to receiving streams.

Prescribed Grazing or Livestock Restriction
Livestock that have unrestricted access to a stream or wetland have the potential to degrade water quality and aquatic habitats. Through defecation, livestock introduce nutrients and *E. coli* to stream ecosystems. Trampling removes riparian vegetation and weakens stream banks to increase bank erosion. Trampling also compacts soils in riparian areas, which reduces the infiltration of runoff. Specific practices include fencing and alternative watering sources.

Reduced Tillage
Reduced tillage involves one or more tillage trips, which disturbs the entire soil surface and is performed before or during planting. 15 to 30% residue cover is retained after planting.

Riparian Buffers: Urban & Agricultural
Riparian buffers are the vegetated area near a stream that is typically forested. Riparian buffers help to stabilize streambanks, reduce nutrients and sediment from overland flow and reduce water temperatures by providing shade.

Septic System Maintenance
Onsite septic systems are the dominant method for sewage treatment throughout most of the LCEB even though soils in this area range from somewhat limited to very limited for onsite septic systems. Poorly functioning and malfunctioning septic systems contribute raw sewage (includes *E. coli*, nitrogen, and phosphorus) to streams and ground water. Annual maintenance of these systems helps to address potential problems and reduce the loss of pollutants to local waterways.

Streambank Stabilization:
Streambank stabilization is the use of a structure or vegetation to stabilize a streambank and reduce erosion. A wide array of methodologies and products can be used for the implementation of this BMP.

Tree, Shrub, and Native Plant Establishment
Tree, shrub, and native plant establishment is the planting of perennial vegetation that will develop deep roots, stabilize soil and retain soil nutrients.

9.2 Best Management Practice Selection

The LCEB Steering Committee and Technical Committee selected best management practices. BMPs were selected based on their ability to address the parameter of concern, their appropriateness for this watershed.

Table 26. Best management practices suggested for critical areas

Reason for Being Critical	Critical Area	Suggested BMP
Sediment (TSS)	Drainage Area 12	Extended Wet Detention
		Porous Pavement
		Infiltration Swales
	Drainage Areas 30, 31, 24, 35, 36, and 43	Cover Crops
		Filter Strips
		Reduced Tillage
		Riparian Buffers
		Septic System Maintenance
		Tree & Shrub Planting
Nutrients (nitrogen and phosphorus)	Drainage Area 22	Porous Pavement
		Extended Wet Detention
		Infiltration Swales
		Rain Barrels & Rain Gardens
		Forested Buffers
	Drainage Areas 22, 30, 31, 34, 35, 36, and 43	Cover Crops
		Filter strips
		Reduced Tillage
		Nutrient Management
		Riparian Buffers

Reason for Being Critical	Critical Area	Suggested BMP
		Septic System Maintenance
		Tree & Shrub Planting
E. coli	Drainage Areas 12 and 22	Extended Wet Detention
		Infiltration Swales
	Drainage Areas 22, 30, 34, 43	Riparian Buffers
		Septic System Maintenance
Biological Communities	Drainage Areas 22	Porous Pavement
		Extended Wet Detention
		Forested Buffers
		Infiltration Swales
		Rain Barrels & Rain Gardens
	Drainage Areas 22, 30, 31, 35, and 43	Cover Crops
		Filter Strips
		Reduced Tillage
		Nutrient Management
		Riparian Buffers
		Septic System Maintenance
		Tree & Shrub Planting
Dissolved Oxygen	Drainage Areas 12 and 22	Porous Pavement
		Extended Wet Detention
		Infiltration Swales
	Drainage Area 22	Forested Buffers
		Rain Barrels & Rain Gardens
	Drainage Areas 22, 31, 34, 35, and 36	Cover Crops
		Filter Strips
		Reduced Tillage
		Nutrient Management
		Riparian Buffers
		Septic System Maintenance
		Tree & Shrub Planting

9.3 Load Reduction by Best Management Practice

Load reductions were calculated using the EPA's Spreadsheet Tool for Estimating Pollutant Load (STEPL). STEPL was designed to model the reduction efficiencies of nonpoint source pollution best management practices on a watershed scale. With assistance from the county Soil and Water Conservation Districts and the Steering Committee, a suite of nonpoint source best management practices and possible relevant acreages were carefully selected based on land use and personal knowledge of watershed conditions. The BMPs selected were considered most likely to be effective and could readily be implemented. Load reductions (for nitrogen, phosphorus, and sediment) were calculated (using the selected BMPs) for the critical areas and the three subwatersheds using STEPL. Load reductions were calculated for the stated goals of 5 years for the critical areas and the stated goals of 15 years and 25 years for the sub-watershed. Tables 27, 28, and 29 describe each selected BMP, its acreage, and the resulting pollutant reduction for the critical areas (grouped by subwatershed). Tables 30, 31, and 32 describe each selected BMP, its acreage, and the resulting pollutant reduction for the 15-year and 25-year goals.

For the 25-year goal, we were unable to reach the target load reductions for all the water quality parameters. This was likely due to the inability of STEPL to quantify all desired BMPs. For example, the widespread implementation of septic system maintenance is likely to have an important effect on water quality by reducing nutrients and *E. coli*. Unfortunately, STEPL does not model *E. coli* and does not have a reduction efficiency for septic system maintenance. Additionally, due to the complexity and expense of addressing tile drainage, the Steering Committee decided to focus attention on other BMPs. Nonetheless, tile drainage is likely a significant contributor of nutrients to the LCEB. The Steering Committee would like to address tile drainage in a future WMP revision.

Table 27. Reynolds Creek subwatershed critical area (5-year goal) load reductions from BMPs

Critical Drainage Area	**43**			
Suggested BMP	**Acres**	**Nitrogen lb/yr**	**Phosphorus lb/yr**	**Sediment lbs/yr**
Cover Crops	57	26.2	1.8	400.0
Filter Strips	4	9.2	2.2	1867.4
Reduced Tillage	29	61.0	14.3	15622.8
Nutrient Management	29	10.6	3.9	0.0
Riparian Buffers	4	7.4	1.8	1867.4
Septic System Maintenance		NA	NA	NA
Tree & Shrub Planting	1	NA	NA	NA
Reduction Sum		**114.4**	**24.0**	**19757.5**

Calculated percent reductions for the Reynolds Creek subwatershed (5-year goal) are 1% for nitrogen, 0.6% for phosphorus, and 10% for sediment.

Table 28. Kemper Ditch subwatershed critical area (5-year goal) load reductions from BMPs

Critical Drainage Area	**30**				**Critical Drainage Area**	**31**			
Suggested BMP	**Acres**	**Nitrogen lb/yr**	**Phosphorus lb/yr**	**Sediment lbs/yr**	**Suggested BMP**	**Acres**	**Nitrogen lb/yr**	**Phosphorus lb/yr**	**Sediment lbs/yr**
Cover Crop	53	24.3	1.7	400.0	Cover Crop	53	24.3	1.7	400.0
Filter Strips	5	13.2	3.1	2461.6	Filter Strips	5	13.2	3.1	2461.6
Reduced Tillage	53	122.1	28.6	15.6	Reduced Tillage	53	122.1	28.6	31245.5
Nutrient Management	53	19.7	7.0	0.0	Nutrient Management	53	19.7	7.0	0.0
Riparian Buffers	3	6.8	1.7	1692.5	Riparian Buffers	3	6.8	1.7	1692.5
Septic System Maintenance		NA	NA	NA	Septic System Maintenance		NA	NA	NA
Tree & Shrub Planting	2	NA	NA	NA	Tree & Shrub Planting	2	NA	NA	NA
Reduction Sum		**186.0**	**42.0**	**4569.7**	**Reduction Sum**		**186.0**	**42.0**	**35799.6**
Critical Drainage Area	**34**				**Critical Drainage Area**	**35**			
Suggested BMP	**Acres**	**Nitrogen lb/yr**	**Phosphorus lb/yr**	**Sediment lbs/yr**	**Suggested BMP**	**Acres**	**Nitrogen lb/yr**	**Phosphorus lb/yr**	**Sediment lbs/yr**
Cover Crop	106	48.5	3.4	800.0	Cover Crop	53	24.3	1.7	400
Filter Strips	5	13.2	3.1	2461.6	Filter Strips	5	13.2	3.1	2461.6
Reduced Tillage	106	244.2	57.1	62491.0	Reduced Tillage	53	122.1	28.6	15.6
Nutrient Management	106	39.4	14.0	0.0	Nutrient Management	53	19.7	7.0	0.0
Riparian Buffers	13	27.2	6.8	6769.9	Riparian Buffers	3	6.8	1.7	1692.5
Septic System Maintenance		NA	NA	NA	Septic System Maintenance		NA	NA	NA
Tree & Shrub Planting	2	NA	NA	NA	Tree & Shrub Planting	2	NA	NA	NA
Reduction Sum		**372.4**	**84.4**	**72522.5**	**Reduction Sum**		**186.0**	**42.0**	**4569.7**

Critical Drainage Area	**36**			
Suggested BMP	**Acres**	**Nitrogen lb/yr**	**Phosphorus lb/yr**	**Sediment lbs/yr**
Cover Crop	265	289	41	41661
Filter Strips	5	13.2	3.1	2461.6
Reduced Tillage	106	244.2	57.1	62491.0
Nutrient Management	106	39.4	14.0	0.0
Riparian Buffers	13	27.2	6.8	6769.9
Septic System Maintenance		NA	NA	NA
Tree & Shrub Planting		NA	NA	NA
Reduction Sum		**613.4**	**122.1**	**113383.2**

Calculated percent reductions for the Kemper Ditch subwatershed (5-year goal) are 6% for nitrogen, 3% for phosphorus, and 46% for sediment.

Table 29. Coffee Creek subwatershed critical areas (5-year goal) load reductions from BMPs

Critical Drainage Area	**12**				**Critical Drainage Area**	**22**			
Suggested BMP	**Acres**	**Nitrogen lb/yr**	**Phosphorus lb/yr**	**Sediment lb/yr**	**Suggested BMP**	**Acres**	**Nitrogen lb/yr**	**Phosphorus lb/yr**	**Sediment lb/yr**
Extended Wet Detention	5	16.0	2.0	1000.00	Porous Pavement	5	24.7	1.9	979.6
Porous Pavement	10	49.3	3.8	1959.1	Extended Wet Detention	5	16	2	1000.00
Infiltration Swale	5	14.5	1.9	1000	Forested Buffers	5	7.3	1.5	600.0
Tree & Shrub Planting	1	NA	NA	NA	Infiltration Swale	5	14.5	1.9	1000
Reduction Sum		**79.8**	**7.7**	**3959.1**	Rain Barrels & Rain Gardens	10	58	5.8	2200
					Cover Crop	21	9.7	3.3	800.0
					Filter Strip	1	3.3	0.8	615.4
					Reduced Tillage	11	23.6	5.4	2.8
					Nutrient Management	21	8	3	0
					Riparian Buffer	3	5.3	1.3	0.6
					Septic System Maintenance		NA	NA	NA
					Tree & Shrub Planting	1	NA	NA	NA
					Reduction Sum		**170.2**	**26.7**	**7198.4**

Calculated percent reductions for the Coffee Creek subwatershed (5-year goal) are 1% for nitrogen, 0.3% for phosphorus, and 2% for sediment.

Table 30. Reynolds Creek subwatershed 15-year and 25-year load reductions from BMPs

Target Timeline:	15 Years				25 Years			
Suggested BMP	Acres	Nitrogen lb/yr	Phosphorus lb/yr	Sediment lbs/yr	Acres	Nitrogen lb/yr	Phosphorus lb/yr	Sediment lbs/yr
Cover Crop	714	784	113	114,916	1,427	1,568	225	229,831
Forage & Biomass Crops	285	NA	NA	NA	571	NA	NA	NA
Filter Strips, Ag	143	367	88	74,695	143	367	88	74,695
Reduced Tillage	571	1,328	313	344,747	856	1,993	469	0
Riparian Buffers, Ag	29	59	15	14,939	143	296	74	0
Land Conversion: crop to wetland	428	1557	372	337,852	571	2077	496	0
Land Conversion: crop to grassland	571	1054	338	367,730	856	1582	507	0
Nutrient Management	571	212	78	0	1,427	530	195	0
Porous Pavement	10	49	4	1,959	25	123	9	0
Tree & Shrub Planting	143	NA	NA	NA	285	NA	NA	NA
Septic System Maintenance		NA	NA	NA		NA	NA	NA
Education & Outreach		NA	NA	NA		NA	NA	NA
Sum		**5,411**	**1,320**	**1,256,838**		**8,535**	**2,064**	**304,526**
Needed Reductions		11,415	4,151	199,831		11,415	4,151	199,831
% Reduction		**47%**	**32%**	**629%**		**75%**	**50%**	**152%**

Table 31. Kemper Ditch subwatershed (15-year and 25 year) load reductions from BMPs

Target Timeline:	**15 Years**				**25 Years**			
Suggested BMP	**Acres**	**Nitrogen lb/yr**	**Phosphorus lb/yr**	**Sediment lbs/yr**	**Acres**	**Nitrogen lb/yr**	**Phosphorus lb/yr**	**Sediment lbs/yr**
Cover Crop	1324	1447	206	208,303	2,649	2,895	412	416,607
Forage & Biomass Crops	530	NA	NA	NA	1,059	NA	NA	NA
Filter Strips, Ag	265	675	161	135,397	265	675	161	135,397
Reduced Tillage	795	1831	428	468,000	1,059	2,442	571	624,910
Riparian Buffers, Ag	53	109	27	15,623	265	544	135	312,455
Land Conversion: cropland to wetland	795	2867	681	6,200	1,059	3823	909	124,982
Land Conversion: cropland to grassland	530	966	309	27,079	1,059	1,932	618	135,397
Nutrient Management	1,059	393	145	612,412	2,649	983	362	816,550
Porous Pavement	10	49	4	333,286	25	123	9	666,571
Tree & Shrub Planting	200	NA	NA	NA	300	NA	NA	NA
Septic System Maintenance		NA	NA	NA		NA	NA	NA
Education & Outreach		NA	NA	NA		NA	NA	NA
Sum		**8,338**	**1,961**	**1,806,301**		**13,417**	**3,177**	**3,232,870**
Needed Reductions		25,695	9,903	507,721		25,695	9,903	507,721
% Reduction		**32%**	**20%**	**356%**		**52%**	**32%**	**637%**

Table 32. Coffee Creek subwatershed (15-year and 25 year) load reductions from BMPs

Target Timeline:	**15 Years**				**25 Years**			
Suggested BMP	**Acres**	**Nitrogen lb/yr**	**Phosphorus lb/yr**	**Sediment lbs/yr**	**Acres**	**Nitrogen lb/yr**	**Phosphorus lb/yr**	**Sediment lbs/yr**
Cover Crop	532	569	78	75,742	1,065	1,138	156	151,484
Forage & Biomass Crops	213	NA	NA	NA	426	NA	NA	NA
Filter Strips, Ag	106	263	62	49,232	106	263	62	49,232
Reduced Tillage	213	472	107	113,613	426	943	215	227,225
Riparian Buffers, Ag	21	42	10	9,846	106	210	51	49,232
Land Conversion: cropland to wetland	319	1115	259	222,681	426	1487	346	296,908
Land Conversion: cropland to grassland	213	368	116	121,187	426	736	232	242,374
Nutrient Management	426	158	58	0	1,065	395	146	0
Porous Pavement	10	49	4	1,959	25	123	9	4,898
Tree & Shrub Planting	200	NA	NA	NA	300	NA	NA	NA
Septic System Maintenance		NA	NA	NA		NA	NA	NA
Extended Wet Detention	50	160	20	9,400	75	239	30	14,000
Filter Strips, Urban	200	618	71	28,298	300	927	107	42,447
Riparian Buffers, Urban	50	290	58	21,768	100	435	87	32,652
Education & Outreach		NA	NA	NA		NA	NA	NA
Sum		**4,104**	**844**	**653,726**		**6,898**	**1,440**	**1,110,452**
Needed Reductions		23,187	10,518	515,051		23,187	10,518	515,051
% Reduction		**18%**	**8%**	**127%**		**30%**	**14%**	**216%**

10.0 Strategies and Milestones for Reaching Goals

Goal statements and indicators were developed in Section 7. These goals were based on stakeholder concerns, water quality data, and potential sources of pollution. The goal statements represent the Steering Committee's desire to reach the target pollutant concentrations by 2030. The short-term targets of 5 years and 15 years were designed to provide realistic and achievable goals. Many of the selected strategies may apply to multiple goals and will be listed in several tables. Activities to be completed will be listed in each action register below. A water quality monitoring program and additional social indicator surveys will be used to measure the outcomes from implementation efforts.

10.1 Reduce Nutrient Loading

Table 33. Action register to reduce nutrient loading

Objective	Strategy	Target Audience	Milestone	Cost	Possible Partners (PP) and needed Technical Assistance (TA)
Increase cover crop acreage	Reynolds Creek: Increase cover crops 57 acres by 2021 and 714 by 2031.	Agricultural landowners and operators	Annually identify cover crop funding options	$1,000	PP = Watershed Group (WG)
			Develop a cover crop demonstration area by 2017	$2,000*	PP = WG & SWCD TA = SWCD to provide guidance, location, and audience
	Kemper Ditch: Increase cover crops 530 acres by 2021 and 1,324 by 2031		Develop a cost-share program in 2016	$15,000*	PP = WG & SWCD TA = SWCD, NRCS, and Purdue Extension to provide guidance and promotion
			Host a biannual cover crop workshop (every other year from 2016 – 2031)	$20,000	PP = WG & SWCD TA = SWCD, NRCS and Purdue Extension to provide guidance, location, and audience
	Coffee Creek: Increase cover crops 21 acres by 2021 and 532 by 2031		Create a contractors list for specific cover crop seeding in 2016	$500	PP = WG
			Implement 260 acres of cover crops annually (2021 – 2031)	$104,000	PP = WG & SWCD

Objective	Strategy	Target Audience	Milestone	Cost	Possible Partners (PP) and needed Technical Assistance (TA)
			Implement 608 acres of cover crops in critical areas by 2021	$24,500	PP = Watershed Group (WG) & SWCD
Increase filter strip. Infiltration swale, forested buffer, and riparian buffer acreage	Reynolds Creek: increase buffers 8 acres by 2021 and 172 acres by 2031	Agricultural land owners and operators, urban and rural landowners	Annually identify funding opportunities for filter strips and riparian buffers	$1,000	PP = WG
	Kemper Ditch: increase buffers 60 acres by 2021 and 318 acres 2031		Develop and host a biannual BMP field day from 2016 - 2031	$20,000	PP = WG & SWCD TA = SWCD, NRCS and Purdue Extension to provide guidance, location, and audience
	Coffee Creek: increase buffers 19 acres by 2021 and 377 by 2031		Develop a cost share program in 2016	*See Note	PP = WG & SWCD TA = SWCD, NRCS and Purdue Extension to provide guidance and promotion
			Implement 87 acres of buffers annually (2021-2031)	$87,000	PP = WG & SWCD
			Implement 87 acres of buffers in critical areas by 2021	$8,700	PP = WG & SWCD
Increase the acreage of fields using nutrient management	Reynolds Creek: increase use of nutrient mgmt. 29 acres by 2012 and 571 by 2031	Agricultural landowners and operators	Annually identify funding opportunities for nutrient management	$1,000	PP = WG
	Kemper Ditch: increase use of nutrient mgmt. 371 acres by 2021 and 1,059 by 2031		Develop and host a biannual BMP field day (2016 – 2031)	$20,000	PP = WG & SWCD TA = SWCD, NRCS and Purdue Extension to provide guidance, location, and audience
	Coffee Creek: increase use of nutrient mgmt. 21 acres by 2021 and		Develop a cost share program	*See Note	PP = WG & SWCD TA = SWCD, NRCS and Purdue Extension to provide guidance and promotion

Objective	Strategy	Target Audience	Milestone	Cost	Possible Partners (PP) and needed Technical Assistance (TA)
	426 by 2031		Implement 206 acres nutrient management annually (2021-2031)	$31,000	PP = Watershed Group (WG) & SWCD
			Implement 421 acres of nutrient management in critical areas by 2021	$6,400	PP = WG & SWCD
Increase the acreage of fields using reduced tillage	Reynolds Creek: increase use of reduced tillage by 29 acres by 2021 and 571 by 2031	Agricultural landowners and operators	Implement 158 acres of reduced tillage annually (2021-2031)	$5,000	PP = WG & SWCD
	Kemper Ditch: increase use of reduced tillage by 371 acres by 2021 and 795 by 2031				
	Coffee Creek: increase use of reduced tillage by 11 acres by 2021 and 106 by 2031		Implement 411 acres of reduced tillage in critical areas by 2021	$5,000	PP = WG & SWCD
Increase landowner awareness of septic system maintenance	Reynolds Creek: Reduce nutrient loading from septic systems	Rural and urban landowners	Develop and implement a workshop on septic system maintenance and education (2016-2031)	$40,000	PP = WG & Septics Coordination Group
	Kemper Ditch: reduce nutrient loading from septic systems		Annually identify funding for septic system maintenance and education	$1,000	PP = WG
	Coffee Creek: reduce nutrient loading from septic systems				

Objective	Strategy	Target Audience	Milestone	Cost	Possible Partners (PP) and needed Technical Assistance (TA)
Increase acreage of extended wet detention	Coffee Creek: increase application of extended wet detention by 10 acres by 2021 and 50 by 2031	Urban landowners	Implement 10 acres of extended wet detention in the critical areas by 2021	$4,000,000	PP = WG & MS4
			Implement 5 acres of extended wet detention annually (2021-2031)	$20,000,000	PP = WG & MS4
Increase acreage of porous pavement	Coffee Creek: increase application of porous pavement by 15 acres by 2021 and 10 acres by 2031	Urban landowners	Implement 15 acres of porous pavement in the critical areas by 2021	$6,500,000	PP = WG
			Implement 1 acre of porous pavement annually (2021-2031)	$4,400,000	PP = WG
Increase acreage of tree and shrub planting	Reynolds Creek: increase tree & shrub planting by 1 acre 2021 and 143 by 2031	Rural and urban landowners	Implement 13 acres of tree & shrub planting in the critical areas by 2021	$400,000	PP = WG
	Kemper Ditch: increase tree & shrub planting by 10 acres by 2021 and 200 by 2031		Implement 54 acres of tree planting annually (2021-2031)	16,200,000	PP = WG
	Coffee Creek: increase tree & shrub planting by 2 acre in 2021 and 200 by 2031		Annually identify funding opportunities for tree and shrub planting	$1,000	PP = WG

*One cost share program and three education program plans will be developed covering the identified strategies. Educational program costs are for one-half the Watershed Coordinator's salary for 16 months plus meeting and program materials. The education plans include salary for the Watershed Coordinator to implement education and outreach for five years.

Indicators for Success

Water quality and social data will be used to demonstrate progress toward these goals. The Hoosier Riverwatch volunteer program will be utilized to monitor water quality advances. Sampling for each subwatershed both before and after implementation will provide indications of progress. A social indicators survey will be conducted no less than five years after the start of implementation. The survey will be compared with the baseline survey to demonstrate progress.

