Pretty Lake Post-Construction Monitoring Report

July 6, 2018

Project No. J16X402500

Cardno
Shaping the Future

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Executive Summary

The Pretty Lake Conservation Club (PLCC) received a Lake and River Enhancement (LARE) grant from the Indiana Department of Natural Resources (IDNR) in August of 2016 to complete a watershed monitoring and management update study. Since the completion of the 2007 Pretty Lake Diagnostic Study a variety of watershed management projects focused on reducing non-point source pollution have been completed, in addition to in-lake management practices such as controlling invasive aquatic plants and dredging activities. The purpose of this study was to gather current data on watershed, tributary and in-lake, physical, chemical, biological, habitat and landuse conditions and compare those results to historical data to determine if positive or negative trends can be observed. Additionally, based on current conditions, recommendations for future watershed management projects to address non-point source pollution, landuse, and in-lake management activities are discussed.

The PLCC has been actively working to reduce non-point source pollution by completing water quality improvement construction projects throughout the Pretty Lake watershed. Since the completion of the 2007 diagnostic study and 2009 feasibility study, five water quality improvement projects have been completed. The projects were constructed between 2010 and 2012 and included catch basin modification/improvements, tile repair, roadside rock channel construction, grass swale construction and the installation of 300 feet of two-stage ditch on Deal Ditch. Additionally, a sediment removal plan was completed in 2013 with follow-up dredging operations completed at three sites from 2014-2016. In 2008, an aquatic vegetation management plan (AVMP) was completed to document the existing aquatic plant community and develop management strategies. During the 2008 AVMP the invasive species Eurasian watermilfoil (*Myriophyllum spicatum,* EWM) was identified and was estimated to cover approximately 16 acres. EWM was not treated from 2008 through 2012, however after suggested increase in coverage of the invasive species, active treatment of infestations areas was initiated in 2013 and has occurred and been monitored annually since. The original amount of area treated for EWM in 2013 was approximately 28 acres, but with successful management of the species the average area treated since 2016 is around 4 acres. While Eurasian watermilfoil is not gone from Pretty Lake it is now present at a more manageable level.

Management recommendations as a result of the study include a variety of projects within the Pretty lake watershed. Some of the recommended project outlined in this report were discussed previously in the 2007 Diagnostic Study or 2009 Feasibility Study, while some were identified during the current study. Construction projects include installing a rain garden at the Elementary School, catch basin modifications at two sites along CR 890 E, limited paving of CR 890 E, catch basin spillway stabilization east of CR 890 E, construction of a two-stage ditch east of CR 875 E on Deal Ditch, stabilization of Deal Ditch streambanks between CR 400 S and CR 430 S, and a grass swale along CR 480 S. A general cost estimate was developed for each of the recommended projects and ranged in price from $6,500 to $78,000. Additional management recommendations included stakeholder initiative type projects such as promoting proper septic system care and maintenance, natural shoreline plantings and lakescaping, and agricultural best management practices.

Sampling during this study included both tributary and in-lake sampling events. The project scope identified up to four tributary sites would be sampled and one lake sampling site. The selected tributary sites were agreed upon by the PLCC, IDNR and Cardno and selected based on physical feasibility of collecting water samples and connection with past sampling efforts such that the 2017 data could be directly compared to previous years. Tributary water sampling was completed during one sampling event which took place on May 25th, 2017, following a 1.62 in (4.11 cm) rain event on May 24th, and another sampling event was completed on November 13th, 2017 to collect macroinvertebrate and habitat data. Three of the four tributary sampling site were located along Deal Ditch, with Site 1 located at the crossing

of County Road 875 E, Site 2 immediately downstream of the County Road 400 S crossing and Site 3 immediately upstream from County Road 430 S crossing. The frequency of sampling locations along the length of Deal Ditch was desirable because it would allow water quality, biological and habitat characteristics to be tracked along the length of the stream. Site 4 was located at the outlet stream of Pretty Lake near the outlet structure at County Road 930 E (Figure 22).

Results of the tributary sampling indicated all physical parameters sampled such as temperature, pH, conductivity, etc. were at acceptable and normal levels however a couple of the chemical parameters sampled exceeded State standards or were at levels of concern. The two parameters which exceeded Indiana State Standards were ammonia and *E.coli* and were exceeded at the three sampling sites within Deal Ditch. Ammonia concentrations were highest in the most upstream sampling location and lowest in the most downstream sampling location. Due to the *E. coli* analytical method used and the high levels sampled, increases or decreases from upstream to downstream along Deal Ditch could not be identified. Ultimately, the *E. coli* results indicate *E. coli* concentrations are an issue along the entire length of the stream sampled. Source tracking of *E. coli* was completed at all sites to identify what percent *of E. coli* present is human vs animal origin. Source tracking results indicate human sources are the overwhelmingly dominate source of E. coli impairment accounting for 94-95%, while animal sources only account for 5-6%. This dominance of human sources for E. coli was consistent with previous sampling along Deal Ditch during the 2007 Diagnostic Study. Nitrate concentrations within the three Deal Ditch sites were also of concern. While nitrate concentrations did not exceed the State standard they were at levels at which can have a negative impacts to aquatic life that live in the stream and provide excess nitrogen loading to Pretty Lake.

The in-lake sampling event took place on September 6, 2017 during the summer stratification period and was located in the middle portion of the lake at the deepest point of the lake. Water samples were collected from the epilimnion (near water surface) and hypolimnion (near bottom sediments). A temperature and oxygen profile was completed from the surface to the bottom of the water column with measurements taken at 1 meter intervals. A light extinction profile was completed and included taking measurement at 1 meter intervals down to the 1% light level. A vertical plankton tow was completed from approximately the 1% light level to the surface to evaluate the phytoplankton and zooplankton communities. Water transparency was measured using a secchi disk.

Overall in-lake water quality sampling suggests Pretty Lake has good water quality and better water quality then most lakes in the region. This is supported by the relatively high secchi disk reading, low chlorophyll a concentration and low to moderate plankton abundance. Phosphorus concentrations were greater than expected and on the higher end of historical measurements. Phosphorous levels measured in the epilimnion and hypolimnion indicate internal phosphorus loading from bottom sediments is occurring. Proof of this is shown by the increase in soluble reactive phosphorus (SRP) in the epilimnion to the hypolimnion. The percentage of total phosphorus which was soluble (SRP) increased between the epilimnion and hypolimnion with SRP accounting for 82.8% and 94.6%, respectively. Dissolved oxygen and temperature profiles sampled in 2017 indicates Pretty Lake was stratified, such that surface water and bottom waters were not mixing due to temperature-induced density differences. At the time of sampling, the epilimnion was confined to the upper approximately 20 ft. (6.1 m) of water (Figure 23), while the hypolimnion occupied water deeper than 46 ft. (14.0 m). The dissolved oxygen profile mirrored the temperature profile, however oxygen becomes essentially absent at approximately 30 ft. (9.1 m). The lake was saturated (100% oxygen percent) from the surface to a depth of approximately 16 ft. (4.9 m). Water below approximately 25 ft. (7.6 m) did not contain sufficient dissolved oxygen to support fish and other aquatic organisms. Only approximately 25% of the water column was suitable for fish habitation.

During the September sampling Pretty Lake's 1% light level was located at a depth of approximately 33 ft. (10.0 m; Figure 24). Based in the depth-area curve Pretty Lakes littoral zone is approximately 150 acres (60.7 ha) in size and covers approximately 81% of the lake. Based on Pretty Lake's depth-volume curve, approximately 3,500 acre-feet of Pretty Lake (73% of total lake volume) lies above the 33 ft. (10.0 m) 1% light level.

Phytoplankton density was determined to be 8,826 natural units (nu)/L and zooplankton density was determined to be 6,242 animals/L, for a total plankton density of 15,068 nu/L. Pretty Lake plankton community density is below the median values of most Indiana lakes according to a Clean Lake Program data set and suggests Pretty Lake contains increased water quality as higher plankton densities usually indicate excessive nutrients within a waterbody. At the time of the plankton sampling, the Pretty Lake phytoplankton community was dominated by blue-green algae (Cyanophyta) which accounted for 88.8% of the plankton community. A review of available plankton data from the Indiana Trophic State Index (ITSI) calculations show that blue-green algae has been the dominate algae since 1993. Plankton density during the most recent study did show an increase from previous survey years however the overall plankton density is considered relatively low.

Comparing the secchi disk readings from 2006 and 2017 indicate Pretty Lake water clarity has remained relatively unchanged and is further suggested to be in-line with other historical sampling efforts. Pretty Lake with a secchi disk reading of 13.1 ft. (4 m) remains well above the median value of 6.9 ft. (2.1 m) for most lakes in Indiana.

The total Indiana Trophic State Index (ITSI) score was 21 which places Pretty Lake in the lower mesotrophic range (TSI scores of 16-31). Most metrics received low to moderate scores while total phosphorus scored slightly higher with a score of 3 out of a potential 5. The only metric which would be considered “high” is the additional 10 points assigned to the overall score for the dominance of blue-green algae in the plankton sample; however, the overall plankton density metric scored low. Overall the ITSI suggests Pretty Lake is a moderately productive system and therefore, contains moderate to good water quality. Overall, the TSI score calculated during 2017 and a review of available historical scores does not show a discernible increase or decrease in overall water quality and suggests Pretty Lake water quality has remained relatively stable.

Section1: Pretty Lake Watershed Characteristics

1 Pretty Lake Watershed Characteristics

1.1 Watershed Size and Location

Pretty Lake is a 184-acre (74.5-ha) natural lake that lies in the southeast corner of LaGrange County, Indiana. Specifically, the lake is located in Sections 15 and 16 of Milford Township 36 North, Range 11 East in LaGrange County, Indiana. The Pretty Lake watershed stretches out to the north and west of the lake encompassing approximately 1,231 acres (497.7 ha or 1.9 square miles; Figure 1). Water discharges through the lake's outlet in the northeast corner. Water from Pretty Lake's outlet combines with water from Mud Lake to flow north into Little Turkey Lake. Water from Little Turkey Lake exits through Turkey Creek and flows north until it empties into the Pigeon River near Mongo, Indiana. The Pigeon River transports water to the St. Joseph River, which eventually discharges into Lake Michigan.

Figure 1. General location map of Pretty Lake watershed, LaGrange County, Indiana.

Surface water drains to Pretty Lake via three primary routes: through Deal Ditch, through an unnamed tributary which enters near the public access site, and via direct drainage (Figure 2). Deal Ditch drains approximately 651 acres (263.5 ha or 53%) of the watershed north of Pretty Lake (Figure 2; Table 1). This stream empties into Pretty Lake in the lake's northeast corner. The drain was originally constructed as a tile drain in 1902 and was subsequently reconstructed in 1952 as an open drain (Rex Pranger, personal communication). This drain is a legal drain, which means that the drain is maintained by the drainage board. Furthermore, any activity in and around the drain must be approved by the drainage board prior the activity occurring. An unnamed tributary transports water to Pretty Lake from the watershed west of the lake emptying into the lake along its western boundary. In total, this tributary drains 160 acres (64.7

ha) of the Pretty Lake watershed. The remaining 19% of the land in the Pretty Lake watershed (236 acres or 95.5 ha) drains directly to Pretty Lake or via a series of small swales along the lake's western shoreline. McGinty (1966) noted that the main inlet to Pretty Lake (Deal Ditch) supplied 80% of the surface water to the lake. However, it should be noted that a majority of water likely enters Pretty Lake as groundwater. Historic fluctuations in surface water level typically occurred due to a large spring associated with the lake (McGinty, 1966).

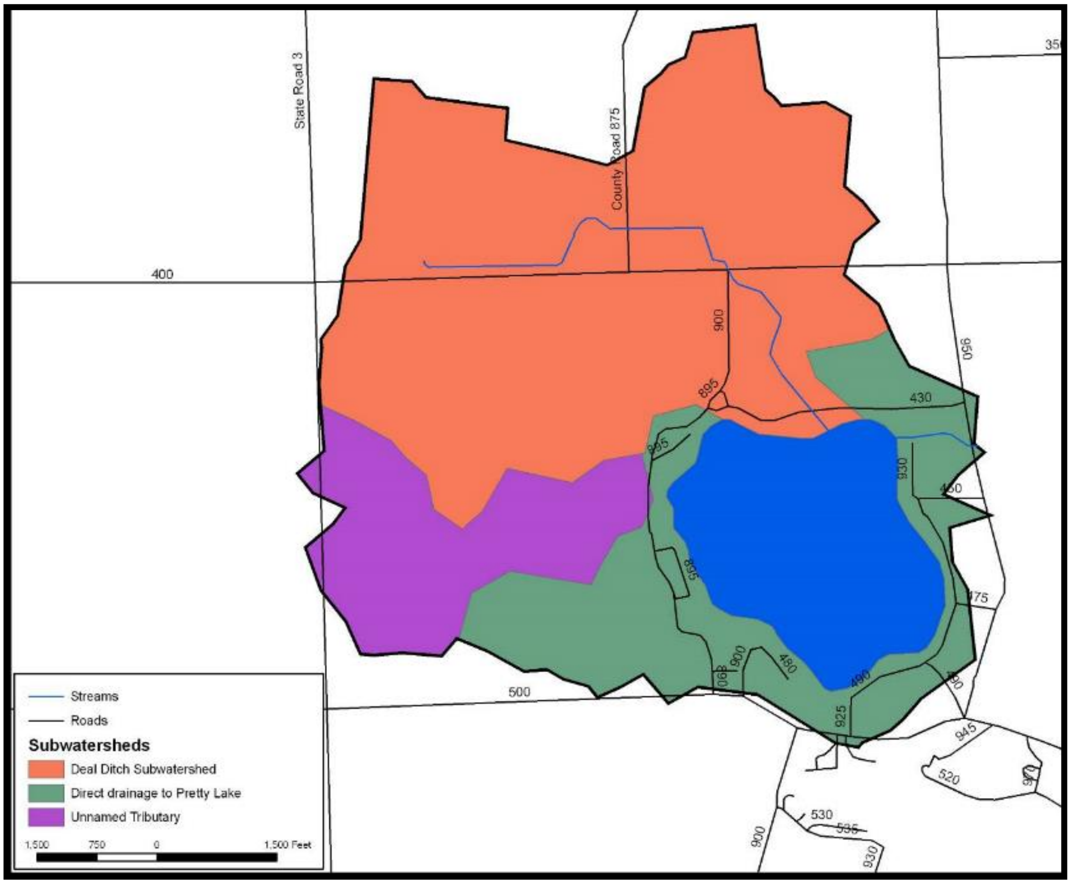

Figure 2. Pretty Lake subwatersheds.

Table 1. Pretty Lake watershed and subwatershed sizes.

Subwatershed/Lake	Area (acres)	Area (hectares)	Percent of Watershed
Deal Ditch	651	263.5	52.8%
Unnamed Tributary (West)	160	64.7	13.1%
Area draining directly to Pretty Lake	236	95.5	19.2%
Watershed Draining to Lake	**1,047**	**423.7**	**85.1%**
Pretty Lake	184	74.5	14.9%
Total Watershed	**1,231**	**498.2**	**100%**
Watershed to Lake Area Ratio	6.7:1		

1.2 Climate

The climate of the Pretty Lake watershed is characterized as having four well-defined seasons of the year. Winter temperatures average 27º F (-2.7º C), while summers are warm, with temperatures averaging 71º F (21.7º C). The growing season typically begins in early April and ends in September. Yearly annual rainfall averages 37.21 inches (94.5 cm). Winter snowfall averages about 33 inches (83.82 cm). During summers, relative humidity varies from about 65 percent in mid-afternoon to near 80 percent at dawn. Prevailing winds typically blow from the southwest except during the winter when westerly and northwesterly winds predominate. In 2017, the total precipitation measured from Station IN-LG-11, located at Latitude 41.648611 Longitude -85.230556, or approximately 5 miles north of Pretty Lake was 38.37 inches (97.45 cm; Table 2.

Table 2. Monthly rainfall data (in inches) for year 2017 as compared to average monthly rainfall.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Total
2017	3.06	2.49	2.76	3.24	7.53	1.42	3.36	2.18	2.39	4.59	5.16	0.19	38.37
Average	1.97	1.79	2.08	3.25	4.11	4.00	3.91	4.25	3.37	3.02	3.11	2.35	37.21

All data were recorded at Station IN-LG-11 from CoCoRaHS Network Site, LaGrange County, Indiana. https://www.cocorahs.org/WaterYearSummary/State.aspx?state=IN&year=2017 Accessed on April 3, 2018. Averages are based on 30 Year average by PRISM (1981-2010).

1.3 Geology

The advance and retreat of the glaciers in the last ice age (the Wisconsin Age) shaped much of the landscape found in Indiana today. As the glaciers moved, they laid thick till material over the northern two thirds of the state. Ground moraine left by the glaciers covers much of the central portion of the state. In the northern portion of the state, ground moraines, end moraines, lake plains, and outwash plains create a more geologically diverse landscape compared to the central portion of the state. End moraines, formed by the layering of till material when the rate of glacial retreat equals the rate of glacial advance, add topographical relief to the landscape. Distinct glacial lobes, such as the Michigan Lobe, Saginaw Lobe, and the Erie Lobe, left several large, distinct end moraines, including the Valparaiso Moraine, the Maxinkuckee Moraine, and the Packerton Moraine, scattered throughout the northern portion of the state. Glacial drift and ground moraines cover flatter, lower elevation terrain in northern Indiana. Major rivers in northern Indiana cut through sand and gravel outwash plains. These outwash plains formed as the glacial meltwaters flowed from retreating glaciers, depositing sand and gravel along the meltwater edges. Lake plains, characterized by silt and clay deposition, are present where lakes existed during the glacial age.

Pretty Lake is located within a series of kettle lakes that are generally oriented in a northwest-southeast direction. These lakes occur in line with a stress plain associated with the Saginaw Lobe. The movement and stagnation of the Saginaw and Erie Lobes of the Wisconsin glacial age shaped much of the Pretty Lake watershed. The Saginaw glacial lobe moved out of Canada to the south carrying a mixture of Canadian bedrock with it. The Packerton Moraine, an end moraine which marks the edge of the Saginaw Lobe's advance into Indiana, forms the southern boundary of Pretty Lake's watershed and the general boundary between the St. Joseph River Basin and the Wabash River Basin. The Packerton Moraine formed as remnant ice chunks from the Saginaw Lobe melted. However, some of these ice blocks remained when the Erie Lobe moved into Indiana from the northeast overriding the eastern edge of the Saginaw Lobe. Pretty Lake is located within the area where the Saginaw and Erie Lobes overlapped (Williams, 1974). Specifically, the lake is located within remnant Saginaw glacial drift (Hough, 1958).

The geology and resulting physiography of the Pretty Lake watershed typify the physiographic region in which the watershed lies. The Pretty Lake watershed lies within Malott's Steuben Morainal Lake Area. Schneider (1966) notes that the landforms common in this diverse physiographic region include till knobs and ice-contact sand and gravel kames, kettle holes and lakes, meltwater channels lined with outwash deposits or organic sediment, valley trains, outwash plains, and small lacustrine plains. Specifically, kames, kettle lakes, outwash plains, and meltwater channels exist within the Pretty Lake watershed and surrounding area (Williams, 1974). Many of these landforms are visible on the Pretty Lake watershed landscape. Pretty Lake is a good example of a deep (relative to many lakes in the region) kettle lake lying in an end moraine. It's part of the "knob and kettle" topography that is characteristic of end moraines. As Williams (1974) noted, the original ice block that formed as Pretty Lake has undergone some modifications as sediments accumulated within the glacial drift. Till knobs and kames occur along the watershed's southwestern edge. Many other reminders of the watershed's geologic history exist for those who look closely.

Surficial geology indicates that Pretty Lake lies within glacial till material. Glacial drift covers the Pretty Lake watershed to a depth of 300 to 400 feet (91.2 to 122 m; Wayne, 1966). The watershed's surficial geology originates from silty clay loam and clay loam till materials. The bedrock underlying the watershed's surficial geology includes rock from one period. Coldwater shale underlies the entire Pretty Lake watershed (Gray, 1989). Shale was laid to a depth of 90 and 350 feet (27.4 to 106.7 m). The underlying bedrock is a broad lowland which possesses moderate relief, the Dekalb Lowland. This lowland formed on Upper Devonian and Lower Mississippian shales (Wayne, 1966; Gutschick, 1966).

1.4 Topography

Pretty Lake is a headwaters lake in the Great Lakes Basin. The lake and its 1,231-acre (498-ha) watershed lie north of the north-south continental divide. Similar to its more famous cousin, the east-west Continental Divide which divides the United States into two watersheds, one that drains to the Atlantic Ocean and one that drains to the Pacific Ocean, the north-south continental divide separates the Mississippi River Basin (land that drains south to the Mississippi River) from the Great Lakes Basin (land that drains north to the Great Lakes). As part of the St. Joseph River Basin, water exits Pretty Lake near the lake's northeast corner and flows east then north through Lagrange County as Turkey Creek. Turkey Creek combines with the Pigeon River south of Mongo, which eventually discharges into the St. Joseph River in Michigan directly north of Bristol, Indiana. The St. Joseph River flows northwest carrying water into Lake Michigan at St. Joseph/Benton Harbor.

The topography of the Pretty Lake watershed reflects the geological history of the watershed. The highest areas of the watershed lie along the watershed's southern and eastern edges, where the Erie Lobe of the last glacial age left end moraines. Along the watershed's northern boundary, the elevation nears 1,030 feet (313.9 m) above mean sea level. The ridges along the watershed's southwestern boundary are nearly as high (1,020 feet msl), and are equally as steep as the ridge along the northern watershed boundary. Deal Ditch, its floodplain, and Pretty Lake occupy a lower elevation valley in the watershed. Pretty Lake, elevation 964 feet (293.8 m) above mean sea level, is the lowest point in the watershed. This surface water elevation is one of the highest elevations for lakes in Lagrange County (Grant, 1989). Figure 3 presents a topographical relief map of the Pretty Lake watershed.

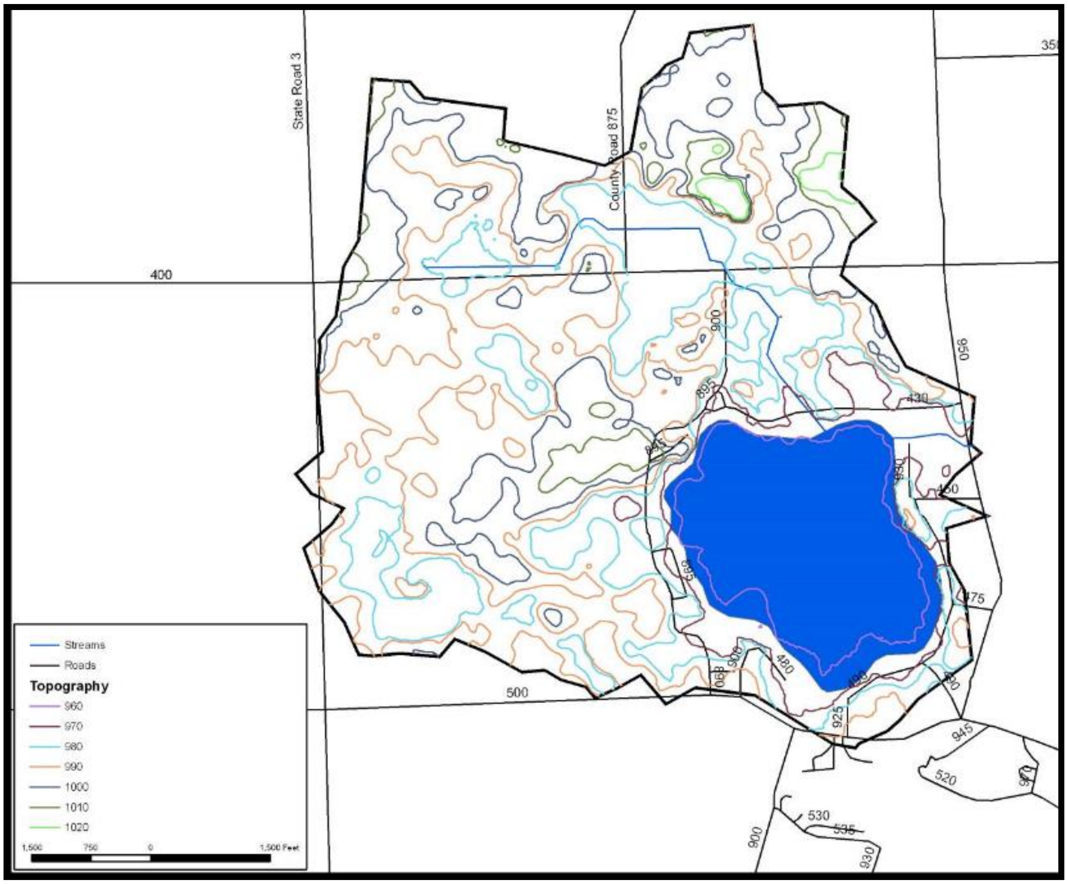

Figure 3. Topographical map of the Pretty Lake watershed.

1.5 Landuse

Figure 4 and Table 3 present current land use information for the Pretty Lake watershed. Landuse data is from the United States Geological Survey (USGS) 2011, National Land Cover Database (NCLD). Like many Indiana watersheds, agricultural uses dominate the Pretty Lake watershed accounting for approximately 51% of the watershed. Row crops are the most dominate form of landuse covering 37.8% (465 ac; 188 ha), while hay and pasture cover an additional 13.5% (166 ac; 67 ha). Woody wetland habitats cover a significant portion of the watershed and are suggested to cover 18.7% of the watershed (230 ac; 93.1 ha), which is the second most prevalent landuse in the watershed overall. Open water habitats which include Pretty Lake, account for the third most abundant landuse at 15% (184 ac; 74 ha). Upland forest environments which include deciduous forest and evergreen forest cover a total of 5.6% of the watershed (69.2 ac; 28 ha). Developed space in the watershed accounts for approximately 8% and is composed primarily of single family homes and maintained open spaces around the perimeter of Pretty Lake.

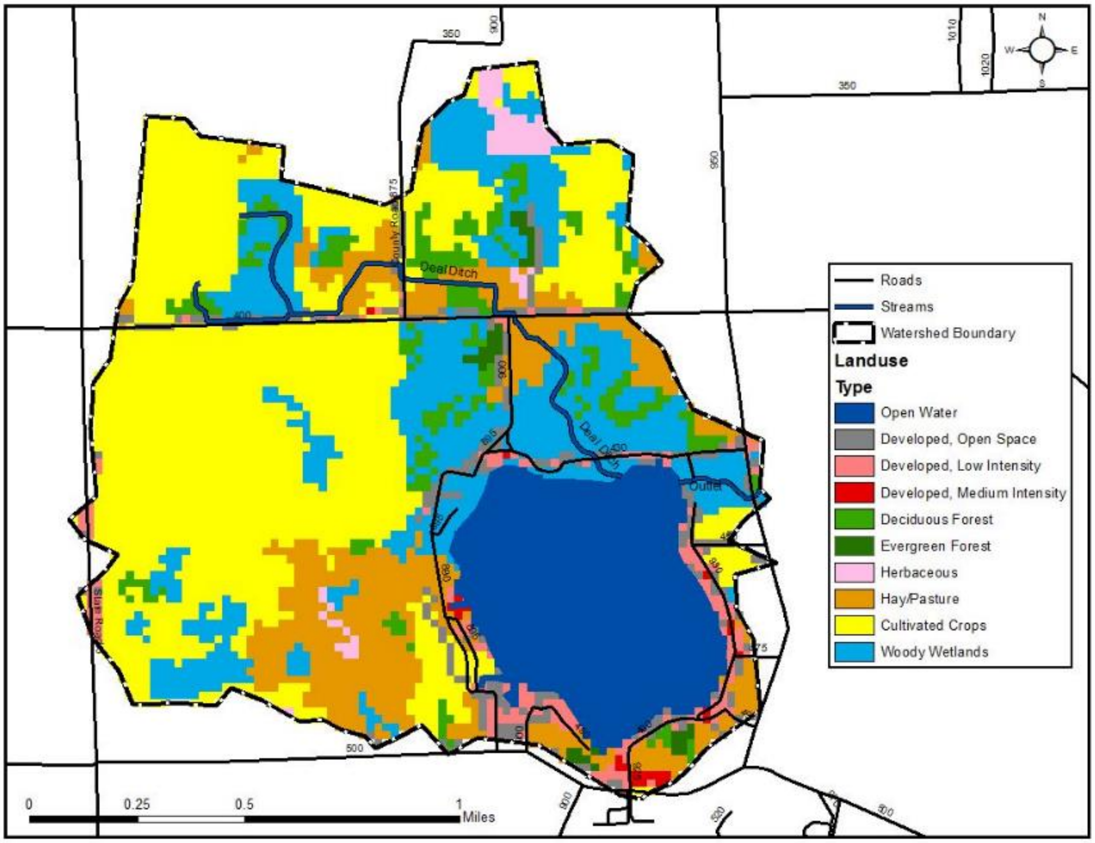

Figure 4. Pretty Lake landuse map, LaGrange County, Indiana.

Table 3. Pretty Lake landuse characteristics.

Type	Acres	Hectares	% of Watershed
Developed, Medium Intensity	5.6	2.3	0.5
Evergreen Forest	8.7	3.5	0.7
Herbaceous	16.7	6.8	1.4
Developed, Low Intensity	37.8	15.3	3.1
Developed, Open Space	56	22.7	4.5
Deciduous Forest	60.5	24.5	4.9
Hay/Pasture	166.1	67.2	13.5
Open Water	184.4	74.6	15.0
Woody Wetlands	230	93.1	18.7
Cultivated Crops	465.2	188.3	37.8
Total	**1,231**	**498.2**	**100**

1.6 Changes in Landuse and Conservation Practice

A comparison of available landuse datasets from 1998 and 2011 shown in Table 4 suggests some significant changes in abundance by cover type, such as reduction of cultivated crops by 12.4%, an increase in woody wetlands by 15.6% and reduction of deciduous forest by 7.7% from 1998-2011. The changes in landuse type are not as drastic as indicated and alternatively represent the landuse designations used by the 1998 and 2011 datasets. This is best represented by the increase in woody wetlands and decrease in deciduous forests. It appears a significant amount of deciduous forest designations were changed to woody wetlands from 1998 to 2011, most notably in the forested portion immediately north of the lake and in the northwest portion of the watershed near the headwaters of Deal Ditch. It is suggested that the designation of woody wetlands vs deciduous forest is more closely representative of landuse type. The reduction of cultivated crops is apparent when viewing historical aerials from 1998 to 2011. The most significant decrease in cultivated crops is located in the south-western portion of the watershed where cultivated crops were converted to tree plantings and hay/pasture cover between 1998 and 2011.

Table 4. Pretty Lake watershed landuse comparison between 1998 and 2011 datasets.

Type	Acres (2011)	Acres (1998)	% of Watershed (2011)	% of Watershed (1998)	% Change 1998-2011
Emergent Herbaceous Wetland	-	8.3	-	0.7	- 0.7
High Intensity Commercial/Residential	-	1.6	-	0.1	- 0.1
Mixed Forest	-	0.2	-	<0.1	- <0.1
Developed, Medium Intensity	5.6	-	0.5	-	+0.5
Evergreen Forest	8.7	1.1	0.7	0.1	+0.6
Herbaceous	16.7	-	1.4	-	+1.4
Developed, Low Intensity	37.8	14.7	3.1	1.2	+1.9
Developed, Open Space	56	-	4.5	-	+4.5
Deciduous Forest	60.5	155.5	4.9	12.6	-7.7
Hay/Pasture	166.1	207	13.5	16.8	-3.3
Open Water	184.4	187.2	15.0	15.2	-0.2
Woody Wetlands	230	37.6	18.7	3.1	+15.6
Cultivated Crops	465.2	618.1	37.8	50.2	-12.4
Total	**1,231**	**1,231**	**100**	**100**	

Conservation practices such as no-till or reduced till agriculture are widely used throughout the Pretty Lake watershed and have not changed noticeably since the 2007 diagnostic study. A review of historical aerials back to 1998, indicate reduced till agricultural practices have been in use for a significant amount of time and is the dominate tillage type for agricultural lands. Other conservation practices associated with wetland creation, restoration or enhancement appear to be similar to that present during the diagnostic study and an increase in wetland habitat is not suggested to have occurred since the diagnostic study. Other changes to conservation practices have occurred within the watershed and include those projects listed in the Table 37 which involved construction of a rock-channel, catch basin and tile repair, grass swale and two-stage ditch construction.

Section 2: Watershed and In-lake Management Since 2007

2 Watershed and In-lake Management Since 2007

2.1 Watershed and In-Lake Management Activities Since 2007

The PLCC has been actively working to reduce non-point source pollution by completing water quality improvement construction projects throughout the Pretty Lake watershed. Since the completion of the 2007 diagnostic study and 2009 feasibility study, five water quality improvement projects have been completed (Figure 5). The site names identified in Figure 5 are those used in the 2009 feasibility study and are described in more detail in Table 5. Additionally, a sediment removal plan was completed which identified three locations within Pretty Lake where dredge activities would be completed. The three dredge sites included the inlet area at the public boat launch on the west side of the lake, the two channels on the southwest corner of the lake, and at the mouth of Deal Ditch on the north end of the lake. In 2008, an aquatic vegetation management plan (AVMP) was completed to document the existing aquatic plant community and develop management strategies. During the 2008 AVMP the invasive species Eurasian watermilfoil (*Myriophyllum spicatum,* EWM) was identified and was estimated to cover approximately 16 acres. EWM was not treated from 2008 through 2012, however after suggested increase in coverage of the invasive species, active treatment of infestations areas was initiated in 2013 and has occurred and been monitored annually since (Table 5). The IDNR has completed a number of fisheries assessments since 2007 (Table 5). In 2010, the IDNR completed a general fisheries assessment and included standard sampling of the fish community, fish harvest by anglers, and population estimates of walleye and largemouth bass. Additionally, the IDNR has been completing annual fall walleye electrofishing assessments since 1993 to determine stocking success. Water quality monitoring activities that have been completed or are actively being completed include in-lake sampling by the Clean Lakes Program (CLP) in 2010 and 2012, in-lake sampling in 2013-2015 as part of the LaGrange County Lakes 23 lake study, and annual in-lake sampling by the PLCC as part of the LaGrange County Lakes Council (Table10).

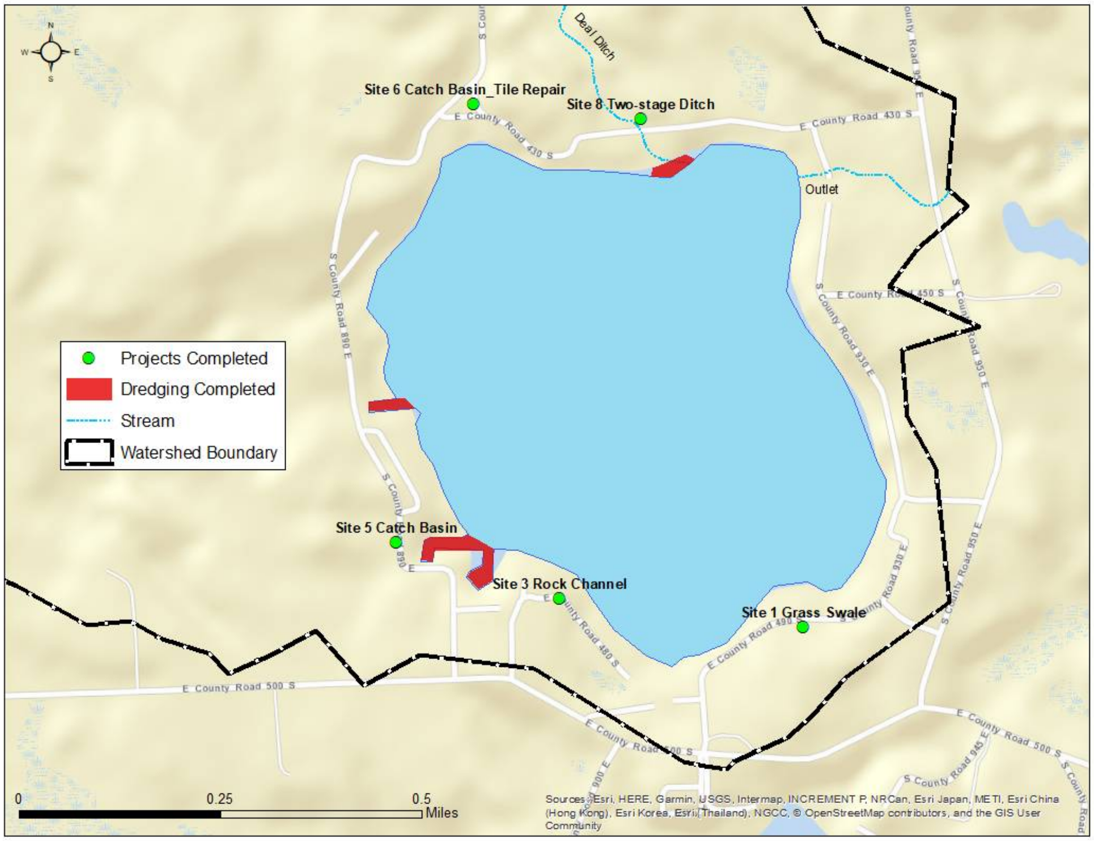

Figure 5. Watershed improvement projects completed since 2007 diagnostic study and outlined in the 2009 Feasibility Study and 2013 Sediment Removal Plan.

Table 5. Construction and monitoring activities completed in the Pretty Lake watershed since 2007 Diagnostic Study.

Project Type	Year Completed	Completed By	Description
Aquatic Vegetation Management Plan (AVMP)	2008	Cardno	Completed tier II aquatic plant sampling to assess plant community. Developed management recommendations based on survey results. Eurasian watermilfoil was estimated to be present at 16 acres.
Engineering/Feasibility Study	2007-2009	Cardno	Investigated entire watershed to develop a set of potential water quality improvement projects to reduce non-point source pollution. A total of eight project sites were identified and discussed.
General Fisheries Assessment	2010	IDNR	General fish community sampling, fish harvest by anglers and population estimates of walleye and largemouth bass.
Fall Walleye Electrofishing Assessments	1993-2016	IDNR	Annual fall walleye sampling to determine stocking survival, natural reproduction, population dynamics, growth rates and assess stocking rates.

Project Type	Year Completed	Completed By	Description
Clean Lakes Program (CLP) Sampling	2010	Indiana University	In-lake assessment of chemical and physical conditions.
Water Quality Improvement Projects Construction Sites 1, 3 and 6	2010	LARE, PLCC	Construction of Sites 1, 3 and 6 identified in the 2009 Feasibility Study. LARE funded.
Water Quality Improvement Project Construction Site 5	2011	LARE, PLCC	Construction of Site 5 identified in the 2009 Feasibility Study. Site 5 involved the installation of a sediment basin, catch basin and tile modification to increase storage of stormwater and increase infiltration. LARE funded.
CLP Sampling	2012	Indiana University	In-lake assessment of chemical and physical conditions.
Water Quality Improvement Project Construction Site 8	2012	LARE, PLCC	Construction of Site 8 identified in the 2009 Feasibility Study. Project involved the construction of 300 ft. of two-stage ditch on Deal Ditch immediately north of County Road 430 S. LARE funded.
Sediment Removal Plan	2012-2013	PLCC	Develop sediment removal plan for three locations within Pretty Lake. Involved sediment depth, composition and testing, spoils disposal planning and treatment. LARE funded.
LaGrange County Lakes Sampling Effort	2013-2015	LaGrange County Lakes Council	23 lakes sampled in 2013 for various physical, chemical and plankton analysis. Additional in-lake sampling completed for Pretty Lake in 2011, 2012, and 2014. IDEM 319 Program funding.
AVMP Update	2013	Aquatic Weed Control	Eurasian watermilfoil treatment (27.85 acres). Tier II aquatic plant sampling and management plan recommendations.
AVMP Update	2014	Aquatic Weed Control	Eurasian watermilfoil treatment (27.85 acres, + 3.19 acres retreatment). Tier II aquatic plant sampling and management plan recommendations.
Dredging	2014-2016	LARE, PLCC	Completed dredging at three sites outlined in the 2013 Sediment Removal Plan.
AVMP Update	2015	Aquatic Weed Control	Eurasian watermilfoil treatment (28.02 acres, + 3.84 acres retreatment). Tier II aquatic plant sampling and management plan recommendations.
AVMP Update	2016	Aquatic Weed Control	Eurasian watermilfoil treatment (3.9 acres). Tier II aquatic plant sampling and management plan recommendations.

Project Type	Year Completed	Completed By	Description
AVMP Update	2017	Aquatic Weed Control	Eurasian watermilfoil treatment (3.3 acres, + 2.69 acres retreatment). Tier II aquatic plant sampling and management plan recommendations.
Annual in-lake sampling	2014-present	PLCC, LaGrange County Lakes Council	Annual sampling of total phosphorus within the lake during summer months (June, July, September). Completed by PLCC members.

Section 3: 2017 Tributary and In-lake Sampling Scope, Methods, Results and Data Analysis.

3 2017 Tributary and In-lake sampling Scope, Methods, Results and Data Analysis

3.1 2017 Tributary Sampling Scope

The project scope identified up to four tributary sites would be sampled. The selected tributary sites were agreed upon by the PLCC, IDNR and Cardno and selected based on physical feasibility of collecting water samples and connection with past sampling efforts such that the 2017 data could be directly compared to previous years. Tributary water sampling was completed during one sampling event which took place on May 25th, 2017, following a 1.62 in (4.11 cm) rain event on May 24th, and another sampling event was completed on November 13th, 2017 to collect macroinvertebrate and habitat data. Communication with PLCC and IDNR indicated water sampling should take place following a significant storm event (>1.0 in; 2.54 cm). A storm sampling event was desired because for most watersheds a significant portion of the overall yearly nutrient loading occurs during storm events when surface runoff, streambank erosion and discharge are increased. Additionally, previous sampling efforts from the diagnostic study were completed in May so the current study wanted to correspond with the seasonal sampling timeframe.

Three of the four tributary sampling sites were located along Deal Ditch, with Site 1 located at the crossing of County Road 875 E, Site 2 immediately downstream of the County Road 400 S crossing and Site 3 immediately upstream from County Road 430 S crossing (Figure 6). The frequency of sampling locations along the length of Deal Ditch was desirable because it would allow water quality, biological and habitat characteristics to be tracked along the length of the stream. Site 4 was located at the outlet stream of Pretty Lake near the outlet structure at County Road 930 E (Figure 6). Previous sampling efforts for water quality, biological and habitat parameters were completed in 2006 during the development of the diagnostic study at Site 3 and Site 4.

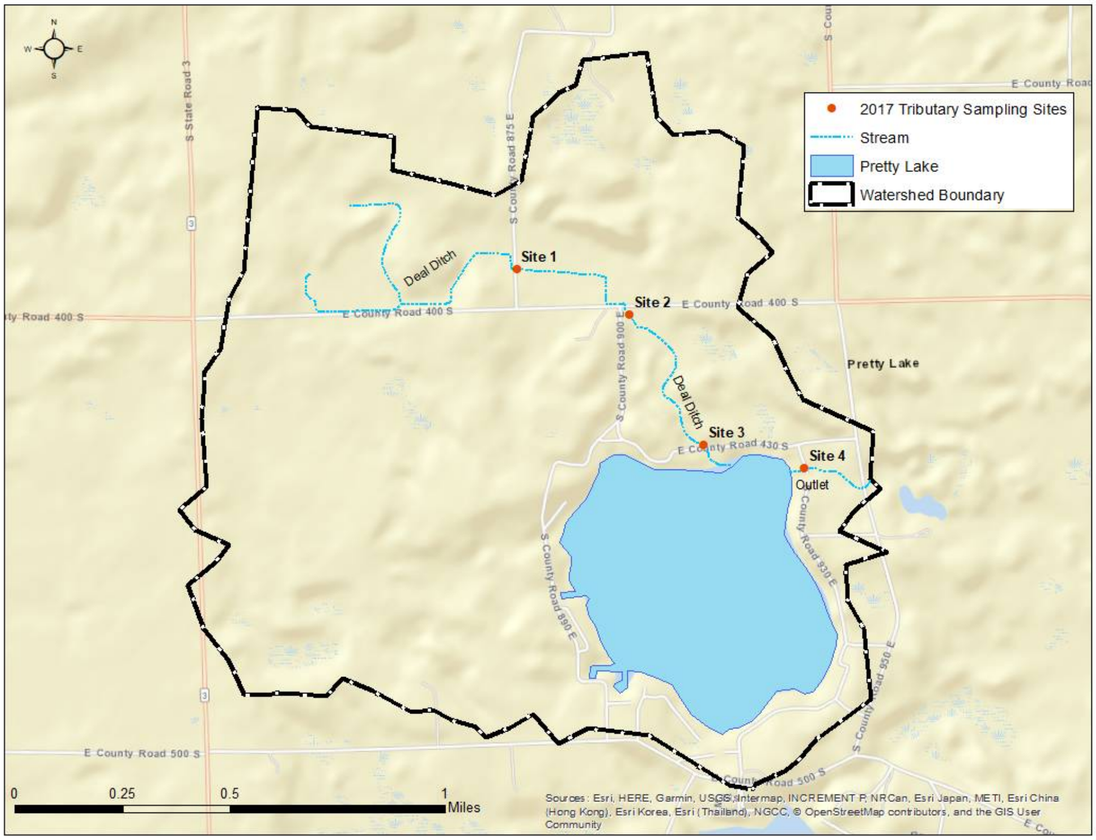

Figure 6. 2017 Pretty Lake tributary sampling locations.

3.2 Tributary Sampling Methods

Water Quality

Tributary sites were sampled by one Cardno staff member and one PLCC representative on May 25, 2017. At each of the four tributary sampling sites the following physical and chemical parameters were assessed: total phosphorus (TP), soluble reactive phosphorus (SRP), nitrate-nitrogen (NO3-N), nitrite-nitrogen (NO2-N), ammonia-nitrogen (NH3-N), total Kjeldahl nitrogen (TKN), *E. coli* , stream discharge, temperature, dissolved oxygen (mg/L and % saturation), turbidity, total suspended solids (TSS), pH, and conductivity. All parameters were collected using standard sampling methods and water samples were a grab collection. Chemical parameters were analyzed at Cardno laboratories in Walkerton, Indiana, with the exception of TSS and E. coli which were analyzed by Environmental Labs Inc. in Plymouth Indiana. Additionally, source tracking samples were collected for *E. coli* at each of the sites and those samples were analyzed by Scientific Methods, Inc. in Granger Indiana.

Macroinvertebrate

Aquatic macroinvertebrates are important indicators of environmental change. Numerous studies have shown that different macroinvertebrate orders and families react differently to pollution sources. Additionally, aquatic biota integrate cumulative effects of sediment and nutrient pollution (Ohio EPA, 1995). Thus, a stream's insect community composition provides a long term reflection of the stream's water quality.

To help evaluate the water quality flowing into Pretty Lake, macroinvertebrates were collected during base flow conditions on November 13th, 2017 from the four tributary sampling sites using the multihabitat approach detailed in the USEPA Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers, 2nd ed. (Barbour et al., 1999). The benthic community in the streams was evaluated using IDEM's macroinvertebrate Index of Biotic Integrity (mIBI). The mIBI analysis protocol was used so that the current study could be compared to samples collected during the 2007 diagnostic study. 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". It is likely that this definition of biological integrity is what IDEM means by biological integrity as well. The mIBI consists of ten metrics (Table 6) which measure the species richness, evenness, composition, and density of the benthic community at a given site. The metrics include family-level HBI (Hilsenhoff's FBI or family level biotic index; Hilsenhoff, 1988), number of taxa, number of individuals, percent dominant taxa, EPT Index, EPT count, EPT count to total number of individuals, EPT count to Chironomid count, Chironomid count, and total number of individuals to number of squares sorted. (EPT stands for the *Ephemeroptera, Plecoptera*, and *Trichoptera* orders.) A classification score of 0, 2, 4, 6, or 8 is assigned to specific ranges for metric values. For example, if the benthic community being assessed supports nine different families, that community would receive a classification score of 2 for the "Number of Taxa" metric. The mIBI is calculated by averaging the classification scores for the ten metrics. mIBI scores of 0-2 indicate the sampling site is severely impaired; scores of 2-4 indicate the site is moderately impaired; scores of 4-6 indicate the site is slightly impaired; and scores of 6-8 indicate that the site is non-impaired.

IDEM developed the classification criteria based on five years of wadeable riffle-pool data collected in Indiana. Because the values for some of the metrics can vary depending upon the collection and subsampling methodologies used to survey a stream, it is important to adhere to the collection and subsampling protocol IDEM used when it developed the mIBI. Since the multihabitat approach detailed in the USEPA Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers, 2nd ed. (Barbour et al., 1999) was utilized in this survey to ensure adequate representation of all macroinvertebrate taxa, the mIBI at each site was calculated without the protocol dependent metrics of the mIBI (number of individuals and number of individuals to number of squares sorted). (Protocol dependent methods were defined by Steve Newhouse, IDEM, in personal correspondence.) Eliminating the protocol dependent metrics allows the mIBI scores at sites surveyed using different survey protocols to be compared to mIBI scores at sites sampled using the IDEM recommended protocol.