10.2 Reduce Sediment Loading

Table 34. Action register to reduce sediment loading

Objective	Strategy	Target Audience	Milestone	Cost	Possible Partners (PP) and needed Technical Assistance (TA)
Increase cover crop acreage	Reynolds Creek: Increase cover crops 57 acres by 2021 and 714 by 2031.	Agricultural landowners and operators	Annually identify cover crop funding options	$1,000	PP = Watershed Group (WG)
			Develop a cover crop demonstration area by 2017	$2,000*	PP = WG & SWCD TA = SWCD to provide guidance, location, and audience
	Kemper Ditch: Increase cover crops 530 acres by 2021 and 1,324 by 2031		Develop a cost-share program in 2016	$15,000*	PP = WG & SWCD TA = SWCD, NRCS, and Purdue Extension to provide guidance and promotion
			Host a biannual cover crop workshop (every other year from 2016 – 2031)	$20,000	PP = WG & SWCD TA = SWCD, NRCS and Purdue Extension to provide guidance, location, and audience
	Coffee Creek: Increase cover crops 21 acres by 2021 and 532 by 2031		Create a contractors list for specific cover crop seeding in 2016	$500	PP = WG
			Implement 260 acres of cover crops annually (2021 – 2031)	$104,000	PP = Watershed Group (WG) & SWCD

Objective	Strategy	Target Audience	Milestone	Cost	Possible Partners (PP) and needed Technical Assistance (TA)
			Implement 608 acres of cover crops in critical areas by 2021	$24,500	PP = WG & SWCD
Increase filter strip, forested buffer, infiltration swale, and riparian buffer acreage	Reynolds Creek: increase buffers 8 acres by 2021 and 172 acres by 2031	Agricultural land owners and operators, urban and rural landowners	Annually identify funding opportunities for filter strips and riparian buffers	$1,000	PP = WG
	Kemper Ditch: increase buffers 60 acres by 2021 and 318 acres 2031		Develop and host a biannual BMP field day from 2016 - 2031	$20,000	PP = WG & SWCD TA = SWCD, NRCS, and Purdue Extension to provide guidance, location and audience
	Coffee Creek: increase buffers 19 acres by 2021 and 377 by 2031		Develop a cost share program	*See Note	PP = WG & SWCD TA = SWCD to provide guidance and promotion
			Implement 87 acres of buffers annually (2021-2031)	$87,000	PP = WG
			Implement 87 acres of buffers in critical areas by 2021	$8,700	PP = WG
Increase the acreage of fields using reduced tillage	Reynolds Creek: increase use of reduced tillage by 29 acres by 2021 and 571 by 2031	Agricultural landowners and operators	Implement 158 acres of reduced tillage annually (2021-2031)	$5,000	PP = WG & SWCD
	Kemper Ditch: increase use of reduced tillage by 371 acres by 2021 and 795 by 2031				
	Coffee Creek: increase use of reduced tillage by 11 acres by 2021 and 106 by 2031		Implement 411 acres of reduced tillage in critical areas by 2021	$5,000	PP = Watershed Group (WG)

Objective	Strategy	Target Audience	Milestone	Cost	Possible Partners (PP) and needed Technical Assistance (TA)
Increase acreage of extended wet detention	Coffee Creek: increase application of extended wet detention by 10 acres by 2021 and 50 by 2031	Urban landowners	Implement 10 acres of extended wet detention in the critical areas by 2021	$4,000,000	PP = WG
			Implement 5 acres of extended wet detention annually (2021-2031)	$20,000,000	PP = WG
Increase acreage of porous pavement	Coffee Creek: increase application of porous pavement by 15 acres by 2021 and 10 acres by 2031	Urban landowners	Implement 15 acres of porous pavement in the critical areas by 2021	$6,500,000	PP = WG
			Implement 1 acre of porous pavement annually (2021-2031)	$4,400,000	PP = WG

*One cost share program will be developed.

Indicators for Success

Water quality and social data will be used to demonstrate progress toward these goals. The Hoosier Riverwatch volunteer program will be utilized to monitor water quality advances. Sampling for each subwatershed both before and after implementation will provide indications of progress. A social indicators survey will be conducted no less than five years after the start of implementation. The survey will be compared with the baseline survey to demonstrate progress.

10.3 Reduce *E. coli* Loading

Table 35. Action register to reduce *E. coli* loading

Objective	Strategy	Target Audience	Milestone	Cost	Possible Partners
Increase landowner awareness of septic system maintenance	Reynolds Creek: Reduce *E. coli* loading from septic systems	Rural and urban landowners	Develop and implement workshop on septic system	$40,000	PP = WG & Septics Coordation Group

			maintenance and education (2016-2031)		
	Kemper Ditch: reduce *E. coli* loading from septic systems		Annually identify funding for septic system maintenance and education	$1,000	PP = WG
	Coffee Creek: reduce *E. coli* loading from septic systems				

Indicators for Success

Water quality and social data will be used to demonstrate progress toward these goals. The Hoosier Riverwatch volunteer program will be utilized to monitor water quality advances. Sampling for each subwatershed both before and after implementation will provide indications of progress. A social indicators survey will be conducted no less than five years after the start of implementation. The survey will be compared with the baseline survey to demonstrate progress.

10.4 Improve Biological Communities

Table 36. Action register to improve biological communities

Objective	Strategy	Target Audience	Milestone	Cost	Possible Partners
Increase cover crop acreage	Reynolds Creek: Increase cover crops 57 acres by 2021 and 714 by 2031.	Agricultural landowners and operators	Annually identify cover crop funding options	$1,000	PP = Watershed Group (WG)
			Develop a cover crop demonstration area by 2017	$2,000*	PP = WG & SWCD TA = SWCD to provide guidance, location, and audience
	Kemper Ditch: Increase cover crops 530 acres by 2021 and 1,324 by 2031		Develop a cost-share program in 2016	$15,000*	PP = WG & SWCD TA = SWCD, NRCS, and Purdue Extension to provide guidance and promotion
			Host a biannual cover crop workshop (every other year from 2016 – 2031)	$20,000	PP = WG & SWCD TA = SWCD, NRCS and Purdue Extension to provide guidance, location, and audience

Objective	Strategy	Target Audience	Milestone	Cost	Possible Partners
	Coffee Creek: Increase cover crops 21 acres by 2021 and 532 by 2031		Create a contractors list for specific cover crop seeding in 2016	$500	PP = WG
			Implement 260 acres of cover crops annually (2021 – 2031)	$104,000	PP = WG & SWCD
			Implement 608 acres of cover crops in critical areas by 2021	$24,500	PP = WG & SWCD
Increase filter strip, infiltration swale, forested buffer, and riparian buffer acreage	Reynolds Creek: increase buffers 8 acres by 2021 and 172 acres by 2031	Agricultural land owners and operators, urban and rural landowners	Annually identify funding opportunities for filter strips and riparian buffers	$1,000	PP = WG
	Kemper Ditch: increase buffers 60 acres by 2021 and 318 acres 2031		Develop and host a biannual BMP field day from 2016 - 2031	$20,000	PP = WG & SWCD TA = SWCD, NRCS, and Purdue Extension to provide guidance, location and audience
	Coffee Creek: increase buffers 19 acres by 2021 and 377 by 2031		Develop a cost share program	*See Note	PP = WG & SWCD TA = SWCD to provide guidance and promotion
			Implement 87 acres of buffers annually (2021-2031)	$87,000	PP = WG
			Implement 87 acres of buffers in critical areas by 2021	$8,700	PP = WG
Increase the acreage of fields using nutrient management	Reynolds Creek: increase use of nutrient mgmt. 29 acres by 2012 and 571 by 2031	Agricultural landowners and operators	Annually identify funding opportunities for nutrient management	$1,000	PP = WG
	Kemper Ditch: increase use of nutrient mgmt. 371 acres by 2021 and 1,059 by 2031		Develop and host a biannual BMP field day from 2016 - 2031	$20,000	PP = WG & SWCD TA = SWCD, NRCS and Purdue Extension to provide guidance, location, and audience

Objective	Strategy	Target Audience	Milestone	Cost	Possible Partners
	Coffee Creek: increase use of nutrient mgmt. 21 acres by 2021 and 426 by 2031		Develop a cost share program	*See Note	PP = WG & SWCD TA = SWCD, NRCS and Purdue Extension to provide guidance and promotion
			Implement 206 acres nutrient management annually (2021-2031)	$31,000	PP = WG & SWCD
			Implement 421 acres of nutrient management in critical areas by 2021	$6,400	PP = WG & SWCD
Increase the acreage of fields using reduced tillage	Reynolds Creek: increase use of reduced tillage by 29 acres by 2021 and 571 by 2031	Agricultural landowners and operators	Implement 158 acres of reduced tillage annually (2021-2031)	$5,000	PP = WG & SWCD
	Kemper Ditch: increase use of reduced tillage by 371 acres by 2021 and 795 by 2031				
	Coffee Creek: increase use of reduced tillage by 11 acres by 2021 and 213 by 2031		Implement 411 acres of reduced tillage in critical areas by 2021	$5,000	PP = WG & SWCD
Increase landowner awareness of septic system maintenance	Reynolds Creek: Reduce nutrient & *E. coli* loading from septic systems	Rural and urban landowners	Develop and implement a workshop on septic system maintenance and education (2016-2031)	$40,000	PP = WG & Septics Coordination Group
	Kemper Ditch: reduce nutrient & *E. coli* loading from septic systems		Annually identify funding for septic system maintenance and education	$1,000	PP = WG

Objective	Strategy	Target Audience	Milestone	Cost	Possible Partners
	Coffee Creek: reduce nutrient & *E. coli* loading from septic systems				
Increase acreage of extended wet detention	Coffee Creek: increase application of extended wet detention by 10 acres by 2021 and 50 by 2031	Urban landowners	Implement 10 acres of extended wet detention in the critical areas by 2021	$4,000,000	PP = WG & MS4
			Implement 5 acres of extended wet detention annually (2021-2031)	$20,000,000	PP = WG & MS4
Increase acreage of porous pavement	Coffee Creek: increase application of porous pavement by 15 acres by 2021 and 10 acres by 2031	Urban landowners	Implement 15 acres of porous pavement in the critical areas by 2021	$6,500,000	PP = WG
			Implement 1 acre of porous pavement annually (2021-2031)	$4,400,000	PP = WG
Increase acreage of tree and shrub planting	Reynolds Creek: increase tree & shrub planting by 1 acre 2021 and 143 by 2031	Rural and urban landowners	Implement 13 acres of tree & shrub planting in the critical areas by 2021	$400,000	PP = WG
	Kemper Ditch: increase tree & shrub planting by 10 acres by 2021 and 200 by 2031		Implement 54 acres of tree planting annually (2021-2031)	$16,200,000	PP = WG
	Coffee Creek: increase tree & shrub planting by 2 acre in 2021 and 200 by 2031		Annually identify funding opportunities for tree and shrub planting	$1,000	PP = WG

Indicators for Success

Water quality and social data will be used to demonstrate progress toward these goals. The Hoosier Riverwatch volunteer program will be utilized to monitor biological communities and their habitat. Annual sampling for each subwatershed will provide indications of progress. A social indicators survey will be conducted no less than five years after the start of implementation. The survey will be compared with the baseline survey to demonstrate progress.

10.5 Increase Public Awareness and Participation

Table 37. Action register to increase public awareness and participation

Objective	Strategy	Target Audience	Milestone	Cost	Possible Partners (PP) and needed Technical Assistance (TA)
Increase community involvement and participation with watershed implementation activities	Develop a local volunteer water quality monitoring program using the Hoosier Riverwatch volunteer monitoring program	General public, businesses, schools	Facilitate training of key personnel and volunteers (2015-2021)	$3,500	PP = Watershed Group (WG)
			Annually recruit volunteers (2015-2031	$5,000	PP = WG
			Profile volunteers on partner websites and marketing efforts (2015-2031)	$3,500	PP = WG
			Monthly sampling at key sites throughout watershed	$50,000	PP = WG
Increase public awareness of watershed activities and participation in implementation activities	Share and communicate past, current, and future activities	General public, businesses, schools	Update watershed group activities to Save the Dunes website and provide information to partner organizations	$5,000	PP = WG
			Host semi-annual public meetings where stakeholders can receive updates and comment on watershed activities	$10,000	PP = WG
			Create pamphlets, brochures, and marketing materials as needed	$10,000	PP = Watershed Group (WG)

Objective	Strategy	Target Audience	Milestone	Cost	Possible Partners (PP) and needed Technical Assistance (TA)
			Create press releases quarterly or as needed	$1,000	PP = WG
Public understanding of water quality and watershed processes	Develop and conduct a social indicators survey	General public	Develop social indicator survey (2019 and 2029)	$20,000	PP = WG TA = Purdue University to do survey
			Disseminate survey to watershed home and landowners	$20,000	PP = WG
			Compile and analyze results	$20,000	PP = WG TA = Purdue University to do survey
Increase public knowledge of water quality and watershed processes	Host a field day or other educational event	General Public	Host field days with partner organizations to encourage the use of popular BMPs	$30,000	PP = WG
			Host educational workshops highlighting water quality, water pollution , and stream ecology	$10,000	PP = WG

10.6 Lack of Jurisdictional Coordination

Table 38. Action register for jurisdictional coordination

Objective	Strategy	Target Audience	Milestone	Cost	Possible Partners
Strengthen relationship with local governments to support watershed related policies	Encourage all municipalities to adopt watershed plan	Local politicians and other town officials	Present watershed plan and Implementation programs to NIRPC, drainage boards, and town councils (2015 – 2031)	$5,000	PP = WG

Increase cooperation among agencies to fund implementation	Develop and conduct educational workshops for municipalities and other agencies	Local politicians and other town officials	Host annual educational workshops for groups that typically do not attend watershed meetings to emphasize the benefits of implementation (2015-2031	$5,000	PP = WG

11.0 Project Tracking and Future Effectiveness

11.1 Indicator Tracking

The ultimate success of a watershed management plan relies on the ability of the stakeholders implement restoration activities. To track the progress of implementation action items, the Steering Committee will meet annually and as needed to evaluate progress and make changes.

Water quality indicators are measurements of water chemistry, biological communities, and aquatic habitats. Data will be collected as part of a volunteer water quality monitoring program developed using the Hoosier Riverwatch volunteer monitoring program. Data collected will include nitrate+nitrite, orthophosphorus, and turbidity, macroinvertebrate community composition, and stream habitat. Data will be collected at the subwatershed 'pour points' so that loading reductions can be calculated on a subwatershed level. This monitoring program will be conducted (at minimum) after 5, 15 and 25-years following implementation to assess progress made toward each interim goal. Water quality indicators will be compared to the 2012 Baseline study and will identify changes in water quality over time, changes in the biological community, and will quantify the effectiveness of BMP implementation. Data will be tracked using the Hoosier Riverwatch water quality database. Additional monitoring will supplement the volunteer monitoring, as funding allows.

A Water Quality Monitoring Committee will be convened annually to assess water quality reports and determine effectiveness of implemented best management practices. This committee will make recommendations for refining future implementation activities.

Social indicators provide information on stakeholder awareness, attitudes, and behaviors concerning water quality and watershed protection. Social indicators will track changes in stakeholder:

- knowledge of watershed processes
- attitudes toward BMPs and water quality improvement
- awareness of watershed activities, concerns, and accomplishments
- participation in watershed activities
- participation in cost-share and education activities

Social indicator data will be tracked using the social indicators survey. Funding will need to be acquired for this activity. The cost is estimated to be approximately $20,000. The LCEB Education Committee and Steering Committee will plan and implement the survey that will be conducted within 5 years, or as needed.

11.2 Future Plans and Considerations

To ensure the success of future watershed management plan updates, a long-term water quality dataset must be developed. An active volunteer driven water quality monitoring program will be developed using the Hoosier Riverwatch volunteer monitoring program. A committee will be created to evaluate monitoring efforts and collected data. The committee will meet annually to review data and provide recommendations to enhance and secure future water quality data collection.

The social indicators survey will be conducted no less than 5 years following the beginning of implementation. Additional social indicators surveys will be conducted as each phase of implementation progresses. The education committee will assist with the implementation and evaluation of each social indicators survey to determine changes in stakeholder knowledge, attitudes, and behavior.

Permission to implement BMPs on any piece of land must be obtained by the landowner prior to any installation. Many restoration activities require permits. All applicable permits must be acquired prior to any work on site.

A BMP Technical Committee will be established to evaluate the needs and effectiveness of any BMP implemented. This committee will meet annually and as needed during the different phases of implementation. The Steering Committee will meet annually at minimum to discuss the BMPs installed, plans for additional BMPs, plans for acquiring grant funds, and potential collaborations to increase implementation.

Each action item will be tracked on a quarterly basis and data will be maintained in a database. Progress will be tracked with measurable items such as BMPs installed, meetings and events held, and number of attendees at meetings and events.

Watershed management plans are intended to be living documents. Revisions and updates will be made as needed or desired by Save the Dunes and/or the Steering Committee. The LCEB Steering Committee suggests an update for this plan in five years.

For more information on this watershed management plan, please contact:

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Appendix 1. Social Indicator Study

LCEB Social Indicators Study
Your Views on Local Water Resources

A social indicators study was conducted within the LCEB watershed to identify the needs and concerns of the community regarding water quality. Another primary goal of the survey was to inform the watershed plan's planning and implementation activities. This survey also provides baseline data that can be used to estimate changes in community knowledge and concerns over time. The survey covered the social indicators developed for use in 319 funded watershed projects. The indicators are grouped into four categories: awareness, attitudes, constraints, and behaviors. Sociodemographic information was also collected.

A regional team of researchers from University of Illinois, Purdue University, Michigan State University, University of Minnesota, The Ohio State University, and University of Wisconsin developed the Social Indicator Planning and Evaluation System (SIPES) for Nonpoint Source Management. The survey produced for the LCEB watershed was a subset of relevant questions provided by SIPES. For more information on the SIPES project, please go to http://greatlakeswater.uwex.edu/social-indicators.

The survey was implemented using a five-wave mailing survey (Dillman, 2000). The 12-page survey was sent to 750 households in the LCEB watershed with 254 responses, which is an overall response rate of 34%. An advance notice letter was sent to potential respondents to inform them of the survey's purpose and that it would arrive the following week. The letter also included instructions on how to complete the survey on-line. The paper survey was sent the following week and a postcard reminder was sent two weeks later. A replacement survey was sent a week after the postcard. After two more weeks, a third replacement survey was sent to those not responding.

Rating of Water Quality

Overall, how would you rate the quality of the water in your area?

	Poor (1)	Okay (2)	Good (3)	Don't Know	Mean (SD)	Valid/Total Responses
1. For canoeing / kayaking / other boating	13.2	30	28.6	28.2	2.22 (0.73)	158 / 220
2. For eating locally caught fish	26	30.6	18.3	25.1	1.9 (0.76)	164 / 219
3. For swimming	23.2	41.4	22.3	13.2	1.99 (0.73)	191 / 220
4. For picnicking and family activities	7.4	31.9	49.5	11.1	2.47 (0.65)	192 / 216
5. For fish habitat	16	36.5	22.8	24.7	2.09 (0.71)	165 / 219
6. For scenic beauty	5	25.2	65.3	4.5	2.63 (0.58)	212 / 222

Your Water Resources

1. ***Of these activities, which is the most important to you? (Responses: 190)***

9.5% For canoeing / kayaking / other boating

10.5% For eating locally caught fish

17.9% For swimming

10% For picnicking and family activities

15.8% For fish habitat

36.3% For scenic beauty

2. ***Do you know where the rainwater goes when it runs off of your property? (Responses: 222)***

32.9% No

67.1% Yes

3. ***If you answered 'Yes' above, where does your rain water drain to?***

(see appendix for responses)

Your Opinions

Please indicate your level of agreement or disagreement with the statements below.

	Strongly Disagree (1)	Disagree (2)	Neither Agree Nor Disagree (3)	Agree (4)	Strongly Agree (5)	Mean (SD)	Valid/Total Responses
1. The way that I care for my lawn and yard can influence water quality in local streams and lakes.	5	5	6.3	54.8	28.9	3.97 (1)	239 / 239
2. It is my personal responsibility to help protect water quality.	1.3	1.3	13.1	51.3	33.1	4.14 (0.78)	236 / 236
3. It is important to protect water quality even if it slows economic development.	3.8	2.6	18.7	51.5	23.4	3.88 (0.93)	235 / 235
4. My actions have an impact on water quality.	3	2.6	12.1	57.3	25	3.99 (0.87)	232 / 232
5. I would be willing to pay more to improve water quality (for example: though local taxes or fees)	18.6	19.5	31.8	25.8	4.2	2.78 (1.15)	236 / 236
6. I would be willing to change the way I care for my lawn and yard to improve water quality.	4.7	5.1	21.3	53.6	15.3	3.7 (0.95)	235 / 235
7. The quality of life in my community depends on good water quality in local streams, rivers and lakes.	2.1	2.5	14.7	49.6	31.1	4.05 (0.87)	238 / 238

Water Impairments

Below is a list of water pollutants and conditions that are generally present in water bodies to some extent. The pollutants and conditions become a problem when present in excessive amounts. In your opinion, how much of a problem are the following water impairments in your area?

	Not a Problem (1)	Slight Problem (2)	Moderate Problem (3)	Severe problem (4)	Don't Know	Mean (SD)	Valid/Total Responses
1. Sedimentation (dirt and soil) in the water	11.4	13.6	25.8	11.9	37.3	2.61 (0.99)	148 / 236
2. Nitrogen	5.9	5.9	17.2	7.1	63.9	2.71 (0.97)	86 / 238
3. Phosphorus	5.9	5.5	15.7	7.2	65.7	2.7 (0.99)	81 / 236
4. Bacteria and viruses in the water (such as *E.coli* / coliform)	6.3	7.6	20.2	19.3	46.6	2.98 (0.99)	127 / 238
5. Salt / TDS / Chlorides	6.7	7.6	11.8	10.5	63.4	2.71 (1.08)	87 / 238
6. Not enough oxygen in the water	7.2	8.1	12.3	8.1	64.3	2.6 (1.05)	84 / 235
7. Invasive aquatic plants and animals	7.2	6.8	23.6	21.5	40.9	3.01 (0.99)	140 / 237
8. Habitat alteration harming local fish	7.6	8.8	19.3	13.9	50.4	2.8 (1.02)	118 / 238
9. High water temperature	13.1	9.7	12.7	5.5	59.1	2.26 (1.05)	97 / 237
10. Pesticides	4.7	6.4	20.8	17.8	50.4	3.04 (0.93)	117 / 236

Sources of Water Pollution

The items listed below are sources of water quality pollution across the country. In your opinion, how much of a problem are the following sources in your area?

	Not a Problem (1)	Slight Problem (2)	Moderate Problem (3)	Severe Problem (4)	Don't Know	Mean (SD)	Valid/Total Responses
1. Discharges from industry into streams and lakes	5.6	6.5	29.4	41.1	17.3	3.28 (0.88)	191 / 231
2. Discharges from sewage treatment plants	7.8	10.4	28.1	29.9	23.8	3.05 (0.97)	176 / 231
3. Soil erosion from construction sites	8.5	17	32.3	9.4	32.7	2.63 (0.88)	150 / 223
4. Soil erosion from farm fields	10.4	22.6	25.2	8.7	33	2.48 (0.91)	154 / 230
5. Soil erosion from shorelines and/or streambanks	11.3	22.6	28.3	10	27.8	2.51 (0.92)	166 / 230
6. Excessive use of lawn fertilizers and/or pesticides	5.2	17.8	30.4	21.7	24.8	2.91 (0.89)	173 / 230
7. Grass clippings and leaves entering storm drains	14.4	22.3	24	8.3	31	2.38 (0.95)	158 / 229
8. Improperly maintained septic systems	10	15.2	22.5	11.7	40.7	2.61 (0.99)	137 / 231
9. Manure from farm animals	14.8	20.5	17	9.2	38.4	2.33 (1)	141 / 229
10. Waste material from pets	19.6	23.9	13	6.5	37	2.1 (0.96)	145 / 230
11. Excessive use of fertilizers for crop production	8.6	15.5	23.3	18.1	34.5	2.78 (1)	152 / 232
12. Urban stormwater runoff	9.6	14.9	29.8	11	34.6	2.64 (0.93)	149 / 228
13. Residential stormwater runoff	10.9	19.7	29.7	6.6	33.2	2.48 (0.88)	153 / 229
14. Channelization of streams	10.9	9.6	15.7	7.9	55.9	2.47 (1.05)	101 / 229
15. Removal of riparian vegetation	8.4	8	14.7	6.7	62.2	2.52 (1.03)	85 / 225
16. Drainage/filling of wetlands	9.6	9.6	24.9	17.5	38.4	2.82 (1.02)	141 / 229
17. Wildlife	27.8	20.4	9.6	3	39.1	1.8 (0.88)	140 / 230
18. Yard maintenance	13.9	21.6	26.4	5.2	32.9	2.34 (0.89)	155 / 231

Consequences of Poor Water Quality

Poor water quality can lead to a variety of consequences for communities. In your opinion, how much of a problem are the following issues in your area?

	Not a Problem (1)	Slight Problem (2)	Moderate Problem (3)	Severe Problem (4)	Don't Know	Mean (SD)	Valid/Total Responses
1. Contaminated drinking water	38.7	18.3	16.5	9.1	17.4	1.95 (1.06)	190 / 230
2. Beach closures	7.3	22.8	42.2	19.4	8.2	2.8 (0.86)	213 / 232
3. Contaminated fish	6.5	19	28.9	23.3	22.4	2.89 (0.93)	180 / 232
4. Loss of desirable fish species	6.5	12.1	26.4	25.1	29.9	3 (0.95)	162 / 231
5. Reduced beauty of lakes or streams	16.5	27.8	24.3	16.5	14.8	2.48 (1.02)	196 / 230
6. Reduced quality of water recreation activities	10.7	26.6	28.3	15.5	18.9	2.6 (0.94)	189 / 233
7. Excessive aquatic plants or algae	8.6	15.9	25	20.7	29.7	2.82 (0.99)	163 / 232
8. Odor	20.2	26.6	17.2	11.2	24.9	2.26 (1.02)	175 / 233
9. Lower property values	24.9	18.5	15	10.3	31.3	2.16 (1.08)	160 / 233

Practices to Improve Water Quality

Please indicate which statement most accurately describes your level of experience with each practice listed below.

	Not Relevant for my Property	Never Heard of it (1)	Somewhat Familiar with it (2)	Know How to Use it; Not Using it (3)	Currently Use it (4)	Mean (SD)	Valid/Total Responses
1. Following the manufacturer's instructions when fertilizing lawn or garden	12.8	0	12	18.8	56.4	3.51 (0.73)	204 / 234
2. Keep grass clippings and leaves out of the roads, ditches, and gutters	13.3	3	10.3	8.6	64.8	3.56 (0.83)	202 / 233
3. Follow pesticide application instructions for lawn and garden	16.3	0.4	11.2	21	51.1	3.47 (0.74)	195 / 233
4. Regular servicing of septic system	45.9	2.2	7.8	6.5	37.7	3.47 (0.89)	125 / 231
5. Repair home sewage treatment system	50.4	3.9	10.5	7.9	27.2	3.18 (1.03)	113 / 228
6. Properly dispose of household waste (chemicals, batteries, florescent light bulbs, etc.)	2.6	0.9	12.8	9.8	73.9	3.61 (0.75)	228 / 234
7. Create wetland	58.6	10.8	16.8	3.4	10.3	2.32 (1.12)	96 / 232
8. Restore/enhance wetland	57.2	10	18.3	5.7	8.7	2.31 (1.05)	98 / 229
9. Protect streambanks and/or shorelines with vegetation	59	7	19.7	3.1	11.4	2.46 (1.07)	94 / 229
10. Use grass swales	47	27.6	8.2	4.7	12.5	2.04 (1.25)	123 / 232
11. Use wetland detention	57.8	21.7	10	3.9	6.5	1.89 (1.11)	97 / 230
12. Use porous pavement	42.7	25.9	13.8	6.9	10.8	2.05 (1.15)	133 / 232

Specific Constraints of Practices

Rain Garden: A garden that uses native plants to absorb and filter stormwater collected off a roof, parking lot, sidewalk, or driveway.

1. How familiar are you with this practice? (Responses: 232)

11.6% Not relevant
28.4% Never heard of it
35.8% Somewhat familiar with it
12.5% Know how to use it; not using it
11.6% Currently use it

2. If the practice is not relevant, please explain why.
(See appendix for responses)

3. Are you willing to try this practice? (Responses: 203)

28.6% Yes or already do
51.2% Maybe
20.2% No

How much do the following factors limit your ability to implement this practice?

	Not at All (1)	A Little (2)	Some (3)	A Lot (4)	Don't Know	Mean (SD)	Valid/Total Responses
4. Don't know how to do it	20.8	17.8	26.2	18.3	16.8	2.49 (1.09)	168 / 202
5. Time required	18.7	15.7	30.8	17.2	17.7	2.44 (1.06)	163 / 198
6. Cost	14.6	13.1	26.3	23.7	22.2	2.24 (1.08)	154 / 198
7. The features of my property make it difficult	19.3	17.8	13.2	19.8	29.9	2.52 (1.17)	138 / 197
8. Insufficient proof of water quality benefit	30.5	15.5	11.5	6	36.5	3.11 (1.02)	127 / 200
9. Desire to keep things the way they are	35.5	16.2	17.8	12.7	17.8	2.91 (1.12)	162 / 197
10. Physical or health limitations	50.7	15.4	11.4	9.5	12.9	3.23 (1.05)	175 / 201
11. Hard to use with my farming system	59.7	3.1	3.1	2.6	31.6	3.75 (0.71)	134 / 196
12. Lack of equipment	23.9	13.9	15.9	14.9	31.3	2.68 (1.17)	138 / 201

Phosphate Free Fertilizer: Fertilizer without phosphates, designed to reduce phosphorus runoff and water pollution

13. How familiar are you with this practice? (Responses: 229)

19.2% Not relevant

30.1% Never heard of it

28.8% Somewhat familiar with it

10% Know how to use it; not using it

11.8% Currently use it

14. If the practice is not relevant, please explain why.
(See appendix for response)

15. Are you willing to try this practice? (Responses: 195)

37.4% Yes or already do

46.7% Maybe

15.9% No

How much do the following factors limit your ability to implement this practice?

	Not at all (4)	A little (3)	Some (2)	A lot (1)	Don't Know	Mean (SD)	Valid/Total Responses
16. Don't know how to do it	34.9	8.9	14.1	20.3	21.9	2.75 (1.27)	150 / 192
17. Time required	38.9	11.6	15.3	10	24.2	3.05 (1.12)	144 / 190
18. Cost	27.5	10.1	18.5	14.8	29.1	2.71 (1.19)	134 / 189
19. The features of my property make it difficult	48.7	8.4	5.8	6.3	30.9	3.44 (0.98)	132 / 191
20. Insufficient proof of water quality benefit	41.7	8.3	7.8	5.7	36.5	3.35 (1.01)	122 / 192
21. Desire to keep things the way they are	50	7.9	13.7	6.3	22.1	3.3 (1.03)	148 / 190
22. Physical or health limitations	56.3	11.1	6.8	6.3	19.5	3.46 (0.95)	153 / 190
23. Hard to use with my farming system	58.8	2.1	2.7	2.1	34.2	3.79 (0.67)	123 / 187
24. Lack of equipment	39.6	7.3	9.8	5.5	37.8	3.3 (1.03)	102 / 164

Proper Pet Waste Disposal (including horses): Disposing of pet waste in a manner that prevents runoff to local waterways.

25. How familiar are you with this practice? (Responses: 229)

47.2% Not relevant
16.2% Never heard of it
14% Somewhat familiar with it
5.2% Know how to use it; not using it
17.5% Currently use it

26. If the practice is not relevant, please explain why.
(See appendix for responses)

27. Are you willing to try this practice? (Responses: 155)

47.1% Yes or already do
23.2% Maybe
29.7% No

How much do the following factors limit your ability to implement this practice?

	Not at all (4)	A little (3)	Some (2)	A lot (1)	Don't Know	Mean (SD)	Valid/Total Responses
28. Don't know how to do it	50.6	5.6	9.9	9.9	24.1	3.28 (1.12)	123 / 162
29. Time required	53.5	8.2	9.4	3.1	25.8	3.51 (0.87)	118 / 159
30. Cost	54.1	5.7	7	4.5	28.7	3.54 (0.91)	112 / 157
31. The features of my property make it difficult	59.5	5.1	3.8	0.6	31	3.79 (0.58)	109 / 158
32. Insufficient proof of water quality benefit	56.3	5.7	4.4	3.8	29.7	3.63 (0.83)	111 / 158
33. Desire to keep things the way they are	56.4	5.1	9	5.8	23.7	3.47 (0.97)	119 / 156
34. Physical or health limitations	64.2	3.1	4.4	3.1	25.2	3.71 (0.76)	119 / 159
35. Hard to use with my farming system	62.8	1.9	0.6	0	34.6	3.95 (0.26)	102 / 156
36. Lack of equipment	57.7	3.8	3.8	1.9	32.7	3.74 (0.69)	105 / 156

Rain Barrels: Devices designed to collect stormwater from roofs and gutters that can later be used to water a garden, lawn, or house plants.

37. How familiar are you with this practice? (Responses: 233)

6.4% Not relevant
3.4% Never heard of it
32.6% Somewhat familiar with it
42.9% Know how to use it; not using it
14.6% Currently use it

38. If the practice is not relevant, please explain why.
(See appendix for responses)

39. Are you willing to try this practice? (Responses: 208)
43.3% Yes or already do
38.9% Maybe
17.8% No

How much do the following factors limit your ability to implement this practice?

	Not at all (4)	A Little (3)	Some (2)	A Lot (1)	Don't Know	Mean (SD)	Valid/Total Responses
40. Don't know how to do it	54.2	17.7	12	6.8	9.4	3.32 (0.97)	174 / 192
41. Time required	43.9	18.4	20.9	7.7	9.2	3.08 (1.02)	178 / 196
42. Cost	33.8	15.9	21	17.4	11.8	2.75 (1.17)	172 / 195
43. The features of my property make it difficult	51.5	10.8	14.9	9.3	13.4	3.21 (1.08)	168 / 194
44. Insufficient proof of water quality benefit	58.2	12.4	7.7	5.2	16.5	3.48 (0.9)	162 / 194
45. Desire to keep things the way they are	61	6.2	12.8	8.2	11.8	3.36 (1.04)	172 / 195
46. Physical or health limitations	64.1	10.1	6.6	7.1	12.1	3.49 (0.94)	174 / 198
47. Hard to use with my farming system	70.8	2.7	2.7	1.6	22.2	3.83 (0.58)	144 / 185
48. Lack of equipment	36.5	9.5	16.9	21.2	15.9	2.73 (1.26)	159 / 189

Making Decisions for my Property

In general, how much does each issue limit your ability to change your management practices?

	Not at All (4)	A Little (3)	Some (2)	A Lot (1)	Don't Know	Mean (SD)	Valid/Total Responses

1. Personal out-of-pocket expense	15.1	16	29.8	32	7.1	2.15 (1.07)	209 / 225
2. My own physical abilities	40.2	16.1	21.4	16.1	6.2	2.86 (1.15)	210 / 224
3. Not having access to the equipment that I need	19.1	20.9	30.9	19.5	9.5	2.44 (1.05)	199 / 220
4. Lack of available information about a practice	19.1	21.4	27.7	22.3	9.5	2.41 (1.08)	199 / 220
5. No one else I know is implementing the practice	32.9	17.1	21.3	7.9	20.8	2.95 (1.04)	171 / 216
6. Approval of my neighbors	60.8	8.3	8.8	4.6	17.5	3.52 (0.9)	179 / 217
7. Don't know where to get information and/or assistance about those practices	29.2	18.7	25.6	12.3	14.2	2.76 (1.08)	188 / 219
8. Environmental damage caused by practice	42.5	9.3	15	3.7	29.4	3.28 (0.98)	151 / 214
9. Legal restrictions on my property	44.7	8.8	6.5	7.8	32.3	3.33 (1.06)	147 / 217
10. Concerns about resale value	47.5	13.8	12.4	7.8	18.4	3.24 (1.03)	177 / 217
11. Not being able to see a demonstration of the practice before I decide	32.6	17	22.5	11.5	16.5	2.85 (1.09)	182 / 218
12. The need to learn new skills or techniques	29.9	18.7	25.7	11.7	14	2.78 (1.07)	184 / 214

Interest in a Cost-Share Program

13. Would you be interested in participating in a cost-share program that could reimburse you for a portion of the expenses associated with installing practices on your property that improve water quality? (Responses: 226)

22.6% Yes

46% Unsure

31.4% No

About You

1. Do you make the home and lawn care decisions in your household? (Responses: 235)

88.9% Yes

11.1% No

2. What is your gender? (Responses: 231)

57.1% Male

42.9% Female

3. What is your age?

(Mean=57.52; SD = 14.37; Min = 22; Max = 91; Range = 69; n = 218)

4. What is the highest grade in school you have completed? (Responses: 231)

1.7% Some formal schooling

23.8% High school diploma/GED

20.8% Some college

7.4% 2 year college degree

26.4% 4 year college degree

19.9% Post-graduate degree

5. What was your total household income last year? (Responses: 191)

8.4% Less than $24,999

20.4% $25,000 to $49,999

19.4% $50,000 to $74,999

19.4% $75,000 to $99,999

32.5% $100,000 or more

6. What is your occupation?

(See appendix for responses)

7. What is the approximate size of your residential lot? (Responses: 234)

37.6% 1/4 acre or less

18.4% More than 1/4 acre but less than 1 acre

32.1% 1 acre to less than 5 acres

12% 5 acres or more

8. Do you own or rent your home? (Responses: 234)

99.6% Own

0.4% Rent

9. How long have you lived at your current residence (years)?

(Mean=19.82; SD = 14.38; Min = 0.5; Max = 66; Range = 65.5; n = 229)

10. Which of the following best describes where you live? (Responses: 233)

54.5% In a town, village, or city

25.8% In an isolated, rural, non-farm residence

16.7% Rural subdivision or development
3% On a farm

11. In addition to your residence, which of the following do you own or manage? (check all that apply)(Responses: 228)

4.8% An agricultural operation
9.6% Forested land
3.9% Rural recreational property
86.8% None of these

12. Do you use a professional lawn care service? (Responses: 231)

5.2% Yes, just for mowing
2.6% Yes, for mowing and fertilizing
10.4% Yes, just for fertilizing and pest control
2.6% Yes, for mowing, fertilizing, and pest control
79.2% No

13. Where are you likely to seek information about water quality issues? (Responses: 233)

38.2% Newsletters/brochure/fact sheet
45.5% Internet
6.4% Radio
43.3% Newspapers/magazines
18% Workshops/demonstrations/meetings
28.3% Conversations with others
10.7% None of the above

Information Sources

People get information about water quality from a number of different sources. To what extent do you trust those listed below as a source of information about soil and water?

	Not at all (1)	Slightly (2)	Moderately (3)	Very Much (4)	I Am Not Familiar	Mean (SD)	Valid/Total Responses
1. Local watershed project	4.4	7.1	24.8	40.7	23	3.32 (0.87)	174 / 226
2. Local government	9.3	24	42.2	16.4	8	2.71 (0.88)	207 / 225
3. U.S. Environmental Protection Agency	11.9	17.3	35.4	28.3	7.1	2.86 (1)	210 / 226
4. University Extension	7.5	5.8	30.1	42.9	13.7	3.26 (0.92)	195 / 226
5. State environmental agency	11	17.6	38.3	23.3	9.7	2.82 (0.96)	205 / 227
6. Environmental groups	11.5	19	31.4	28.3	9.7	2.85 (1.01)	204 / 226
7. Local garden center	5.8	16.6	36.8	32.7	8.1	3.05 (0.89)	205 / 223
8. Lawn care company	31.6	28.9	23.6	3.1	12.9	1.98 (0.88)	196 / 225
9. Neighbors / friends	14.2	31.4	33.2	13.7	7.5	2.5 (0.93)	209 / 226
10. State natural resources agency	10.3	15.2	33.9	27.7	12.9	2.91 (0.98)	195 / 224
11. County Health department	11.2	17.9	37.9	22.3	10.7	2.8 (0.96)	200 / 224
12. Land trust	15.6	17.4	20.1	11.2	35.7	2.42 (1.04)	144 / 224

Septic Systems

1. Do you have a septic system? (Responses: 229)

52.4% No

1.3% Don't Know

46.3% Yes

2. If you answered 'yes' to the previous question, in what year was it installed?

(Mean=1987.09; SD = 14.75; Min = 1955; Max = 2013; Range = 58; n = 78)

3. Within the last five years, have you had any of the following problems? (Check all that apply) (Responses: 185)

14.1% Slow drains

5.4% Sewage backup in house

6.5% Bad smells near tank or drain field

1.6% Sewage on the surface

0.5% Sewage flowing to ditch

0.5% Frozen septic

1.1% Other

78.9% None

1.6% Don't know

4. In the future, would you like a reminder from your local health department regarding inspection/maintenance of your septic system? (Responses: 171)

14.6% Yes

69.6% No

15.8% Don't know

5. Do you have a garbage disposal? (Responses: 196)

13.8% Yes, I use it daily

18.4% Yes, I use it occasionally

6.1% Yes, but I don't use it

61.7% No

6. Does your septic system have an absorption field (finger system)? (Responses: 156)

52.6% Yes

24.4% No

23.1% Don't know

7. How would you know if your septic system was NOT working properly? (Check all that apply) (Responses: 145)

46.9% Slow drains

50.3% Sewage backup in house

49.7% Bad smells
46.9% Toilet backs up
45.5% Wet spots in lawn
15.9% Pumping tank monthly or more
6.9% Straight pipe to ditch
10.3% Frozen septic
22.8% Don't know
10.3% Other

8. Is your septic system designed to treat sewage or get rid of waste? (Responses: 140)

14.3% Treat sewage
15% Get rid of waste
20.7% Both
10% Neither
40% Don't know

9. Do you think a local government agency should handle inspection and maintenance of septic systems?(Responses: 203)

30.5% Yes
48.3% No
21.2% Don't Know

Social Indicators Study Appendix

3. If you answered 'Yes' above, where does your rain water drain to?

Lower wetland
Absorbed into ground
River
Coffee Creek
Ground
Some to city drains, other to ground
Retention pond
Water table
Coffee creek watershed
Local retention pond
It goes into our pond and if the pond overflows {which is seldom} it goes thru a culvert into a marshy area on church property
Storm sewer to retention pond
Ditch behind property
The grass
Pope O'Connor Ditch
Storm sewer or into the ground
Storm sewer
Into sewer grates near the front and side yard
Storm drain
Retention pond
Little cal river
Into public sewers
Runs to the creek just to the south of our home
City water
Ground
Into a wetland
Coffee Creek and Chubb Lake
Drainage ditches, creeks, and ultimately to Lake Michigan
Next door and street to street drains
Streams
Salt Creek?
Ditches
Porter water plant
Porter water plant
Porter water plant
Sewer lift station
Little Calumet River
Sand Creek
Most ends up in town storm water system
From wake robin to little calumet river
Creeks at either ends of the street

My basement
South to farm acreage
Little Calumet River
In front to city sewer in back to ditch
To river but house is on 3.8 arc
Ditch on south side I-94
Storm sewer in roadway
County sewer
Carlson Pond
Storm ditches
West to a marsh
Lake Michigan
Farmers field
In the ground
Pope ditch
Into storm drain in street
We live in the country - drains eventually into a creek
Storm drain into yard
Aquifer
Local ditch
Storm water pipes direct to sand creek to little calumet
Supposed to drain to the pope O'Connor ditch, but I do not think it does from my yard. To much scrub plants and woods stopping it
The Ground
Into Coffee Creek
Coffee Creek
To a pond and in the ground
Little Calumet
Porter, IN. Sewers then into LCEB
Storm sewers
Sewer
Coffee Creek
Into the Little Calumet
The street and then to a stream
Coffee Creek
Little Calumet River
It drains to the bottom of our lot {we are on a hill, ridge} when there is a small pond on our neighbors property
Storm sewers
Street drains
Coffee Creek - stream runs behind me
Storm Drain
Town storm sewer
Ground-fields
Back into sky- down to ground water- LC River
Water retention area

Sewer at curb - then back to water shed
Storm sewer - city water
Creek @ back of property and Kemper ditch
Into retention pond in my front yard
Ground or neighbors property {north}
In the ground
Storm drain - Little Calumet River
Ditch
Runs into a swale in back or the street in front to the west into a small lake
To storm sewer
Into our wells, and rivers, and lakes
Over the land
The public rain drainage system {we are on a hill}
To the back ditch
Local creek to Little Calumet River
Eventually, Lake Michigan
Sewer then not sure
Storm drain
County ditch to neighboring stream
Our local creek
Coffee Creek
My yard
The ground into aquifer
Coffee Creek
Mud Lake
It sits in my backyard
Wetland to the south
To an illegal wetland
The beginning of Coffee Creek in Jackson TWSP
Swamp areas of our property
Pond, little Cal River
Ground
To front run off ditch which runs into creek
Sewers
Storm sewer inlet at Porter Ave. then north
Rivers and streams
Little Calumet River
To the wetland
Maybe east branch Little Calumet R.
Into the woods
Goes to the river
Yard and street
Drains North to creek just West {near Rice Lake}
Into Chesterton water plant or if full spills into creeks leading to Lake Michigan
Peterson ditch, Little Cal, Lake Michigan
Percolate

To the east of my property, a low swampy area
Wetland conservation area
Griffin Lake
Retention pond - creek
Carver ditch via underground drain pipes
In to coffee creek, but 99 percent stays on my property
Storm water intakes
A drain {storm drain} @ the junction of street and driveway
Drainage ditch
Storm drain
Into the ground or sewer-storm run off
Lake Michigan
My front yard and neighbors pond
Into the town storm sewer or soaks into lawn
I believe it goes to the storm sewer located in the back corner of our property
Wetlands - greater than Little Cal
Storm sewers
Low lying area

2. Rain Garden: If the practice is not relevant, please explain why.

Large parcel with plenty of natural drainage
My property is a farm field with no structures
No garden
No garden
Not a rain garden but permanent plantings 3 sides of home to absorb water
Small yard
no room
RURAL AREA
no gardens
water drains away swiftly into ground
stream behind me
Do not Garden
Live in the dunes, sand base
my property is a hay field
No garden
I do not collect
space not available-mosquitos
not enough yard
no garden at present
yard is large and absorbs water well

14. Phosphate-Free Fertilizer: If the practice is not relevant, please explain why.

do not fertilize
do not fertilize
Don’t use fertilizer
I rent the property
We do not fertilize
No Major Pollution
do not use fertilizer
Do not farm
Do not fertilize but if decide to will watch ingredients
Do not fertilize
do not fertilize
do not use fertilizer
I do not use lawn fertilizers
do not fertilize
we do not use any fertilizer
We do not fertilize
Do not fertilize
I do not farm- do not fertilize farm plants
I do not fertilize my property
not a farmer
not interested
do not fertilize
don’t use fertilizer
like weeds
I do not fertilizer
Do not use fertilizer
do not use fertilizer
Do not use fertilizer
do not ever fertilizer
do not use fertilizer
I do not farm my property- I rent it out
not farming
not farming
use prof. service
do not use any fertilizer
do not use any
do not use fertilizer
we use no fertilizer
do not use fertilizer in laws or garden

26. Proper Pet Waste Disposal: If the practice is not relevant, please explain why.

I dispose of pet waste in trash
No pets
No pets
No pets
cats
do not own a pet
No pets
No Animals
no pets
no pets
No Pets
no pets
I have no pets.
No pets or animals
No animals
No Pets
Do not own pet
No pets or horses
I do not have a farm
No Animals
no pets
no pets
I do not have pets
No pets, horses, etc.
Have no pets
no pets
no pets
no pets
no pets
no pets
no pets
no pets
no pets
no pets
No pets
No pet
Do not own animals
do not farm
no pets
no animals
no pet waste
do not have pet
no pets
do not own any

no pet
Have dogs - Not cattle
no pets
do not have horses
property does not drain to waterways
no animals
I have no pets
no pet
No Animals
business location-no animals
have no pets
no dogs
no pets
No pets
no pets
no pets
do not have animals
We do not have animals
not a farmer-no pets
we have no pets
we have a dog that is 1.5 lbs
no pets
have no pets
do not have pets
I have 1-2 acre residential, no farm animals
no animals
do not have a pet
no animals
No pets
no animals
no outside pets
no pets
no pets
No pets
no pets
No pets
very small pet dog
not a farmer
no animals
no pets
no animals presently
2 cats - only and always outside
do not have pet
Do not own a pet
do not have pets

38. Rain Barrel: If the practice is not relevant, please explain why.

Barrels fill up so fast it is useless. A 55 gal. drum fills in minutes in a big rain. Unless you store hundreds of gallons, it's a joke
Live on lake
I never water anything
Do not water
have sprinkler system
no gutters
do not water my plants
absorbed by property
good gutters and good water shed
storm water absorbed by yard

6. What is your occupation?

medical
programmer
Retired
Vice President
Computer tech
Consultant
retired
auto repair
Broker
chemist
technical sales
Manager of Manufacturing
Technology
Homemaker
Retired
Small Business Owner
Retired
Bus driver-cashier-sales
Retired
Data center manager
retired
Teacher
retired
dental office
retired
retired