Table 6. Benthic macroinvertebrate scoring criteria used by IDEM in the evaluation of pool-riffle streams in Indiana.

	SCORING CRITERIA FOR THE FAMILY LEVEL MACROINVERTEBRATE INDEX OF BIOTIC INTEGRITY (mIBI) USING PENTASECTION AND CENTRAL TENDENCY ON THE LOGARITHMIC TRANSFORMED DATA DISTRIBUTIONS OF THE 1990-1995 RIFFLE KICK SAMPLES				
	CLASSIFICATION SCORE				
	0	**2**	**4**	**6**	**8**
Family Level HBI	≥5.63	5.62- 5.06	5.05-4.55	4.54-4.09	≤4.08
Number of taxa	≤7	8-10	11-14	15-17	≥18
Number of individuals	≤79	129-80	212-130	349-213	≥350
Percent dominant taxa	≥61.6	61.5-43.9	43.8-31.2	31.1-22.2	<22.1
EPT index	≤2	3	4-5	6-7	≥8
EPT count	≤19	20-42	43-91	92-194	≥195
EPT count to total number of individuals	≤0.13	0.14-0.29	0.30-0.46	0.47-0.68	≥0.69
EPT count to chironomid count	≤0.88	0.89-2.55	2.56-5.70	5.71-11.65	≥11.66
Chironomid count	≥147	146-55	54-20	19-7	≤6
Total number of individuals to number of squares sorted	≤29	30-71	72-171	172-409	≥410

Where: 0-2 = Severely Impaired, 2-4 = Moderately Impaired, 4-6 = Slightly Impaired, 6-8 = Non-impaired

Although the Indiana Administrative Code does not include mIBI scores as numeric criteria for establishing whether streams meet their aquatic life use designation, the IDEM hints that it may be using mIBI scores to make this determination. (Under state law, all waters of the state, except for those noted as Limited Use in the Indiana Administrative Code, must be capable of supporting recreational and aquatic life uses.) In the 2008 303(d) listing methodology, the IDEM suggests that those waterbodies with mIBI scores less than 2.2 when using the multi-habitat approach are considered non-supporting for aquatic life use. Similarly, waterbodies with mIBI scores greater than 2.2 when assessed using the multi-habitat approach are considered fully supporting for aquatic life use (IDEM, 2008). It is important to note that in 2010, IDEM developed a new mIBI using mHAB (multi-habitat method) which uses 12 metrics to assess the macroinvertebrate community. This new method was not utilized during this study because previous sampling efforts during the 2007 diagnostic study did not use the new method.

Habitat

Habitat was assessed at the four tributary sampling sites on November 13, 2017 utilizing the Qualitative Habitat Evaluation Index (QHEI) which was developed by the Ohio EPA for streams and rivers in Ohio (Rankin, 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. Various attributes of the habitat are scored based on the overall importance of each to the maintenance of viable, diverse, and functional aquatic faunas. The type(s) and quality of substrate; amount and quality of in-stream cover; channel morphology; extent and quality of riparian vegetation; pool, riffle, and run development and quality; and gradient are the metrics used to determine the QHEI score. Each metric is scored individually then summed to provide the total QHEI score. QHEI scores typically range from 20 to 100.

The QHEI is used to evaluate the characteristics of a stream segment, as opposed to the characteristics of the entire stream. As such, individual segments may have worse physical habitat due to a localized disturbance yet still support aquatic communities closely resembling those sampled in adjacent segments with better habitat, provided water quality conditions are similar. QHEI scores from hundreds of stream segments in Ohio indicate that values greater than 60 are *generally* conducive to the existence of warm-water faunas. Scores greater than 75 are characteristic of stream conditions that are capable of supporting exceptional warm-water faunas (Ohio EPA, 1999). IDEM indicates that QHEI scores less than 51 indicate poor habitat and may not support the stream’s aquatic life use designation (IDEM, 2006).

3.3 Tributary Results

Section 3.3 describes the tributary sampling results from the 2017 sampling effort. The 2017 results will be compared to historical sampling efforts later in Section 4.1. Sampling datasheets and laboratory analysis reports completed for tributary sampling can be found in Appendix A.

3.3.1 Water Quality

Table 7 displays the results of physical sampling parameters sampled on May 25, 2017. As described earlier, Sites 1-3 occur along Deal Ditch, with Site 1 being the most upstream location sampled while Site 3 is the downstream most site; therefore, the measured discharge increased when moving downstream. Temperature sampled along Deal Ditch was very consistent from upstream to downstream and within the Indiana State water quality standard (327 Indiana Administrative Code (IAC) 2-1-6) for the month of May which should not exceed 80° F (26.7°C). Dissolved oxygen levels were within Indiana State standards (>4.0 mg/L) along the length of Deal Ditch and was greatest at the downstream site (Site 3). pH levels in the stream were slightly lower than expected but still within IAC standards which states pH levels should be between 6-9. Conductivity was consistent at all Deal Ditch sites and within the normal range for streams in the area. TSS was the greatest at Site 3 and within acceptable ranges throughout.

Site 4 physical parameters were significantly different from that sampled at Sites 1-3. Site 4 is more representative of Pretty Lake surface water physical characteristics due to the close proximity of the sample site to the open water lake environment. All physical parameters collected at Site 4 were within normal ranges to be expected and demonstrates Pretty Lake is releasing suitable water quality to downstream resources.

Table 7. 2017 Pretty Lake tributary sampling physical parameters results.

Sampling Location	Date	Event	Discharge (cfs)	Temp (°C)	Temp (°F)	DO (mg/L)	% Sat	pH	Cond. (µs/cm)	TSS (mg/L)	Turbidity (NTU)
Site 1	5/25/2017	Storm	1.485	14.1	57.4	5.49	56.1	6.04	400	7	8.38
Site 2	5/25/2017	Storm	3.732	14.3	57.7	5.35	54.7	6.53	410	4	6.65
Site 3	5/25/2017	Storm	4.435	14.2	57.5	6.88	70.3	6.81	416	10	9.54
Site 4	5/25/2017	Storm	3.793	17.8	64.1	9.70	107.0	7.76	335	3	1.4

Table 8 displays the chemical results from tributary sampling on May 25, 2017. Overall, there were a number of chemical parameters that either exceed IAC surface water quality standards or were sampled at concentrations outside of desirable ranges. Chemical parameters which exceed IAC standards include ammonia-nitrogen (NH3-N) and *E. coli*.

Table 8. 2017 Pretty Lake tributary sampling chemical parameters results.

Sampling Location	Date	Event	NH3-N (mg/L)	NO3-- N (mg/L)	NO2- N (mg/L)	NO3+NO2 (mg/L)	TKN (mg/L)	SRP-P (mg/L)	TP-P (mg/L)	*E. coli* (MPN/100mL)
Site 1	5/25/2017	Storm	0.109	8.560	0.077	8.64	1.790	0.028	0.098	>2,419.6
Site 2	5/25/2017	Storm	0.100	7.480	0.058	7.54	1.020	0.027	0.080	>2,419.6
Site 3	5/25/2017	Storm	0.090	6.420	0.054	6.47	1.060	0.030	0.083	>2,419.6
Site 4	5/25/2017	Storm	0.040	0.381	0.006	0.39	0.820	-	0.007	32

Ammonia (NH3-N)

The IAC standard for ammonia is dependent on pH and temperature. Considering the sampled pH and temperature at Sites 1-3, ammonia concentrations should not exceed between 0.020 mg/L and 0.030 mg/L. Ammonia concentrations at Sites 1-3 ranged between 0.090-0.109 mg/L, which exceeds the IAC standard by a significant amount. As a note, if pH levels were greater, such as 7.5 or higher, the ammonia standard would not have been exceeded at Sites 1-3. The measured ammonia concentration at Site 4 was at an acceptable level and significantly lower than that sampled at Sites 1-3. For comparison, the ammonia concentration at Site 4 would need to be greater than 0.150 mg/L to exceed IAC standards considering the measured pH and temperature. Important sources of ammonia include fertilizers and animal manure. Ammonia is also a by-product by bacteria as dead plant and animal matter are decomposing.

E. coli (MPN/100mL)

The IAC standard states *E. coli* concentrations should not exceed 235 mpn/100mL for any one sample. The measured *E. coli* concentrations at Sites 1-3 were all reported as >2,419.6 mpn/100mL which exceeds IAC standards. Due to the *E. coli* analytical method used and the high levels sampled, increases or decreases from upstream to downstream along Deal Ditch could not be identified. Ultimately, the *E. coli* results indicate *E. coli* concentrations are an issue along the entire length of the stream sampled. The *E. coli* concentration at Site 4 was low at only 32 mpn/100mL and was within IAC standards for recreational waterbodies.

Source tracking of *E. coli* was completed at all sites to identify what percent *of E. coli* present is human vs animal origin. Source tracking results shown is Table 9 indicate human sources are the overwhelmingly dominate source of E. coli impairment accounting for 94-95%, while animal sources only account for 5-6%. Common sources of *E. coli* include leaking septic systems, direct sewage discharge to water bodies, and animal waste.

Table 9. 2017 Pretty Lake tributary sampling sites *E. coli* source tracking results.

Sampling Location	Date	% Human	% Animal
Site 1	5/25/2017	94	6
Site 2	5/25/2017	95	5
Site 3	5/25/2017	95	5
Site 4	5/25/2017	NA	NA

Nitrate (NO3-N) and Nitrite (NO2-N)

Nitrate concentrations were high during the May sampling event at Sites 1-3 however, the IAC standard for Nitrate + Nitrite in drinking water of <10 mg/L was not exceeded. Nitrate concentrations did decrease from upstream to downstream with Site 1 having the highest concentration at 8.560 mg/L and Site 3 the lowest concentration at 6.420 mg/L. While Sites 1-3 did not exceed the IAC drinking water standard for nitrate +nitrite the nitrate levels are of concern. An Ohio EPA study suggest nitrate concentrations greater than 1.0 mg/L could impair aquatic life, and concentrations of 3-4 mg/L there was a definite correlation between nitrate levels and aquatic life impairment (Ohio EPA, 1999). Nitrite concentrations are normally low in surface water because it is less stable then nitrate. Nitrites were low overall and are best described when considering the total of nitrate+nitrite. The sampled nitrite levels were low at all four sites. Site 4 nitrate and nitrite concentrations were low and at acceptable levels. Common sources of nitrate to streams include fertilizers, atmosphere and human and animal waste.

Total Kjeldahl Nitrogen (TKN)

The IAC does not list a standard for TKN however the U.S. EPA suggests desirable TKN concentrations should be <0.571. Considering the U.S. EPA suggestion all Sites had higher TKN concentrations than is desired and TKN concentration did decrease from upstream to downstream. TKN is the measure of organic nitrogen (nitrogen found in plant and animal material) plus ammonia-nitrogen. TKN levels would likely be lower during stream baseflow conditions when less organic materials would be found in the stream.

Total phosphorus (TP) and Soluble Reactive Phosphorus (SRP)

Total phosphorus includes dissolved (SRP) and particulate forms of phosphorus. During storm events soluble phosphorus levels are generally lower then particulate forms of phosphorus due to the increase in sediment, human or animal waste, yard waste etc. that is transported to streams. The IAC does not have a standard for phosphorus but the Indiana Department of Environmental Management (IDEM) lists water bodies with total phosphorus concentrations of greater than 0.3 mg/L as impaired. None of the sites sampled exceeded the IDEM impaired concentration and TP did decrease from upstream to downstream. SRP concentrations were consistent from Site 1-3. Overall, phosphorus levels considering they were captured following a significant storm event, were at acceptable levels. The Ohio EPA study (1999) suggests total phosphorus levels >0.1 mg/L could impair aquatic life and while Site 1-3 were close to this they did not exceed it.

3.3.2 Tributary Chemical Loading Rates

Daily loading rates for the various chemical parameters measured were calculated using the available measured chemical concentrations and stream discharges. The daily loading rates shown in Table 10 are representative of the amount of a nutrient (kg) transported to Pretty Lake (Site 3) or potentially flowing out of Pretty Lake (Site 4) to downstream resources, following a significant storm event. Since Sites 1-3 are located along Deal Ditch the overall loading rate to consider when assessing the transport of nutrients to Pretty Lake would be the values shown for Site 3 because this is the most downstream point and close to the discharge to Pretty Lake.

Table 10. 2017 Pretty Lake tributary sampling chemical loading results.

Sampling Location	Date	Event	NH3-N (kg/d)	NO3--N (kg/d)	NO2-N (kg/d)	NO3+NO2 (kg/d)	TKN (kg/d)	SRP-P (kg/d)	TP-P (kg/d)	TSS (kg/d)
Site 1	5/25/2017	Storm	0.40	31.10	0.28	31.38	6.50	0.10	0.36	25.43
Site 2	5/25/2017	Storm	2.05	153.54	1.19	154.73	20.94	0.55	1.65	36.52
Site 3	5/25/2017	Storm	0.98	69.66	0.59	70.25	11.50	0.33	0.90	108.51
Site 4	5/25/2017	Storm	0.38	3.65	0.06	3.71	7.86	-	0.06	27.84

3.3.3 Habitat

Stream habitat was assessed using the QHEI at the four sampling locations. Habitat score ranged from a low of 24 at Site 1 to a high of 44 at Site 3 (Table 11). IDEM considers scores of less than 51 to have poor habitat quality and therefore may not support the biota that may be using the waterbody. All scores fell below the 51 threshold and therefore would be considered to have poor stream habitat. Overall, most metrics assessed would be considered to be poor to moderate quality and the low scores are indicative of a channelized stream where natural channel developments such as riffle-pool-run complexes, various types of instream cover and diverse substrate types are minimal to absent. Completed QHEI assessment forms can be found in Appendix B.

Table 11. Pretty Lake tributary sites QHEI metric scoring values.

Site	Substrate Score	Cover Score	Channel Score	Riparian Score	Pool Score	Riffle Score	Gradient Score	Total Score
Maximum Possible	*20*	*20*	*20*	*10*	*12*	*8*	*10*	***100***
Site 1	0	7	5	5	1	0	6	**24**
Site 2	12	7	7	6	1	1	6	**40**
Site 3	14	6	8	6	4	0	6	**44**
Site 4	11	3	6	5	3	0	6	**34**

3.3.4 mIBI

The mIBI was completed at all four tributary sites to determine the quality of aquatic macroinvertebrate communities living in the various stream segments. The results of mIBI analysis are reported in Tables 17-24. The laboratory macroinvertebrate bench sheets for each site are available in Appendix C.

Site 1-Deal Ditch

Site 1 macroinvertebrate community assemblage and mIBI analysis are displayed in Tables 17 and 18. The mIBI score determined at Site 1 was 2.4 which is considered to be moderately impaired (Table 12). According to pre 2010 IDEM mIBI assessment criteria Site 1 would be considered fully supporting of it life use designation as a warm-water stream because the mIBI score is greater than 2.2. Overall, there were 10 different families identified, of which two families, Asillidae and Crangoncyticdae, accounted for 46% and 31% of the total number of individuals identified, respectively (Table 13). Only one family (Philopotamidae) was identified from the more pollution intolerant orders Ephemeroptera, Plecoptera and Trichoptera (EPT; Table 12. Absence of EPT orders is usually indicative of reduced instream habitat and water quality. The majority of families present at Site 1 are moderate to very pollution tolerant which is indicated by higher number in the tolerance column in Table 13.

Table 12. Tributary sampling Site 1 mIBI metric values and scoring.

mIBI Metric		Metric Score
HBI	6.34	0
Number of Taxa (family)	10	2
Total Count (Number of individuals)	84	2
Percent Dominant Taxa	46.4	2
EPT Index (Number of families)	1	0
EPT Count (Number of individuals)	1	0
EPT Count/Total Count	0.01	0
EPT Abundance/Chironomid Abundance	-	8
Chironomid Count	0	8
mIBI Score	**2.4**	
	Moderately Impaired	

Table 13. Tributary sampling Site 1 macroinvertebrate community assemblage.

Class/Order	Family	#	EPT	# w/t	Tolerance (t)	# x t	%
Amphipoda	Crangonyctidae	26		26	4	104	30.95
Amphipoda	Gammaridae	4		4	4	16	4.76
Coleoptera	Elmidae	1		1	4	4	1.19
Gastropoda	Lymnaeidae	9		9	6.9	62.1	10.71
Gastropoda	Physidae	1		1	8	8	1.19
Gastropoda	Planorbidae	1		1	7	7	1.19
Hemiptera	Belostomatidae	1		0		0	1.19
Isopoda	Asillidae	39		39	8	312	46.43
Trichoptera	Philopotamidae	1	1	1	3	3	1.19
Collembola		1		1	10	10	1.19
TOTALS	**10**	**84**	**1**	**83**		**526.1**	**100.00**

Site 2-Deal Ditch

Site 2 macroinvertebrate community assemblage and mIBI analysis are provided in Tables 19 and 20. The overall mIBI score determine at Site 2 was 1.8 which suggests the macroinvertebrate community is severely impaired (Table 14). According to pre 2010 IDEM mIBI assessment criteria, Site 2 would be considered not supporting of its life use designation as a warm-water stream because the mIBI score is less than 2.2. Site 2 received the lowest mIBI score between all sites. A total of 12 families were identified and of which the most dominant family account approximately 50% of the total number of individuals identified. A total of two EPT families were identified at Site 2 and those taxa represented 8.5% of the total number of individuals identified. Individuals from family Chironomidae were much more abundant than that assessed at Site 1 and Site 4 and similar to that identified at Site 3. Overall all families identified at Site 2 are considered moderate to very tolerant to pollution.

Table 14. Tributary sampling Site 2 mIBI metric values and scoring.

mIBI Metric		Metric Score
HBI	5.51	2
Number of Taxa (family)	12	4
Total Count (Number of individuals)	105	2
Percent Dominant Taxa	49.5	2
EPT Index (Number of families)	2	0
EPT Count (Number of individuals)	9	0
EPT Count/Total Count	0.09	0
EPT Abundance/Chironomid Abundance	0.17	0
Chironomid Count	52	6
mIBI Score	**1.8**	
	Severely Impaired	

Table 15. Tributary sampling Site 2 macroinvertebrate community assemblage.

Class/Order	Family	#	EPT	# w/t	Tolerance (t)	# x t	%
Amphipoda	Crangonyctidae	13		13	4	52	12.38
Bivalvia	Sphaeriidae	1		1	8	8	0.95
Coleoptera	Elmidae	8		8	4	32	7.62
Diptera	Chironomidae	52		52	6	312	49.52
Diptera	Culicidae	2		2	8	16	1.90
Diptera	Empididae	1		1	6	6	0.95
Diptera	Tabanidae	1		1	6	6	0.95
Diptera	Tipulidae	5		5	3	15	4.76
Gastropoda	Lymnaeidae	8		8	6.9	55.2	7.62
Gastropoda	Physidae	5		5	8	40	4.76
Trichoptera	Hydropsychidae	2	2	2	4	8	1.90
Trichoptera	Limnephilidae	7	7	7	4	28	6.67
TOTALS	**12**	**105**	**9**	**105**		**578.2**	**100.00**

Site 3-Deal Ditch

Site 3 macroinvertebrate community assemblage and mIBI analysis are displayed in Table 16 and 17. The assessed mIBI value at Site 3 was 2.0 which suggests the macroinvertebrate community is moderately impaired. According to pre 2010 IDEM mIBI assessment criteria, Site 3 would be considered not supporting of its life use designation as a warm-water stream because the mIBI score is less than 2.2. Site 3 had the second highest number of taxa between sites at 14 families (Table 16). Two families from the EPT orders were identified at Site 3 and are the same two families identified at Site 2. Site 3 dominate taxa was Chironomidae and accounted for 47% of individuals identified. Overall, most families present at Site 3 are characteristic of water bodies is reduced water quality and/or habitat quality.

Table 16. Tributary sampling Site 3 mIBI metric values and scoring.

mIBI Metric		Metric Score
HBI	5.36	2
Number of Taxa (family)	14	4
Total Count (Number of individuals)	140	4
Percent Dominant Taxa	47.1	2
EPT Index (Number of families)	2	0
EPT Count (Number of individuals)	8	0
EPT Count/Total Count	0.06	0
EPT Abundance/Chironomid Abundance	0.12	0
Chironomid Count	66	6
mIBI Score	**2.0**	
	Moderately Impaired	

Table 17. Tributary sampling Site 3 macroinvertebrate community assemblage.

Class/Order	Family	#	EPT	# w/t	Tolerance (t)	# x t	%
Amphipoda	Crangonyctidae	9		9	4	36	6.43
Bivalvia	Sphaeriidae	2		2	8	16	1.43
Coleoptera	Elmidae	29		29	4	116	20.71
Diptera	Ceratopognidae	3		3	6	18	2.14
Diptera	Chironomidae	66		66	6	396	47.14
Diptera	Culicidae	4		4	8	32	2.86
Diptera	Simuliidae	1		1	6	6	0.71
Diptera	Tipulidae	8		8	3	24	5.71
Hirudinea		1		1	10	10	0.71
Isopoda	Asillidae	7		7	8	56	5.00
Odonata	Aeshnidae	1		1	3	3	0.71
Oligochaeta		1		1	5	5	0.71
Trichoptera	Hydropsychidae	5	5	5	4	20	3.57
Trichoptera	Limnephilidae	3	3	3	4	12	2.14
TOTALS	**14**	**140**	**8**	**140**		**750.0**	**100.00**

Site 4- Outlet Stream

Site 4 macroinvertebrate community assemblage and mIBI analysis in displayed in Table 18 and 19. The mIBI score at Site 4 was determined to be 4.7 which is considered to be slightly impaired and is the highest mIBI value between all sites. According to pre 2010 IDEM mIBI assessment criteria, Site 4 would be considered fully supporting of its life use designation as a warm-water stream because the mIBI score is greater than 2.2. Site 4 had the greatest number of taxa at 16 families identified and of those there were six families from the EPT orders. There was a much more even distribution of families at Site 4 with the dominate taxa representing approximately 23% of the number of individuals collected; however, it should be noted that there were only 35 individuals collected and identified from Site 4.

Table 18. Tributary sampling Site 4 mIBI metric values and scoring.

mIBI Metric		Metric Score
HBI	4.92	4
Number of Taxa (family)	16	6
Total Count (Number of individuals)	35	0
Percent Dominant Taxa	22.9	6
EPT Index (Number of families)	6	6
EPT Count (Number of individuals)	11	0
EPT Count/Total Count	0.31	4
EPT Abundance/Chironomid Abundance	-	8
Chironomid Count	0	8
mIBI Score	**4.7**	
	Slightly Impaired	

Table 19. Tributary sampling Site 4 macroinvertebrate community assemblage.

Class/Order	Family	#	EPT	# w/t	Tolerance (t)	# x t	%
Amphipoda	Crangonyctidae	4		4	4	16	11.43
Amphipoda	Gammaridae	8		8	4	32	22.86
Diptera	Ceratopognidae	2		2	6	12	5.71
Diptera	Culicidae	2		2	8	16	5.71
Ephemeroptera	Ephemerellidae	1	1	1	1	1	2.86
Gastropoda	Lymnaeidae	1		1	6.9	6.9	2.86
Gastropoda	Planorbidae	1		1	7	7	2.86
Hirudinea		1		1	10	10	2.86
Odonata	Coenagrionidae	3		3	6.1	18.3	8.57
Oligochaeta		1		1	5	5	2.86
Trichoptera	Helicopsychidae	1	1	1	3	3	2.86
Trichoptera	Hydropsychidae	3	3	3	4	12	8.57
Trichoptera	Limnephilidae	1	1	1	4	4	2.86
Trichoptera	Polycentropodidae	2	2	0		0	5.71
Trichoptera	Philopotamidae	3	3	3	3	9	8.57
Collembola		1		1	10	10	2.86
TOTALS	**16**	**35**	**11**	**33**		**162.2**	**100.00**

3.3.5 Tributary Sampling Results Summary

Physical sampling parameters collected at the four tributary sites included water temperature, dissolved oxygen, pH, conductivity, and total suspended solids were all within acceptable ranges and did not exceed any state standards. Chemical parameters which exceeded state standards included ammonia at Sites 1-3 and E. coli at Sites 1-3. Ammonia concentrations at Sites 1-3 ranged between 0.090-0.109 mg/L, which exceeds the IAC standard by a significant amount. As a note, if pH levels were greater, such as 7.5 or higher, the ammonia standard would not have been exceeded at Sites 1-3.

The IAC standard states *E. coli* concentrations should not exceed 235 mpn/100mL for any one sample. The measured *E. coli* concentrations at Sites 1-3 were all reported as >2,419.6 mpn/100mL which exceeds IAC standards. Due to the *E. coli* analytical method used and the high levels sampled, increases or decreases from upstream to downstream along Deal Ditch could not be identified. Ultimately, the *E. coli* results indicate *E. coli* concentrations are an issue along the entire length of the stream sampled. Source tracking of *E. coli* was completed at all sites to identify what percent *of E. coli* present is human vs animal origin. Source tracking results indicate human sources are the overwhelmingly dominate source of E. coli impairment accounting for 94-95%, while animal sources only account for 5-6%.