Disabled
military
Park Ranger
teacher
Accountant
steel sales
Retired
Retired
Education - teachers
Supervisor
pipefitter
steelworker
laborer and landscaper
millwright
Electrician and AC tech
retired
Office Staff
Art Teacher and Egg Grower
Sales
Sales
Sales
Nursing
education
Retired
educator
millwright
retired teacher
Engineer
Retired
teacher
construction
truck driver
retired power plant mechanic
steel mills
housewife
construction estimator
HR supervisor
steel worker
homemaker
sales
retired
teacher
researcher at museum

retired
baker
retired
teacher
at-home-mother
retired
forestry
millwright
retired
Self Employed
Bus Repair
Retired with a part-time job + rental property
teacher
retired
maintenance supervisor
retired
medical assistant
electrician
retired public school teacher
retired
manufacturing
retired
retired
retired
Environmental Scientist
retired
retail
welder
retired
steel worker
insurance agent
steel worker
retired
retired
Accountant-Administrator
business owner
drafter
retired
retied
business owner
retired
pharmacist
executive assistant-secretary

military
engineer
retired
Financial Advisor
retired
retired
business owner
college prof.
home health aide
operations manager
housewife
retired
retired
carpenter
farmer
retail sales
editor
sheet metal worker
custody officer
trucking manager
RE development
retired
housewife
retired educator
domestic
stay at home mom --_ husband is an electrician
firefighter
retired
veterinarian
environmental scientist
inside sales rep
retired teacher
production worker
self employed
craneman
retired
retired
homemaker
landscape architect
steel worker
retired
disability
retired

shipping supervisor
teacher aide
retired
house wife
retired
retired
retired
teacher
union millwright
consultant
retired engineer
steelworker
RN
librarian
electrical cont.
retired
social worker
engineer
millwright
teacher
retired
ret.
maintenance
retired
bus driver
power plant operator
retired educator
housewife
retired educator
retired printer
house maker
aquatic biologist
artist
factory worker
attorney
business owner
retired journalist
retired
teacher
carpenter
self employment
retired
supervisor

electrician
sales

Appendix 2. Endangered, Threatened, and Rare Species

ENDANGERED, THREATENED, AND RARE SPECIES
VASCULAR PLANTS
CURRENT RECORDS – 1951 TO PRESENT

SPECIES NAME	COMMON NAME	STATE STATUS	FED STATUS	HABITAT
Actaea rubra	Red baneberry	SR	**	Wetland
Andromeda glaucophylla	Bog rosemary	SR	**	Wetland
Arenaria stricta	Michaux's stitchwort	SR	**	Sand Dune, Prairie
Botrychium matricariifolium	Chamomile grape-fern	SR	**	Sand Dune, Forest
Calla palustris	Wild calla	SE	**	Wetland
Carex atlantica capillacea	Howe sedge	SE	**	Wetland
Carex leptonervia	Finely-nerved sedge	SE	**	Wetland, Forest
Carex pedunculata	Longstalk sedge	SR	**	Forest, Floodplain
Carex scabrata	Rough sedge	SE	**	Wetland, Forest
Chrysosplenium americanum	American golden-saxifrage	ST	**	Wetland
Cypripedium calceolus	Small yellow lady's-slipper	SR	**	Forest
Cypripedium candidum	Small white lady's-slipper	SR	**	Prairie, Wetland
Diervilla lonicera	Northern bush-honeysuckle	SR	**	Forest
Eriophorum angustifolium	Narrow-leaved cotton-grass	SR	**	Wetland
Eriophorum gracile	Slender cotton-grass	ST	**	Wetland
Juglans cinerea	Butternut	WL	**	Forest
Juncus articulatus	Jointed rush	SE	**	Wetland
Juncus balticus littoralis	Baltic rush	SR	**	Wetland
Lycopodium hickeyi	Hickey's clubmoss	SR	**	Forest
Malaxis unifolia	Green adder's-mouth	SE	**	Wetland
Panax trifolius	Dwarf ginseng	WL	**	Forest
Pinus banksiana	Jack pine	SR	**	Forest
Pinus stobus	Eastern white pine	SR	**	Forest

SPECIES NAME	COMMON NAME	STATE STATUS	FED STATUS	HABITAT
Platanthera hyperborean	Leafy northern green orchid	ST	**	Wetland, Forest
Poa alsodes	Grove meadow grass	SR	**	Forest
Potamogeton vaseyi	Vasey's pondweed	SE	**	Aquatic
Sparganium androcladum	Branching bur-reed	ST	**	Aquatic
Spiranthes lucida	Shining ladies'-tresses	SR	**	Wetland
Utricularia geminiscapa	Hidden-fruited bladderwort	SE	**	Wetland
Valerianella chenopodiifolia	Goose-foot corn-salad	SE	**	Forest
Viburnum opulus americanum	Highbush-cranberry	SE	**	Forest, Wetland

STATE EX – Extirpated SE – Endangered ST – Threatened SR – Rare SC – Special concern
WL – Watch list SG - Significant ** - Rarity warrants concern

FEDERAL LE – Endangered LT – Threatened CA – Candidate ** - Not listed

ENDANGERED, THREATENED, AND RARE SPECIES
MAMMALS AND BIRDS

SPECIES NAME	COMMON NAME	STATE STATUS	FED STATUS	HABITAT
Condylura cristata	Star-nosed mole	**SC**	**	Wetlands
Spermophilus franklinii	Franklin's ground squirrel	**SE**	**	Prairie
Taxidea taxus	American badger	**SE**	**	Prairie, Forest
Ammodramus henslowii	Henslow's sparrow	**SE**	**SC**	Prairie
Ardea alba	Great egret	**SC**	**	Wetland
Ardea herodias	Great blue heron	**	**	Wetland
Botarurus lentiginosus	American bittern	**SE**	**	Wetland
Cistothorus platensis	Sedge wren	**SE**	**	Wetland
Dendroica cerulean	Cerulean warbler	**SE**	**SC**	Forest
Dendroica virens	Black-throated green warbler	**	**	Forest
Ixobrychus exilis	Least bittern	**SE**	**	Wetland
Lanius ludovicianus	Loggerhead Shrike	**SE**	**SC**	Prairie
Lasiurus borealis	Eastern Red bat	**SC**	**	Forest
Lasiurus cinereus	Hoary Bat	**SC**	**	Forest
Lynx rufus	Bobcat	**SC**	**	Forest, Prairie
Myotis lucifugus	Little Brown bat	**SC**	**	Forest
Myotis sodalis	Indiana Bat	**SE**	**LE**	Forest
Nycticorax nycticorax	Black-crowned night heron	**SE**	**	Wetland
Pipistrellus subflavus	Eastern pipistrelle	**SC**	**	Forest
Rallus elegans	King rail	**SE**	**	Wetland
Vermivora chrysoptera	Golden-winged warbler	**SE**	**	Forest, Wetland
Wilsonia canadensis	Canada warbler	**	**	Forest
Wilsonia citrine	Hooded Warbler	**SC**	**	Forest

STATE EX – Extirpated SE – Endangered ST – Threatened SR – Rare SC – Special concern
WL – Watch list SG - Significant ** - Rarity warrants concern

FEDERAL LE – Endangered LT – Threatened CA – Candidate ** - Not listed

ENDANGERED, THREATENED, AND RARE SPECIES
AMPHIBIANS AND REPTILES

SPECIES NAME	COMMON NAME	STATE STATUS	FED STATUS	HABITAT
Ambystoma laterale	Blue-spotted salamander	SC	**	Forest
Clemmys guttata	Spotted turtle	SE	**	Wetland, Aquatic
Emydoidea blandingii	Blandings turtle	SE	**	Wetland, Aquatic
Necturus maculosus	Common mudpuppy	SC	**	Aquatic
Rana pipiens	Northern leopard frog	SC	**	Wetland

ENDANGERED, THREATENED, AND RARE SPECIES
INSECTS

SPECIES NAME	COMMON NAME	STATE STATUS	FED STATUS	HABITAT
Aeshna mutate	Spatterdock darner	SR	**	Wetland
Sympetrum semicimctum	Band-winged meadowhawk	ST	**	Wetland

STATE EX – Extirpated SE – Endangered ST – Threatened SR – Rare SC – Special concern
WL – Watch list SG - Significant ** - Rarity warrants concern

FEDERAL LE – Endangered LT – Threatened CA – Candidate ** - Not listed

Appendix 3. Description of Study Sites

2012 Baseline Sampling Sites						
SITE ID	IDEM Site #	County	Latitude (DD)	Longitude (DD)	Stream Name	Description
1	LMG060-0005	Porter	41.6125	-87.173889	Burns Waterway	CRISMAN RD
2	LMG-03-0002	Porter	41.599583	-87.146438	Salt Creek Outlet	US HWY 20
3	LMG-04-0043	Porter	41.611505	-87.150245	Little Calumet River East Branch 11	IN DUNES NATIONAL LAKESHORE
4	LMG-04-0044	Porter	41.612456	-87.147137	Samuelson Ditch Downstream	IN DUNES NATIONAL LAKESHORE
5	LMG060-0008	Porter	41.616944	-87.126111	Little Calumet River East Branch 10	SR 149
6	LMG-04-0001	Porter	41.622533	-87.094516	Little Calumet River East Branch 9	HOWE RD
7	LMG-04-0002	Porter	41.620309	-87.091617	Peterson Ditch Downstream	HOWE RD
8	LMG-04-0003	Porter	41.607661	-87.094115	Peterson Ditch Upstream	OLD PORTER RD
9	LMG-04-0004	Porter	41.622104	-87.087075	Little Calumet River East Branch 8	HOWE RD
10	LMG-04-0005	Porter	41.62219	-87.067504	Little Calumet River East Branch 7	WAVERLY RD
11	LMG-04-0006	Porter	41.621305	-87.049151	Little Calumet River East Branch 6	CALUMET RD
12	LMG-04-0007	Porter	41.617223	-87.050261	Coffee Creek 6	CALUMET RD
13	LMG-04-0008	Porter	41.608867	-87.049684	Coffee Creek 5	MORGAN AVE - COFFEE CREEK PARK
14	LMG-04-0009	Porter	41.599712	-87.048395	Pope O'Connor Ditch Downstream	CALUMET RD
15	LMG-04-0010	Porter	41.586329	-87.061366	Pope O'Connor Ditch Upstream	CR 1050 N
16	LMG-04-0011	Porter	41.593686	-87.040189	Coffee Creek 4	CR 1100 N
17	LMG-04-0012	Porter	41.57013	-87.030305	Johnson Ditch	UNNAMED ROAD
18	LMG-04-0013	Porter	41.571135	-87.027963	Coffee Creek 3	CR 200 E
19	LMG-04-0014	Porter	41.573136	-87.028068	Shooter Ditch	CR 200 E
20	LMG-04-0015	Porter	41.555632	-87.007617	Coffee Creek 2	MANDER RD
21	LMG-04-0016	Porter	41.542129	-87.003628	Coffee Creek 1	OLD SUMAN ROAD
22	LMG-04-0017	Porter	41.616913	-87.03231	Lower Sand Creek	INDIAN BOUNDARY RD
23	LMG-04-0018	Porter	41.585804	-87.009135	Middle Sand Creek	CR 1050 N
24	LMG-04-0019	Porter	41.571279	-86.989096	Upper Sand Creek	CR 400 E
25	LMG-04-0020	Porter	41.616947	-87.022035	Little Calumet River East Branch 5	WOODLAN RD
26	LMG-04-0021	Porter	41.62249	-87.010524	CR 1200 N Tributary	CR 1300 N
27	LMG-04-0022	Porter	41.606911	-86.989634	Rice Lake Outlet	CR 1200 N
28	LMG-04-0023	Porter	41.593937	-86.989876	Mar Mac Lake Creek	CR 400 E
29	LMG-04-0024	Porter	41.593799	-86.975069	Rice Lake Inlet East	CR 475 E

2012 Baseline Sampling Sites						
SITE ID	**IDEM Site #**	**County**	**Latitude (DD)**	**Longitude (DD)**	**Stream Name**	**Description**
30	LMG-04-0025	Porter	41.609392	-86.980248	CR 450 E Tributary	CR 450 E
31	LMG-04-0026	Porter	41.622471	-86.987077	CR 1300 N Tributary	CR 1300 N
32	LMG-04-0027	Porter	41.623877	-86.980522	Little Calumet River East Branch 4	CR 450 E
33	LMG-04-0028	Porter	41.6274	-86.951488	Little Calumet River East Branch 3	600 E
34	LMG-04-0029	Porter	41.629716	-86.941804	Carver Ditch Downstream	CR 1350 N
35	LMG-04-0030	Porter	41.64406	-86.951364	Kelleys Ditch	CR 600 E
36	LMG-04-0031	Porter	41.651302	-86.941878	Carver Ditch Upstream	CR 1500 N
37	LMG-04-0032	Porter	41.651432	-86.9325	Kemper Ditch	CR 1500 N
38	LMG-04-0033	Porter	41.617216	-86.946359	Massauga Creek Downstream	CR 1275 N
39	LMG-04-0034	Porter	41.606993	-86.948035	Spring Branch	CR 1200 N
40	LMG-04-0035	Porter	41.602435	-86.936543	Massauga Creek Upstream	CR 1200 N
41	LMG-04-0036	Porter	41.61722	-86.941943	Reynolds Creek Downstream	CR 1275 N
42	LMG-04-0037	Laporte	41.598106	-86.92209	Reynolds Creek Upstream	SNYDER RD
43	LMG-04-0038	Porter	41.621951	-86.932241	Little Calumet River East Branch 2	COUNTY LINE RD
44	LMG-04-0039	Laporte	41.612775	-86.906092	Little Calumet River East Branch 1	OTTIS RD
45	LMG-04-0040	Laporte	41.599986	-86.895417	Lake Lee Outlet	SNYDER RD
46	LMG-04-0041	Laporte	41.614002	-86.885886	Walton Lake Outlet	HOMESVILLE RD
47	LMG-04-0042	Laporte	41.602372	-86.880367	Round Lake Outlet	HOMESVILLE RD
48	LMG-04-0045	Porter	41.6194	-87.1453	Samuelson Ditch Upstream	US-12 (N side of South Shore RR)
49		Porter	41.35443	-86.59391	Mar Mac Lake Inlet	CR 450 E
50		Porter	41.35441	-86.59511	Mar Mac Lake Outlet	CR 450 E

Appendix 4. Water Quality Data

Date	Site ID	Temp (deg C)	DO (mg/l)	pH	Ammonia (mg/l)	Nitrate + Nitrite (mg/l)	Total phosphorus (mg/l)	Total Suspended Solids (mg/l)	E. coli (CFU/100 ml)	Chloride (mg/l)
11/28/11	3	9.0	11.0	8.01	<0.1	0.5	0.12	21	387.3	36
1/3/12	3	5.7	14.2	8.04	0.3	0.6	0.05	12	72.8	44
2/6/12	3	7.3	13.3	8.18	0.1	0.7	<0.03	4	26.6	41
3/5/12	3	8.3	12.7	8.23	0.2	0.7	<0.05	5	38.8	43
4/2/12	3	15.5	10.6	8.22	0.2	0.7	<0.05	<10	14.6	32
4/30/12	3	17.1	9.0	7.96	0.2	0.8	0.08	<10	39.3	35
6/4/12	3	21.9	7.8	8.05	0.2	1	0.07	<10	88.6	39
6/12/12	3	26.2	7.9	8.14						
7/2/12	3	27.5	6.6	7.94	0.2	0.78	0.06	<10	64.4	33
8/6/12	3	27.7	7.2	8.04	0.2	0.6	0.08	<10	78.4	29
8/6/12	3	28.4	7.4	8.05						
9/10/12	3	23.9	7.9	8.21	0.2	1	0.10	10	150	37
10/1/12	3	22.4	7.9	8.02	0.2	0.7	<0.05	<10	60.9	30
11/13/12	3	13.6	10.8	8.35	0.3	0.8	0.06	<10	86	23
11/28/11	4	14.2	9.4	8.12	0.3	0.4	0.04	6	5.2	30
1/3/12	4	8.9	12.4	8.09	0.4	0.4	0.04	7	7.2	40
2/6/12	4	9.7	12.6	8.37	0.3	0.4	<0.03	4	13.2	34
3/5/12	4	12.0	10.9	8.35	0.4	0.5	<0.03	4	6.3	35
4/2/12	4	17.3	8.9	8.17	0.3	0.4	<0.05	<10	2	28
4/30/12	4	18.8	8.6	7.91	0.3	0.5	0.06	<10	13.5	26
6/4/12	4	24.6	7.8	8.03	0.2	0.4	<0.05	<10	29.9	28
6/12/12	4	27.1	7.8	7.88						
8/6/12	4	29.6	7.7	8.10	0.2	0.3	0.07	<10	26.5	29
8/6/12	4	29.7	7.3	7.95						
9/10/12	4	27.3	7.4	8.20	0.2	0.4	0.07	<10	12.1	26
10/1/12	4	24.0	7.3	8.07	0.2	0.3	0.06	<10	7.5	25
11/13/12	4	15.2	9.3	8.18	0.4	0.5	<0.05	13	13.2	27
12/1/11	5	2.7	11.8	8.25	<0.1	0.7	0.06	10		43
1/17/12	5	2.7	12.7	8.26	<0.1	0.8	0.05	15		89
2/23/12	5	3.1	12.7	8.37	<0.1	1.1	<0.03	5	260	67
3/20/12	5	16.8	8.4	8.37	<0.1	1.3	0.04	17	100	56
4/19/12	5	14.1	8.7	8.12	<0.1	1.3	0.04	13	64	55
5/22/12	5	16.1	8.5	8.18	<0.1	1.5	0.10	29	550	49
6/5/12	5	19.9	8.5	8.16						
6/26/12	5	18.2	7.9	8.23	<0.1	2.6	0.07	23	200	63
7/24/12	5	24.3	6.8	8.17	<0.1	2.3	0.09	34	920	62
8/13/12	5	19.1	7.8	7.71						

Date	Site ID	Temp (deg C)	DO (mg/l)	pH	Ammonia (mg/l)	Nitrate + Nitrite (mg/l)	Total phosphorus (mg/l)	Total Suspended Solids (mg/l)	E. coli (CFU/100 ml)	Chloride (mg/l)
8/14/12	5	18.2	8.1	8.21	<0.1	2	0.10	40	1000	60
9/26/12	5	14.3	9.0	8.09	<0.1	2.6	0.05	19	550	61
10/16/12	5	10.7	9.2	8.00	<0.1	1.3	0.06	14	320	49
11/20/12	5	7.7	10.6	8.00	<0.1	1.9	0.03	7	140	58
11/28/11	6	6.5	11.0	7.85	<0.1	0.5	0.17	19	387.3	38
1/3/12	6	0.0	14.3	8.07	<0.1	0.6	0.05	7	83.9	47
2/6/12	6	2.7	14.0	8.27	<0.1	1.2	0.03	6	108.1	49
3/5/12	6	2.5	14.1	8.14	<0.1	0.9	<0.03	6	95.9	54
4/30/12	6	11.7	9.3	7.91	<0.1	0.9	0.10	11	248.1	41
6/4/12	6	18.7	8.0	7.94	<0.1	1.2	0.15	17	285.1	40
6/7/12	6	20.2	7.4	8.28						
7/2/12	6	23.2	6.9	7.48	<0.1	2	0.19	18	387.3	45
8/6/12	6	22.6	7.6	8.01	<0.1	1.1	0.21	15	435.2	38
8/13/12	6	18.8	7.2	7.75						
9/10/12	6	14.6	9.2	7.91	0.1	0.7	0.14	<10	307.6	110
10/1/12	6	13.8	9.0	8.05	<0.1	2.9	0.15	10	290.9	48
11/13/12	6	7.0	11.9	7.96	<0.1	1	0.06	<10	186	38
11/28/11	7	6.8	10.8	7.74	<0.1	0.3	0.10	5	365.4	64
1/3/12	7	1.4	14.5	7.87	<0.1	0.5	0.04	<4	35.4	106
2/6/12	7	3.3	15.7	8.21	<0.1	0.3	<0.03	<4	67	102
3/5/12	7	4.6	14.3	8.00	<0.1	0.3	<0.03	4	21.6	114
4/2/12	7	13.3	13.4	8.38	<0.1	0.2	<0.05	<10	57.3	100
4/30/12	7	11.8	9.7	7.81	<0.1	0.5	0.11	<10	547.5	95
5/18/12	7	15.2	9.5	8.33						
6/4/12	7	18.3	9.3	7.83	<0.1	0.7	0.10	<10	178.9	140
7/2/12	7									
8/6/12	7									
8/6/12	7	21.6	8.8	7.85						
9/10/12	7	17.3	8.1	7.94	<0.1	1.3	0.14	17	461.1	46
10/1/12	7									
11/13/12	7	5.8	11.3	7.77	<0.1	0.6	0.08	<10	613.1	100
6/19/12	7	22.8	7.9	7.86	0.10	0.68	<0.1	4.4	689.6	
6/26/12	7	19.8	9.0	7.97		0.73	<0.1	3.6	774.6	
7/2/12	7	22.6	7.7	7.77	0.087	0.65	<0.1	4.4	976.8	
7/10/12	7	21.3	9.8	8.02		0.75	<0.1	4.2	476.4	
7/17/12	7	22.3	7.6	7.81	0.095	0.67	0.19	4.2	1454.0	
7/19/12	7	23.4	6.1	7.39		0.83	0.18	19	11000.0	
7/19/12	7	23.5	6.1	7.40	Dup at 38				6400.0	
7/24/12	7	22.4	6.4	7.53	0.2	0.64		11	7945.2	
7/31/12	7	22.0	6.6	7.46	0.097	0.65	0.13	9.8	9678.4	
8/7/12	7	21.4	8.0	7.86	0.07	0.68	<0.1	2.4	1960.8	
8/14/12	7	20.0	7.3	7.7		<0.5	<0.1	<2	1844.4	

Date	Site ID	Temp (deg C)	DO (mg/l)	pH	Ammonia (mg/l)	Nitrate + Nitrite (mg/l)	Total phosphorus (mg/l)	Total Suspended Solids (mg/l)	E. coli (CFU/100 ml)	Chloride (mg/l)
11/28/11	8	7.0	10.3	7.53	<0.1	0.3	0.07	<4	146.7	57
1/3/12	8	2.0	15.0	7.59	<0.1	0.4	0.04	<4	62	77
2/6/12	8	3.8	15.1	7.92	<0.1	0.4	<0.03	4	47.9	83
3/5/12	8	5.8	13.6	7.55	<0.1	0.3	<0.03	<4	27.9	101
4/2/12	8	14.0	13.4	7.72	<0.1	0.4	0.07	<10	67.7	21
4/30/12	8	11.8	10.5	7.6	<0.1	0.5	0.10	<10	579.4	79
6/4/12	8	15.9	5.6	7.62	0.2	1.1	0.17	<10	187.2	86
6/4/12	8	15.7	5.5	7.82						
7/2/12	8	18.3	4.5	7.54	0.2	1	0.18	<10	579.4	57
8/6/12	8	18.0	4.8	6.55						
9/10/12	8	15.7	5.0	7.95	0.1	1.5	0.30	<10	1046.2	70
10/1/12	8	13.1	5.9	7.59	<0.1	1.6	0.20	<10	137.6	73
11/13/12	8	6.5	7.1	7.79	<0.1	1.2	0.17	13	178.5	69
11/28/11	9	6.4	10.0	7.86	<0.1	0.6	0.16	18	613.1	39
1/3/12	9	0.1	14.4	8.03	<0.1	0.8	0.06	5	123.4	45
2/6/12	9	2.8	14.1	8.27	<0.1	1.2	0.03	4	25.6	49
3/5/12	9	2.6	14.1	8.6	<0.1	1.1	<0.03	9	83.6	55
4/2/12	9	11.5	11.5	8.27	<0.1	1.3	0.07	<10	37.3	48
4/30/12	9	11.5	9.3	7.84	<0.1	1.2	0.11	10	165.8	44
6/4/12	9	18.8	8.3	7.96	<0.1	1.2	0.12	14	344.8	40
6/6/12	9	17.2	8.5	8.13						
7/2/12	9	23.8	7.5	7.94	<0.1	1.2	0.11	14	435.2	40
8/6/12	9	22.4	7.6	8.02	<0.1	1.1	0.18	17	579.4	39
8/6/12	9	22.9	7.4	7.84						
9/10/12	9	17.5		8.14	0.1	1	0.12	19	488.4	43
10/1/12	9	14.0	9.6	8.07	<0.1	1.3	0.11	12	298.7	41
11/13/12	9	7.0	11.8	8.12	<0.1	0.8	0.12	<10	146.7	39
6/26/12	9	21.5	7.6	8.08		1.3	<0.1	17	615.2	
7/2/12	9	24.2	7.1	7.97	0.069	1.4	<0.1	16	402.8	
7/10/12	9	24.6	7.1	8.03		1.3	<0.1	14	396.6	
7/17/12	9	27.0	6.0	7.94	0.071	1.3	<0.1	13	402.8	
7/19/12	9				0.1	1	0.14	49	9400	
7/24/12	9	24.4	6.1	7.87	0.097	2.3		24	1461.6	
7/31/12	9	24.1	6.3	7.86	0.15	1.6	<0.1	21		
8/7/12	9	23.1	6.9	7.91	0.061	1.3	<0.1	19	334.0	
8/14/12	9	19.8	7.6	7.95			0.11	22	471.2	
11/28/11	10	6.4	10.2	7.88	<0.1	0.6	0.16	20	228.2	38
1/3/12	10	0.5	14.7	8.07	<0.1	1	0.07	7	167.4	46
3/5/12	10	3.2	14.6	8.22	<0.1	1.2	<0.03	6	172.5	53
4/2/12	10	11.6	11.4	8.28	<0.1	1.3	0.07	<10	50.4	43
4/30/12	10	11.7	9.3	7.76	<0.1	1.5	0.13	12	275.5	40
6/4/12	10	18.0	8.5	7.99	<0.1	2.5	0.11	12	218.7	41
6/5/12	10	16.0	10.0	8.11						
7/2/12	10	23.1	7.7	7.85	<0.1	2.6	0.21	14	488.4	40