Nitrate concentrations were high during the May sampling event at Sites 1-3 however, the IAC standard for Nitrate + Nitrite in drinking water of <10 mg/L was not exceeded. Nitrate concentrations did decrease from upstream to downstream with Site 1 having the highest concentration and Site 3 the lowest concentration. While Sites 1-3 did not exceed the IAC drinking water standard for nitrate +nitrite the nitrate levels are of concern. None of the sites sampled exceeded the concentration of 0.3 mg/L which IDEM considers a waterbody to be impaired for phosphorus. TP did decrease from upstream to downstream and SRP concentrations were consistent from Site 1-3. Overall, phosphorus levels were at acceptable levels considering they were captured following a significant storm event.

Stream habitat was assessed using the QHEI at the four sampling locations. Habitat score ranged from a low of 24 at Site 1 to a high of 44 at Site 3 (Table 11). IDEM considers scores of less than 51 to have poor habitat quality and therefore may not support the biota that may be using the waterbody. All scores fell below the 51 threshold and therefore would be considered to have poor stream habitat. The sampled macroinvertebrate communities were indicative of impaired environments or environments that have poor instream habitat as that shown by the QHEI. The three sampling sites within Deal Ditch had the most impaired macroinvertebrate communities assessed, with two of the sites listed as moderately impaired (Sites 1 and 3) and one site listed as severely impaired (Site 2). Site 4 located in the outlet stream had the highest mIBI score and was rated as only slightly impaired.

3.4 2017 In-Lake Sampling Scope and Methods

The in-lake sampling scope for the project included one sampling event during peak summer stratification. The in-lake sampling effort was completed by one Cardno staff member and one PLCC representative on September 6, 2017 during the summer stratification period. Sampling efforts were conducted at the deepest point in the lake and were completed using standard sampling methods (Figure 7). Water samples were collected from the epilimnion and hypolimnion and assessed for the following physical and chemical parameters: total phosphorus (TP), soluble reactive phosphorus (SRP), nitrate-nitrogen (NO3-N), nitrite-nitrogen (NO2-N), ammonia-nitrogen (NH3-N), total Kjeldahl nitrogen (TKN), chlorophyll a, temperature, dissolved oxygen (mg/L and % saturation), turbidity, pH, and conductivity. A temperature and oxygen profile was completed from the surface to the bottom of the water column with measurements taken at 1 meter intervals. A light extinction profile was completed and included taking measurement at 1 meter intervals down to the 1% light level. A vertical plankton tow was completed from approximately the 1% light level to the surface to evaluate the phytoplankton and zooplankton communities. Water transparency was measured using a secchi disk. Chemical analysis of samples was completed at the Cardno Lab in Walkerton, Indiana. Chlorophyll a analysis was completed by ALS Environmental in Washington. Plankton sample processing and analysis was completed by PhycoTech Inc. in St. Joseph, Michigan.

Sampling during the summer stratification period is desirable because it allows water quality parameters to be tracked/assessed at various points along the water column. Water quality parameters which are generally impacted by increasing or decreasing water depth include phosphorus, dissolved oxygen, light penetration, temperature and nitrogen (most significantly ammonia as nitrogen). For example, the summer stratification period allows for the detection of internal loading of phosphorus from lake sediments. Often times in the deeper portions of the water column anoxic conditions are present (dissolved oxygen is not present) due to decomposition of organic matter which uses up all available oxygen. When this occurs phosphorus can be released from the lake sediments in the form of soluble reactive phosphorus (SRP). Water samples taken at surface waters (epilimnion) and bottom waters (hypolimnion) will show an increase in total phosphorus amounts usually due to increases in SRP, which is being released from bottom sediments. Additionally, measuring oxygen and temperature profiles during peak summer stratification is important because it helps determine amount of area fish can survive during this time. In general dissolved oxygen concentrations below 4 mg/L are not supportive for the majority of fish species.

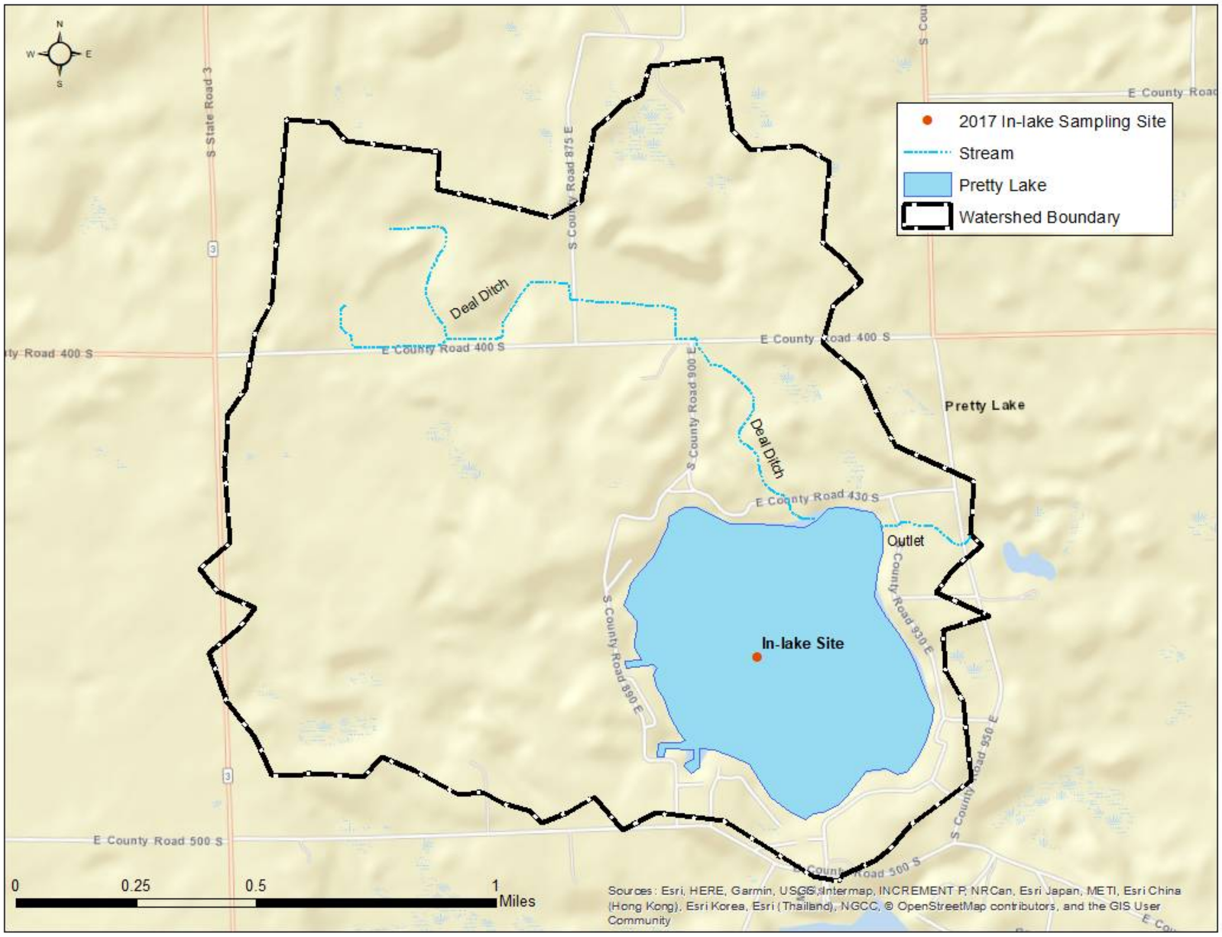

Figure 7. 2017 Pretty Lake in-lake sampling site location.

3.5 In-Lake Results

Results of the in-lake sampling effort on September 6, 2017 are discussed in Section 3.5 below and compared to expected results from an Indiana lake study completed by the Clean Lakes Program. Comparisons to historical sampling efforts will be discussed in more detail in Section 4.5. All field datasheets and laboratory analysis sheets from in-lake sampling effort are available in Appendix D.

3.5.1 Chemical

Results of chemical analysis are presented in Table 20. Samples were collected from surface waters (approximately two feet below surface) identified as the epilimnion and from bottom waters (approximately two feet above lake bed) identified as the hypolimnion.

Table 20. Water quality characteristics of Pretty Lake, September 6, 2017.

Site Name	Date	Secchi Disk (m)	pH	Cond. (µs/cm)	Turbidity (NTU)	NH3-N (mg/L)	NO3--N (mg/L)	NO2-N (mg/L)	NO3+NO2 (mg/L)	TKN (mg/L)	SRP (mg/L)	TP (mg/L)	Plankton (organisms/L)	Chlorophyll a (µg/L)
Lake 1 Epilimnion	9/6/2017	4	8.25	345	0.82	0.014	0.185	0.009	0.194	0.732	0.048	0.058	22.844	2.7
Lake 1 Hypolimnion	9/6/2017	-	7.55	388	5.08	0.284	0.178	0.009	0.187	1.120	0.070	0.074		-
Mean		-	7.90	367	2.950	0.149	0.182	0.009	0.191	0.926	0.059	0.066	-	-

Secchi Disk

Pretty Lake continues to exhibit good water clarity and greater than average clarity compared to most Indiana lakes. The measured secchi disk reading was 4 m (13.1 ft.; Table 21).

Table 21. Water quality characteristics of 456 Indiana lakes sampled from 1994 through 2004 by the Indiana Clean Lakes Program. Means of epilimnion and hypolimnion samples were used.

	Secchi Disk (ft.)	NO_3 (mg/L)	NH_4 (mg/L)	TKN (mg/L)	SRP (mg/L)	TP (mg/L)	Chl *a* (µg/L)	Plankton (#/L)	Blue-Green Dominance
Minimum	0.3	0.01	0.004	0.230	0.01	0.01	0.013	39	0.08%
Maximum	32.8	9.4	22.5	27.05	2.84	2.81	380.4	753,170	100%
Median	6.9	0.275	0.818	1.66	0.12	0.17	12.9	35,570	53.8%
Pretty	**13.1**	**0.182**	**0.149**	**0.926**	**0.059**	**0.066**	**2.7**	**15,068**	**88.8%**

pH

pH levels varied between the epilimnion and hypolimnion samples with readings of 8.25 and 7.55, respectively and had an average pH of 7.90. pH levels were within the normal range for Indiana lakes and within IAC standards.

Conductivity

Conductivity varied slightly between epilimnion and hypolimnion samples with values of 345 µg/cm and 388 µg/cm, respectively. Conductivity levels were within the normal range for Indiana lakes.

Turbidity

Turbidity levels varied between epilimnion and hypolimnion samples with values of 0.82 NTU and 5.08 NTU, respectively. Overall turbidity levels were at acceptable levels.

Ammonia (NH3-N)

Ammonia concentration varied significantly between epilimnion and hypolimnion samples, which is not uncommon since ammonia concentrations usually increase when oxygen is absent (anoxic) such as at the bottom depth of lakes during stratification periods and is produced as by product by bacteria as dead plant and animal matter are decomposed. The ammonia concentration at the epilimnion was 0.014 mg/L and within acceptable ranges. Ammonia in the epilimnion is reduced do the presence of dissolved oxygen. Ammonia in the hypolimnion was much higher at 0.284 which indicate anoxic conditions. The mean ammonia concentration of the epilimnion and hypolimnion was 0.149 mg/L and is lower than most Indiana lakes (Table 15).

Nitrate (NO3-N)

Nitrate concentrations did not vary significantly between epilimnion and hypolimnion samples with concentrations of 0.185 mg/L and 0.178 mg/L. Nitrate concentrations were below the median values of most Indiana lakes (Table 21).

Total Kjeldahl Nitrogen (TKN)

TKN concentrations were greater in the hypolimnion than the epilimnion with concentrations of 1.120 mg/L and 0.732 mg/L, respectively. Higher hypolimnion concentrations are expected because TKN is a measure of the particulate (organic nitrogen) and ammonia-nitrogen. With ammonia concentrations increasing in the hypolimnion TKN concentrations increase. The 2017 mean TKN value is below the median value of other Indiana lakes as shown in Table 21.

Phosphorus (SRP and TP)

Phosphorous levels measured in the epilimnion and hypolimnion indicate internal phosphorus loading from bottom sediments is occurring. Proof of this is shown by the increase in SRP from a concentration of 0.048 mg/L in the epilimnion to a concentration of 0.070 mg/L in the hypolimnion. Total phosphorus also increased from 0.058 mg/L in the epilimnion to 0.074 mg/L in the hypolimnion. The percentage of total phosphorus which was soluble (SRP) increased between the epilimnion and hypolimnion with SRP accounting for 82.8% and 94.6%, respectively. Total phosphorus and SRP mean concentrations measured in 2017 were below the median value report in the CLP study, indicating Pretty Lake has better than average water quality compared to most Indiana lakes (Table 21). While Pretty Lake total phosphorus concentrations are well below the 0.3 mg/L concentration that IDEM would list the lake as impaired for phosphorus, the measured concentrations were above the generally accepted threshold at which phosphorus can contribute to nuisance algae blooms which is 0.03 mg/L (0.03 ppm – parts per million or 30 ppb – parts per billion). The USEPA’s recommended nutrient criterion for total phosphorus is fairly low, 0.014.75 mg/L (USEPA, 2000a) and is an unrealistic target for many Indiana lakes. What this means is that while Pretty Lake phosphorus concentrations are low relative to the median average of other Indiana Lakes, there is still the potential that current phosphorus levels can cause undesirable water quality impacts.

Chlorophyll a

The measure chlorophyll a concentration in Pretty Lakes was 2.7 µg/L and is significantly lower than the median value of other Indiana lakes assessed as part of the CLP study (Table 21). In general, chlorophyll a concentrations below 2 µg/L are considered low, while those above 10 µg/L are considered high.

3.5.2 Dissolved Oxygen and Temperature Profiles

Dissolved oxygen and temperature profiles sampled during the 2017 sampling indicates Pretty Lake was stratified, such that surface water and bottom waters were not mixing due to temperature-induced density differences (Figure 8). The boundary between these two zones, where temperature changes most rapidly with depth is called the metalimnion. At the time of sampling, the epilimnion was confined to the upper approximately 20 ft. (6.1 m) of water (Figure 8). The decline in temperature between 20 ft. (6.1 m) and 46 ft. (14.0 m) defines the metalimnion or transition zone. The hypolimnion occupied water deeper than 46 ft. (14.0 m).

The dissolved oxygen profile mirrors the temperature profile, however oxygen becomes essentially absent at approximately 30 ft. (9.1 m). The lake was saturated (100% oxygen percent) from the surface to a depth of approximately 16 ft. (4.9 m). Water below approximately 25 ft. (7.6 m) did not contain sufficient dissolved oxygen to support fish and other aquatic organisms. In general, dissolved oxygen levels <4 mg/L are not capable of support the majority of fish species. Only approximately 25% of the water column was suitable for fish habitation.

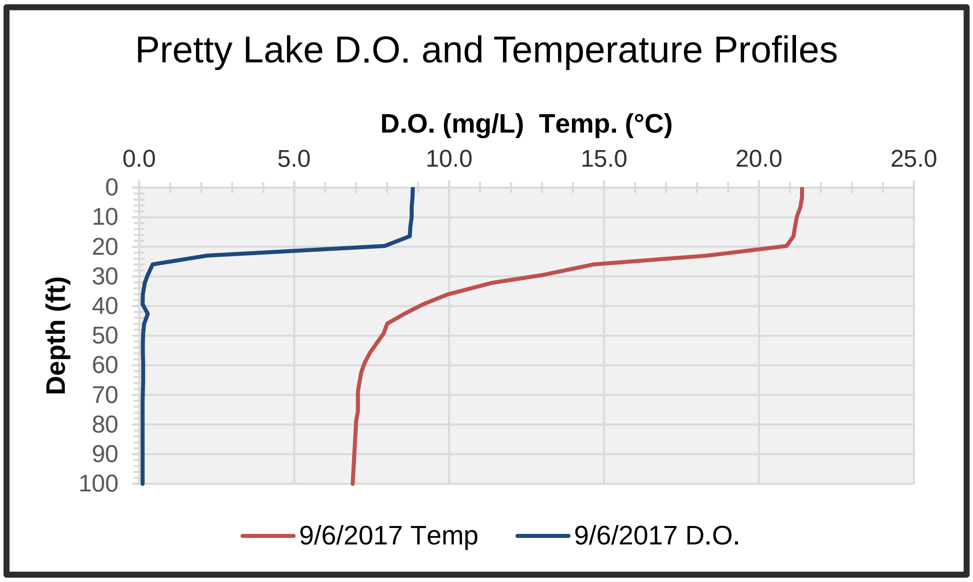

Figure 8. Sampled dissolved oxygen and temperature profiles within Pretty Lake, September 6, 2017.

3.5.3 Light Extinction Profile

The light extinction profile measured during the 2017 sampling event is shown in Figure 9. Results of the sampling indicate the 1% light level was located at a depth of approximately 33 ft. (10.0 m; Figure 9). At this point there is only 1% of the light available at the surface. The 1% light levels helps define the littoral area of the lake. The littoral zone is the area of the lake which water is shallow enough to support aquatic plant growth. Limnologists often use the lakes 1% light level to determine the lower limit of sufficient light to support plant photosynthesis, or growth. Based in the depth-area curve shown in Figure 10, this would mean Pretty Lakes littoral zone is approximately 150 acres (60.7 ha) in size and covers approximately 81% of the lake. The lakes 1% light level also defines the lake's photic zone. A lake's photic zone is the volume of water with sufficient light to support algae growth. Based on Pretty Lake's depth-volume curve (Figure 10), approximately 3,500 acre-feet of Pretty Lake (73% of total lake volume) lies above the 33 ft. (10.0 m) 1% light level.

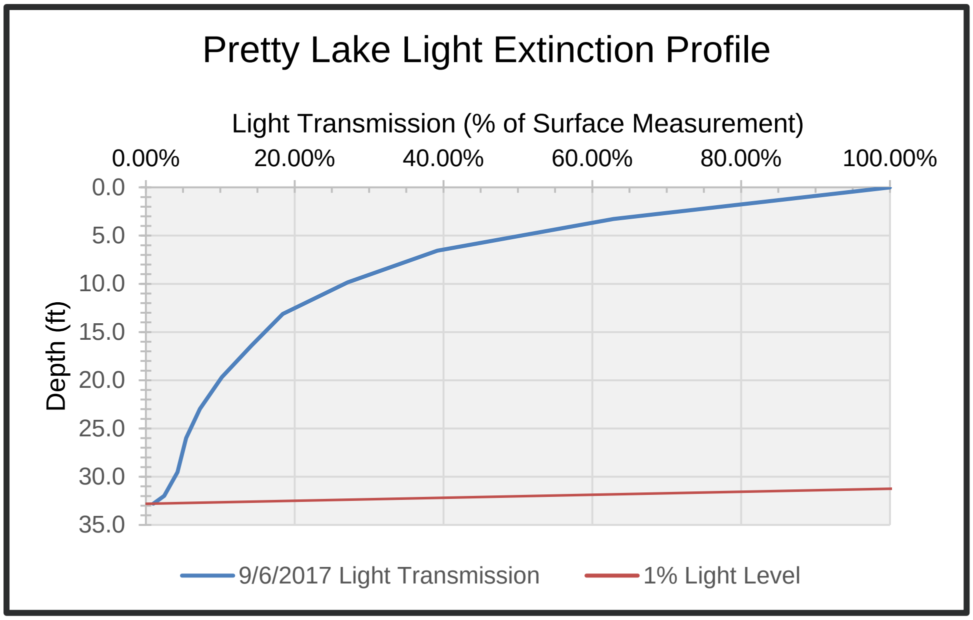

Figure 9. Pretty Lake light extinction profile sampled September 6, 2017.

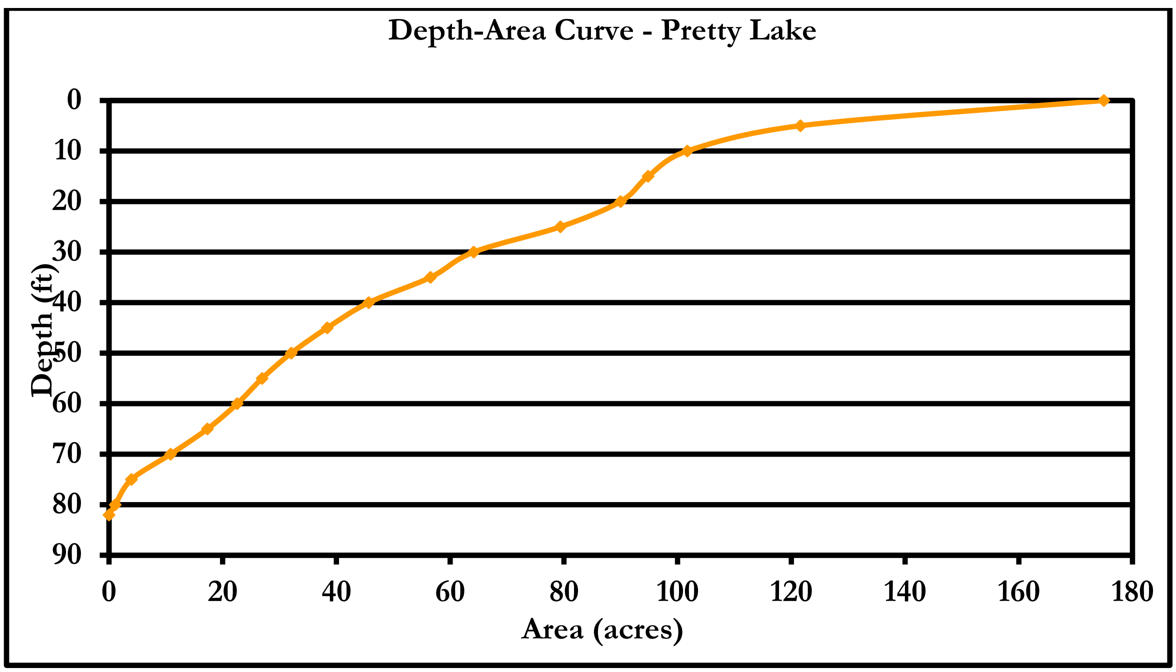

Figure 10. Depth-area curve for Pretty Lake.

3.5.4 Plankton Community Assessment

Results of the Pretty Lake plankton assessment which includes both phytoplankton and zooplankton, are displayed in Table 22 and 23. Phytoplankton density was determined to be 8,826 natural units (nu)/L (Table 22) and zooplankton density was determined to be 6,242 animals/L (Table 23), for a total plankton density of 15,068 nu/L. Plankton density compared to the CLP data set in Table 21, indicates Pretty Lake plankton community density is below the median values of most Indiana lakes. This would suggest Pretty Lake contains increased water quality as high plankton densities usually indicate excessive nutrients within a waterbody. Chlorophyll a results discussed in Section 3.5.1 are comparable to the sampled plankton densities, as chlorophyll a is generally a direct estimate of algal biomass.

Phytoplankton

At the time of the plankton sampling, the Pretty Lake phytoplankton community was dominated by blue-green algae (Cyanophyta) which accounted for 88.8% of the plankton community. Within the Cyanophyta Division, three genus dominated which included Woronichinia spp. (74%), Synechocystis spp. (15%), and Microcystis spp. (8%; Table 22). The second most abundant phytoplankton Division was Bacillariophyta (Diatoms) which accounted for 5% of the overall phytoplankton sample (Table 22). Overall, 28 different phytoplankton genus were identified from the Pretty Lake plankton sample, representing seven different Divisions. It is important note the 88% dominance by blue-green algae is higher than the median amount determined in the CLP dataset in Table 21.

Zooplankton

At the time of the plankton sampling event, the Pretty Lake zooplankton community was dominated by copepods from the Cyclopoida Order, which accounted for 46% of the sample and followed by Calanoida Order which comprised 27% of the community (Table 22). Overall 10 different zooplankton genus were identified from the Pretty Lake plankton sample, representing five different Orders.

Table 22. 2017 Pretty Lake Phytoplankton sampling results.