Date	Site ID	Temp (deg C)	DO (mg/l)	pH	Ammonia (mg/l)	Nitrate + Nitrite (mg/l)	Total phosphorus (mg/l)	Total Suspended Solids (mg/l)	E. coli (CFU/100 ml)	Chloride (mg/l)
8/6/12	10	22.3	7.9	8.02	<0.1	2.5	0.19	25	435.2	44
8/13/12	10	18.4	8.0	7.81						
9/10/12	10	16.8	9.2	8.16	<0.1	2.2	0.15	13	325.5	45
10/1/12	10	13.5	9.7	8.08	<0.1	3.1	0.16	10	410.6	43
11/13/12	10	6.7	11.5	8.13	<0.1	1.5	0.06	<10	161.6	35
11/28/11	11	6.3	10.0	7.85	<0.1	0.3	0.16	17	249.5	31
1/3/12	11	0.6	15.4	8.11	<0.1	0.2	0.04	7	3.0	34
2/6/12	11	3.2	15.3	8.38	<0.1	0.2	<0.03	5	22.3	33
3/5/12	11	4.2	15.2	8.3	<0.1	0.2	<0.03	7	5.2	37
4/2/12	11	13.1	12.0	8.39	<0.1	<0.1	0.06	11	35.9	28
4/30/12	11	12.5	9.3	7.87	<0.1	<0.1	0.10	10	133.3	29
6/4/12	11	19.5	8.8	8.01	<0.1	0.1	0.15	19	214.2	31
6/5/12	11	16.0	8.3	8.15						
7/2/12	11	24.3	7.6	7.98	<0.1	0.13	0.10	20	461.1	29
8/6/12	11	23.6	7.8	8	<0.1	0.1	0.23	27	307.6	29
8/14/12	11	17.0	7.6	7.78						
9/10/12	11	16.6	8.5	8.12	0.1	<0.1	0.16	16	461.1	30
10/1/12	11	12.3	9.0	8.03	<0.1	<0.1	0.12	16	325.5	26
11/13/12	11	6.4	11.1	8.08	<0.1	<0.1	<0.05	<10	78.0	29
11/28/11	12	6.3	11.5	8.05	<0.1	0.4	0.06	6	325.5	51
1/3/12	12	0.1	15.6	8.16	<0.1	0.2	<0.03	4	13.4	53
2/6/12	12	2.7	14.8	8.33	<0.1	0.2	<0.03	5	95.9	54
3/5/12	12	3.4	14.2	8.17	<0.1	0.2	<0.03	5	16.1	71
4/2/12	12	12.6	12.0	8.39	<0.1	<0.1	<0.05	<10	52.0	45
4/30/12	12	12.0	9.6	7.91	<0.1	<0.1	0.08	<10	488.4	37
6/4/12	12	18.7	8.5	7.96	<0.1	0.1	0.10	12	290.9	35
6/4/12	12	19.2	8.4	8.41						
7/2/12	12	23.8	8.1	8.03	<0.1	0.14	0.07	<10	816.4	30
8/6/12	12	22.9	8.9	8.18	<0.1	<0.1	0.12	<10	579.4	29
8/7/12	12	20.3	7.3	8.01						
8/7/12	12	20.3	7.3	8.01						
9/10/12	12	16.9	9.3	8.14	0.1	<0.1	0.11	<10	410.6	32
10/1/12	12	12.9	10.0	8.07	<0.1	<0.1	0.08	<10	344.8	28
6/11/12	12	20.8	6.7	8.12		0.18	<0.1	33	922.2	
6/19/12	12	22.1	6.5	8.03	0.26	<0.5	<0.1	29	1034.4	
6/26/12	12	18.0	7.7	8.15		0.14	<0.1	31	976.8	
7/2/12	12	21.7	6.7	8.03	0.095	0.18	<0.1	26	1095.0	
7/10/12	12	21.4	6.6	7.98		0.16	0.11	34	922.2	
7/17/12	12	24.2	6.2	7.97	0.068	0.17	<0.1	16	651.0	
7/19/12	12	23.6	5.6	7.64	0.11	0.45	0.24	100	9000.0	
7/24/12	12	23.9	6.4	7.84	0.19	0.29		73	5654.4	
7/31/12	12	22.3	6.3	7.87		0.33	0.10	30		
8/7/12	12	20.3	6.9	8.03	0.071	0.16	<0.1	17	1397.6	
8/14/12	12	17.7	7.8	8.05		0.14	<0.1		1549.2	

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11/28/11	13	6.2	11.6	8.05	<0.1	0.4	0.04	4	290.9	50
1/3/12	13	0.1	14.9	8.15	<0.1	0.2	<0.03	4	18.3	48
2/6/12	13	2.8	14.3	8.31	<0.1	0.2	<0.03	7	99.0	52
3/5/12	13	4.1	13.7	8.18	<0.1	0.2	<0.03	5	18.9	62
4/2/12	13	13.5	12.1	8.42	<0.1	<0.1	<0.05	<10	43.9	42
4/30/12	13	12.1	9.6	7.98	<0.1	0.1	0.11	12	365.4	44
6/4/12	13	19.2	8.3	8.09	<0.1	<0.1	0.10	<10	365.4	31
6/4/12	13	19.6	8.2	8.42						
7/2/12	13	24.4	7.9	8.08	<0.1	0.12	0.07	<10	579.4	29
8/6/12	13	23.3	8.2	8.17	<0.1	<0.1	0.15	<10	517.2	26
8/7/12	13	20.3	8.2	8.06						
9/10/12	13	17.5	9.0	8.31	<0.1	<0.1	0.10	<10	344.8	29
10/1/12	13	13.0	10.1	8.21	<0.1	<0.1	<0.05	<10	727.0	26
11/13/12	13	6.3	12.1	8.14	<0.1	<0.1	<0.05	<10	65.0	27
11/28/11	14	6.4	9.6	7.67	<0.1	0.8	0.06	<4	272.3	113
1/3/12	14	0.7	15.3	7.85	<0.1	0.5	<0.03	4	90.6	128
2/6/12	14	2.5	16.6	8.16	<0.1	0.4	<0.03	<4	290.9	140
4/2/12	14	16.6	15.4	8.52	<0.1	<0.1	<0.05	<10	30.5	140
4/30/12	14	12.9	9.0	7.21	<0.1	<0.1	0.08	11	285.1	120
6/4/12	14	21.5	9.9	7.93	0.2	0.5	0.21	<10	90.6	120
6/4/12	14	22.3	8.3	8.17						
7/2/12	14	27.9	3.1	7.66	1.6	0.14	0.59	<10	307.6	73
8/6/12	14	25.7	5.2	7.71	0.3	0.3	0.27	<10	290.9	92
8/7/12	14	22.4	5.3	7.51						
9/10/12	14	19.4	8.1	8.11	0.1	0.2	0.18	<10	686.7	71
10/1/12	14	13.8	7.4	7.92	<0.1	<0.1	0.14	<10	517.2	180
11/13/12	14	6.9	9.6	7.95	<0.1	<0.1	0.14	20	290.9	84
11/28/11	15	6.2	9.3	7.46	<0.1	0.9	0.05	<4	260.3	128
2/6/12	15	2.0	16.8	7.98	<0.1	0.6	<0.03	<4	18.7	134
3/5/12	15	5.8	15.1	7.75	<0.1	0.6	<0.03	<4	6.3	152
4/2/12	15	13.5	19.9	7.63	<0.1	<0.1	<0.05	<10	20.9	160
4/30/12	15	12.4	10.3	7.62	<0.1	<0.1	0.05	<10	235.9	170
6/4/12	15	18.3	7.2	7.89	0.7	<0.1	0.37	<10	37.3	140
11/28/11	16	5.4	10.7	7.93	<0.1	0.3	<0.03	4	261.3	35
1/3/12	16	0.1	15.4	8.15	<0.1	0.2	<0.03	6	12.0	37
2/6/12	16	2.8	14.2	8.3	<0.1	0.2	<0.03	5	44.8	36
3/5/12	16	4.2	14.0	8.21	<0.1	0.2	<0.03	4	12.1	39
4/2/12	16	13.8	11.6	8.42	<0.1	<0.1	<0.05	<10	18.5	29
4/30/12	16	14.1	9.8	7.9	<0.1	<0.1	0.09	12	235.9	39
6/4/12	16	20.4	8.2	8.17	<0.1	<0.1	0.14	11	135.4	24
6/4/12	16	20.7	10.2	8.54						
7/2/12	16	25.2	8.1	8.16	<0.1	0.091	0.05	<10	579.4	22
8/6/12	16	24.0	8.6	8.31	<0.1	<0.1	0.11	<10	387.3	24
8/7/12	16	22.6	13.1	8.08						

Date	Site ID	Temp (deg C)	DO (mg/l)	pH	Ammonia (mg/l)	Nitrate + Nitrite (mg/l)	Total phosphorus (mg/l)	Total Suspended Solids (mg/l)	E. coli (CFU/100 ml)	Chloride (mg/l)
8/7/12	16	22.6	13.1	8.08						
8/7/12	16	22.6	13.1	8.08						
9/10/12	16	18.4	9.3	8.28	<0.1	<0.1	0.08	<10	387.3	23
10/1/12	16	13.6	9.9	8.22	<0.1	<0.1	<0.05	<10	365.4	19
11/13/12	16	6.1	12.3	8.14	<0.1	<0.1	<0.05	<10	86.0	24
11/28/11	17	5.7	11.1	7.87	<0.1	0.2	0.06	14	1413.6	35
1/3/12	17	0.4	14.2	8.02	<0.1	0.1	<0.03	<4	34.5	39
2/6/12	17	2.8	14.8	8.23	<0.1	0.1	<0.03	<4	65.0	39
3/5/12	17	4.6	14.5	8.18	<0.1	0.1	<0.03	<4	8.6	37
4/2/12	17	14.4	13.1	8.4	<0.1	<0.1	0.06	<10	66.3	30
4/30/12	17	11.6	9.8	7.81	<0.1	<0.1	0.11	<10	866.4	29
6/4/12	17	19.1	8.0	8.06	<0.1	0.2	0.20	50	> 2419.6	27
6/5/12	17	17.6	8.6	8.50						
7/2/12	17	24.3	7.4	8.06	<0.1	0.2	0.11	22	1119.9	27
8/6/12	17	22.8	8.2	8.38	<0.1	0.1	0.14	<10	727.0	26
8/7/12	17	23.8	8.1	8.07						
9/10/12	17	17.6	8.9	8.25	<0.1	<0.1	0.13	<10	613.1	27
10/1/12	17	13.6	9.1	8.09	<0.1	<0.1	0.09	<10	2419.6	24
11/13/12	17	5.4	11.7	8.02	<0.1	<0.1	0.12	<10	107.1	35
11/29/11	18	5.2	11.3	8.01	<0.1	0.2	0.05	6	228.2	21
1/3/12	18	0.7	14.8	8.09	<0.1	0.1	0.04	5	38.9	22
2/6/12	18	2.7	14.1	8.23	<0.1	0.2	<0.03	12	45.0	22
3/5/12	18	4.1	13.0	8.16	<0.1	0.2	<0.03	5	16.1	22
4/2/12	18	14.5	10.6	8.35	<0.1	<0.1	0.06	<10	41.4	20
4/30/12	18	12.3	9.7	7.88	<0.1	<0.1	0.08	<10	91.0	19
6/4/12	18	19.6	8.3	8.04	<0.1	<0.1	0.07	<10	139.6	19
6/5/12	18	18.1	8.6	8.46						
7/2/12	18	23.9	7.8	7.98	<0.1	0.073	0.05	<10	156.5	19
8/6/12	18	23.4	8.3	8.23	<0.1	<0.1	0.15	<10	166.4	20
8/7/12	18	23.4	8.0	7.98						
9/10/12	18	17.8	9.0	8.18	<0.1	<0.1	0.07	<10	307.6	18
10/1/12	18	13.4	9.9	8.07	<0.1	<0.1	0.06	<10	613.1	18
11/13/12	18	5.4	12.2	8.08	<0.1	<0.1	<0.05	<10	68.9	18
11/29/11	19	4.5	9.6	7.68	<0.1	0.3	0.07	4	131.4	59
1/3/12	19	1.3	13.5	7.6	0.2	0.3	0.06	16	48.8	72
2/6/12	19	2.7	12.3	7.8	0.2	0.2	0.05	19	24.1	101
3/5/12	19	4.3	12.3	7.77	<0.1	0.2	<0.03	8	14.4	63
4/2/12	19	15.4	12.0	8.27	<0.1	<0.1	0.10	17	86.0	71
4/30/12	19	12.6	5.4	7.61	<0.1	<0.1	0.11	<10	816.4	91
6/5/12	19	20.2	9.0	8.15						
7/2/12	19	20.1	1.2	7.39	0.6	0.067	0.14	17	50.4	57
8/6/12	19	22.0	1.6	7.32	0.2	<0.1	0.24	14	67.7	45
8/8/12	19	20.3	2.3	7.24						
9/10/12	19	18.5	5.5	7.81	0.1	<0.1	0.23	27	101.9	85

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10/1/12	19	13.1	5.0	7.74	0.2	<0.1	0.13	25	307.6	40
11/13/12	19	7.0	10.9	7.87	<0.1	<0.1	0.27	33	151.5	65
11/29/11	20	5.5	11.0	7.9	<0.1	0.3	0.05	4	517.2	21
1/3/12	20	2.1	14.4	7.99	<0.1	0.2	<0.03	4	21.8	22
2/6/12	20	4.0	13.5	8.15	<0.1	0.2	<0.03	7	18.3	23
3/5/12	20	7.0	11.9	8.04	<0.1	0.2	<0.03	6	11.0	24
4/2/12	20	16.1	10.5	8.25	<0.1	<0.1	0.05	<10	36.9	21
4/30/12	20	12.9	9.3	7.78	<0.1	<0.1	0.14	16	365.4	21
6/4/12	20	21.0	8.4	8.08	<0.1	<0.1	<0.05	<10	95.9	21
6/5/12	20	21.0	7.4	8.12						
7/2/12	20	25.9	7.8	7.99	<0.1	0.065	0.06	<10	517.2	21
8/6/12	20	23.8	7.9	8.16	<0.1	<0.1	0.11	<10	290.9	22
8/8/12	20	17.3	8.5	7.86						
8/8/12	20	17.3	8.5	7.86						
9/10/12	20	19.5	9.0	8.15	<0.1	<0.1	0.12	<10	228.2	20
10/1/12	20	14.7	9.4	8.06	<0.1	<0.1	0.08	11	248.1	19
11/13/12	20	7.7	11.3	7.98	<0.1	<0.1	0.08	<10	137.4	20
6/11/12	20	22.9	7.9	8.14		<0.5	<0.1	8.2	181.2	
6/19/12	20	24.6	8.0	8.05	0.11	<0.5	<0.1	8.4	208.6	
6/26/12	20	21.5	8.6	8.05		<0.5	<0.1	6.6	251.8	
7/2/12	20	23.6	7.8	7.96	0.14	<0.5	<0.1	6.8	551.0	
7/10/12	20	21.2	8.1	7.97		<0.5	<0.1	8.0	497.8	
7/17/12	20	26.5	7.2	7.96	0.027	0.11	<0.1	6.2	730.8	
7/24/12	20	22.5	7.5	7.81	0.1	0.14	<0.1	9.4	1163.6	
7/31/12	20	22.2	7.6	7.80		<0.5	<0.1	6.8		
7/31/12	20	22.3	7.5	7.81		0.11	<0.1	8.6		
8/7/12	20	21.9	7.5	7.89	0.035	0.11	<0.1	3.8	130.6	
8/14/12	20	21.1	7.6	7.82	0.089	0.21	<0.1	11	211.2	
8/14/12	20	21.1	7.6	7.82			<0.1		226.0	
11/29/11	21	5.3	8.9	7.73	<0.1	0.5	0.16	66	1413.6	12
1/3/12	21	1.6	15.0	7.89	<0.1	0.2	<0.03	7	9.7	13
2/6/12	21	3.6	13.4	8.06	<0.1	0.2	<0.03	4	30.1	11
3/5/12	21	6.2	12.5	7.93	<0.1	0.3	<0.03	6	70.3	12
4/2/12	21	16.1	9.5	8.09	<0.1	<0.1	0.06	<10	39.9	12
4/30/12	21	13.0	9.0	7.72	<0.1	<0.1	0.11	<10	93.3	11
6/4/12	21	22.7	7.8	7.95	<0.1	<0.1	0.09	<10	190.4	11
6/5/12	21	22.2	7.5	8.77						
7/2/12	21	27.3	7.4	7.99	<0.1	0.084	0.08	<10	1299.7	11
8/6/12	21	25.2	7.3	8.07	<0.1	<0.1	0.15	14	378.4	12
8/8/12	21	20.2	8.6	7.93						
10/1/12	21	15.8	9.1	8.02	<0.1	<0.1	0.09	14	201.4	10
11/13/12	21	7.3	11.2	7.95	<0.1	0.1	0.13	<10	29.5	10
11/28/11	22	6.8	11.0	8.14	<0.1	0.4	0.07	7	37.3	34
1/4/12	22	0.2	15.3	8.11	<0.1	0.5	0.04	<4	85.7	40

Date	Site ID	Temp (deg C)	DO (mg/l)	pH	Ammonia (mg/l)	Nitrate + Nitrite (mg/l)	Total phosphorus (mg/l)	Total Suspended Solids (mg/l)	E. coli (CFU/100 ml)	Chloride (mg/l)
2/7/12	22	2.9	13.8	8.2	<0.1	0.5	<0.03	5	22.8	42
3/6/12	22	4.1	13.7	8.18	<0.1	0.4	<0.03	9	12.1	42
4/3/12	22	11.8	9.3	8.09	<0.1	<0.1	0.20	38	62.7	37
6/5/12	22	15.6	7.7	7.75	0.1	0.6	0.15	<10	579.4	49
6/5/12	22	16.2	8.5	8.98						
7/3/12	22	22.0	7.6	7.58	0.1	0.61	0.30	11	980.4	62
8/7/12	22	22.1	6.7	7.86	0.1	0.5	0.23	<10	579.4	64
8/13/12	22	18.4	8.9	7.57						
9/11/12	22	15.5	8.6	8	<0.1	0.4	0.25	<10	1203.3	72
10/1/12	22	12.6	7.1	7.89	<0.1	0.4	0.18	<10	547.5	76
11/13/12	22	4.1	12.1	7.97	<0.1	<0.1	<0.05	<10	126.7	47
6/26/12	22	15.6	7.6	7.82		0.66	<0.1	53	976.8	
7/2/12	22	19.9	5.6	7.68	0.15	0.67	0.13	5.4	1373.4	
7/10/12	22	19.2	5.8	7.74		0.59	0.17	8.4	656.4	
7/17/12	22	22.8	5.1	7.67	0.15	0.53	0.15	6.2	2092.4	
7/19/12	22	22.8	5.0	7.03	0.18	0.73	0.32	56	6700.0	
7/24/12	22	23.1	5.6	7.40	0.39	0.43		21	6212.4	
7/31/12	22	20.9	5.5	7.51	0.25		0.12	9.4	9678.4	
8/7/12	22	18.3	5.2	7.62	0.13	0.43	0.12	7	615.2	
8/14/12	22	17.3	5.8	7.53			<0.1		1379.2	
11/29/11	23	5.5	11.3	7.88	<0.1	0.4	0.09	10	920.8	54
1/4/12	23	1.0	16.1	8.11	<0.1	0.4	0.04	<4	78.0	60
2/7/12	23	3.3	16.2	8.34	<0.1	0.4	<0.03	<4	114.5	55
4/3/12	23	10.7	14.0	8.34	<0.1	0.1	0.05	<10	435.2	50
5/1/12	23	12.4	11.2	8.09	<0.1	0.3	0.05	<10	275.5	67
6/4/12	23	16.0	9.0	7.81						
6/5/12	23	15.4	9.3	7.91	0.1	0.5	<0.05	<10	> 2419.6	46
7/3/12	23	21.0	9.0	7.78	<0.1	0.53	0.11	48	866.4	45
8/7/12	23	21.0	9.7	8.3	<0.1	0.3	0.12	<10	155.3	48
8/14/12	23	18.1	9.5	8.14						
9/11/12	23	15.5	9.2	8.15	<0.1	0.4	0.10	12	488.4	47
10/2/12	23	12.5	9.7	8.12	<0.1	0.2	0.10	<10	517.2	64
11/14/12	23	4.8	12.9	7.92	<0.1	<0.1	<0.05	<10	111.2	52
11/29/11	24	4.7	11.0	7.61	<0.1	0.2	0.12	24	> 2419.6	93
1/4/12	24	0.6	15.4	7.64	<0.1	0.2	<0.03	9	4.1	647
2/7/12	24	2.3	14.7	7.98	<0.1	0.2	<0.03	4	12.0	488
3/6/12	24	6.7	13.1	7.91	<0.1	0.1	<0.03	<4	3.1	580
4/3/12	24	9.9	11.0	7.88	<0.1	0.2	<0.05	<10	110.6	500
5/1/12	24	12.4	9.5	7.67	<0.1	0.1	0.12	<10	48.7	820
11/28/11	25	6.2	10.0	7.86	<0.1	0.3	0.16	14	66.3	30
1/4/12	25	0.7	13.8	8.06	<0.1	0.2	<0.03	5	63.8	34
2/7/12	25	3.0	13.5	8.26	<0.1	0.2	<0.03	<4	30.5	30
3/6/12	25	3.3	13.1	8.11	<0.1	0.2	<0.03	8	35.9	38
4/3/12	25	11.5	9.5	8.16	<0.1	<0.1	0.12	13	122.3	26

Date	Site ID	Temp (deg C)	DO (mg/l)	pH	Ammonia (mg/l)	Nitrate + Nitrite (mg/l)	Total phosphorus (mg/l)	Total Suspended Solids (mg/l)	E. coli (CFU/100 ml)	Chloride (mg/l)
5/1/12	25	12.0	9.5	7.85	0.1	0.4	0.15	23	272.3	32
6/5/12	25	15.6	6.2	7.99	<0.1	0.1	0.06	19	549.3	24
6/6/12	25	15.7	8.4	8.12						
7/3/12	25	22.0	7.9	7.75	<0.1	0.13	0.10	23	410.6	29
8/7/12	25	20.2	8.4	8.2	<0.1	<0.1	0.15	16	613.1	28
8/14/12	25	16.4	8.7	7.91						
9/11/12	25	15.6	7.9	8.07	<0.1	<0.1	0.13	14	435.2	27
11/14/12	25	4.4	12.6	7.99	<0.1	<0.1	<0.05	<10	98.7	28
6/13/12	25	17.3	8.3	8.34		0.17	<0.1	16	689.6	
6/13/12	25	17.5	8.2	8.27		0.17	<0.1	15	496.2	
6/19/12	25	21.6	6.6	8.07	0.16	0.18	<0.1	27	651.0	
1/4/12	26	0.5	13.0	7.66	<0.1	0.2	0.05	<4	32.3	86
2/7/12	26	2.3	7.9	7.92	<0.1	0.2	0.03	10	124.6	82
3/6/12	26	2.7	13.5	7.75	<0.1	0.2	0.04	5	44.6	116
4/3/12	26	9.9	8.7	7.73	<0.1	<0.1	0.12	<10	107.1	75
5/1/12	26	12.0	8.9	7.7	1.1	1.8	0.16	20	770.1	190
6/5/12	26	14.5	6.8	7.59	0.1	0.1	0.14	19	86.0	110
6/6/12	26	13.6	4.5	7.16						
7/3/12	26									
8/7/12	26	20.3	3.7	7.78	0.2	<0.1	0.44	17	344.8	100
8/13/12	26	18.6	5.3	7.66						
9/11/12	26	15.6	8.8	8.12	<0.1	<0.1	0.25	<10	1203.3	130
10/2/12	26	12.6	3.5	7.85	<0.1	<0.1	0.49	<10	23.3	86
11/14/12	26	3.3	9.7	8	<0.1	<0.1	0.06	<10	410.6	130
11/28/11	27	6.8	11.1	8.08	<0.1	<0.1	<0.03	<4	26.5	35
1/4/12	27	2.5	14.5	8.09	<0.1	0.1	0.03	<4	18.3	34
2/7/12	27	3.7	13.9	8.23	<0.1	0.2	<0.03	4	37.7	33
3/6/12	27	6.0	13.0	8.15	<0.1	<0.1	<0.03	<4	19.7	32
4/3/12	27	13.0	10.7	8.28	<0.1	<0.1	0.09	<10	32.3	28
5/1/12	27	13.5	9.9	8.11	<0.1	<0.1	0.08	<10	34.1	26
6/4/12	27	19.6	7.7	7.98						
6/5/12	27	14.6	8.3	7.92	<0.1	<0.1	0.08	32	248.1	25
7/3/12	27	23.6	7.1	7.71	<0.1	0.34	0.21	<10	866.4	26
8/7/12	27	32.1	7.2	8.03	<0.1	0.3	0.39	14	93.3	25
8/14/12	27	19.5	7.9	7.96						
8/14/12	27	19.5	7.9	7.96						
9/11/12	27	17.8	8.7	8.14	<0.1	0.3	0.25	<10	172.6	24
10/2/12	27	13.7	9.8	8.05	<0.1	<0.1	0.15	<10	191.8	38
11/14/12	27	6.9	11.4	7.94	<0.1	<0.1	<0.05	40	108.1	31
6/13/12	27	18.0	7.9	8.14		0.23	<0.1	7.4	164.0	
6/20/12	27	22.4	6.8	7.88	0.17	0.30	<0.1	6.0	330.0	
6/27/12	27	21.1	7.4	7.90		0.36	<0.1	8.0	251.8	
7/5/12	27	25.8	6.4	8.01	0.051	0.31	0.22	5.8	832.0	
7/11/12	27	21.8	7.5	7.87		0.37	0.14	3.6	520.6	

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7/18/12	27	25.1	6.1	7.72	0.24	0.27	<0.1	8.6	387.0	
7/25/12	27	23.9	6.4	7.80	0.15	1.1	0.18	4.6	159.6	
8/1/12	27	23.5	6.6	7.74	0.16	0.27	0.18	6.2	121.8	
8/8/12	27	23.6	6.2	7.76	0.074	0.29	0.21	4	69.0	
8/15/12	27	21.4	7.0	7.85	0.21	0.26	0.26	5.2	105.8	
11/29/11	28	6.3	10.4	7.93	<0.1	0.2	0.04	<4	23.1	41
1/4/12	28	2.7	13.6	8.02	<0.1	0.2	<0.03	<4	5.2	43
2/7/12	28	3.8	13.4	8.18	<0.1	0.2	<0.03	<4	81.6	37
3/6/12	28	6.3	12.4	8.03	<0.1	0.2	<0.03	<4	172.3	38
4/3/12	28	11.9	10.8	8.21	<0.1	<0.1	0.07	<10	344.8	33
5/1/12	28	12.0	9.7	7.88	0.1	0.1	0.09	<10	172.2	35
6/4/12	28	16.9	7.9	7.96						
6/5/12	28	16.0	3.0	7.84	0.1	0.2	0.10	14	193.5	29
7/3/12	28	21.0	8.1	7.77	<0.1	0.16	0.16	15	435.2	29
8/7/12	28	20.9	8.1	7.95	<0.1	0.1	0.14	<10	201.4	31
8/14/12	28	18.2	8.4	8						
9/11/12	28	16.8	9.3	8.21	<0.1	<0.1	0.16	<10	325.5	35
10/2/12	28	12.9	9.4	8.07	<0.1	<0.1	0.09	<10	816.4	44
11/14/12	28	6.3	10.7	7.9	<0.1	<0.1	<0.05	<10	56.5	44
6/13/12	28	16.9	8.0	8.06		0.20	<0.1	5.4	391.2	
6/20/12	28	18.3	7.6	7.85	0.17	0.21	<0.1	2.8	651.0	
6/20/12	28	18.5	7.6	7.86	0.19	0.24	<0.1	3.0	370.0	
6/27/12	28	19.6	7.8	7.88		0.20	<0.1	3.4	344.4	
6/27/12	28	19.6	7.7	7.88		0.21	<0.1	3.2	293.4	
7/5/12	28	23.3	6.6	7.91	0.060	0.21	<0.1	3.2	3465.8	
7/11/12	28	20.3	7.2	7.85		0.24	<0.1	2.6	254.8	
7/11/12	28	20.3	7.2	7.86		0.24	<0.1	3.4	244.6	
7/18/12	28	22.8	6.6	7.80	0.16	0.21	0.26	3.0	581.8	
7/25/12	28	22.0	7.0	7.82	0.058	0.27	<0.1	3	262.8	
8/1/12	28	21.3	7.0	7.79		0.13	<0.1	2.2	140.6	
8/1/12	28	21.3	7.0	7.80		0.14	<0.1	2.2	197.0	
8/8/12	28	21.4	6.9	7.8	0.023	0.15	<0.1	<2	162.6	
8/15/12	28	19.0	7.7	7.85	0.17	0.17	<0.1	2.6	229.0	
8/15/12	28	19.0	7.7	7.86	0.12	0.14	<0.1	<2	202.4	
1/4/12	29	3.3	7.9	7.94	<0.1	0.4	<0.03	<4	59.1	32
2/7/12	29	3.7	14.4	8.19	<0.1	0.4	<0.03	<4	1299.7	35
3/6/12	29	6.9	12.6	7.99	<0.1	0.4	<0.03	12	488.4	39
4/3/12	29	12.0	11.6	8.02	<0.1	0.2	0.06	<10	224.7	38
5/1/12	29	11.7	9.9	7.82	<0.1	0.2	0.12	20	186.0	34
6/4/12	29	17.8	7.7	7.9						
6/5/12	29	16.0	7.5	7.81	0.1	0.1	0.08	13	2419.6	53
7/3/12	29	21.4	8.5	7.65	<0.1	0.21	0.17	85	> 2419.6	65
8/7/12	29	22.0	8.0	8.21	0.1	0.1	0.21	46	461.1	63
8/14/12	29	17.4	7.9	7.8						

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9/11/12	29	16.4	9.2	8.15	<0.1	<0.1	0.34	42	461.1	55
10/2/12	29	13.6	8.6	7.99	<0.1	<0.1	0.08	<10	1119.9	32
11/14/12	29	6.2	10.8	7.88	<0.1	<0.1	<0.05	<10	150.0	48
11/29/11	30	5.1	10.7	7.88	<0.1	<0.1	0.07	9	344.8	21
1/4/12	30	1.2	13.6	7.9	<0.1	0.1	0.04	<4	24.1	27
2/7/12	30	1.8	13.6	8.09	<0.1	0.1	<0.03	<4	24.5	23
3/6/12	30	4.7	12.6	7.98	<0.1	0.2	<0.03	6	17.1	26
4/3/12	30	10.1	10.1	8.07	<0.1	0.1	0.18	26	206.4	7.8
5/1/12	30	12.0	9.4	7.84	<0.1	<0.1	0.15	28	129.1	22
6/4/12	30	17.4	7.2	7.99						
7/3/12	30	21.5	6.9	7.59	<0.1	0.55	0.34	140	> 2419.6	34
8/7/12	30	20.6	7.7	8.06	<0.1	0.4	0.28	13	1553.1	38
8/13/12	30	17.4	8.8	7.95						
10/2/12	30	12.6	8.1	7.94	<0.1	0.3	0.15	25	> 2419.6	63
11/14/12	30	6.0	10.5	7.87	<0.1	0.2	0.44	720	> 2419.6	41
11/29/11	31	5.6	7.2	7.37	<0.1	0.1	0.19	20	461.1	28
1/4/12	31	0.2	11.3	7.61	<0.1	0.3	0.19	96	866.4	27
2/7/12	31	2.2	13.5	8.04	<0.1	0.2	0.03	<4	30.5	27
3/6/12	31	3.7	13.3	7.8	<0.1	0.2	0.04	5	22.3	23
4/3/12	31	9.9	8.7	7.76	<0.1	<0.1	0.17	<10	58.3	18
5/1/12	31	12.2	9.2	7.69	0.1	<0.1	0.20	<10	435.2	24
6/4/12	31	17.5	5.8	8.18						
8/13/12	31	19.3	5.1	7.61						
9/11/12	31	15.7	7.2	7.83	0.2	0.7	0.28	14	29.5	210
10/2/12	31	12.7	4.4	7.86	0.2	0.3	0.19	18	14.8	250
11/14/12	31	5.0	7.4	7.63	<0.1	0.4	0.70	190	920.8	250
11/29/11	32	5.6	10.8	7.95	<0.1	0.3	0.15	10	228.2	29
2/7/12	32	3.4	13.8	8.3	<0.1	0.2	<0.03	<4	29.2	30
3/6/12	32	3.1	13.7	8.15	<0.1	0.2	<0.03	8	101.9	38
4/3/12	32	10.5	10.1	8.26	<0.1	<0.1	0.09	<10	90.6	27
5/1/12	32	11.8	9.7	7.92	0.1	0.3	0.16	30	160.7	33
6/5/12	32	14.2	8.5	8	<0.1	0.1	<0.05	12	410.6	25
6/6/12	32	13.9	8.7	8.13						
7/3/12	32	20.4	7.9	7.74	<0.1	0.12	0.07	14	727.0	29
8/7/12	32	18.6	9.2	8.3	<0.1	<0.1	0.13	<10	435.2	29
8/14/12	32	16.1	9.6	7.97						
8/14/12	32	16.1	9.6	7.97						
9/11/12	32	14.6	9.6	8.18	<0.1	<0.1	0.12	12	648.8	27
10/2/12	32	12.3	9.6	8.1	<0.1	<0.1	0.09	<10	727.0	28
11/14/12	32	4.0	12.9	8.07	<0.1	<0.1	<0.05	<10	96.0	27
6/11/12	32	18.0	7.9	8.19	0.072	0.18	<0.1	28	551.0	
6/19/12	32	20.0	7.7	8.12	0.11	0.17	<0.1	31	1226.2	
6/26/12	32	15.6	8.8	8.19	0.096	0.14	<0.1	20	870.4	
7/2/12	32	18.7	7.8	8.06	0.079	0.17	<0.1	24	1034.4	

Date	Site ID	Temp (deg C)	DO (mg/l)	pH	Ammonia (mg/l)	Nitrate + Nitrite (mg/l)	Total phosphorus (mg/l)	Total Suspended Solids (mg/l)	E. coli (CFU/100 ml)	Chloride (mg/l)
7/10/12	32	18.6	7.7	8.09	0.030	0.21	<0.1	13	976.8	
7/17/12	32	21.2	6.9	8.02	0.068	0.14	<0.1	8.0	1373.4	
7/19/12	32	20.5	6.7	7.72	0.081	0.50	0.27	210	9800.0	
7/24/12	32	20.8	7.4	8.02	0.061	0.18	<0.1	21	1461.6	
7/31/12	32	19.5	7.5	8.04		0.13	<0.1	19		
8/7/12	32	18.0	7.7	8.08	0.034	0.12	<0.1	14	870.4	
8/7/12	32	18.0	7.6	8.08	0.099	0.13	<0.1	14	522.6	
8/14/12	32	15.9	8.5	8.04			<0.1	29	1953.6	
11/29/11	33	5.6	10.8	7.92	<0.1	0.3	0.22	49	360.9	27
1/4/12	33	1.2	13.3	8.07	<0.1	0.2	<0.03	8	107.6	34
2/7/12	33	3.5	13.6	8.25	<0.1	0.2	<0.03	4	105.0	32
3/6/12	33	3.1	12.9	8.1	<0.1	0.2	<0.03	9	69.7	39
4/3/12	33	10.1	10.2	8.24	<0.1	<0.1	0.08	10	133.4	28
5/1/12	33	11.7	9.6	7.89	<0.1	0.3	0.15	32	290.9	33
6/5/12	33	13.7	8.7	7.97	<0.1	0.1	0.08	17	325.5	26
6/5/12	33	17.2	8.7	8.23						
7/3/12	33	19.5	8.1	7.74	<0.1	0.12	0.08	28	1299.7	30
8/7/12	33	18.1	9.5	8.32	<0.1	<0.1	0.14	15	727.0	27
8/14/12	33	17.5	9.3	8.03						
9/11/12	33	14.4	9.8	8.25	<0.1	<0.1	0.09	12	365.4	27
10/2/12	33	12.0	9.7	8.11	<0.1	<0.1	0.10	<10	613.1	28
11/14/12	33	4.1	12.8	8.07	<0.1	<0.1	<0.05	<10	122.3	27
11/29/11	34	4.8	10.7	7.89	<0.1	0.3	0.51	34	770.1	33
1/4/12	34	-0.3	14.3	7.86	<0.1	0.3	0.07	<4	96.0	61
2/7/12	34	1.6	14.2	8.22	<0.1	0.2	0.04	<4	69.1	56
5/1/12	34	12.5	9.1	7.84	<0.1	1.8	0.23	11	261.3	100
6/5/12	34	15.1	5.3	7.6	0.1	<0.1	0.26	20	1203.3	68
6/5/12	34	20.3	7.9	8.04						
7/3/12	34	23.4	2.0	7.43	0.3	0.025	0.52	29	2419.6	30
8/7/12	34	20.2	4.9	7.67	<0.1	<0.1	0.64	68	201.4	94
8/7/12	34	24.1	8.4	8.27						
9/11/12	34	15.2	9.1	8.19	<0.1	<0.1	0.50	75	1553.1	110
10/2/12	34	12.2	6.4	7.91	<0.1	<0.1	0.16	<10	648.8	24
11/14/12	34	2.0	10.7	8.18	<0.1	<0.1	0.06	40	88.2	62
7/19/12	34	23.4	5.2	7.21		4.80	0.21	100	17000.0	
7/31/12	34	21.9	5.4	7.61		<0.5	0.39	68		
8/7/12	34	20.4	5.4	7.65	0.05	<0.5	0.28	7.8	262.8	
8/14/12	34	18.3	6.9	7.77			0.23		186.0	
11/29/11	35	4.3	10.5	7.64	<0.1	0.1	0.66	40	579.4	28
2/7/12	35	1.8	12.0	7.89	<0.1	0.6	0.08	4	121.1	20
3/6/12	35	4.1	13.8	7.83	<0.1	0.3	0.15	10	27.9	15
5/1/12	35	11.1	7.3	7.63	<0.1	0.3	0.21	<10	178.5	26
6/4/12	35	19.9	10.3	7.63						
6/5/12	35	15.2	6.5	7.44	<0.1	<0.1	0.56	41	29.8	18

Date	Site ID	Temp (deg C)	DO (mg/l)	pH	Ammonia (mg/l)	Nitrate + Nitrite (mg/l)	Total phosphorus (mg/l)	Total Suspended Solids (mg/l)	E. coli (CFU/100 ml)	Chloride (mg/l)
7/3/12	35	22.8	1.9	7.25	0.2	0.048	0.21	56	325.5	21
8/7/12	35	19.9	2.1	7.62	0.4	<0.1	1.30	740	461.1	27
9/11/12	35	15.6	7.7	7.92	0.1	<0.1	0.51	38	78.9	17
11/29/11	36	4.9	9.0	7.48	<0.1	0.2	0.30	<4	435.2	48
2/7/12	36	1.6	13.6	7.93	<0.1	<0.1	0.05	5	37.3	74
3/6/12	36	2.5	13.0	7.76	<0.1	0.2	0.08	22	198.9	89
4/3/12	36	12.5	9.3	7.99	<0.1	<0.1	0.11	<10	201.4	81
6/4/12	36	22.8	9.5	8.04						
5/1/12	36	12.7	6.1	7.61	0.1	1.1	0.15	11	344.8	220
6/5/12	36	17.3	4.3	7.51	<0.1	<0.1	0.17	31	101.9	58
7/3/12	36	23.9	2.0	7.19	0.2	<0.1	0.47	69	209.8	60
8/7/12	36	19.5	2.4	7.95						
8/7/12	36	19.5	2.1	7.8	0.2	<0.1	1.20	500	325.5	130
9/11/12	36	15.3	5.1	7.95	<0.1	<0.1	0.42	38	131.4	140
10/2/12	36	11.6	4.1	7.68	0.1	<0.1	0.49	38	18.1	150
11/14/12	36	3.0	12.3	8.1	<0.1	<0.1	0.25	79	866.4	150
11/29/11	37	4.7	10.1	7.66	<0.1	0.2	0.30	22	517.2	31
1/4/12	37	-0.2	14.3	7.69	<0.1	0.2	0.06	9	11.0	58
3/6/12	37	2.3	15.9	7.95	<0.1	0.1	0.04	7	12.0	95
4/3/12	37	13.6	14.3	8.45	<0.1	<0.1	0.08	<10	8.6	49
5/1/12	37	13.2	10.0	7.72	<0.1	0.3	0.14	<10	980.4	170
6/4/12	37	24.8	18.4	8.85						
6/5/12	37	14.4	4.4	7.41	<0.1	<0.1	0.09	18	66.3	79
7/3/12	37	24.1	1.8	7.44	<0.1	<0.1	0.67	44	365.4	19
8/7/12	37	22.9	9.3	8.08	<0.1	<0.1	0.54	59	111.9	110
8/7/12	37	18.7	4.8	7.93						
10/2/12	37	13.0	4.3	7.63	<0.1	<0.1	0.16	<10	209.8	46
11/29/11	38	6.0	10.4	7.91	<0.1	0.3	0.12	38	579.4	24
1/4/12	38	1.7	12.8	8.01	<0.1	0.2	<0.03	10	43.5	27
2/7/12	38	3.7	13.1	8.17	<0.1	0.2	<0.03	6	7.5	26
3/6/12	38	8.2	12.3	8.08	<0.1	0.2	<0.03	7	54.8	27
4/3/12	38	9.7	10.1	8.19	<0.1	<0.1	0.12	15	55.6	23
5/1/12	38									
6/5/12	38	12.6	8.3	7.91	<0.1	0.1	<0.05	23	478.6	25
6/6/12	38	14.5	9.3	8.27						
7/3/12	38	17.9	8.2	7.73	<0.1	0.11	0.10	44	1986.3	29
8/7/12	38	16.2	10.5	8.2	<0.1	<0.1	0.14	11	770.1	27
8/7/12	38	21.3	8.6	8.48						
9/11/12	38	13.7	9.3	8.24	<0.1	<0.1	0.15	16	920.8	27
10/2/12	38	11.7	9.7	8.13	<0.1	<0.1	0.13	19	325.5	28
11/14/12	38	3.8	12.5	8.02	<0.1	<0.1	0.11	<10	135.4	27
6/11/12	38	18.9	8.2	8.21		0.16	<0.1	19	279.2	
6/19/12	38	19.5	8.2	8.07	0.066	0.19	<0.1	18	1095.0	
6/19/12	38	19.5	8.1	8.09	0.075	0.13	<0.1	19	1297.6	

Date	Site ID	Temp (deg C)	DO (mg/l)	pH	Ammonia (mg/l)	Nitrate + Nitrite (mg/l)	Total phosphorus (mg/l)	Total Suspended Solids (mg/l)	E. coli (CFU/100 ml)	Chloride (mg/l)
6/26/12	38	15.6	9.1	8.15		0.14	<0.1	13	870.4	
7/2/12	38	18.0	8.3	8.03	0.048	0.17	<0.1	19	581.8	
7/10/12	38	16.3	8.6	8.06		0.11	<0.1	14	1095.0	
7/17/12	38	20.7	7.9	8.06	0.064	0.11	<0.1	15	1732.8	
7/19/12	38									
7/19/12	38	21.0	6.6	7.80		0.37	0.15	38	9900.0	
7/24/12	38	18.6	7.7	7.98	0.058	0.19		48	2595.2	
7/31/12	38	17.8	8.1	7.98		0.15	<0.1	30		
8/7/12	38	17.1	8.5	8.05	0.031	0.11	<0.1	8	449.4	
8/14/12	38	16.0	8.5	8			<0.1		665.6	
11/29/11	39	5.3	10.2	7.85	<0.1	<0.1	0.07	5	686.7	16
1/4/12	39	1.3	12.8	7.9	<0.1	<0.1	<0.03	7	15.5	21
2/7/12	39	3.0	13.0	8.06	<0.1	<0.1	<0.03	4	21.3	20
3/6/12	39	2.5	12.5	7.96	<0.1	<0.1	<0.03	5	46.4	21
4/3/12	39	10.0	9.9	8.18	<0.1	<0.1	0.11	20	21.6	16
5/1/12	39	11.4	9.3	7.79	<0.1	<0.1	0.13	22	137.9	23
6/4/12	39	17.3	8.1	8.06						
6/5/12	39	12.9	8.8	7.9	<0.1	<0.1	0.06	21	231.0	17
7/3/12	39	17.9	8.5	7.73	<0.1	0.093	0.09	20	1553.1	19
8/7/12	39	16.6	10.0	8.17	<0.1	<0.1	0.14	11	1299.7	20
8/8/12	39	18.0	8.6	8.52						
9/11/12	39	13.5	9.5	8.14	<0.1	<0.1	0.11	<10	816.4	19
10/2/12	39	11.6	10.2	8.1	<0.1	<0.1	0.08	14	648.8	18
11/14/12	39	4.5	11.3	7.93	<0.1	<0.1	0.06	<10	161.6	18
11/29/11	40	6.4	11.5	7.91	<0.1	0.3	0.07	21	488.4	29
1/4/12	40	4.3	12.7	8.05	<0.1	0.2	<0.03	21	70.3	38
2/7/12	40	5.5	12.7	8.25	<0.1	0.2	<0.03	8	21.3	35
3/6/12	40	4.8	12.2	8.09	<0.1	0.2	<0.03	15	69.1	37
4/3/12	40	9.5	10.9	8.19	<0.1	0.1	0.08	<10	27.5	32
5/1/12	40	11.2	10.0	7.87	<0.1	0.1	0.08	13	58.1	35
6/5/12	40	12.0	9.3	7.93	<0.1	<0.1	<0.05	11	165.8	33
6/5/12	40	12.2	11.0	8.8						
7/3/12	40	15.7	9.0	7.62	<0.1	0.084	0.12	16	920.8	33
8/8/12	40	14.8	9.0	8.46						
8/8/12	40	14.8	9.0	8.46						
9/11/12	40	12.8	9.7	8.18	<0.1	<0.1	0.10	<10	275.5	34
10/2/12	40	11.4	9.8	8.12	<0.1	<0.1	0.06	<10	172.2	34
11/14/12	40	6.1	11.9	8.02	<0.1	0.1	0.09	<10	63.1	35
11/29/11	41	6.2	11.4	8.07	<0.1	0.1	0.04	11	325.5	34
1/4/12	41	2.1	13.6	8.17	<0.1	<0.1	<0.03	5	20.1	29
2/7/12	41	4.3	13.3	8.34	<0.1	<0.1	0.03	<4	26.2	30
3/6/12	41	3.7	13.2	8.19	<0.1	<0.1	<0.03	9	31.5	36
4/3/12	41	10.0	10.3	8.3	<0.1	<0.1	0.12	<10	137.4	24
5/1/12	41	11.5	10.2	7.94	<0.1	<0.1	0.10	20	105.4	24