Phytoplankton				
Division	**Taxa Identification**	**Count (organisms/L)**	**Total Count (Natural Units/L)**	**Division Percentage of Relative Abundance**
Bacillariophyta	*Achnanthes* spp.	34.010	442.133	5.01%
	Cyclotella spp.	34.010		
	Fragilaria spp.	357.108		
	Tabellaria spp.	17.005		
Chlorophyta	*Chlorococcaceae*	68.021	239.098	2.71%
	Chlamydomonas spp.	170.051		
	Oedogonium spp.	1.026		
Chrysophyta	Unknown	51.016	238.072	2.70%
	Dinobryon spp.	68.021		
	Dinobryon spp.	51.016		
	Mallomonas spp.	17.005		
	Syncrypta spp.	17.005		
	Synura spp.	34.010		

Cryptophyta	*Cryptomonas* spp.	17.005	68.021	0.77%
	Rhodomonas minuta	51.016		
Cyanophyta	*Aphanocapsa* spp.	34.010	7839.367	88.81%
	Cylindrospermopsis raciborskii	17.005		
	Dolichospermum spp.	34.010		
	Gloeotrichia spp.	17.005		
	Lyngbya spp.	17.005		
	Microcystis spp.	612.185		
	Microcystis spp.	17.005		
	Pseudanabaena spp.	102.031		
	Synechocystis spp.	1173.354		
	Woronichinia spp.	5764.741		
	Woronichinia spp.	51.016		
Haptophyta	*Chrysochromulina* spp.	34.010	0.085	0.001%
Pyrrhophyta	*Ceratium* spp.	17.005	0.042	0.0005%
		Total	**8826.818**	**100%**

Table 23. Pretty Lake zooplankton sampling results.

Zooplankton				
Phylum Order	**Taxa Identification**	**Count (organisms/L)**	**Total Count (animals/L)**	**Order Percentage of Relative Abundance**
Arthropoda_ Copepoda	Unknown spp.	731	731	11.711%
Arthropoda_ Calanoida	*Diaptomus spp.*	562	1687	27.03%
	Unknown spp.	1125		
Arthropoda_ Cyclopoida	Unknown spp.	2699	2924	46.84%
	Cyclops spp.	225		
Arthropoda_ Diplostraca	*Daphnia spp.*	450	731	11.71%
	Diaphanosoma spp.	281		
Rotifera_ Ploima	*Kellicottia spp.*	56	169	2.707%
	Branchionus spp.	56		
	Asplanchna spp.	56		
		Total	**6242**	**100.00%**

3.5.5 Trophic State Indices

Indiana Trophic State Index (ITSI)

The Indiana TSI (ITSI) was developed by the Indiana Stream Pollution Control Board and published in 1986 (IDEM, 1986). The original ITSI differed slightly from the one in use today. Today's ITSI uses ten different water quality parameters to calculate a score. Table 24 shows the point values assigned to each parameter.

Table 24. The Indiana Trophic State Index.

Parameter and Range			Eutrophy Points
I.	Total Phosphorus (ppm)		
	A.	At least 0.03	1
	B.	0.04 to 0.05	2
	C.	0.06 to 0.19	3
	D.	0.2 to 0.99	4
	E.	1.0 or more	5
II.	Soluble Phosphorus (ppm)		
	A.	At least 0.03	1
	B.	0.04 to 0.05	2
	C.	0.06 to 0.19	3
	D.	0.2 to 0.99	4
	E.	1.0 or more	5
III.	Organic Nitrogen (ppm)		
	A.	At least 0.5	1
	B.	0.6 to 0.8	2
	C.	0.9 to 1.9	3
	D.	2.0 or more	4
IV.	Nitrate (ppm)		
	A.	At least 0.3	1
	B.	0.4 to 0.8	2
	C.	0.9 to 1.9	3
	D.	2.0 or more	4
V.	Ammonia (ppm)		
	A.	At least 0.3	1
	B.	0.4 to 0.5	2
	C.	0.6 to 0.9	3
	D.	1.0 or more	4
VI.	Dissolved Oxygen: Percent Saturation at 5 feet from surface		
	A.	114% or less	0
	B.	115% to 119%	1
	C.	120% to 129%	2
	D.	130% to 149%	3
	E.	150% or more	4

VII.	Dissolved Oxygen: Percent of measured water column with at least 0.1 ppm dissolved oxygen		
	A.	28% or less	4
	B.	29% to 49%	3
	C.	50% to 65%	2
	D.	66% to 75%	1
	E.	76% to 100%	0
VIII.	Light Penetration (Secchi Disk)		
	A.	Five feet or under	6
IX.	Light Transmission (Photocell): Percent of light transmission at a depth of 3 feet		
	A.	0 to 30%	4
	B.	31% to 50%	3
	C.	51% to 70%	2
	D.	71% and up	0
X.	Total Plankton per liter of water sampled from a single vertical tow between the 1% light level and the surface:		
	A.	less than 3,000 organisms/L	0
	B.	3,000 - 6,000 organisms/L	1
	C.	6,001 - 16,000 organisms/L	2
	D.	16,001 - 26,000 organisms/L	3
	E.	26,001 - 36,000 organisms/L	4
	F.	36,001 - 60,000 organisms/L	5
	G.	60,001 - 95,000 organisms/L	10
	H.	95,001 - 150,000 organisms/L	15
	I.	150,001 - 5000,000 organisms/L	20
	J.	greater than 500,000 organisms/L	25
	K.	Blue-Green Dominance: additional points	10

Values for each water quality parameter are totaled to obtain an ITSI score. Based on this score, lakes are then placed into one of five categories:

TSI Total	Water Quality Classification
0-15	Oligotrophic
16-31	Mesotrophic
32-46	Eutrophic
47-75	Hypereutrophic

These categories correspond to the qualitative lake productivity categories described earlier (IDEM, 2000). A rising TSI score for a particular lake from one year to the next indicates that water quality is worsening, while a lower TSI score indicates improved conditions. However, natural factors such as climate variation can cause changes in TSI scores that do not necessarily indicate a long-term change in lake condition. Jones (1996) suggests that changes in TSI scores of 10 or more points are indicative of changes in trophic status, while smaller changes in TSI scores may be more attributable to natural fluctuations in water quality parameters.)

The Indiana Trophic State Index (ITSI) was calculated from the 2017 Pretty Lake sampling using the mean epilimnetic and hypolimnetic values and the results are presented in Table 25. The total ITSI score was 21 which places Pretty Lake in the lower mesotrophic range (TSI scores of 16-31). Most metrics received low to moderate scores (scores 0-2), while total phosphorus scored slightly higher with a score of 3 out of a potential 5. The only metric which would be considered “high” is the additional 10 points assigned to the overall, score for the dominance of blue-green algae in the plankton sample; however, the overall plankton density metric scored low (2). Overall the ITSI suggests Pretty Lake is a moderately productive system and therefore, contains moderate to good water quality.

Table 25. Pretty Lake water quality characteristics and ITSI point values.

Parameter	Epilimnetic Sample	Hypolimnetic Sample	Indiana TSI Points (based on mean values)
pH	8.25	7.55	-
Conductivity	345	388	-
Secchi Depth Transparency	4.0 m	-	0
Light Transmission @ 3ft.	65%	-	2
1% Light Level	32.8 ft.	-	-
Total Phosphorus	0.058 mg/L	0.074 mg/L	3
Soluble Reactive Phosphorus	0.048 mg/L	0.070 mg/L	2
Nitrate-Nitrogen	0.185 mg/L	0.178 mg/L	0
Nitrite-Nitrogen	0.009 mg/L	0.009 mg/L	-
Ammonia-Nitrogen	0.014 mg/L	0.284 mg/L	0
Organic Nitrogen	0.718 mg/L	0.836 mg/L	2
Total Kjeldahl nitrogen	0.732 mg/L	1.120 mg/L	-
Turbidity	0.82 NTU	5.08 NTU	-
Oxygen Saturation @ 5ft.	103%	-	0
% Water Column D.O. > 0.1 mg/L	100%	-	0
% Water Column Oxic. (D.O. ≥ 1.0 mg/L)	25%	-	-
Plankton Density	15,068 nu/L	-	2
Blue Green Dominance	0.8546	-	10
Chlorophyll *a*	2.7 µg/L	-	-
TSI Score			**21 (Mesotrophic)**

Carlson Trophic State Index

Developed by Bob Carlson (1977), the Carlson TSI is the most widely used and accepted TSI. Carlson analyzed summertime total phosphorus, chlorophyll a, and Secchi disk transparency data for numerous lakes and found statistically significant relationships among the three parameters. He developed mathematical equations for these relationships, and these relationships form the basis for the Carlson TSI. Using this index, a TSI value can be generated by one of three measurements: Secchi disk transparency, chlorophyll a, or total phosphorus. Data for one parameter can also be used to predict a value for another. The TSI values range from 0 to 100. Each major TSI division (10, 20, 30, etc.) represents a doubling in algal biomass (Figure 11).

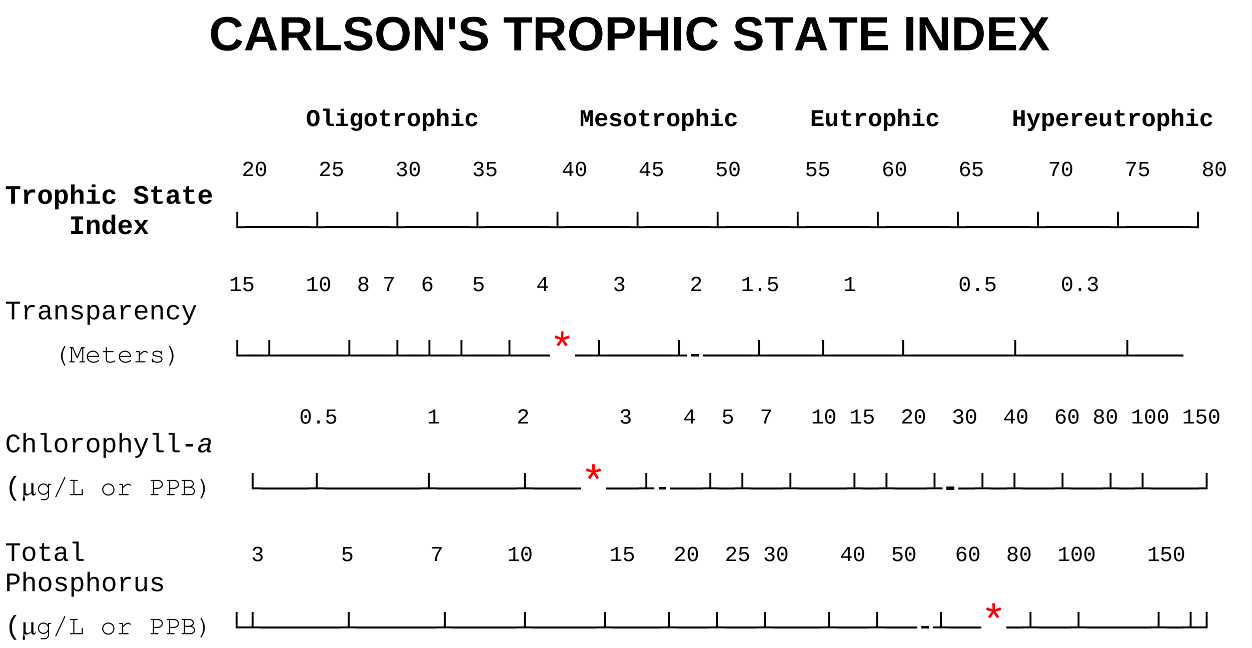

Figure 11. Carlson's Trophic State Index with Pretty Lake results indicated by red asterisks.

As a further aid in interpreting TSI results, Carlson's scale is divided into four lake productivity categories: oligotrophic (least productive), mesotrophic (moderately productive), eutrophic (very productive), and hypereutrophic (extremely productive).

Using Carlson's index, a lake with a summertime Secchi disk depth of 1 meter (3.3 feet) would have a TSI of 60 points (located in line with the 1 meter or 3.3 feet). This lake would be in the eutrophic category. Because the index was constructed using relationships among transparency, chlorophyll a, and total phosphorus, a lake having a Secchi disk depth of 1 meter (3.3 feet) would also be expected to have 20 µg/L chlorophyll a and 48 µg/L total phosphorus.

Not all lakes have the same relationship between transparency, chlorophyll a, and total phosphorus as Carlson's lakes do. Other factors such as high suspended sediments or heavy predation of algae by zooplankton may keep chlorophyll a concentrations lower than might be otherwise expected from the total phosphorus concentrations or transparency measurements. High suspended sediments would also make transparency worse than otherwise predicted by Carlson's index.

It is also useful to compare the actual trophic state points for a particular lake from one year to the next to detect any trends in changing water quality. While climate and other natural events will cause some variation in water quality over time (possibly 5-10 trophic points), larger point changes may indicate important changes in lake quality.

Analysis of Pretty Lake's total phosphorus, transparency, and chlorophyll a data using the Carlson's TSI suggests that the lake is mesotrophic to eutrophic (Figure 11). Pretty Lake's transparency and chlorophyll a place the lake in the low mesotrophic category, while its total phosphorus concentration places it in the eutrophic category. Carlson TSI trophic state designation correlate perfectly for transparency and chlorophyll a, however, total phosphorous concentration is rated much higher than would be expected considering the transparency and chlorophyll a concentrations. It is important to note that water quality parameters can be slightly variable throughout the year and therefore, samples collected during one event may suggest one thing while another sampling event may suggest another. Ideally if multiple samples can be collected throughout the year than an average or "typical" result can be determined. The higher total phosphorus concentration sampled in 2017 is suggested to be on the upper end of the range which would be expected in in Pretty Lake when historical phosphorus concentrations are reviewed (Section 4.6 and 4.7). It is possible that phosphorous concentrations sampled on another day may have resulted in a lower concentration and been more closely correlated with the sampled transparency and chlorophyll a levels as suggested by the Carlson TSI.

3.5.6 In-lake Sampling Results Summary

Overall in-lake water quality sampling suggests Pretty Lake has good water quality and better water quality then most lakes in the region. This is supported by the relatively high secchi disk reading, low chlorophyll a concentration and low to moderate plankton abundance. Phosphorus concentrations were greater than expected and on the higher end of historical measurements. Phosphorous levels measured in the epilimnion and hypolimnion indicate internal phosphorus loading from bottom sediments is occurring. Proof of this is shown by the increase in SRP from a concentration of 0.048 mg/L in the epilimnion to a concentration of 0.070 mg/L in the hypolimnion. The percentage of total phosphorus which was soluble (SRP) increased between the epilimnion and hypolimnion with SRP accounting for 82.8% and 94.6%, respectively. Total phosphorus and SRP mean concentrations measured in 2017 were below the median value report in the CLP study, indicating Pretty Lake has better than average water quality compared to most Indiana lakes (Table 21). While Pretty Lake total phosphorus concentrations are well below the 0.3 mg/L concentration that IDEM would list the lake as impaired for phosphorus, the measured concentrations were above the generally accepted threshold at which phosphorus can contribute to nuisance algae blooms is 0.03 mg/L (0.03 ppm – parts per million or 30 ppb – parts per billion).

Dissolved oxygen and temperature profiles sampled in 2017 indicates Pretty Lake was stratified, such that surface water and bottom waters were not mixing due to temperature-induced density differences. At the time of sampling, the epilimnion was confined to the upper approximately 20 ft. (6.1 m) of water (Figure 8), while the hypolimnion occupied water deeper than 46 ft. (14.0 m). The dissolved oxygen profile mirrored the temperature profile, however oxygen becomes essentially absent at approximately 30 ft. (9.1 m). The lake was saturated (100% oxygen percent) from the surface to a depth of approximately 16 ft. (4.9 m). Water below approximately 25 ft. (7.6 m) did not contain sufficient dissolved oxygen to support fish and other aquatic organisms. In general, dissolved oxygen levels <4 mg/L are not capable of support the majority of fish species. Only approximately 25% of the water column was suitable for fish habitation.

During the September sampling Pretty Lake's 1% light level was located at a depth of approximately 33 ft. (10.0 m; Figure 24). Based in the depth-area curve Pretty Lakes littoral zone is approximately 150 acres (60.7 ha) in size and covers approximately 81% of the lake. Based on Pretty Lake's depth-volume curve, approximately 3,500 acre-feet of Pretty Lake (73% of total lake volume) lies above the 33 ft. (10.0 m) 1% light level.

Phytoplankton density was determined to be 8,826 natural units (nu)/L (Table 22) and zooplankton density was determined to be 6,242 animals/L (Table 23), for a total plankton density of 15,068 nu/L. Plankton density compared to the CLP data set in Table 21, indicates Pretty Lake plankton community density is below the median values of most Indiana lakes. This would suggest Pretty Lake contains increased water quality as high plankton densities usually indicate excessive nutrients within a waterbody. At the time of the plankton sampling, the Pretty Lake phytoplankton community was dominated by blue-green algae (Cyanophyta) which accounted for 88.8% of the plankton community. It is important note the 88% dominance by blue-green algae is higher than the median amount determined in the CLP dataset in Table 21.

The total ITSI score was 21 which places Pretty Lake in the lower mesotrophic range (TSI scores of 16-31). Most metrics received low to moderate scores (scores 0-2), while total phosphorus scored slightly higher with a score of 3 out of a potential 5. The only metric which would be considered "high" is the additional 10 points assigned to the overall score for the dominance of blue-green algae in the plankton sample; however, the overall plankton density metric scored low (2). Overall the ITSI suggests Pretty Lake is a moderately productive system and therefore, contains moderate to good water quality.

Section 4: Observed Tributary and In-lake Trends

4 Observed Tributary and In-lake Trends

Section 4 outlines and discusses any discernible trends between the 2017 study and the 2007 diagnostic study in regards to water quality parameters sampled at tributary and in-lake sites, biological comparison for macroinvertebrates, plankton, and fish, stream habitat, and general trends on aquatic plant management efforts.

4.1 Tributary Water Quality Trends

When comparing tributary sampling sites from the current study to the 2007 diagnostic study, only Site 3 and Site 4 have previously available data. Additionally, it is important to note a water quality improvement project was completed at Site 3 since the 2006 sampling was conducted and could have potential localized effects on the sampled parameters due the modification to the stream channel immediately upstream from the Site 3 collection point. The addition of a two-stage ditch at Site 3 could have an effect on characteristics such as TSS, and nutrient concentrations because storm flows now have a floodplain bench to deposit sediment and associated nutrients at high flows.

Table 26 presents the results of physical parameters sampled during 2006 and 2017. Looking at discharge amounts listed from the two sampling years, it is apparent that the 2017 sampling event captured a larger storm event than that sampled in 2006. Overall, physical parameters appear to be similar between the two sampling years. One parameter of interest is TSS, which as state earlier could be lower due to the construction of a two-stage ditch at Site 3. Considering the storm event in 2017 was greater than that in 2006, it would be assumed TSS values may be higher as increased rainfall could produce more overland flow, streambank scouring and produce increased amount of suspended sediments. Despite the increased storm flow (stream discharge) in 2017 TSS values were lower than that sampled in 2006, at 10 and 12 mg/L, respectively. This suggests the two-stage ditch floodplain area could be functioning as designed and allow for sediments to be deposited, thereby reducing the amount of sediment and nutrient loading to Pretty Lake.

Table 26. Pretty Lake tributary sampling physical results from 2006 and 2017.

Sampling Location	Date	Event	Discharge (cfs)	Temp (°C)	Temp (°F)	DO (mg/L)	% Sat	pH	Cond. (μs/cm)	TSS (mg/L)	Turbidity (NTU)
Site 1	5/25/2017	Storm	1.485	14.1	57.4	5.49	56.1	6.04	400	7	8.38
Site 2	5/25/2017	Storm	3.732	14.3	57.7	5.35	54.7	6.53	410	4	6.65
Site 3	5/11/2006	Storm	1.18	11.8	53.2	8.00	74.6	7.60	575	12.22	-
Site 3	7/27/2006	Base	0.5	19.3	66.7	7.20	75.4	-	648	1.83	-
Site 3	5/25/2017	Storm	4.435	14.2	57.5	6.88	70.3	6.81	416	10	9.54
Site 4	5/11/2006	Storm	1.17	13.7	56.7	6.50	63.5	7.60	418	3.63	-
Site 4	7/27/2006	Base	1.58	26.2	79.2	8.30	102.0	-	376	1.26	-
Site 4	5/25/2017	Storm	3.793	17.8	64.1	9.70	107.0	7.76	335	3	1.4

Table 27 presents the results of chemical parameters sampled in 2006 and 2017 at the tributary sites. Chemical parameters sampled at Sites 3 and 4 show differences between the two sampling years. First, nitrate (NO3-N) showed a significant increase from 2006 to 2017 at Site 3, increasing from 1.521 mg/L to 6.420 mg/L, respectively. As discussed in Section 2.2, nitrate concentrations greater than 1.5 mg/L could have negative impacts on aquatic life and concentrations of 3-4 mg/L definitely showed a negative correlation, therefore, the increase from 2006 to 2017 is concerning. Other forms of nitrogen sampled

(NH3-N and TKN) did not show a significant change from 2006 to 2017, however, TKN concentrations decreased from 2006 to 2017 by a moderate amount. Ammonia levels in both 2006 and 2017 exceeded IAC standards, but the 2017 concentration exceeded the IAC standard by a greater margin. TKN concentrations are still higher than the desired concentration of <0.571 mg/L suggested by the EPA. Ultimately it appears there is a nitrogen problem in Deal Ditch, considering nitrates, ammonia and TKN are at concentrations above desirable levels and have not improved since 2006. Nitrogen parameters did increase at Site 4 as well between 2006 and 2017, however none of the increases were significant enough to cause concern. At Site 3 soluble reactive phosphorus was sampled at similar levels between the two years, while total phosphorus decreased from 0.146 mg/L in 2006 to 0.083 mg/L in 2017. As mentioned earlier, the installation of a two-stage ditch at Site 3 could reduce nutrients such as total phosphorus because of the floodplain now available to storm flow event. Total phosphorus at Site 4 showed a moderate decrease from 0.055 mg/L in 2006 to 0.007 mg/L in 2017. E. coli levels sampled in 2017 at Site 3 increased from 1,240 mpn/100mL in 2006 to >2,419.6 mpn/100mL in 2017, suggesting sources for E. coli to Deal Ditch have not been reduced during base flow conditions. E. coli at Site 4 showed a significant decrease from 2006 to 2017. While E. coli levels measured during both the storm and base flow events in 2006 exceeded the IAC standard for recreational waterbodies of 235 mpn/100 mL, the 2017 E. coli level was well within IAC standards with a concentration of 32 mpn/100 mL. Provided in Table 28 are E. coli source tracking results from 2006 and 2017 sampling along Deal Ditch. Results of both the 2006 and 2017 source tracking indicate humans account for the largest percent of E. coli present within the collected samples at all sites along Deal Ditch. Animal contributions from 2006 to 2017 did show a decrease. As the 2006 and 2017 source tracking data indicate, reductions of E. coli levels in Deal Ditch will need to be addressed by reducing human inputs to the stream.

Table 27. Pretty Lake tributary sampling chemical results from 2006 and 2017.

Sampling Location	Date	Event	NH3-N (mg/L)	NO3--N (mg/L)	NO2-N (mg/L)	NO3+NO2 (mg/L)	TKN (mg/L)	SRP-P (mg/L)	TP-P (mg/L)	*E. coli* (MPN/100mL)
Site 1	5/25/2017	Storm	0.109	8.560	0.077	8.64	1.790	0.028	0.098	>2,419.6
Site 2	5/25/2017	Storm	0.100	7.480	0.058	7.54	1.020	0.027	0.080	>2,419.6
Site 3	5/11/2006	Storm	0.100	1.521	-	-	2.147	0.029	0.146	1,240
Site 3	7/27/2006	Base	0.091	1.235	-	-	1.117	0.043	0.076	890
Site 3	5/25/2017	Storm	0.090	6.420	0.054	6.47	1.060	0.030	0.083	>2,419.6
Site 4	5/11/2006	Storm	0.018	0.013	-	-	0.777	0.023	0.055	520
Site 4	7/27/2006	Base	0.018	0.020	-	-	0.703	0.010	0.024	950
Site 4	5/25/2017	Storm	0.040	0.381	0.006	0.39	0.820	-	0.007	32

Table 28. E. coli source tracking results within Deal Ditch as sampled in 2006 and 2017.