Date	Site ID	Temp (deg C)	DO (mg/l)	pH	Ammonia (mg/l)	Nitrate + Nitrite (mg/l)	Total phosphorus (mg/l)	Total Suspended Solids (mg/l)	E. coli (CFU/100 ml)	Chloride (mg/l)
6/5/12	41	13.5	9.3	7.99	<0.1	<0.1	<0.05	19	201.4	21
6/5/12	41	14.1	8.6	8.66						
7/3/12	41	18.7	8.7	7.8	<0.1	0.06	0.08	20	770.1	24
8/7/12	41	17.2	10.6	8.3	<0.1	<0.1	0.10	<10	224.7	25
8/7/12	41	20.0	8.5	8.44						
9/11/12	41	14.0	10.1	8.31	<0.1	<0.1	0.08	11	344.8	21
10/2/12	41	11.8	9.9	8.01	<0.1	<0.1	0.07	<10	387.3	20
11/14/12	41	4.6	12.7	8.14	<0.1	<0.1	<0.05	13	84.2	23
6/11/12	41	18.4	9.2	8.25		<0.5	<0.1	16	419.6	
6/19/12	41	19.5	8.9	8.15	0.039	<0.5	<0.1	15	522.6	
6/26/12	41	15.8	9.7	8.18		<0.5	<0.1	13	497.8	
7/2/12	41	18.0	8.9	8.10	0.059	0.10	<0.1	13	551.0	
7/2/12	41	18.0	8.8	8.10	0.16	0.14	<0.1	14	402.8	
7/10/12	41	17.4	8.9	8.10		<0.5	<0.1	8.0	522.6	
7/17/12	41	20.5	8.4	8.04	0.02	<0.5	<0.1	8.4	615.2	
7/19/12	41	20.5	7.4	7.86	0.81	0.23	0.14	68.0	5300.0	
7/24/12	41	18.6	8.4	8.01	0.05	0.18		71.0	2595.2	
7/24/12	41	18.6	8.2	8.02	0.05	0.14	0.10	69.0	2190.0	
7/31/12	41	17.9	8.3	8.06		0.16	0.16	83.0		
8/7/12	41	17.3	8.5	8.10	0.027	<0.5	0.28	7.8	321.4	
8/14/12	41	15.9	9.3	8.06			<0.1		444.8	
11/29/11	42	6.5	10.9	8.02	<0.1	<0.1	<0.03	<4	139.6	29
1/4/12	42	3.3	13.9	8.03	<0.1	<0.1	<0.03	4	16.0	30
2/7/12	42	5.0	12.9	8.24	<0.1	<0.1	<0.03	<4	10.9	32
3/6/12	42	4.2	12.6	8.07	<0.1	<0.1	<0.03	4	26.9	37
4/3/12	42	9.7	10.3	8.2	<0.1	<0.1	0.09	<10	43.2	26
5/1/12	42	11.2	10.1	7.88	<0.1	<0.1	0.08	<10	72.7	28
6/5/12	42	12.3	9.3	7.92	<0.1	<0.1	<0.05	13	201.4	23
6/5/12	42	12.3	11.1	8.37						
7/3/12	42	16.8	8.9	7.66	<0.1	0.04	<0.05	10	344.8	25
8/6/12	42	18.4	8.8	8.14						
8/7/12	42	15.2	10.1	7.93	<0.1	<0.1	0.10	<10	272.3	26
9/11/12	42	13.2	9.7	8.17	<0.1	<0.1	0.05	<10	228.2	22
11/14/12	42	5.7	12.4	8.04	<0.1	<0.1	0.08	<10	34.1	24
11/29/11	43	5.6	11.4	8.06	<0.1	0.2	0.06	15	275.5	36
1/4/12	43	0.9	14.0	8.16	<0.1	0.2	<0.03	<4	241.1	39
2/7/12	43	3.1	13.5	8.28	<0.1	0.2	<0.03	4	18.9	34
3/6/12	43	2.8	13.4	8.17	<0.1	0.1	<0.03	4	43.1	38
4/3/12	43	10.3	10.5	8.27	<0.1	<0.1	0.06	<10	36.9	32
5/1/12	43	11.9	9.9	7.96	<0.1	0.1	0.13	26	224.7	33
6/5/12	43	14.1	8.9	8.02	<0.1	0.2	0.14	14	285.1	31
6/5/12	43	16.1	9.4	8.39						
8/7/12	43	19.0	9.1	8.22	<0.1	0.1	0.12	15	1046.2	33
10/2/12	43	12.3	9.6	8.17	<0.1	<0.1	0.12	<10	920.8	32

Date	Site ID	Temp (deg C)	DO (mg/l)	pH	Ammonia (mg/l)	Nitrate + Nitrite (mg/l)	Total phosphorus (mg/l)	Total Suspended Solids (mg/l)	E. coli (CFU/100 ml)	Chloride (mg/l)
6/11/12	43	19.5	8.7	8.28		0.21	<0.1	13	922.2	
6/19/12	43	20.8	8.4	8.16	0.066	0.21	<0.1	19	1373.4	
6/26/12	43	16.4	9.4	8.21		0.19	<0.1	8.6	1540.2	
6/26/12	43	16.5	9.4	8.21		0.19	<0.1	9.0	1226.2	
7/2/12	43	19.9	8.3	8.13	0.023	0.19	<0.1	13	774.6	
7/10/12	43	18.5	8.3	8.11		0.18	<0.1	10	1841.6	
7/10/12	43	18.5	8.3	8.11		0.19	<0.1	10	2092.4	
7/17/12	43	22.2	8.1	8.09	0.027	0.21	<0.1	7.4	870.4	
7/19/12	43	21.5	7.0	7.79		0.32	0.41	230		
7/24/12	43	21.2	7.6	8.09		0.24	<0.1	38	6212.4	
7/31/12	43	19.2	7.7	7.90		0.33	0.49	280	9678.4	
8/7/12	43	19.3	8.0	8.11	0.062	0.17	<0.1	12	1226.2	
8/7/12	43	18.4	8.3	8.49						
8/14/12	43	17.2	8.7	8.1			<0.1	26	774.0	
11/29/11	44	5.6	11.2	8.04	<0.1	0.2	0.04	10	344.8	41
3/6/12	44	2.4	13.3	8.09	<0.1	0.2	<0.03	4	64.4	45
4/3/12	44	9.9	10.2	8.23	<0.1	0.1	0.06	<10	42.0	38
5/1/12	44	11.7	9.9	7.86	<0.1	0.1	0.10	20	261.3	38
6/5/12	44	13.8	8.3	7.89	<0.1	0.2	0.06	18	648.8	35
6/5/12	44	14.9	8.8	8.2						
7/3/12	44	20.2	7.8	7.66	<0.1	0.16	0.09	38	1203.3	35
8/6/12	44	20.9	8.1	8.31						
8/7/12	44	18.2	8.9	8.03	<0.1	0.1	0.14	<10	866.4	37
9/11/12	44	14.8	9.5	8.18	<0.1	0.1	0.08	10	365.4	34
10/2/12	44	12.6	9.4	8.06	<0.1	<0.1	0.07	<10	1046.2	35
11/14/12	44	4.2	12.3	8.05	<0.1	<0.1	<0.05	<10	88.0	23
11/29/11	45	6.0	11.9	7.97	<0.1	0.2	0.04	6	120.1	86
1/4/12	45	1.4	14.1	8.05	<0.1	0.3	0.03	6	20.3	79
2/7/12	45	3.0	13.5	8.23	<0.1	0.3	<0.03	10	9.6	67
3/6/12	45	2.1	13.0	8.02	<0.1	0.3	<0.03	5	155.3	82
4/3/12	45	8.8	11.0	8.18	<0.1	0.3	0.09	12	248.9	63
5/1/12	45	10.5	10.0	7.87	<0.1	0.3	0.10	<10	218.7	79
6/5/12	45	11.7	10.0	8.15	<0.1	0.4	<0.05	33	166.4	68
6/5/12	45	11.7	9.7	8.06						
7/3/12	45	17.8	8.6	7.7	<0.1	0.17	<0.05	21	920.8	35
8/6/12	45	18.0	8.7	8.27						
8/7/12	45	15.7	9.3	8.04	<0.1	0.3	0.12	<10	461.1	51
9/11/12	45	13.3	9.6	8.49	<0.1	0.3	0.09	<10	272.3	63
10/2/12	45	11.5	10.1	8.31	<0.1	0.3	0.08	<10	186.0	63
11/14/12	45	4.3	8.4	8.39	<0.1	0.2	0.06	16	44.8	67
11/29/11	46	4.8	10.1	7.81	<0.1	<0.1	<0.03	8	15.5	14
1/4/12	46	1.8	10.9	7.67	<0.1	<0.1	<0.03	4	5.2	16
2/7/12	46	2.3	10.4	7.83	<0.1	<0.1	<0.03	6	32.8	13
3/6/12	46	2.7	10.5	7.71	<0.1	<0.1	<0.03	6	3.1	14

Date	Site ID	Temp (deg C)	DO (mg/l)	pH	Ammonia (mg/l)	Nitrate + Nitrite (mg/l)	Total phosphorus (mg/l)	Total Suspended Solids (mg/l)	E. coli (CFU/100 ml)	Chloride (mg/l)
4/3/12	46	11.8	5.5	7.7	<0.1	<0.1	0.10	14	26.2	12
5/1/12	46	12.4	7.1	7.68	<0.1	<0.1	<0.05	<10	193.5	11
6/5/12	46	19.4	2.0	7.61	<0.1	<0.1	0.11	20	178.9	9.7
7/3/12	46	26.3	0.9	7.13	<0.1	<0.1	0.12	18	579.4	9.4
8/7/12	46	22.2	1.7	7.43	<0.1	<0.1	0.15	<10	111.2	11
9/11/12	46	18.1	2.6	7.82	<0.1	<0.1	0.11	<10	63.1	15
10/2/12	46	14.5	4.8	7.78	<0.1	<0.1	0.08	16	78.9	14
11/14/12	46	4.2	9.4	8	<0.1	<0.1	0.12	<10	7.3	37
11/29/11	47	5.1	11.3	8.13	<0.1	<0.1	<0.03	5	435.2	33
1/4/12	47	1.8	13.4	7.98	<0.1	<0.1	<0.03	5	2.0	44
2/7/12	47	3.2	12.6	7.97	<0.1	<0.1	<0.03	<4	6.3	40
3/6/12	47	3.3	13.3	8.09	<0.1	<0.1	<0.03	<4	5.2	46
4/3/12	47	11.4	10.5	8.26	<0.1	<0.1	0.07	<10	13.2	41
5/1/12	47	12.5	10.4	7.97	<0.1	<0.1	0.08	<10	15.8	39
6/5/12	47		6.9	7.59	<0.1	<0.1	<0.05	<10	48.7	36
6/5/12	47	16.9	8.7	8.05						
7/3/12	47	20.9	6.8	7.49	<0.1	<0.1	0.08	<10	64.4	36
8/6/12	47	22.2	6.5	7.71						
8/7/12	47	19.6	5.1	7.54	<0.1	<0.1	0.11	<10	21.1	36
9/11/12	47	15.1	7.0	8.12	<0.1	<0.1	0.08	<10	22.8	31
10/2/12	47	12.7	9.0	8.05	<0.1	<0.1	<0.05	<10	121.1	35
11/14/12	47		11.4	8.06	<0.1	<0.1	<0.05	15	14.6	35
6/11/12	47	21.2	8.8	7.98		<0.1	<0.1	2.6	78.6	
6/11/12	47	21.2	8.8	7.98		<0.1	<0.1	3.0	72.8	
6/19/12	47	23.3	7.4	7.72	0.029	<0.1	<0.1	4.4	95.8	
6/26/12	47	20.3	8.5	7.80		<0.1	<0.1	3.8	73.6	
7/2/12	47	22.7	6.7	7.59	0.033	<0.1	<0.1	4.0	90.0	
7/10/12	47	21.1	7.3	7.62	<0.02	<0.1	<0.1	2.8	46.2	
7/17/12	47	23.3	6.4	7.57	0.13	<0.1	<0.1	4.0	84.0	
7/24/12	47	21.8	5.6	7.49	0.14	<0.1	<0.1	7.4	99.0	
7/31/12	47	21.6	5.9	7.45						
8/7/12	47	21.8	5.8	7.52	0.05	<0.1	<0.1	3.8	14.8	
8/14/12	47	19.2	5.9	7.43		<0.1	<0.1		94.0	
1/3/12	48	4.5	14.0	8.18	0.2	0.4	<0.03	22	15.6	21
2/6/12	48	4.0	14.7	8.23	0.5	0.3	<0.03	11	14.4	25
3/5/12	48	7.6	14.3	8.15	0.8	0.4	<0.03	9	37.3	32
4/2/12	48	13.7	11.8	8.09	0.6	0.3	<0.05	<10	18.1	28
6/4/12	48	21.1	9.3	8.17						
6/4/12	48	21.4	9.8	8.29	0.1	0.3	0.06	55	36.4	21
7/2/12	48	21.3	9.8	8.06	0.2	0.31	<0.05	<10	30.5	22
8/6/12	48	26.0	10.9	8.54	0.3	0.2	<0.05	<10	6.2	20
8/7/12	48	23.9	8.4	8.15						
9/10/12	48	24.4	8.5	8.15	0.4	0.3	0.05	<10	4.1	26
10/1/12	48	21.3	9.2	8.2	0.4	0.3	<0.05	<10	2.0	20

Date	Site ID	Temp (deg C)	DO (mg/l)	pH	Ammonia (mg/l)	Nitrate + Nitrite (mg/l)	Total phosphorus (mg/l)	Total Suspended Solids (mg/l)	E. coli (CFU/100 ml)	Chloride (mg/l)
11/13/12	48	11.8	11.0	8.03	0.7	0.4	<0.05	27	14.6	21

Appendix 5. Qualitative Habitat Evaluation Index (QHEI)

Site	Substrate (20)	In-Stream Cover (20)	Channel Morphology (20)	Riparian Zone (10)	Pool/ Current (12)	Riffle/ Run (8)	Gradient (10)	Total QHEI Score
3	11	12	10	9	10	0	6	58
4	13	10	8	10	10	0	6	57
5	7	13	13	8	10	0	4	55
6	10	15	12	8	5	3	4	57
7	12	15	15	10	7	0	4	63
8	10	12	14	8	3	0	4	51
9	6	14	13	7	10	0	4	54
10	7	12	13	10	9	0	8	59
11	11	13	13	7	9	0	8	61
12	8	13	16	5	8	5	6	61
13	11	14	16	8	7	0	10	66
14	1	8	6	3	3	0	4	25
15								
16	6	14	16	5	8	3	10	62
17	12	11	16	5	4	5	10	63
18	10	13	13	8	7	0	10	61
19	0	6	10	9	0	0	8	33
20	12	18	13	8	6	0	6	63
21	1	11	6	3	7	0	6	34
22	3	11	11	7	4	0	8	44
23	8	12	15	5	3	0	10	53
24								
25	10	15	13	7	9	0	6	60
26	3	13	13	5	4	0	6	44
27	14	8	14	6	7	2	10	61
28	10	6	18	10	3	4	10	61
29	5	6	11	5	2	0	10	39
30	2	6	8	5	2	0	8	31
31	1	7	9	5	0	0	6	28
32	10	12	10	4	10	6	6	58
33	11	13	9	3	9	0	6	51
34	1	4	7	3	8	0	6	29
35	1	7	8	5	2	0	4	27
36	1	7	5	6	6	0	4	29
37	1	6	7	5	4	0	6	29
38	11	14	11	4	10	0	10	60
39	12	9	12	5	6	2	10	56
40	11	13	16	4	5	2	10	61
41	10	13	9	2	4	0	10	48
42	11	14	16	7	8	7	10	73
43	12	10	10	6	5	0	10	53
44	11	7	11	3	7	0	10	49
45	14	13	18	8	5	4	4	66
46								
47	15	5	18	8	3	5	10	64
48	9	14	7	8	7	0	6	51

Appendix 6. Critical and Priority Area Metrics

Nitrogen Critical/Protection Area Metric													
Site ID	**Mean**	**Mean Rank**	**% Exceed**	**% Exceed Rank**	**Single Highest Sample**	**Highest Sample Rank**	**Load (lb/yr)**	**Load Rank**	**Load/Acre (lb/ac/yr)**	**Load/acre Rank**	**Rank Total**	**Total Possible**	**Percent Score (Grade)**
3	0.74	6	0%	11	1.0	10	100015	2	2.2	2	31	93	33%
4	0.41	11	0%	11	0.5	15					37	67	55%
5	1.62	2	83%	1	2.6	4					7	67	10%
6	1.18	4	45%	4	2.9	3					11	67	16%
7	0.59	7	5%	9	1.3	8	2972	9	1.5	3	36	93	39%
8	0.79	5	36%	5	1.6	7					17	67	25%
9	1.22	3	75%	3	2.3	5	138394	1	3.3	1	13	93	14%
10	1.82	1	82%	2	3.1	2					5	67	7%
11	0.13	33	0%	11	0.3	17	15944	4	0.5	10	75	93	81%
12	0.18	22	0%	11	0.5	15	8560	6	0.9	5	59	93	63%
13	0.13	33	0%	11	0.4	16					60	67	90%
14	0.29	14	0%	11	0.8	12					37	67	55%
15	0.52	9	0%	11	0.9	11					31	67	46%
16	0.14	30	0%	11	0.3	17					58	67	87%
17	0.11	37	0%	11	0.2	18					66	67	99%
18	0.11	36	0%	11	0.2	18					65	67	97%
19	0.14	30	0%	11	0.3	17					58	67	87%
20	0.11	35	0%	11	0.5	15	2619	10	0.6	8	79	89	89%
21	0.16	27	0%	11	0.5	15					53	67	79%
22	0.50	10	0%	11	0.7	13	4189	7	1.2	4	45	93	48%
23	0.33	12	0%	11	0.5	15					38	67	57%
24	0.17	25	0%	11	0.2	18					54	67	81%
25	0.17	24	0%	11	0.4	16	16178	3	0.6	8	62	93	67%
26	0.26	17	10%	7	1.8	6					30	67	45%
27	0.26	16	5%	10	1.1	9	678	13	0.4	12	60	93	65%
28	0.18	23	0%	11	0.3	17	834	12	0.7	7	70	93	75%

Nitrogen Critical/Priority Area Metric													
Site ID	Mean	Mean Rank	% Exceed	% Exceed Rank	Single Highest Sample	Highest Sample Rank	Load (lb/yr)	Load Rank	Load/Acre (lb/ac/yr)	Load/acre Rank	Rank Total	Total Possible	Percent Score (Grade)
29	0.20	19	0%	11	0.4	16					46	67	69%
30	0.20	18	0%	11	0.6	14					43	67	64%
31	0.26	17	0%	11	0.7	13					41	67	61%
32	0.17	26	0%	11	0.5	15	11609	5	0.6	8	65	93	70%
33	0.15	29	0%	11	0.3	17					57	67	85%
34	0.59	8	15%	6	4.8	1					15	67	22%
35	0.19	21	0%	11	0.6	14					46	67	69%
36	0.15	29	9%	8	1.1	9					46	67	69%
37	0.12	34	0%	11	0.3	17					62	67	93%
38	0.15	28	0%	11	0.4	16	1857	11	0.6	9	75	93	81%
39													NA
40	0.14	31	0%	11	0.3	17					59	67	88%
41	0.07	38	0%	11	0.5	15					64	67	96%
42													NA
43	0.19	20	0%	11	0.3	17	3224	8	0.5	11	67	93	72%
44	0.13	32	0%	11	0.2	18					61	67	91%
45	0.28	15	0%	11	0.4	16	562	14	0.8	6	62	93	67%
46													NA
47													NA
48	0.32	13	0%	11	0.4	16					40	67	60%

Phosphorus Critical/Protection Area Metric													
Site ID	Mean	Mean Rank	% Exceed	% Exceed Rank	Single Highest Sample	Highest Sample Rank	Load	Load Rank	Load/Acre	Load/acre Rank	Rank Total	Total Possible	Percent Score (Grade)
3	0.06	33	17	23	0.12	27	8933	3	0.20	15	101	147	69%
4	0.05	41	0	27	0.07	30					98	100	98%
5	0.06	37	25	21	0.10	29					87	100	87%
6	0.12	14	64	6	0.21	20					40	100	40%
7	0.08	26	37	15	0.19	22	429	16	0.21	14	93	147	63%
8	0.12	12	55	10	0.30	13					35	100	35%
9	0.09	22	50	11	0.18	23	10160	1	0.24	9	66	147	45%
10	0.12	12	64	6	0.21	20					38	100	38%
11	0.10	16	58	9	0.23	18	9292	2	0.30	5	50	147	34%
12	0.08	27	29	18	0.24	17	1627	9	0.16	19	90	147	61%
13	0.06	34	33	16	0.15	25	9292	2	0.97	1	78	147	53%
14	0.16	8	55	10	0.59	6					24	100	24%
15	0.08	25	17	23	0.37	10					58	100	58%
16	0.05	40	25	21	0.14	26	1003	10	0.13	23	120	147	82%
17	0.10	18	58	9	0.20	21	154	21	0.22	13	82	147	56%
18	0.06	36	8	25	0.15	25	871	12	0.16	21	119	147	81%
19	0.13	10	64	6	0.27	15					31	100	31%
20	0.06	38	13	24	0.14	26	740	14	0.17	17	119	147	81%
21	0.09	21	55	10	0.16	24					55	100	55%
22	0.14	9	63	7	0.32	12	995	11	0.28	7	46	147	31%
23	0.07	31	45	12	0.12	27					70	100	70%
24	0.12	13	33	16	0.12	27					56	100	56%
25	0.09	23	43	13	0.16	24	7388	4	0.28	8	72	147	49%
26	0.18	6	60	8	0.49	7					21	100	21%
27	0.13	11	50	11	0.39	9	409	18	0.23	11	60	147	41%
28	0.07	30	26	20	0.26	16	185	20	0.16	20	106	147	72%
29	0.11	15	36	15	0.34	11					41	100	41%
30	0.17	7	60	8	0.44	8					23	100	23%

Phosphorus Critical/Protection Area Metric													
Site ID	**Mean**	**Mean Rank**	**% Exceed**	**% Exceed Rank**	**Single Highest Sample**	**Highest Sample Rank**	**Load**	**Load Rank**	**Load/Acre**	**Load/acre Rank**	**Rank Total**	**Total Possible**	**Percent Score (Grade)**
31	0.22	5	78	4	0.70	3					12	100	12%
32	0.08	24	30	17	0.27	15	5922	6	0.31	4	66	147	45%
33	0.09	20	42	14	0.22	19	6093	5	0.34	3	61	147	41%
34	0.29	3	79	3	0.64	5	2723	7	0.55	2	20	147	14%
35	0.46	1	88	1	1.30	1					3	100	3%
36	0.34	2	82	2	1.20	2					6	100	6%
37	0.23	4	67	5	0.67	4					13	100	13%
38	0.10	17	36	15	0.15	25	765	13	0.23	10	80	147	54%
39	0.08	24	42	14	0.14	26	435	15	0.22	12	91	147	62%
40	0.07	29	27	19	0.12	27					75	100	75%
41	0.07	28	29	18	0.28	14	415	17	0.17	18	95	147	65%
42	0.06	39	18	22	0.10	29					90	100	90%
43	0.09	23	27	19	0.49	7	1965	8	0.30	6	63	147	43%
44	0.07	30	30	17	0.14	26					73	100	73%
45	0.06	35	33	16	0.12	27	120	22	0.18	16	116	147	79%
46	0.09	19	50	11	0.15	25	77	23	0.15	22	100	147	68%
47	0.07	32	5	26	0.11	28	288	19	0.10	24	129	147	88%
48	0.03	42	0	27	0.06	31					100	100	100%

Total Suspended Solids (TSS) Critical/Protection Area Metric													
Site ID	**Mean**	**Mean Rank**	**% Exceed**	**% Exceed Rank**	**Single Highest Sample**	**Highest Sample Rank**	**Annual Load**	**Load Rank**	**Load/Acre**	**Load/acre Rank**	**Rank Total**	**Total Possible**	**Percent Score (Grade)**
3	7.1	34	0%	18	21	24					76	90	84%
4	6.0	37	0%	18	13	29					84	90	93%
5	18.8	13	17%	11	40	17					41	90	46%
6	11.1	26	0%	18	19	26					70	90	78%
7	5.8	38	0%	18	19	26	36965	13	18.049	14	109	121	90%
8													NA
9	15.7	17	5%	17	49	15	1548644	1	36.680	9	59	121	49%
10	12.0	23	0%	18	25	21					62	90	69%
11	13.5	20	0%	18	27	20	1262995	2	40.87	6	66	121	55%
12	21.7	8	24%	6	100	7	292918	7	29.578	11	39	121	32%
13	5.7	39	0%	18	12	30					87	90	97%
14	4.3	42	0%	18	20	25					85	90	94%
15													NA
16	6.0	37	0%	18	12	30					85	90	94%
17	8.5	30	8%	16	50	14					60	90	67%
18	6.1	36	0%	18	12	30					84	90	93%
19	17.0	14	9%	15	33	19					48	90	53%
20	7.5	33	0%	18	16	27	89278	11	20.958	13	102	121	84%
21	12.8	21	9%	15	66	10					46	90	51%
22	14.4	19	16%	12	56	12	175493	8	49.983	4	55	121	45%
23	6.9	35	9%	15	48	16					66	90	73%
24	7.8	32	100%	1	24	22					55	90	61%
25	14.6	18	0%	18	27	20	1066138	3	40.562	7	66	121	55%
26	9.0	29	0%	18	20	25					72	90	80%
27	8.3	31	9%	15	40	17	31087	14	17.391	15	92	121	76%
28	3.7	43	0%	18	15	28					89	90	99%
29	21.3	10	27%	5	85	8					23	90	26%
30	96.9	2	20%	8	720	2					12	90	13%

Total Suspended Solids (TSS) Critical/Protection Area Metric													
Site ID	**Mean**	**Mean Rank**	**% Exceed**	**% Exceed Rank**	**Single Highest Sample**	**Highest Sample Rank**	**Annual Load**	**Load Rank**	**Load/Acre**	**Load/acre Rank**	**Rank Total**	**Total Possible**	**Percent Score (Grade)**
31	38.7	4	22%	7	190	6					17	90	19%
32	23.6	7	9%	15	210	5	894995	5	47.43	5	37	121	31%
33	16.4	15	17%	11	49	15	998796	4	55.936	1	46	121	38%
34	36.0	5	46%	4	100	7					16	90	18%
35	116.5	1	70%	2	740	1					4	90	4%
36	72.5	3	55%	3	500	3					9	90	10%
37	20.4	11	18%	9	59	11					31	90	34%
38	19.9	12	18%	10	48	16	168910	9	51.780	2	49	121	40%
39	11.7	24	0%	18	22	23	62097	12	32.02	10	87	121	72%
40	12.4	22	0%	18	21	24					64	90	71%
41	21.4	9	17%	11	83	9	93799	10	38.721	8	47	121	39%
42	4.4	41	0%	18	13	29					88	90	98%
43	34.7	6	14%	13	280	4	340180	6	51.720	3	32	121	26%
44	11.5	25	10%	14	38	18					57	90	63%
45	11.0	27	8%	16	33	19					62	90	69%
46	9.8	28	0%	18	20	25	15229	15	29.38	12	98	121	81%
47	4.6	40	0%	18	15	28					86	90	96%
48	16.1	16	10%	14	55	13					43	90	48%

Temperature Critical/Priority Area Metric									
Site ID	Mean	Mean Rank	% Exceed	% Exceed rank	Single Highest Sample	Highest Sample Rank	Total Score	Total Possible	Percent Score (Grade)
3	22.1	2	50%	5	25.6	2	9	113	8%
4	23.6	1	46%	7	27.1	1	9	113	8%
5	16.7	24	7%	26	18.2	25	75	113	66%
6	16.5	25	15%	20	18.8	20	65	113	58%
7	19.1	10	45%	8	22.2	8	26	113	23%
8	14.1	38	0%	29	15.7	32	99	113	88%
9	19.8	6	45%	8	23.7	3	17	113	15%
10	16.5	26	15%	20	18.0	26	72	113	64%
11	16.1	31	14%	21	16.9	28	80	113	71%
12	19.6	8	36%	11	22.1	9	28	113	25%
13	16.8	22	14%	21	19.5	17	60	113	53%
14	19.7	7	0%	29	22.3	7	43	113	38%
15	14.6	36	31%	12	13.2	35	83	113	73%
16	18.5	12	31%	12	22.6	5	29	113	26%
17	17.0	20	21%	17	18.7	21	58	113	51%
18	17.1	19	21%	17	19.2	19	55	113	49%
19	16.2	29	8%	25	20.1	15	69	113	61%
20	20.3	4	48%	6	22.4	6	16	113	14%
21	18.7	11	31%	13	22.2	8	32	113	28%
22	17.7	16	23%	16	20.7	14	46	113	41%
23	15.4	35	0%	29	16.0	30	94	113	83%
24	9.8	46	0%	29	9.1	38	113	113	100%
25	15.8	33	13%	22	17.4	27	82	113	73%
26	14.0	39	0%	29	14.8	33	101	113	89%
27	20.2	5	40%	9	23.5	4	18	113	16%
28	18.3	15	21%	18	20.9	12	45	113	40%
29	16.1	32	15%	20	17.4	27	79	113	70%
30	14.6	37	8%	24	17.4	27	88	113	78%

Temperature Critical/Protection Area Metric									
Site ID	**Mean**	**Mean Rank**	**% Exceed**	**% Exceed rank**	**Single Highest Sample**	**Highest Sample Rank**	**Total Score**	**Total Possible**	**Percent Score (Grade)**
31	13.0	42	0%	29	14.2	34	105	113	93%
32	16.8	21	4%	28	18.6	22	71	113	63%
33	13.8	40	86%	1	16.5	29	70	113	62%
34	18.4	14	25%	14	20.8	13	41	113	36%
35	17.6	17	9%	23	19.9	16	56	113	50%
36	16.7	23	77%	3	19.5	17	43	113	38%
37	18.5	13	23%	15	20.8	13	41	113	36%
38	16.4	27	4%	27	18.6	22	76	113	67%
39	13.3	41	0%	29	15.8	31	101	113	89%
40	12.0	45	0%	29	12.7	37	111	113	98%
41	16.2	28	0%	29	18.5	23	80	113	71%
42	12.7	43	0%	29	13.2	35	107	113	95%
43	17.4	18	13%	22	19.3	18	58	113	51%
44	15.6	34	83%	2	15.7	32	68	113	60%
45	12.4	44	0%	29	12.9	36	109	113	96%
46	16.1	30	17%	19	18.4	24	73	113	65%
47	19.2	9	39%	10	21.7	11	30	113	27%
48	20.9	3	58%	4	22.0	10	17	113	15%

Dissolved Oxygen Critical/Protection Area Metric									
Site ID	Mean	Mean Rank	Low DO % Exceed	Low DO % Exceed Rank	Single Lowest Sample	Lowest Sample Rank	Rank Total	Total Possible	Percent Score (Grade)
3	10.8	24	0%	12	6.6	16	52	90	58%
4	9.9	13	0%	12	7.3	23	48	90	53%
5	10.2	17	0%	12	6.8	18	47	90	52%
6	11.4	31	0%	12	6.8	18	61	90	68%
7	10.5	19	0%	12	6.1	15	46	90	51%
8	11.0	27	50%	1	4.5	10	38	90	42%
9	10.0	14	0%	12	6.0	14	40	90	44%
10	11.4	30	0%	12	7.7	26	68	90	76%
11	11.8	39	0%	12	7.5	25	76	90	84%
12	9.7	10	4%	10	5.6	13	33	90	37%
13	11.8	37	0%	12	7.9	28	77	90	86%
14	11.5	34	0%	12	3.1	7	53	90	59%
15	17.1	45	0%	12	7.1	21	78	90	87%
16	12.4	41	0%	12	8.1	29	82	90	91%
17	11.8	38	0%	12	7.4	24	74	90	82%
18	11.5	35	0%	12	7.8	27	74	90	82%
19	9.9	12	46%	3	1.1	1	16	90	18%
20	9.6	9	0%	12	7.2	22	43	90	48%
21	11.0	26	0%	12	7.2	22	60	90	67%
22	9.4	6	36%	5	5.0	11	22	90	24%
23	12.6	42	0%	12	9.0	32	86	90	96%
24	14.4	44	0%	12	9.5	33	89	90	99%
25	10.6	21	0%	12	6.1	15	48	90	53%
26	9.6	8	33%	6	3.5	8	22	90	24%
27	9.5	7	0%	12	6.1	15	34	90	38%
28	9.1	2	3%	11	3.0	6	19	90	21%
29	10.6	22	0%	12	7.5	25	59	90	66%
30	11.2	28	0%	12	6.9	19	59	90	66%

Dissolved Oxygen Critical/Priority Area Metric									
Site ID	Mean	Mean Rank	Low DO % Exceed	Low DO % Exceed Rank	Single Lowest Sample	Lowest Sample Rank	Rank Total	Total Possible	Percent Score (Grade)
31	10.2	16	27%	8	4.4	9	33	90	37%
32	9.7	10	0%	12	6.7	17	39	90	43%
33	11.4	32	0%	12	8.1	29	73	90	81%
34	9.3	5	38%	4	2.0	5	14	90	16%
35	10.6	20	27%	8	1.9	4	32	90	36%
36	9.2	3	46%	3	2.0	5	11	90	12%
37	12.8	43	31%	7	1.8	3	53	90	59%
38	9.9	11	0%	12	6.6	16	39	90	43%
39	10.9	25	0%	12	8.1	29	66	90	73%
40	11.3	29	0%	12	9.0	32	73	90	81%
41	10.3	18	0%	12	7.4	24	54	90	60%
42	11.7	36	0%	12	8.8	31	79	90	88%
43	10.1	15	0%	12	7.0	20	47	90	52%
44	10.7	23	0%	12	7.8	27	62	90	69%
45	11.4	33	0%	12	8.3	30	75	90	83%
46	8.3	1	50%	2	1.7	2	5	90	6%
47	9.3	4	20%	9	5.1	12	25	90	28%
48	12.1	40	0%	12	8.3	30	82	90	91%

Ammonia Critical/Protection Area Metric									
Site ID	**Mean**	**Mean Rank**	**% Exceed**	**% Exceed Rank**	**Single Highest Sample**	**Highest Sample Rank**	**Rank Total**	**Total Possible**	**Percent Score (Grade)**
3	0.201	4	50%	3	0.3	8	15	54	28%
4	0.291	2	64%	2	0.4	6	10	54	19%
5									NA
6									NA
7	0.096	11	7%	13	0.2	11	35	54	65%
8	0.075	17	33%	6	0.2	11	34	54	63%
9	0.081	14	6%	14	0.15	13	41	54	76%
10									NA
11									NA
12	0.097	10	6%	14	0.26	9	33	54	61%
13									NA
14	0.205	3	18%	10	1.6	1	14	54	26%
15									NA
16									NA
17									NA
18									NA
19	0.160	5	45%	4	0.6	5	14	54	26%
20	0.058	19	0%	16	0.14	14	49	54	91%
21									NA
22	0.112	7	18%	10	0.39	7	24	54	44%
23									NA
24									NA
25									NA
26	0.143	6	20%	9	1.1	2	17	54	31%
27	0.098	9	11%	11	0.24	10	30	54	56%
28	0.081	14	0%	16	0.19	12	42	54	78%
29									NA

30									NA

Ammonia Critical/Protection Area Metric

Site ID	Mean	Mean Rank	% Exceed	% Exceed Rank	Single Highest Sample	Highest Sample Rank	Rank Total	Total Possible	Percent Score (Grade)
31	0.085	13	22%	8	0.2	11	32	54	59%
32	0.070	18	0%	16	0.11	15	49	54	91%
33									NA
34	0.077	16	9%	12	0.3	8	36	54	67%
35	0.099	8	40%	5	0.4	6	19	54	35%
36	0.080	15	27%	7	0.2	11	33	54	61%
37									NA
38	0.057	20	0%	16	0.1	16	52	54	96%
39									NA
40									NA
41	0.092	12	5%	15	0.81	3	30	54	56%
42									NA
43	0.045	21	0%	16	0.1	16	53	54	98%
44									NA
45									NA
46									NA
47	0.044	22	0%	16	0.14	14	52	54	96%
48	0.420	1	80%	1	0.8	4	6	54	11%

E. coli Critical/Protectin Area Metric									
Site ID	**Mean**	**Mean Rank**	**% Exceed**	**% Exceed Rank**	**Single Highest Sample**	**Highest Sample Rank**	**Rank Total**	**Total Possible**	**Percent Score (Grade)**
3	92	43	0%	22	387	30	95	102	93%
4	12	46	0%	22	30	34	102	102	100%
5	410	17	20%	16	1000	17	50	102	49%
6	256	30	0%	22	435	29	81	102	79%
7	2277	1	55%	6	11000	2	9	102	9%
8	278	27	33%	11	1046	16	54	102	53%
9	841	10	25%	13	9400	6	29	102	28%
10	267	28	0%	22	488	27	77	102	75%
11	191	37	0%	22	461	28	87	102	85%
12	1268	5	57%	5	9000	7	17	102	17%
13	286	26	17%	18	727	22	66	102	65%
14	287	25	0%	22	687	24	71	102	70%
15	97	42	8%	21	260	32	95	102	93%
16	210	36	8%	21	579	26	83	102	81%
17	822	11	58%	4	2420	10	25	102	25%
18	159	39	8%	21	613	25	85	102	83%
19	164	38	9%	20	816	21	79	102	77%
20	302	24	9%	20	1164	15	59	102	58%
21	341	20	18%	17	1414	12	49	102	48%
22	1696	3	65%	2	9678	5	10	102	10%
23	580	13	27%	12	2420	10	35	102	34%
24	433	16	17%	18	2420	10	44	102	43%
25	324	21	21%	15	690	23	59	102	58%
26	315	23	20%	16	1203	14	53	102	52%
27	218	34	9%	20	866	20	74	102	73%

28	393	18	15%	19	3466	9	46	102	45%

***E. coli* Critical/Protection Area Metric**

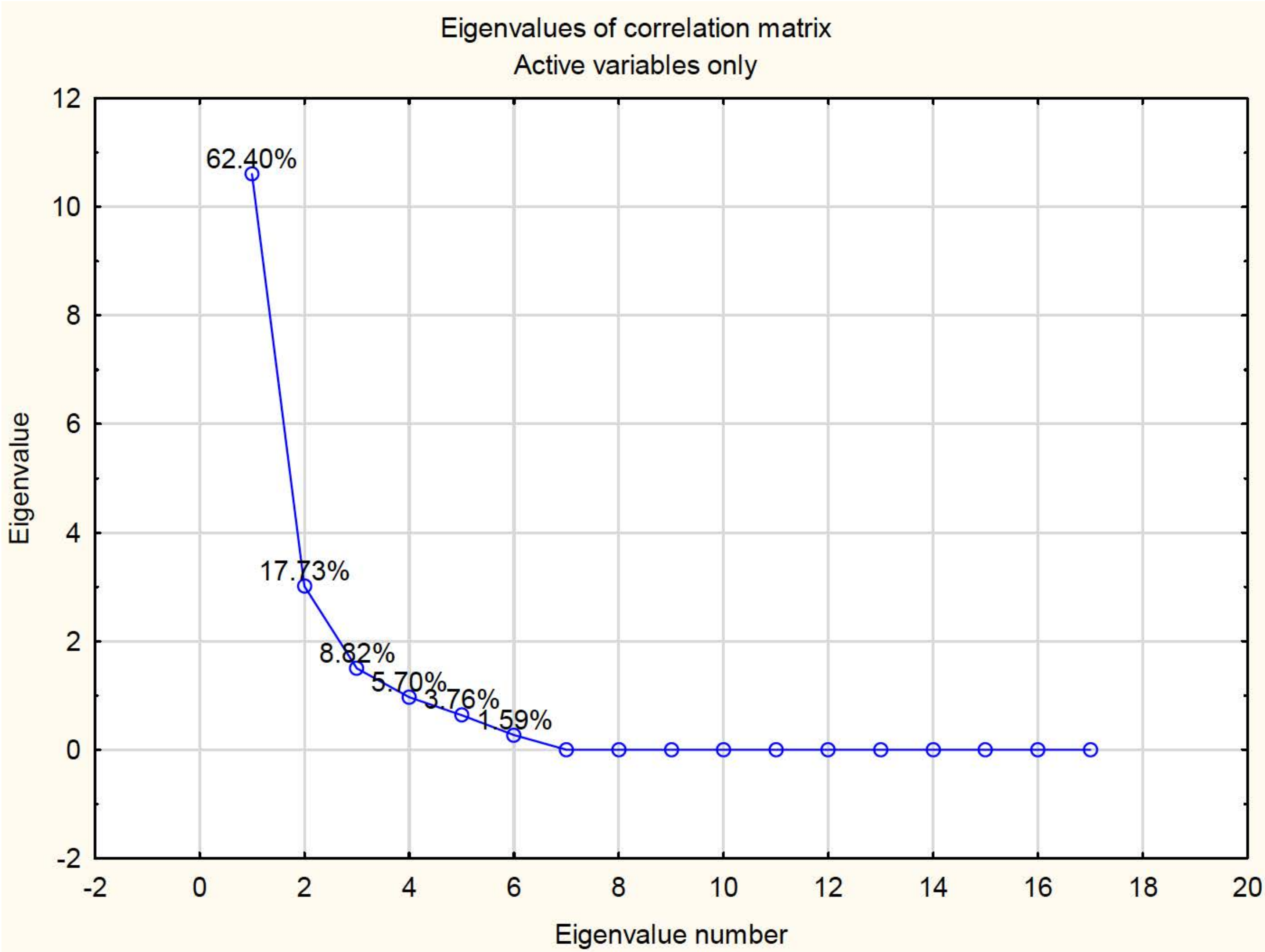
Site ID	Mean	Mean Rank	% Exceed	% Exceed Rank	Single Highest Sample	Highest Sample Rank	Rank Total	Total Possible	Percent Score (Grade)
29	844	9	36%	10	2420	10	29	102	28%
30	956	8	40%	9	2420	10	27	102	26%
31	315	22	22%	14	921	19	55	102	54%
32	1104	7	55%	6	9800	4	17	102	17%
33	377	19	25%	13	1300	13	45	102	44%
34	1905	2	46%	7	17000	1	10	102	10%
35	225	33	20%	16	579	26	75	102	74%
36	261	29	9%	20	866	20	69	102	68%
37	254	31	9%	20	980	18	69	102	68%
38	1178	6	59%	3	9900	3	12	102	12%
39	470	15	42%	8	1553	11	34	102	33%
40	212	35	9%	20	921	19	74	102	73%
41	710	12	21%	15	5300	8	35	102	34%
42	126	40	0%	22	345	31	93	102	91%
43	1506	4	67%	1	9678	5	10	102	10%
44	493	14	40%	9	1203	14	37	102	36%
45	235	32	8%	21	921	19	72	102	71%
46	108	41	8%	21	579	26	88	102	86%
47	69	44	0%	22	435	29	95	102	93%
48	18	45	0%	22	37	33	100	102	98%

Biotic Communities Critical/ Protection Area Metric							
Site ID	mIBI	mIBI Rank	IBI	IBI Rank	Rank Total	Total Possible	Percent Score (Grade)
3	32	8	18	4	12	27	44%
4	32	8	28	8	16	27	59%
5	36	10	38	13	23	27	85%
6	26	3	42	15	18	27	67%
7	22	1	30	9	10	27	37%
8	32	8	26	8	16	27	59%
9	32	8	46	16	24	27	89%
10	32	8	22	6	14	27	52%
11	32	8	24	7	15	27	56%
12	27	4	34	11	15	27	56%
13	32	8	36	12	20	27	74%
14	22	1	12	2	3	27	11%
15							NA
16	27	4	40	14	18	27	67%
17	26	3	18	4	7	27	26%
18	30	7	28	8	15	27	56%
19	28	5	0	1	6	27	22%
20	29	6	30	9	15	27	56%
21	26	3	14	3	6	27	22%
22	32	8	18	4	12	27	44%
23	40	11	32	10	21	27	78%
24	22	1			1	11	9%
25	28	5	22	6	11	27	41%
26	32	8	34	11	19	27	70%
27	28	5	22	6	11	27	41%
28	26	3	34	11	14	27	52%
29	26	3	14	3	6	27	22%
30	22	1	26	8	9	27	33%

Biotic Communities Critical/ Protection Area Metric							
Site ID	**mIBI**	**mIBI Rank**	**IBI**	**IBI Rank**	**Rank Total**	**Total Possible**	**Percent Score (Grade)**
31	22	1	12	2	3	27	11%
32	32	8	38	13	21	27	78%
33	28	5	38	13	18	27	67%
34	30	7	32	10	17	27	63%
35			14	3	3	16	19%
36	30	7	28	8	15	27	56%
37	28	5	28	8	13	27	48%
38	30	7	34	11	18	27	67%
39	26	3	32	10	13	27	48%
40	34	9	36	12	21	27	78%
41	30	7	34	11	18	27	67%
42	32	8	32	10	18	27	67%
43	24	2	20	5	7	27	26%
44	26	3	32	10	13	27	48%
45	34	9	32	10	19	27	70%
46							NA
47	22	1	14	3	4	27	15%
48	28	5	28	8	13	27	48%

Appendix 7. Principal Component Analysis for Critical and Protection Areas

Variable	Mann-Whitney U Test (w/ continuity correction) (Critical Area Analysis_CCM2) By variable Group Marked tests are significant at p <.05000									
	Rank Sum (Group 1)	Rank Sum (Group 2)	U	Z	p-value	Z (adjusted)	p-value	Valid N (Group 1)	Valid N (Group 2)	2*1sided (exact p)
Temp	81.00000	55.0000	19.00000	1.31276	0.189264	1.31276	0.189264	8	8	0.194872
DO	36.00000	100.0000	0.00000	-3.30816	0.000939	-3.30816	0.000939	8	8	0.000155
NTU	97.00000	39.0000	3.00000	2.99310	0.002762	2.99310	0.002762	8	8	0.001088
Cond.	54.00000	82.0000	18.00000	-1.41778	0.156255	-1.41778	0.156255	8	8	0.160528
NH4	76.00000	44.0000	8.00000	2.25669	0.024028	2.33292	0.019653	7	8	0.020513
Nitrate+Nitrite	82.00000	54.0000	18.00000	1.41778	0.156255	1.41778	0.156255	8	8	0.160528
TP	99.00000	37.0000	1.00000	3.20314	0.001360	3.20314	0.001360	8	8	0.000311
TSS	99.00000	37.0000	1.00000	3.20314	0.001360	3.21260	0.001316	8	8	0.000311
Cl	74.00000	62.0000	26.00000	0.57762	0.563524	0.57762	0.563524	8	8	0.573737
TOC	89.00000	47.0000	11.00000	2.15293	0.031325	2.15293	0.031325	8	8	0.028127
Hard.	39.00000	97.0000	3.00000	-2.99310	0.002762	-2.99310	0.002762	8	8	0.001088
TS	62.00000	74.0000	26.00000	-0.57762	0.563524	-0.57762	0.563524	8	8	0.573737
TDS	52.00000	84.0000	16.00000	-1.62783	0.103563	-1.62783	0.103563	8	8	0.104895
Alk.	41.00000	95.0000	5.00000	-2.78306	0.005385	-2.78306	0.005385	8	8	0.002953
TKN	86.00000	50.0000	14.00000	1.83787	0.066083	1.83787	0.066083	8	8	0.064957
Sulfate	42.00000	94.0000	6.00000	-2.67804	0.007406	-2.67804	0.007406	8	8	0.004662
Fl	86.50000	49.5000	13.50000	1.89038	0.058708	1.92026	0.054826	8	8	0.049883
COD	83.00000	53.0000	17.00000	1.52280	0.127809	1.52280	0.127809	8	8	0.130381
Mg	66.50000	69.5000	30.50000	-0.10502	0.916359	-0.10510	0.916298	8	8	0.878477
Ca	40.00000	96.0000	4.00000	-2.88808	0.003876	-2.88808	0.003876	8	8	0.001865
Substrate	43.50000	76.5000	7.50000	-2.31455	0.020638	-2.34619	0.018967	8	7	0.013986
Cover	38.50000	81.5000	2.50000	-2.89319	0.003814	-2.94084	0.003273	8	7	0.001243
Channel	40.00000	80.0000	4.00000	-2.71960	0.006537	-2.77207	0.005570	8	7	0.003730
Bank	53.50000	66.5000	17.50000	-1.15728	0.247161	-1.20212	0.229319	8	7	0.231857
Pool	54.00000	66.0000	18.00000	-1.09941	0.271590	-1.11546	0.264653	8	7	0.280963
Riffle Run	52.50000	67.5000	16.50000	-1.27300	0.203018	-1.51574	0.129586	8	7	0.189277
Gradient	46.00000	74.0000	10.00000	-2.02523	0.042844	-2.15410	0.031233	8	7	0.040093
QHEI	38.50000	81.5000	2.50000	-2.89319	0.003814	-2.91144	0.003598	8	7	0.001243
Water	78.00000	58.0000	22.00000	0.99770	0.318426	0.99770	0.318426	8	8	0.328205
Com.	61.00000	75.0000	25.00000	-0.68264	0.494837	-0.68465	0.493563	8	8	0.505361
Ag	90.00000	46.0000	10.00000	2.25795	0.023949	2.25795	0.023949	8	8	0.020668
HD-Res	71.00000	65.0000	29.00000	0.26255	0.792896	0.26255	0.792896	8	8	0.798446
LD-Res	64.00000	72.0000	28.00000	-0.36757	0.713192	-0.36757	0.713192	8	8	0.720901
G/P	50.00000	86.0000	14.00000	-1.83787	0.066083	-1.83787	0.066083	8	8	0.064957
Forest	46.00000	90.0000	10.00000	-2.25795	0.023949	-2.25795	0.023949	8	8	0.020668
Ind.	64.00000	72.0000	28.00000	-0.36757	0.713192	-0.38371	0.701192	8	8	0.720901



Eigenvalues of correlation matrix
Active variables only
Eigenvalue
Eigenvalue number
62.40%
17.73%
8.82%
5.70%
3.76%
1.59%
12
10
8
6
4
2
0
-2
-2
0
2
4
6
8
10
12
14
16
18
20

Variable	Factor coordinates of the variables, based on correlations Factor 1	Factor 2
Substrate	0.808313	0.160775
Cover	0.818947	-0.111592
Channel	0.869880	-0.276913
QHEI	0.916311	0.102080
DO	0.845256	-0.226556
Hard.	0.842152	-0.520016
TP	-0.907258	-0.279274
TOC	-0.877834	0.320690
NTU	-0.843687	0.326896
NH4	-0.625427	-0.613331
Alk.	0.753178	-0.615480
Ca	0.487809	-0.727212
Ag	-0.694978	-0.667082