Sampling Location	Date	% Human	% Animal
Site 1	7/10/2006	58.3	41.7
Site 1	5/25/2017	94	6
Site 2	7/10/2006	83.3	16.7
Site 2	5/25/2017	95	5
Site 3	7/10/2006	73.7	26.3
Site 3	5/25/2017	95	5
Site 4	5/25/2017	NA	NA

4.2 Tributary Loading Rates

Provided in Table 29 are the calculated loading rates determine from tributary sampling efforts during the 2006 and 2017 survey years. When comparing the loading rates from the two data sets it is important to mention that it appears the 2017 storm event captured was significantly greater than that sampled in 2006, which is noted by the increased discharge between the two years. Because the discharge amounts are so much greater in 2017 than 2006, it is difficult to make comparisons between the two years. As discussed in Section 4.1, and shown in Table 26, TSS concentrations where lower in 2017 at Site 3 than that sampled in 2006; however, TSS loading is shown in Table 29 suggest TSS loading in 2017 was greater than 2006. This large difference in discharge accounts for the increased value observed in Table 26, which can be misleading. Due to this significant difference in discharge between the two years, the nutrient trends discussed in Section 4.1 can be used to assume overall loading rate comparisons between 2006 and 2017. The parameters which were sampled at lower concentrations in 2017 than 2006, and therefore would have lower loading rates include TSS, TP and TKN (Table 26 and 27). Those parameters which had higher concentrations in 2017 than 2006, and therefore would have higher loading rates include NO3 and *E. coli* (Table 27). Additionally, it is important to note that drainage patterns within Deal Ditch along the majority of the stream have not changed since the 2007 Diagnostic Study, with the exception being the construction of a two-stage ditch at the downstream extent of the drainage. If drainage patterns had changed between 2006 and 2017 then overall loading amounts could be interpreted further, such that potential new patterns may have increased or decreased the overall discharge amount/rate within the stream. Without these observed drainage changes the overall nutrient loading is best interpreted from conclusions drawn in Section 4.1.

Table 29. Tributary loading rates determined from 2006 and 2017 Pretty Lake tributary sampling efforts.

Sampling Location	Date	Event	Discharge (cfs)	NH3-N (kg/d)	NO3--N (kg/d)	TKN (kg/d)	SRP-P (kg/d)	TP-P (kg/d)	TSS (kg/d)
Site 1	5/25/2017	Storm	1.485	0.40	31.10	6.50	0.10	0.36	25.43
Site 2	5/25/2017	Storm	3.732	2.05	153.54	20.94	0.55	1.65	36.52
Site 3	5/11/2006	Storm	1.18	0.29	4.39	6.19	0.08	0.42	35.26
Site 3	7/27/2006	Base	0.5	0.11	1.51	1.37	0.05	0.09	2.24
Site 3	5/25/2017	Storm	4.435	0.98	69.66	11.50	0.33	0.90	108.51
Site 4	5/11/2006	Storm	1.17	0.04	0.04	2.22	0.07	0.16	10.38
Site 4	7/27/2006	Base	1.58	0.08	0.08	2.72	0.04	0.09	4.85
Site 4	5/25/2017	Storm	3.919	0.38	3.65	7.86	-	0.06	27.84

4.3 Tributary Habitat (QHEI) Trends

Table 30 displays the habitat scores calculated at Sites 1-4 for survey years 2006, 2008 (Feasibility Study) and 2017. Habitat at Site 1 appears to have changed little since the assessment done during the Feasibility study and possess overall poor quality. Site 2 showed a slight increase in QHEI score from 2008 to 2017, but still is considered poor quality. Reviewing the metric scoring at Site 2 between the two survey years, substrate quality is suggested to have increased. Site 3 QHEI scores during the 2017 assessment were the highest rated during the three survey years. The increase in the overall score is contributed to an increase in the substrate metric score. This increase is not a surprise as the construction of a two-stage ditch channel at the site would support a higher quality/diversity of substrate due to the ability of the stream channel to access a floodplain during storm events which helps to settle-out finer suspended particles, reduces localized streambank erosion and allows for better sorting of a variety of substrate sizes due to reduced channel bed scour. Site 4 QHEI scores were significantly different between 2006 and 2017. It is suggested the reach surveyed during the two years was not the same, which would account for the difference. In 2006, the survey must have included the stream area downstream of the outlet structure, while the 2017 assessment looked at the area from the mouth of outlet stream to the beginning of the woods downstream of the outlet structure. Overall, habitat within Deal Ditch remains poor but as indicated by the project done at Site 3 the potential to increase available stream habitat is possible.

Table 30. Pretty Lake tributary QHEI scores from 2006, 2008 and 2017.

Site	Substrate Score	Cover Score	Channel Score	Riparian Score	Pool Score	Riffle Score	Gradient Score	Total Score
Maximum Possible	*20*	*20*	*20*	*10*	*12*	*8*	*10*	***100***
Site 1 (2008)	-2	12	4	7	0	0	6	**27**
Site 1 (2017)	0	7	5	5	1	0	6	**24**
Site 2 (2008)	7	6	9	4.5	2	0	6	**34.5**
Site 2 (2017)	12	7	7	6	1	1	6	**40**
Site 3 (2006)	4	15	6	6	0	0	8	**39**
Site 3 (2008)	3	3	8	8.5	2	0	6	**30.5**
Site 3 (2017)	14	6	8	6	4	0	6	**44**
Site 4 (2006)	14	12	14	8.5	0	5	8	**61.5**
Site 4 (2017)	11	3	6	5	3	0	6	**34**

4.4 Tributary mIBI Trends

A comparison of mIBI scores at Site 3 between 2006 and 2017 suggest the macroinvertebrate community quality had declined with scores of 3.3 and 2.0, respectively. However, both mIBI scores receive a “moderately impaired” rating (Figure 12). As discussed in Section 3.2, prior to 2010 mIBI classifications, IDEM designates streams as fully supporting of their life use designation (warm water habitat) if scores are greater than 2.2, which would mean in 2006 Site was “fully supporting” while 2017 was considered “not supporting.” The reduction in mIBI score from 2006 to 2017 is surprising because of the increase in QHEI score discussed at Site 3 from the two-stage ditch project. Generally with more stable streambed and increased substrate diversity promotes improved macroinvertebrate communities. A review of the mIBI metric scoring between 2006 and 2017 indicate the 2017 score was lower due to a reduced number of EPT individuals and an increase in chironomid individuals collected. While the number of EPT individuals collected was less in 2017 than 2006, the same number of EPT families were collected at Site 3. Site 4 mIBI scores were similar between 2006 and 2017. The 2017 mIBI score was slightly higher because there were two more families from the EPT orders collected in the 2017 than 2006. It appears continued good water quality at Site 4 is maintaining a suitable macroinvertebrate community.

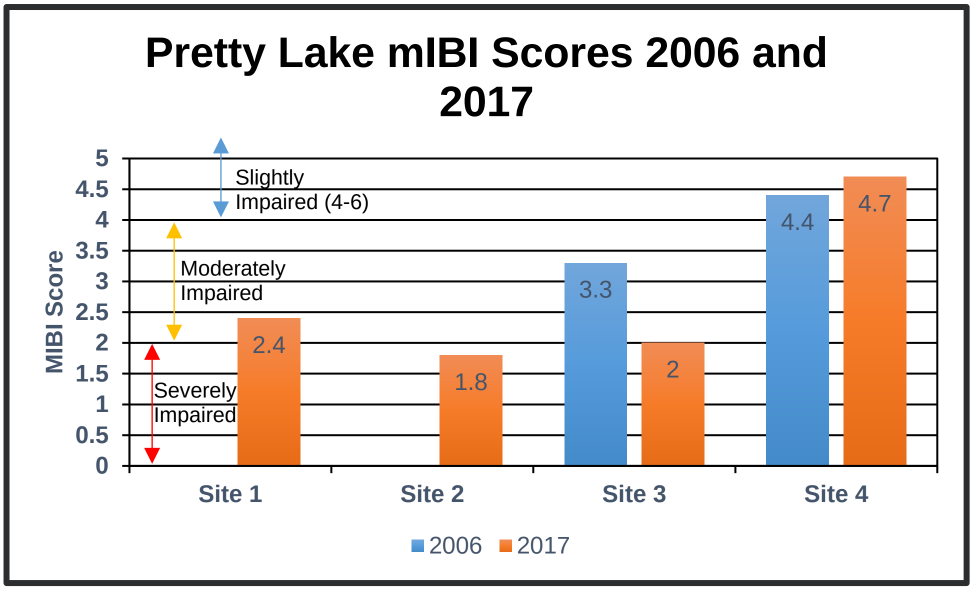

Figure 12. Pretty Lake mIBI scores from Deal Ditch and Lake Outlet stream sampled 2006 and 2017.

4.5 In-Lake Trends/Historical Review

Included in Appendix E is a comprehensive dataset of historical in-lake sampling events with select parameters. The dataset in Appendix E is taken from the 2006 Diagnostic study with post-2006 sampling data added to the set as part of the current study. Figures 23 and 24 are taken from the Appendix E data set to discuss phosphorus and chlorophyll a concentrations below.

4.6 In-lake Water Quality Trends

Secchi Disk

Comparing the secchi disk readings from 2006 and 2017 indicate Pretty Lake water clarity has remained relatively unchanged and is further suggested to be in-line with other historical results as shown in Table 31 and 32. Pretty Lake with a secchi disk reading of 13.1 ft. (4 m) remains well above the median value of 6.9 ft. (2.1 m) for most lakes in Indiana (Table 21).

pH

pH values sampled during the 2006 and 2017 assessments are comparable and within the normal range for lakes in the region. No observable change is pH is suggested between 2006 and 2017.

Conductivity

Conductivity values sampled in 2017 within the hypolimnion where slightly higher than that sampled in 2006 (Table 31). However, epilimnion conductivity measurements were comparable between the two years (Table 31). Overall, conductivity is suggested be similar to that sampled in 2006 and is within the normal range for lakes in the region.

Ammonia (NH3-N)

Ammonia concentrations sampled in 2006 and 2017 were almost identical in both the epilimnion and hypolimnion (Table 31). The consistent increase of ammonia concentrations in the hypolimnion shown in both 2006 and 2017 indicate anoxic conditions.

Nitrate (NO3-N)

2017 nitrate concentrations in both the epilimnion and hypolimnion where significantly greater than that sampled in 2006 (Table 31). However, as shown in Appendix E, the average nitrate concentration of available historical data (0.164 mg/L) is similar to that sampled in 2017. In fact, the 2006 nitrate concentration was the lowest observed sampled between all historical data (Appendix E). A review of available historical data suggest nitrate concentrations within Pretty Lake have remained relatively stable. Additionally, during both the 2006 and 2017 sample years, nitrate concentrations did not show a change between epilimnion and hypolimnion samples, such that nitrate concentrations were consistent throughout the water column in 2006 and 2017. Overall, nitrate concentrations in Pretty Lake are lower than the median concentration of most lakes in Indiana (Table 21).

Total Kjeldahl Nitrogen (TKN)

TKN samples taken from the epilimnion were similar between 2006 and 2017, but samples from the hypolimnion were greater in 2017 then 2006 (Table 31). This higher hypolimnetic concentration sampled in 2017 resulted in a higher mean TKN concentration in 2017 than 2006. TKN is the measure of organic nitrogen plus ammonia. Organic nitrogen includes nitrogen found in plant and animal materials, plus and may in dissolved or particulate form. Because ammonia concentration were similar between epilimnion and hypolimnion samples, then the increase in TKN is due to organic nitrogen levels in the hypolimnion.

Total Phosphorus and Soluble Reactive Phosphorus (TP and SRP)

As shown in Table 31 and Figure 13, total phosphorus concentrations in 2017 were higher than that measured in 2006 in both the epilimnion and the hypolimnion. Additionally, unlike that sampled in 2006, the hypolimnion total phosphorus concentration was higher than the epilimnion concentration in 2017. This increase in total phosphorus is not uncommon and usually observed in stratified lakes such as Pretty Lake, where bottom waters become anoxic during portions of the year. Anoxic conditions allow phosphorous to be released from the bottom sediments, thereby increasing soluble reactive phosphorus levels and phosphorus levels overall. The 2006 sampling event did not show this internal phosphorus loading while the 2017 study suggest some phosphorus is being released from the lake sediments. A review of historical data from the CLP also shows increases in hypolimnion phosphorus levels as that sampled in 2017. This increase in hypolimnion phosphorus concentrations was observed in all CLP sampling years (1989, 1993, 1997, 2002, 2010, and 2012) with the amount of phosphorus increase being variable by the year.

When comparing the 2017 mean total phosphorus concentration to the available historical data presented in Figure 13 and Table 32, the 2017 concentration is significantly higher than the determined average for that dataset (0.031 mg/L). This increase is of concern, however, because the 2017 total phosphorus concentration would show an increase in the lakes trophic state, when other sampled parameters are considering such as secchi disk transparency and chlorophyll a, the water quality of Pretty Lake is suggested to be similar to that of historical levels. More frequent sampling of Pretty Lake's phosphorus levels would provide a better assessment of the typical phosphorus concentrations throughout the year.

Chlorophyll a

Chlorophyll a sampled in 2017 was greater than that sampled in 2006 with an increase from 0.140 µg/L to 2.7 µg/L observed (Table 31; Figure 14). A review of available chlorophyll a concentrations shown in Figure 14 and Table 32 indicates the 2017 sample is slightly higher than the average (2.22 µg/L) determined from historical data and within the range sampled during previous survey years (range 0.14µg/L to 3.5 µg/L). In general, chlorophyll *a* concentrations below 2 µg/L are considered low, while those exceeding 10 µg/L are considered high and indicative of poor water quality. The USEPA recommended a numeric criterion of 2.6 µg/L as a target concentration for lakes in Aggregate Nutrient Ecoregion VII (USEPA, 2000a).

Table 31. Pretty Lake in-lake sampling results from 2006 and 2017.

Site Name	Date	Secchi Disk (m)	pH	Cond. (µs/cm)	NH3-N (mg/L)	NO3--N (mg/L)	TKN (mg/L)	SRP (mg/L)	TP (mg/L)	Chlorophyll a (µg/L)
Epilimnion	7/27/2006	3.6	8.7	322	0.018	0.018	0.706	0.010	0.021	0.140
Lake 1 Epilimnion	9/6/2017	4.0	8.25	345	0.014	0.185	0.732	0.048	0.058	2.7
Hypolimnion	7/27/2006	-	7.50	245	0.275	0.018	0.698	0.010	0.017	-
Lake 1 Hypolimnion	9/6/2017	-	7.55	388	0.284	0.178	1.120	0.070	0.074	-
Mean 2006		-	8.10	284	0.147	0.018	0.702	0.010	0.019	
Mean 2017		-	7.90	367	0.149	0.182	0.926	0.059	0.066	-

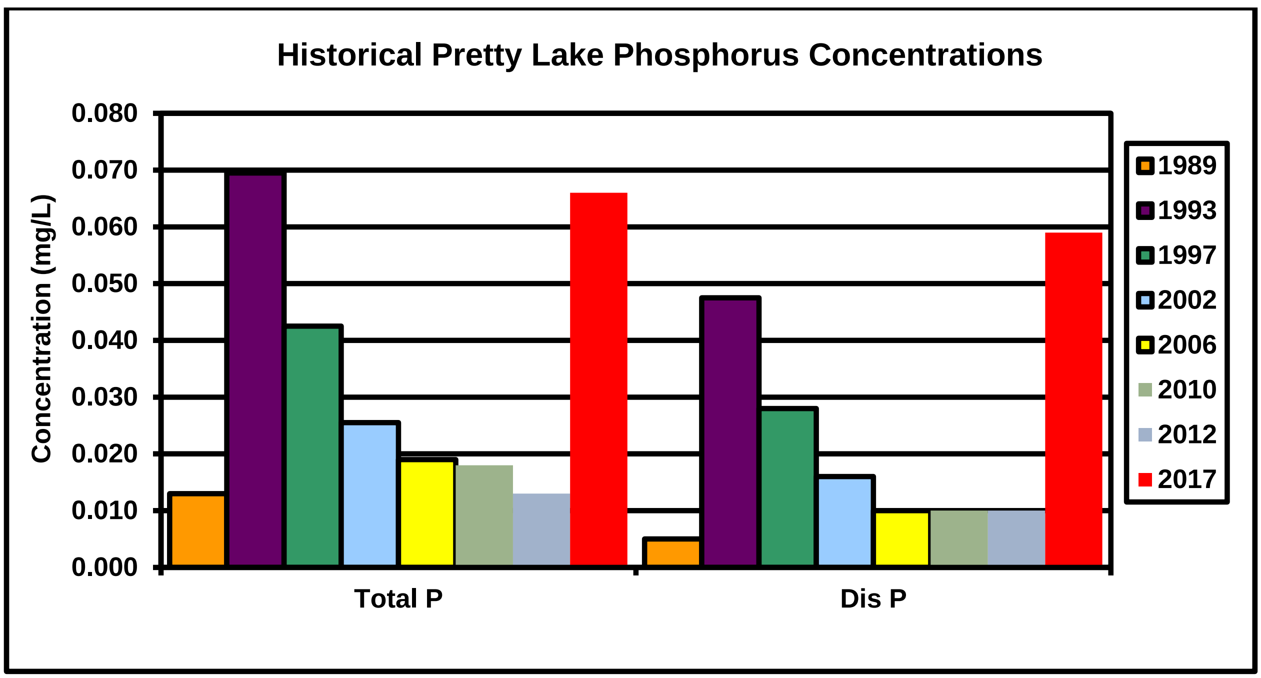

Figure 13. Historical Pretty Lake phosphorus concentrations. Data available in Appendix D.

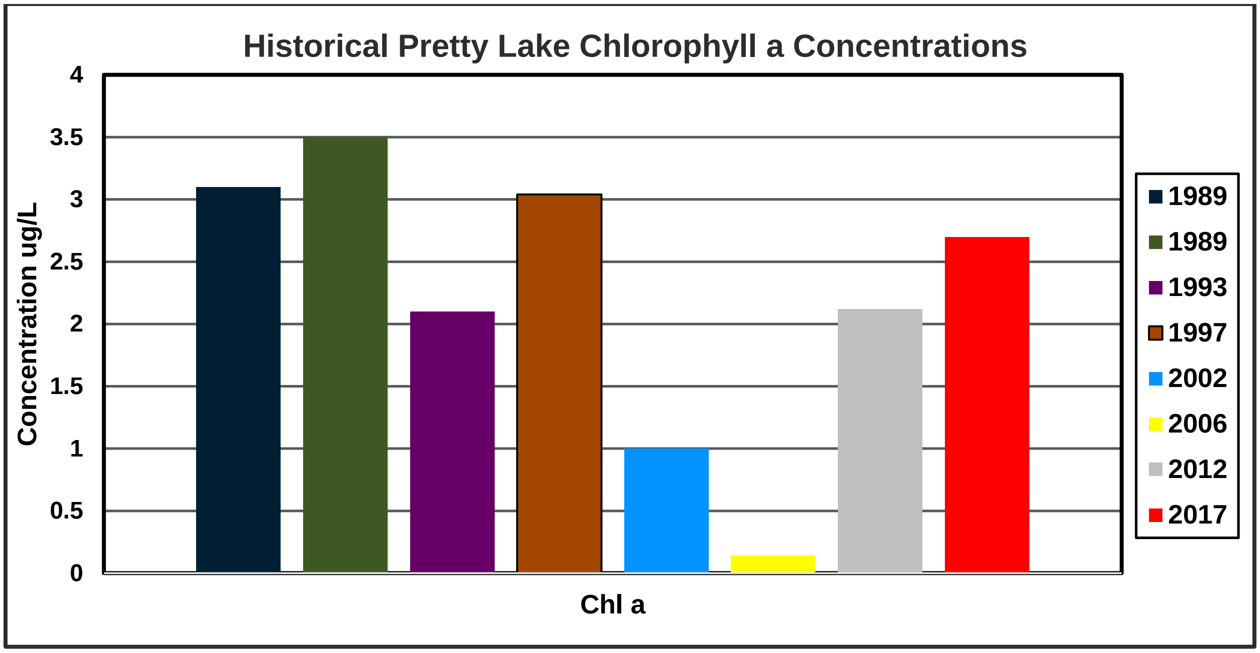

Figure 14. Historical Pretty Lake chlorophyll a concentrations. Data available in Appendix E.

Table 32. Summary of select historical water quality parameters for Pretty Lake. Complete table is available in Appendix D. TP, SRP and Chl a data is also represented in Figures 23 and 24.

Date	Secchi (ft.)	Mean TP (mg/L)	Mean SRP (mg/L)	Chl a (µg/L)	TSI	Source
06/22/64	10.83					McGinty, 1966
08/31/72	10.00	0.300*			25**	IDEM, 1986
07/31/73	11.00					Peterson, 1974
01/01/74		0.040				IDNR, 1974
08/06/79	18.50					Peterson, 1980
09/01/83	12.6					IDNR, 1984
08/07/85	17.00					Ledet, 1986
07/01/88	14.8		0.010			Indiana University, 1988
08/22/88	9.00	0.005				Grant, 1989
07/01/89	9.19	0.013	0.005		7	CLP, 1989
09/15/89	12.4	0.680*	0.030	3.1	13	Earthsource, 1991
10/05/89	13.1	0.190*	0.020	3.5	13	Earthsource, 1991
07/27/93	11.48	0.070	0.048	2.1	22	CLP, 1993
06/17/96	19.00					Ledet, 1998
08/26/97	11.15	0.043	0.028	3.04	21	CLP, 1997
05/21/00	17.0					Volunteer monitor
06/17/00	17.0					Volunteer monitor
05/19/01	16.5					Volunteer monitor
06/23/01	13.5					Volunteer monitor
08/29/01	12.5					Volunteer monitor
09/12/01	11.0					Volunteer monitor

Date	Secchi (ft.)	Mean TP (mg/L)	Mean SRP (mg/L)	Chl a (µg/L)	TSI	Source
10/04/01	16.0					Volunteer monitor
07/05/02	14.0					Volunteer monitor
07/14/02	14.8					Volunteer monitor
08/03/02	14.5					Volunteer monitor
08/12/02	15.75	0.026	0.016	1.00	16	CLP, 2002
08/29/02	16.5					Volunteer monitor
09/30/02	12.9					Volunteer monitor
07/02/03	14.8					Volunteer monitor
06/15/04	13.6					Volunteer monitor
06/19/04	14.2					Volunteer monitor
07/13/04	14.5					Volunteer monitor
07/04/05	15.5					Volunteer monitor
07/27/06	11.5	0.019	0.010	0.14	15	Cardno, 2007 Diagnostic Study
07/30/07	15.5					Cardno, 2008 AVMP
06/21/10	14.0					Koza, 2011 IDNR Fisheries
08/09/10	14.4	0.018	0.010		37^^	CLP, 2010
09/07/11		0.140^				Lagrange County Lakes Council
05/30/12		0.150^				Lagrange County Lakes Council
07/02/12	6.9	0.013	0.010	2.12	^^	CLP, 2012
09/12/12		0.170^				Lagrange County Lakes Council
05/07/13		0.170^				Lagrange County Lakes Council
06/27/13		0.670^				Lagrange County Lakes Council
07/25/13		0.230^				Lagrange County Lakes Council
07/26/13	26.0					Aquatic Weed Control, 2013 AVMP Update
08/22/13		0.280^				Lagrange County Lakes Council
09/26/13		0.130^				Lagrange County Lakes Council
10/24/13		1.070^				Lagrange County Lakes Council
06/26/14		0.180^				Lagrange County Lakes Council
07/24/14		0.250^				Lagrange County Lakes Council
07/30/14	18.2					Aquatic Weed Control, 2014 AVMP Update
08/28/14		0.190^				Lagrange County Lakes Council
07/29/15	12.90					Aquatic Weed Control, 2015 AVMP Update
08/01/15		0.080^				Lagrange County Lakes Council
09/09/15		0.070^				Lagrange County Lakes Council
07/21/16		0.050^				Lagrange County Lakes Council
07/26/16	13.50					Aquatic Weed Control, 2016 AVMP Update
08/22/16		0.070^				Lagrange County Lakes Council
09/16/16		0.060^				Lagrange County Lakes Council
07/30/17		0.070^				Lagrange County Lakes Council
08/01/17	15.00					Aquatic Weed Control, 2017-unpublished

Date	Secchi (ft.)	Mean TP (mg/L)	Mean SRP (mg/L)	Chl a (µg/L)	TSI	Source
08/30/17		0.060^				Lagrange County Lakes Council
09/06/17	13.10	0.066	0.059	2.7	21	Cardno, 2018
09/27/17		0.060^				Lagrange County Lakes Council
Average all years	**14.08**	**0.031**	**0.02**	**2.22**	**17**	

*Water column average; all other values are means of epilimnion and hypolimnion values. Values are not included in "Average all years" calculation.

**Eutrophication Index (EI) score. The EI differs slightly but is still comparable to the TSI used today.

^ Unsure of location within water column where sample is taken. Values are not included in "Average all years" calculation.

^^Clean Lake Program changed plankton sampling methods and therefore the scores for Plankton Density metric and overall ITSI score is not directly comparable to other determined values.

ITSI Values

Historical Pretty Lake ITSI values are shown in Tables 37 and 38 and Figure 15. It is important to note that the "Plankton Density" metric and the overall TSI score shown for 2010 and 2012 are not directly comparable to other survey years due to a change in the plankton sampling protocol used by the CLP. While those two metrics cannot be assessed directly to other reported values all other metric comparisons can be made. The available dataset shows ITSI values have ranged from a low of 7 in 1989 to a high of 22 in 1993/1997 and an average score of 17 between all years (this excludes 2010 and 2012 data; Table 33). The 2017 TSI score showed an increase since the 2006 sampling event however, it is lower than the 1993 and 1997 years. The increase from 2006 to 2017 can mainly be attributed to higher individual metric scores for total phosphorus and soluble reactive phosphorus. All other metrics between 2017 and 2006 are similar. ITSI metrics which have been consistent throughout the years include secchi depth transparency, nitrate-nitrogen, ammonia-nitrogen, oxygen saturation at 5 ft. and blue green dominance (with the exception of 1989). ITSI metrics which have shown greater variability over the various sampling years (≥3 trophic points) include, total phosphorus, soluble reactive phosphorus and % water column D.O. > 0.1 mg/L. Overall, the TSI score calculated during 2017 and a review of available historical scores does not show a discernible increase or decrease in overall water quality and suggests Pretty Lake water quality has remained relatively stable.

Table 33. Historical Pretty Lake ITSI metric scoring and total values, LaGrange County, Indiana.

Parameter	Indiana TSI Points (based on mean values)							
	1989	1993	1997	2002	2006	2010	2012	2017
Secchi Depth Transparency	0	0	0	0	0	0	0	0
Light Transmission @ 3ft.	2	2	3	2	4	4	*	2
Total Phosphorus	0	3	2	0	0	0	0	3
Soluble Reactive Phosphorus	0	3	0	0	0	0	0	2
Nitrate-Nitrogen	2	0	0	0	0	0	0	0
Ammonia-Nitrogen	0	0	0	0	0	0	0	0
Organic Nitrogen	3	1	2	2	1	2	3	2
Oxygen Saturation @ 5ft.	0	0	0	0	0	0	0	0
% Water Column D.O. > 0.1 mg/L	0	2	3	0	0	1	0	0
Plankton Density	0	1	2	2	0	20*	*	2
Blue Green Dominance	0	10	10	10	10	10	10	10
TSI Score	**7**	**22**	**22**	**16**	**15**	**37***	**13***	**21**

*Clean Lake Program changed plankton sampling methods and therefore the scores for Plankton Density metric and overall ITSI score is not directly comparable to other determined values. These values are excluded from average TSI calculation shown in Table 26.

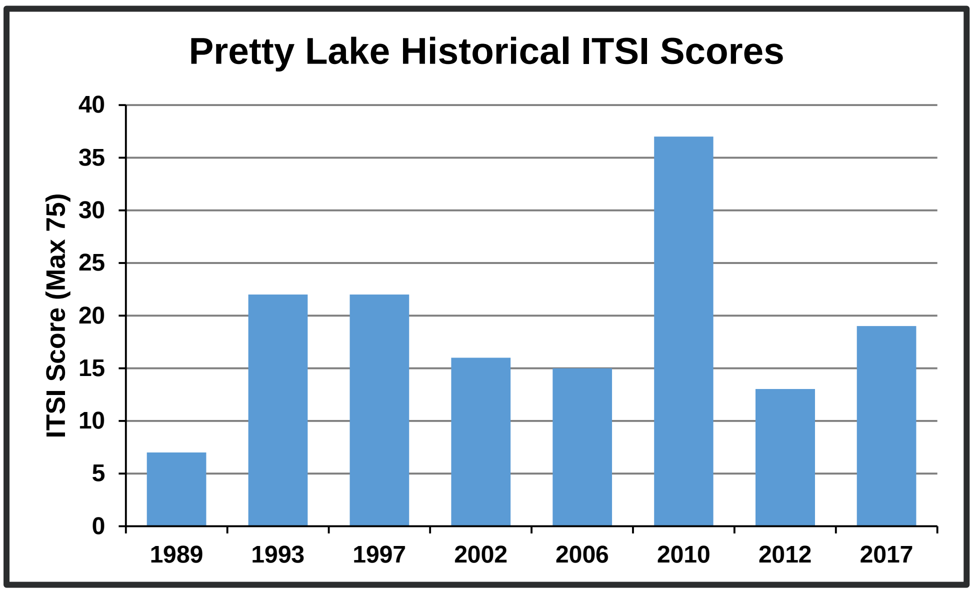

Figure 15. Historical Pretty Lake ITSI scores, LaGrange County, Indiana.

4.7 Plankton Trends

A review of available plankton data from the ITSI calculations show that blue-green (Cyanophyta) algae has been the dominate algae since 1993 (Table 33). Plankton density during the most recent study did show an increase from previous survey years however the overall plankton density is considered relatively low. This is further represented by the low chlorophyll a concentration measured during the current study as chlorophyll a is often used as direct estimate of algal biomass.

4.8 In-lake Dissolved Oxygen and Temperature Profiles Trends

The measured dissolved oxygen and temperature profiles completed during the current study are similar to that sampled during previous studies. Overall, Pretty Lake is a deep lake with multiple deep basins which limit the mixing of surface water and creates a stratified water column during the summer months.

4.9 In-lake Light transmission 1% light Level Trends

The 1% light level determined in 2017 was 33 ft. (10 m) compared 23 ft. (7 m) in 2006. The increase in the 1% light level is not surprising due to the increased secchi disk transparency value recorded in 2017 over 2006. The most recent study shows that water clarity has remained similar if not improved since the diagnostic study.

4.10 Fisheries

Indiana Department of Natural Resources (IDNR) fisheries biologists conducted four fisheries surveys at Pretty Lake in 2010: 1) a general fish community survey; 2) a largemouth bass population estimate; 3) a walleye population/stocking assessment; and 4) an angler creel survey. Nineteen species were collected during the general fish community survey in 2010 (Table 34). Bluegill was the dominate species by number accounting for 55% of individuals collected, followed by redear sunfish (17%) and largemouth bass (7%). Other notable game fish species collected included walleye, yellow perch and northern pike and black crappie. Redear sunfish was the number one species collected by weight (20%), followed by bluegill (18%), largemouth bass (17%) and walleye (15%). Results of the creel survey indicate bluegill and redear were the dominant species harvested by Pretty Lake anglers in 2010, combining to comprise 86% of the total harvest by number and 81% by weight. Anglers averaged 45 hours of fishing pressure per acre while harvesting 0.72 fish/hour. Averages from medium size natural lake creel surveys in Indiana average 50.6 hours of fishing pressure per acre and harvest rate of 0.69 fish/hour. This means that Pretty Lake anglers fished slightly fewer hours per acre than the average and they harvested a similar number of fish/hour. During the 2010 assessment anglers were very satisfied with the fishery as 92% responded that they thought fishing for their species was good and 82% thought fishing was improving in the lake. The 2010 creel survey determined that approximately 20% of anglers surveyed were targeting walleye. Ultimately the walleye stocking program was determined a success in establishing and maintaining a walleye fishery. The largemouth bass fishery is of interest to anglers as the 2010 creel determined 16% of parties targeted the species. However, bass catch rates were below average at 15 fish/acre compared to the average of 23/acre and 0.34 bass/hour compared to 0.42/hour on average. Pretty Lake was determined to have a below average bass population in terms of overall numbers and there was also a shortage of legal size fish in the population.

Indiana Department of Natural Resources Recommendations in the conclusions of the 2010 fisheries surveys included:

- Walleye stockings of advanced fall fingerlings should continue at Pretty Lake on a bi-annual basis along with fall electrofishing evaluations.
- Largemouth bass growth, density and population structure should continue to be evaluated as outlined in Division of Fish and Wildlife Work Plan 300FW1F10D42643.
- Pretty Lake residents should continue with their efforts to control the Eurasian watermilfoil in the lake. Additional funding should be sought through the LARE program to assist with these efforts.

Table 34. Species composition and relative abundance of fish collected during 1964, 1973, 1979, 1983, 1996 and 2010 fisheries surveys of Pretty Lake conducted by IDNR.

Species	1964	1973	1979	1983	1996	2010
Black bullhead	4					
Black crappie	7	3	8	10	17	1
Bluegill	322	114	152	574	664	416
Bluntnose minnow				Common		
Bowfin	3	1	3	6	1	2
Brook silverside					Present	Present
Brook Stickleback	1					
Brown bullhead	7	5	11	28	17	4
Brown trout				1		
Channel catfish						1
Golden shiner	4	3	8	4	2	1
Green sunfish	116	38	21	37	9	2
Hybrid sunfish					1	
Lake chubsucker	22	38	5	25	1	3
Largemouth bass	110	22	67	158	73	58
Northern pike	45	2	4	4	21	3
Pumpkinseed	13	12	13	19	59	31
Rainbow trout	2	13				
Redear	580	28	103	101	184	131
Redfin pickerel	9	1	2	12	3	1
Rock bass	60	15	42	19	70	19
Smallmouth bass	1					
Walleye	9				30	24
Warmouth	79	65	43	37	22	26
White sucker				2		
Yellow bullhead	49	33	56	40	42	17
Yellow perch	70	16	74	92	64	15

IDNR has been sampling for walleye annually since 1993. The PLCC began stocking walleye into Pretty Lake in the mid 1980's. IDNR first stocked walleye into Pretty Lake in 1990 and sampling during the fall of 1990 indicated poor survival of the walleye fingerlings. Pretty Lake was again stocked with by IDNR in 1993 and afterwards sampling in the fall of 1993 demonstrated exceptional survival. Stocking of June walleye fingerlings at a rate of approximately 100 per acre in Pretty Lake persisted annually from 1993 to 2007 (Table 35). Due to the relatively high survival of the 2007 stocking, IDNR decided to change to fall fingerling stocking in alternate years to minimize potential negative impacts on the yellow perch and sunfish forage base. Stocking continued in 2009 through 2015 in alternate years at a rate of 10 individuals per acre or approximately 1,840 walleye per year (Table 35). During the 2015 and 2016 supplemental walleye evaluation survey a total of 49 walleye were collected, concluding that the previous stocking efforts were successful and are providing both open water and ice fishing opportunities.

Indiana Department of Natural Resources Recommendations in conclusion of the 2015 and 2016 surveys include:

- IDNR should continue to pursue the production of fall Walleye fingerlings for stocking as addressed in previous Walleye Management Committee reports and the statewide percid plan.
- Fall Walleyes should be stocked into Pretty Lake in alternate years at a rate of 10 per acre with a minimum size of 7 inches total length.

Table 35. Walleye stocking amounts by year in Pretty Lake by IDNR, 1990 through 2015. Taken from Ledet, 2016.

Year	Number Stocked
1990	18,388
1993	17,350
1994	19,354
1995	20,970
1996	19,900
1997	19,136
1998	18,427
1999	20,595
2000	18,795
2001	18,675
2002	17,900
2003	18,641
2004	18,400
2005	21,781
2006	22,948
2007	20,810
2007	2,280
2009	1,840
2011	1,891
2013	1,841
2015	1,840

4.11 Aquatic Plants

Eurasian watermilfoil (*Myriophyllum spicatum*) an exotic species is impacting the ecology and functional use of Pretty Lake. During the initial survey in 2008 conducted by Cardno, approximately 14.4 acres of Pretty Lake were impacted with Eurasian watermilfoil. The Eurasian watermilfoil continued to expand until it was present in nearly 28 acres of Pretty Lake by 2013 (Figure 16). The PLCC applied for and received LARE funding to treat all areas of Eurasian watermilfoil growth starting in the spring of 2013 continuing through 2016. Prior to 2013 only small areas were targeted no larger than 1.34 acres to minimize damage to the native plant community. Starting each spring in 2013, through 2015 approximately 28 acres were treated for Eurasian watermilfoil with Diquat herbicide (Table 36; Figure 16). This was done in the spring to minimize harming the native plant population. Pretty Lake was then reassessed each summer for regrowth of Eurasian watermilfoil and selectively treated with 2, 4-d herbicide. In 2016, a less aggressive treatment approach was taken in order to evaluate both native and invasive plant abundance after 3 years of aggressive early season treatments. Figure 16 below was provided Aquatic Weed Control and shows the areas of Pretty Lake with historical Eurasian watermilfoil presence and areas treated since 2013. Figure 17 outlines the 4.6 acres to be treated in 2018. A comparison of Figures 26 and 27 and review of historical treatment acres in Table 36, indicates efforts to control Eurasian watermilfoil is working and appears the species is at a manageable level.

Spiny naiad (*Najas marina*) is another exotic species that is very common in Pretty Lake. Previous tier II surveys show that there is not a significant increase in Spiny naiad from 2007 to 2016. Pretty Lake does not appear to be considerably affected by Spiny naiad.

Table 36. Historical herbicide treatments for Eurasian watermilfoil in Pretty Lake since 2005.

Application Date	Acres Treated
2005-2012	Up to 1.34 per year
May 2, 2013	27.85
August 1,2013	0.25
May 12, 2014	27.85
August 7, 2014	3.19
April 30, 2015	28.02
August 3, 2015	3.84
June 2, 2016	3.9
2017	5.99
2018	4.6

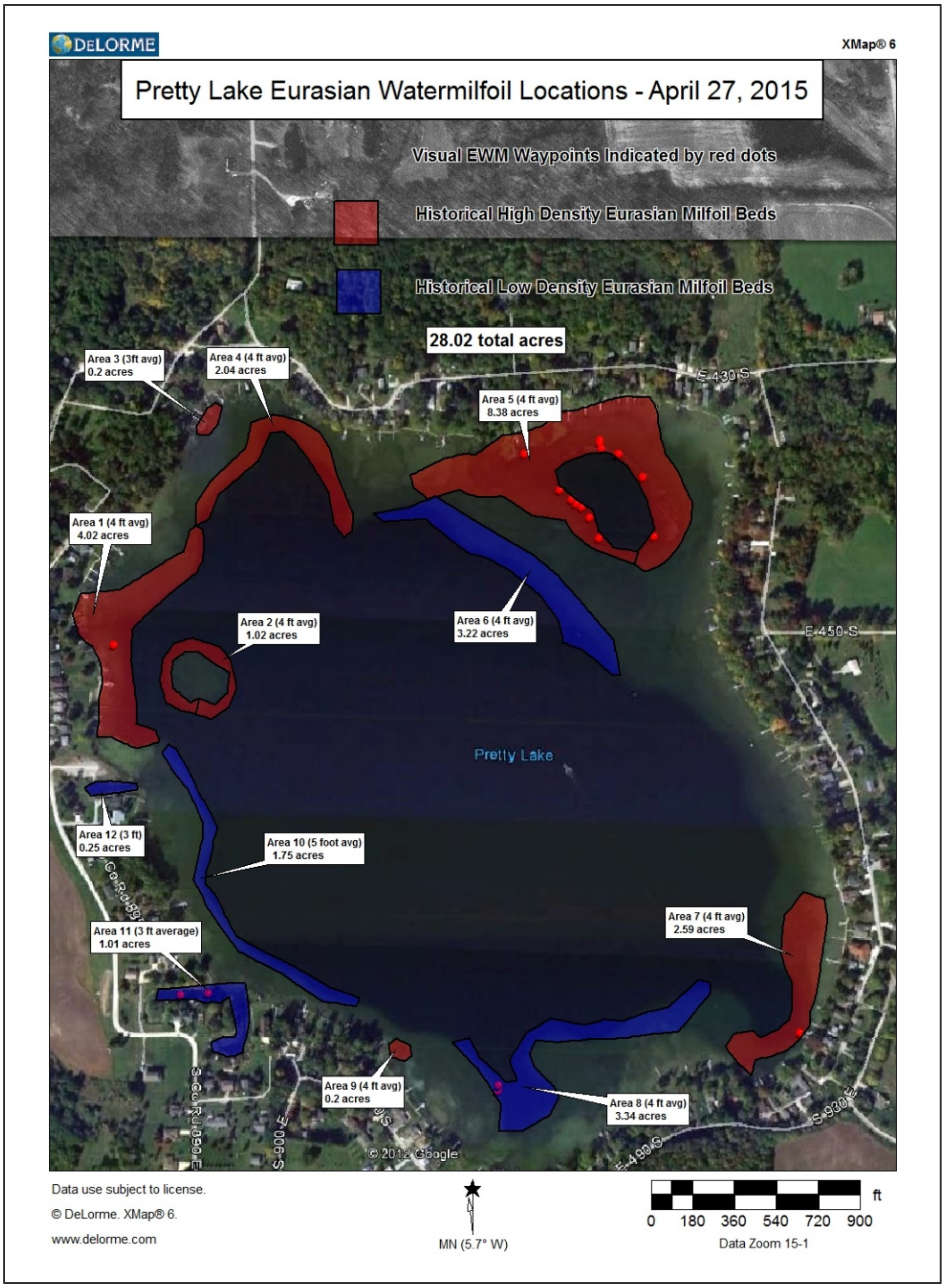

Figure 16. Areas treated in 2015 for Eurasian watermilfoil in Pretty Lake. Source: Aquatic Weed Control.

Figure 17. 2018 Eurasian watermilfoil treatment areas within Pretty Lake. Source Aquatic Weed Control.

Section 5: Management Recommendations

5 Management Recommendations

Overall Pretty Lake possesses good water quality compared to other lakes in the region; however, to maintain good water quality a proactive approach to watershed and in-lake management is encouraged. In terms of lake management, Pretty Lake's relatively low watershed area to lake area ratio means that near lake (i.e. shoreline) and in-lake activities can potentially exert a significant influence on the health of Pretty Lake. Consequently, implementing best management practices along the lake's shoreline, such as maintaining native, emergent vegetated buffers between the lakeside residences and the lake, should rank high when prioritizing management options. Similarly, in-lake management practices such as controlling invasive aquatic species such as Eurasian watermilfoil, should receive special attention. This does not mean that landuse or stream management should be ignored but means that the overall health of Pretty Lakes comes from those activities occurring throughout the watershed. Management activities should be diverse and include all areas of potential impacts from both in-lake/shoreline areas to landuse and stream management.

The management recommendations discussed in this section are a combination of projects/items discussed in earlier studies such as the 2007 Diagnostic Study and the 2009 Feasibility study and any new management projects/considerations noted during the current study. Some of the management recommendations are straight forward projects such as installing a rain garden, constructing a two-stage, ditch, rock-toe treatment to stabilize streambanks or modifications existing storm drains/grates. Other recommendations are based more on initiative type projects such as working to build a culture of lake residents that want to improve native shoreline habitats, working with producers in the watershed that could implement BMPs to control various pollutants on their property, or educational initiatives that have focused discussions with landowners on proper septic system care. Additionally, a proposed water quality monitoring section is included within the recommendations to assist in future tracking of water quality trends within Pretty Lake and Deal Ditch. The location map of site specific recommendation projects is shown in Figure 18.

Prior to proceeding with any of the projects discussed below the PLCC should identify the priorities and outcomes for each project. The probable estimates of cost provided are not meant to be precise because without a completed design, precise quantities of excavation or materials are not known. Therefore, the pricing should only be used as guidance to assist the PLCC in determining priorities on which issues to address.

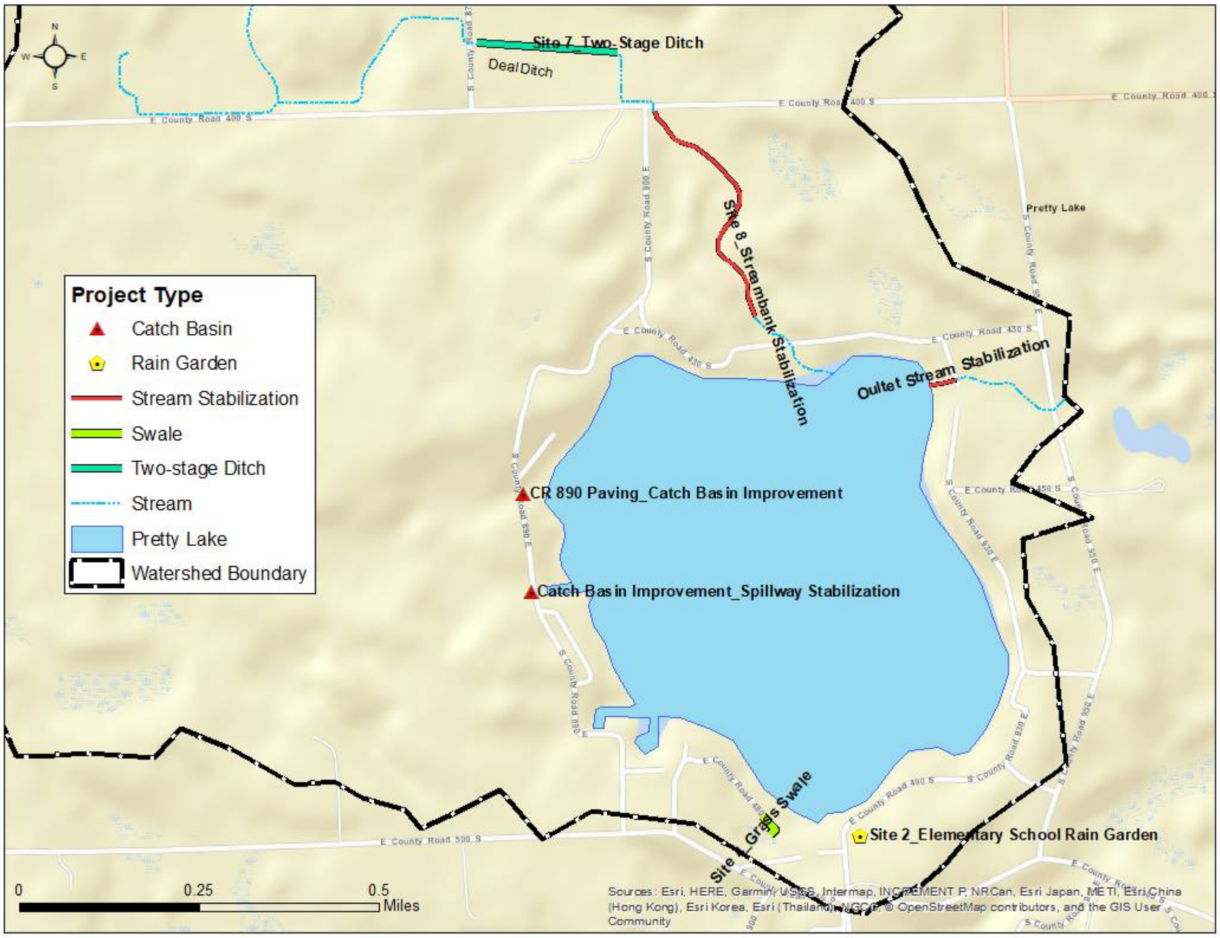

Figure 18. Location map of recommended projects within the Pretty Lake watershed discussed in Section 1.

5.1 Projects not completed from 2007 Diagnostic Study and 2009 Feasibility Study

5.1.1 Site 2 Creation of 1900 Square ft. rain garden adjacent to CR E 490 S at Milford Elementary School (2009 Feasibility Study).

The creation of a rain garden or bio-retention facility on the school property on the southeast corner of S 925 E and E490 S was rated as a high priority project in the 2009 feasibility study to capture runoff from the roof and hard surfaces of the school property (Figure 18). The runoff comes from a pipe that runs over land, across the E 490 S through residential yards and to the lake. Capturing the overland flow in a sand bottom retention basin and forcing the water to infiltrate into the ground would alleviate flooding and pollutants input to the lake. The proposed project is a 1900 square feet rain garden that would absorb up to a 1" rain event within 24 hours. Any additional rainfall would be directed to a positive subsurface drainage system. The total project cost is estimated at 13,320.00 (Table 37). More detailed conceptual design discussions are available in Section 4.2.1 in the 2009 Feasibility Study. Figures 2 and 3 are taken from the 2009 Feasibility Study and show the location of the existing tile outlet and proposed rain garden location.

Table 37. Probable estimates of cost for a rain garden at the Milford Elementary School

ITEM	UNIT COST	UNIT	QUANTITY	TOTAL
Design	$4,000.00	Lump Sum	1	$4,000.00
Permitting	$4,500.00	Lump Sum	0	$0.00
Construction Administration/Observation	$2,000.00	Lump Sum	1	$2,000.00
Services Subtotal	**-**	**-**	**-**	**$6,000.00**
Mobilization/Demobilization	$1,000.00	Each	1	$1,000.00
Excavation	$20	Cubic Yard	105	$2,100.00
Mulch	$50.00	Cubic Yard	22	$1,100.00
Planting	$2.00	Each	1200	$2,400.00
Erosion control	$3.00	Square Yard	240	$720.00
Construction Subtotal				**$7,320.00**
Project Total	**-**	**-**	**-**	**$13,320.00**

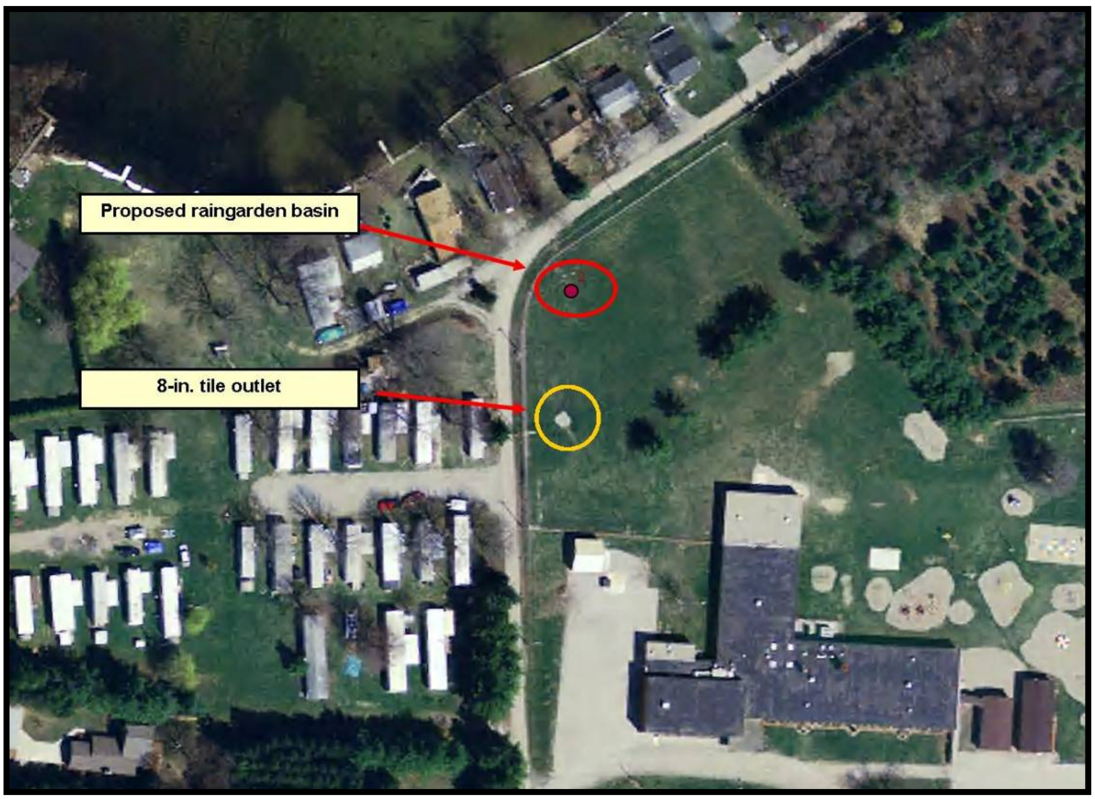

Figure 19. Plan view of proposed raingarden site located at the Milford Elementary School (Site 2). Figure taken from the 2009 Feasibility Study report.

Figure 20. Potential raingarden basin site at the Milford Elementary School (Site 2). Photo taken from 2009 Feasibility Study report.

5.1.2 Site 4 Construction of a Grassy Swale (2009 Feasibility Study)

The widening and enhancement of 180 feet of existing grassy swale along CR E 480 S on the south end of Pretty Lake was a project described in the 2009 feasibility study that could still be completed (Figure 18). The project involves modifying the existing waterway from a narrow turf grass lined channel to a broader swale and vegetating the swale with native plants to increase nutrient absorption. The total project cost is estimated at $6,518.00 (Table 38). A more detailed discussion of this project is available in Section 4.4 of the 2009 Feasibility Study. Figures 4 and 5 below are taken from the 2009 Feasibility Study report and show a more detailed site layout and previously existing conditions at Site 4.

Table 38. Probable estimates of cost for 180 feet of swale modification at CR E480S.

ITEM	UNIT COST	UNIT	QUANTITY	TOTAL
Design	$1,500.00	Lump Sum	1	$1,500.00
Permitting	$4,500.00	Lump Sum	0	$0.00
Construction Administration/Observation	$1,500.00	Lump Sum	1	$1,500.00
Services Subtotal	**-**	**-**	**-**	**$3000.00**
Mobilization/Demobilization	$1,000.00	Each	1	$1,000.00
Excavation	$20.00	Cubic Yard	26	$520
Seeding	$1.50	Square Yard	444	$666.00
Erosion control	$3.00	Square Yard	444	$1,332.00
Construction Subtotal	**$**			**$3,518.00**
Project Total	**-**	**-**	**-**	**$6,518.00**

Figure 21. Location of Site 4 and areas recommended for the construction of a grassy swale, Note the NWI wetland to the south of the designated project area. Figure taken from the 2009 Feasibility Study report.

Figure 22. Example at Site 4 of the narrow channel dominated by turf grass. Photo taken from the 2009 Feasibility Study report.

5.1.3 Site 7 Two-Stage Ditch on Deal Ditch East of CR S 875 E (2009 Feasibility Study)

Deal Ditch flows into the north end of Pretty Lake and has been documented multiple times as having fecal coliform bacteria significantly exceeding the state bodily contact standards. One of the proposed ideas introduced in the 2009 feasibility study was to construct either a two stage channel or a wetland filter east of CR 875E and north of CR E400S (Figure 18). The two stage channel was proposed as being 65 feet wide constructed on one side or split between both sides of the ditch. The constructed wetland filter was proposed as constructing an alternate channel to the north of the existing ditch and making an approximate 500 feet by 75 feet wide wetland in which the ditch would flow. Both of these techniques would expose more surface area of the water to sunlight. Sunlight would reduce the E. coli bacteria levels in the waterway. The total project cost is estimated at $78,250.00 (Table 39). A more detailed discussion of the potential two-stage ditch or wetland project at Site 7 is discussed in Section 4.7 of the 2009 Feasibility Study. Figure 23 below shows the existing conditions taken during the 2017 May tributary sampling effort at Site 7 as viewed facing east from CR 875 E.

Table 39. Probable estimates of cost for turning Deal Ditch into a two stage channel north of CR E400S or rerouting Deal Ditch through a constructed wetland filter on adjacent ground.

ITEM	UNIT COST	UNIT	QUANTITY	TOTAL
Design	$8,000.00	Lump Sum	1	$8,000.00
Permitting	$4,500.00	Lump Sum	1	$4,500.00
Construction Administration/Observation	$2,000.00	Lump Sum	1	$2,000.00
Services Subtotal	**-**	**-**	**-**	**$14,500.00**
Mobilization/Demobilization	$1,000.00	Each	1	$1,000.00
Excavation	$20.00	Cubic Yard	2,200*	$44,000.00
Seeding	$1.50	Square Yard	4167	$6,250.00
Erosion control	$3.00	Square Yard	4167	12,500.00
Construction Subtotal	**$**			**$63,750.00**
Project Total	**-**	**-**	**-**	**$78,250.00**

*Cubic yards estimate is based on feasibility drawing for 500 feet of two-stage ditch. Wetland filter would be nearly double the cubic yards but the cost per yard is significantly less and therefore the dollar value is the same.

Figure 23. View facing east (downstream) from CR 875 E of Deal Ditch at Site 7 taken during the May 2017 tributary sampling event.

5.1.4 Site 8 Alternative Action of rock-toe application along Deal Ditch between E 400 S and E 430 S

The feasibility study identified Deal Ditch from E 400S to E 430 S as being in an eroding condition with steeper banks in a wooded riparian area (Figure 18). Some significant work within this reach of Deal Ditch was completed by the construction of two-stage ditch along 300 ft. of the downstream section of the stream in 2012 which has stabilized that section. Multiple alternatives were discussed within the feasibility document to address the erosion but the simplest methodology was to armor the toe of slope along each embankment. The 2009 study recommended 500 feet of treatment at an estimated cost of $14,794. Updating the cost and extending the project to 1000 feet is now estimated at $58,400.00 (Table 40). A more detailed discussion of options at Site 8 can be found in Section 4.8 of the 2009 Feasibility Study. Figure 24 below is taken from the 2009 Feasibility Study report and provides an example of an actively eroding streambank within Site 8.

Table 40. Probable estimates of cost for 1000 feet of stream stabilization using a rock toe at CR E400S

ITEM	UNIT COST	UNIT	QUANTITY	TOTAL
Design	$8,000.00	Lump Sum	1	$8,000.00
Permitting	$4,500.00	Lump Sum	1	$4,500.00
Construction Administration/Observation	$2,000.00	Lump Sum	1	$2,000.00
Services Subtotal	**-**	**-**	**-**	**$14,500.00**
Mobilization/Demobilization	$1,000.00	Each	1	$1,000.00
Excavation	$20.00	Cubic Yard	300	$6,000.00
Riprap Rock placement	$60.00	Ton	450	$27,000.00*
Seeding	$1.50	Square Yard	2200	$3,300.00
Erosion control	$3.00	Square Yard	2200	$6,600.00
Construction Subtotal				**$43,900.00**
Project Total	**-**	**-**	**-**	**$58,400.00**

*using 12” diameter glacial stone instead of riprap at the toe may increase this to $40,000.00

Figure 24. Example of erosion occurring on streambank at Site 8. Photo taken from the 2009 Feasibility Study report.

5.1.5 <u>6.2.2 Sewer System Connection/Septic System Replacement (2007 Diagnostic Study)</u>

The bottom paragraph is taken from Section 6.2.2 in the 2007 Diagnostic Study and is included in this study because the management recommendation is still encouraged. The current study documented high *E. coli* levels at the three sites sampled in Deal Ditch in 2017 and also *E. coli* source tracking results indicate humans were the main source for the impairment. As a note, there are only four residences draining to the upper part of the watershed where E coli is first documented (above Tributary sampling Site 1, Figure 18). Perhaps working with the homeowners to have their systems inspected by the health department or a private consulting firm to determine if the systems need updating may be in order. If updates are recommended, assisting those homeowners with the expense of the septic system update is likely less expensive and more appropriate than modifying the ditch downstream to address the problem.

The Lagrange County Regional Sewer District operates a sewer system that treats wastewater from all residences adjacent to Pretty Lake's shoreline. However, there are a number of residences immediately adjacent to Deal Ditch and other drainages that are not currently connected to the sewer system. *E. coli* concentrations present in samples collected by the Pretty Lake Conservation Club and during this project indicate that elevated *E. coli* concentrations are present in Deal Ditch and have been for some time. Efforts to identify if the source of this *E. coli* resulted in the identification of human sources as the dominate sources of *E. coli* along Deal Ditch's mainstem upstream of the lake. The exact source of this *E. coli* cannot be identified at this time; however, the Lagrange County Health Department indicated that based on the *E. coli* concentrations and the source tracking samples, they would be willing to talk with landowners who utilize septic systems in areas adjacent to Deal Ditch. They cannot, however, force individuals to upgrade or modify systems or hook on to the Regional Sewer District lines. At this time, the PLCC should continue to work with the Lagrange County Health Department to determine if there are any additional actions that the PLCC can take or if there is any assistance that they may offer to the Health Department.

5.2 Additional Management Recommendations/Considerations

During the water quality monitoring in 2017 additional areas of concern were noted.

5.2.1 <u>Pretty Lake Outlet Stream Bank Stabilization</u>

The stream outlet on the northeast side of the lake has eroding banks for approximately 175 feet (Figure 18). Our recommendation is that these banks should be stabilized by reshaping the outlet to a 100 year discharge capacity, install rock toe protection to a 2-year return discharge elevation and apply native seed and erosion control materials to the remainder of the banks. The total project cost is estimated at $21,700.00 (Table 41). A representative photo of existing conditions at the outlet stream is shown in Figure 25.

Table 41. Probable estimates of cost for stabilization of 175 feet of stream outlet for Pretty Lake.

ITEM	UNIT COST	UNIT	QUANTITY	TOTAL
Design	$6,000.00	Lump Sum	1	$6,000.00
Permitting	$4,500.00	Lump Sum	1	$4,500.00
Construction Administration/Observation	$2,000.00	Lump Sum	1	$2,000.00
Services Subtotal	**-**	**-**	**-**	**$12,500.00**
Mobilization/Demobilization	$1,000.00	Each	1	$1,000.00
Excavation	$20.00	Cubic Yard	80	$1,600.00
Riprap Rock placement	$60.00	Ton	80	$4,800.00*
Seeding	$1.50	Square Yard	400	$600.00
Erosion control	$3.00	Square Yard	400	$1,200.00
Construction Subtotal				**$9,200.00**
Project Total	**-**	**-**	**-**	**$21,700.00**

*using 12” diameter glacial stone instead of riprap at the toe may increase this to $7,200.00

Figure 25. View facing upstream of streambank erosion on outlet stream. Photo taken during December 2017 watershed tour.

5.2.2 Catch Basin Modification, CR 890 Paving, Bioswale

An additional issue brought forth during the 2017 monitoring study was the catch basin on east side of S 890 E, approximately 600 feet north of the public landing on the west side of the lake (Figure 18). The issue is that sediment and debris washes down the chip and seal county road from 400 to 600 feet south and north respectively. The existing catch basin is overwhelmed and fills with sediment. Replacing the chip and seal surface with paving on the 1000 feet of CR 890 E will reduce the gravel being washed into the existing catch basin but will not address winter road salt and sand. Creating a bioswale along the west side of the road and new culvert passing under CR 890 E into the existing catch basin will alleviate the sediment loading to this catch basin. Alternatively, or in addition to the bioswale, a concrete spillway constructed at the bottom of the hill on the east side of the county road directing surface water into the catch basin will eliminate erosion from the road to the catch basin. The total project cost is estimated at $77,950.00 (Table 42). Figures 9 and 10 show existing conditions of the catch basin and roadway area at the site.

Table 42. Probable estimates of cost for addressing sediment issues off CR 890 E 600 feet north of public landing.

ITEM	UNIT COST	UNIT	QUANTITY	TOTAL
Design	$8,000.00	Lump Sum	1	$8,000.00
Permitting	$4,500.00	Lump Sum	0	$0.00
Construction Administration/Observation	$2,000.00	Lump Sum	1	$2,000.00
Services Subtotal	**-**	**-**	**-**	**$12,000.00**
Mobilization/Demobilization	$2,000.00	Each	1	$2,000.00
Paving 1000' of Road	$2.50	Square feet	20,000	$50,000.00
Concrete spillway to catch basin*	$10.00	Square Feet	200	$2,000.00*
Bioswale excavation along roadside	$20.00	Cubic Yard	350	$7,000.00
Planting and erosion control	$4.50	Square Yard	1100	$4,950.00
Construction Subtotal				**$69,950.00**
Project Total	**-**	**-**	**-**	**$77,950.00**

*A new culvert pipe from created bioswale to catch basin is same price as Concrete spillway

Figure 26. Photo of existing catch basin grate located on east-side of CR 890 E, approximately 600 ft. north of the Public Access.

Figure 27. Photo looking south along 890 E at the existing catch basin located on the east-side and potential paving or bioswale area. Existing catch basin is visible on the left margin of the photo.

5.2.3 Catch Basin Modification and Spillway Stabilization near Public Access

A catch basin also exists on the west-side of CR 890E that accepts drainage from the agricultural field and funnels it into a culvert under the road into an open ditch that drains into a lake channel adjacent to the public access (Figure 18). The recommended project to help reduce sediment and nutrient flow to the lake was to replace the standpipe and catch basin on the west side of the road, surround it with new rock and stabilize 60 feet of stream channel on the east side of road. The total project cost is estimated at $11,975.00 (Table 43). Existing conditions photos of the catch basin and spillway areas are available below in Figures 11 and 12.

Table 43. Probable estimates of cost for installing a new catch basin and stabilizing the open ditch adjacent to the public landing.

ITEM	UNIT COST	UNIT	QUANTITY	TOTAL
Design	$4,000.00	Lump Sum	1	$4,000.00
Permitting	$2,000.00	Lump Sum	1	$2,000.00
Construction Administration/Observation	$1,000.00	Lump Sum	1	$1,000.00
Services Subtotal	**-**	**-**	**-**	**$7,000.00**
Mobilization/Demobilization	$1,000.00	Each	1	$1,000.00
New Stand pipe on west side	$1,500.00	Lump Sum	1	$1,500.00
Rock spillway around new standpipe	$60.00	Ton	10	$600.00
60 feet of ditch reshaping	$20.00	Cubic Yard	60	$1,200.00
Seeding and erosion control	$4.50	Square Yard	150	$675.00
Construction Subtotal				**$4975.00**
Project Total	**-**	**-**	**-**	**$11,975.00**

Figure 28. Photo of catch basin located on west-side of CR 890 E, near the public access. Catch basin opening is located within the rocks visible at the bottom margin.

Figure 29. Photo of eroding catch basin spillway on east-side of CR 890 E, near the public access.

5.2.4 Natural Shorelines Initiative (Individual Property Management)

A thorough description of this recommendation is available in Section 6.2.3 of the 2007 Diagnostic Study.

One management measure or initiative that could be a focus of the PLCC around the lake would be the development of a program aimed at increasing the number of natural shorelines, modified natural shorelines and/or shoreline native plant buffer zones around the Pretty Lake. Restoring Pretty Lake's shoreline by planting the area with native vegetation will return the functions the shoreline once provided the lake. In addition to filtering runoff, well-vegetated shorelines are less likely to erode, reducing sediment loading to the lake. A program such as this would seek to convert existing hard armoring shoreline such as seawalls, into more natural materials, modify seawalls by adding a glacial stone toe to the front of seawalls and/or adding native plant buffers at the shoreline. As outlined in the 2007 Diagnostic Study, development around the lake is extensive and 92% of the shoreline had been altered in some form (Figure 30).

Figure 30. Shoreline surface type observed at Pretty Lake, August 2, 2006.

Along much of Pretty Lake's shoreline (64%; 8,735 feet or 2,662 m), trees and emergent vegetation have been thinned; however, these areas possess at least a narrow band of emergent plants. These areas are mapped as modified natural shoreline because they still possess at least a small portion of all these strata (submerged, emergent, and floating). Other portions of the shoreline that are also mapped as modified natural include those areas where individuals removed only the portion of the shoreline vegetation required to view or access the lake. Figure 31 displays the portion of shoreline possessing modified natural characteristics.

Figure 31. Modified natural shoreline present within Pretty Lake taken during 2007 Diagnostic Study. Note that vegetation was removed in areas required to place the dock for access to the lake. The remaining vegetation along the shoreline acts as a natural buffer.

5.2.5 Agricultural Best Management Practices (BMPs)

Agricultural Best management Practices (BMPs) have been updated many times over the last 50 years to reduce nutrients and sediments from agricultural land use. The Natural Resource Conservation Service in cooperation with the Farm Services Administration and the Soil and Water Conservation districts work with individual landowners to design and cost share many of the following BMPs that have been shown to significantly reduce E coli, sediment, nitrogen and phosphorus entering adjacent waterways from the landscape. The PLCC should consider encouraging and assisting property owners with obtaining cost share money and contribute additional funds or labor to implement the following proven practices:
Practice Code 328: Conservation crop rotation
Practice Code 329: Residue and tillage management no till
Practice Code 340: Cover crops
Practice Code 345: Residue and tillage management reduced till
Practice Code 382: Fence
Practice Code 393: Filter strips
Practice Code 390: Herbaceous riparian cover
Practice Code 391: Riparian forest buffers
Practice Code 395: Stream habitat improvement and management
Practice Code 412: Grassed waterways
Practice Code 580: Stream bank and shoreline protection
Practice Code 582: Open channels (two stage ditches included)
Practice Code 587: Structure for water control
Practice Code 590: Nutrient management
Practice Code 638: Water and sediment control basin (WASCOB)
Practice Code 644: Wetland wildlife habitat
Practice Code 656: Constructed (created) wetland
Practice Code 657: Wetland restoration
Practice Code 659: Wetland enhancement

5.2.6 Aquatic Plant Treatments

The PLCC should continue to work with a professional contractor to treat invasive aquatic plant species such as Eurasian watermilfoil as necessary. Pretty Lake possess a high quality native aquatic plant community so it should be the goal of managing invasive species while also maintaining the integrity of the natural community. This management consideration has been a focus of the PLCC since treatment started in 2013. The treatment of aquatic invasive species should continue to be funded in part by the LARE program if possible.

5.3 Potential Funding Sources

No official timeline has been established for undertaking the recommendations. Multiple recommendations can be pursued concurrently, and individual recommendations can be pursued and should be over several years. It is suggested that the PLCC work with organizations such as the LaGrange County Drainage Board, SWCD, and NRCS and allow those organization to take the lead on those items that are within their jurisdiction and existing organizations missions. The following agencies and funding sources are available to help implement these projects.

Indiana Department of Natural Resources (IDNR)

The goal of the Division of Fish and Wildlife's Lake and River Enhancement (LARE) Section is to protect and enhance aquatic habitat for fish and wildlife, to insure the continued viability of Indiana's publicly accessible lakes and streams for multiple uses, including recreational opportunities. This is accomplished through measures that reduce non-point sediment and nutrient pollution of surface waters to a level that meets or surpasses state water quality standards. Each year the LARE program provides fund to assist with aquatic vegetation management, design projects, feasibility studies, lake diagnostic studies, debris jams, and sediment removal plans.

Indiana Department of Environmental Management (IDEM)

The mission of the Indiana Department of Environmental Management (IDEM) is to implement federal and state regulations to protect human health and the environment while allowing the environmentally sound operations of industrial, agricultural, commercial and governmental activities vital to a prosperous economy. The mission of IDEM’s Office of Water Quality (OWQ), under the oversight of the Assistant Commissioner of OWQ, is to concentrate on fulfilling IDEM’s mission where water quality is concerned. More specifically, OWQ is responsible for protecting public health and the environment by assessing the quality of surface water and groundwater through biological and chemical testing; regulating and monitoring drinking water supplies (including wellhead protection), wastewater treatment facilities and the construction of such facilities; and, protecting wetlands for proper drainage, flood protection and wildlife habitat. OWQ serves the citizens of Indiana through fulfilling responsibilities as set forth in the Clean Water Act.

Natural Resource Conservation Service (NRCS)

NRCS offers voluntary programs to eligible landowners and agricultural producers to provide financial and technical assistance to help manage natural resources in a sustainable manner. Through these programs the agency approves contracts to provide financial assistance to help plan and implement conservation practices that address natural resource concerns or opportunities to help save energy, improve soil, water, plant, air, animal and related resources on agricultural lands and non-industrial private forest land.

The NRCS also provides technical assistance through its voluntary Conservation Technical Assistance Program (CTA). CTA is available to any group or individual interested in conserving our natural resources and sustaining agricultural production. The use of NRCS financial and technical assistance will be essential to the implementation of agricultural BMP's in the watershed.

Hoosier River Watch

Hoosier Riverwatch is a program of the Indiana Department of Environmental Management, Office of Water Quality, Watershed Assessment and Planning Branch. The program began in 1996 to increase public awareness of water quality issues and concerns by training volunteers to monitor stream water quality. This resource should be utilized in the future to monitor potential water quality improvements following conservation efforts.

Indiana Clean Lakes Program

The Indiana Clean Lakes Program was created in 1989 as a program within the Indiana Department of Environmental Management's (IDEM) Office of Water Management. The program is administered through a grant to Indiana University's School of Public and Environmental Affairs (SPEA) in Bloomington. The Indiana Clean Lakes Program is a comprehensive, statewide public lake management program having five components including public information, technical assistance, volunteer lake monitoring, lake water quality assessment, and coordination with other state and federal lake programs.

Five Star and Urban Waters Restoration Grant Program

The Five Star and Urban Waters Restoration Program seeks to develop nation-wide-community stewardship of local natural resources, preserving these resources for future generations and enhancing habitat for local wildlife. Projects should address water quality issues in priority watersheds, such as erosion due to unstable streambanks, pollution from stormwater runoff, and degraded shorelines caused by development. The program focuses on the stewardship and restoration of coastal, wetland and riparian ecosystems across the country. Its goal is to meet the conservation needs of important species and habitats, providing measurable and meaningful conservation and educational outcomes. The program requires the establishment and/or enhancement of diverse partnerships and an education/outreach component that will help shape and sustain behavior to achieve conservation goals. More information can be found at the following link: http://www.nfwf.org/fivestar/Pages/home.aspx.

5.4 Future Water Quality Monitoring Plan

Implementing an annual water quality monitoring plan to track the conditions within Deal Ditch and Pretty Lake are recommended to assist with the overall watershed management of Pretty Lake. Annual sampling is beneficial because it allows water quality trends to be tracked overtime and from one season to the next. When investigating water quality trends over time it is beneficial to have as much data as feasible because it allows for the detection of seasonal variability which can be a result of abnormal weather patterns and to develop averages developed from multiple sampling events.

The water quality monitoring strategy below was developed with multiple factors considered which included overall cost, feasibility of collecting samples, and benefit for tracking water quality trends. The sampling plan developed was structured so that the data collected could be compared to historical data collected within the watershed and the amount of data collected would be sufficient for tracking water quality trends. The sampling plan outlined below can be modified as needed by the PLCC depending on management goals and budgets. It is important to note the cost estimates provided are for general planning purposes and should be confirmed by a formal proposal from a third party sampling firm prior finalizing a monitoring plan.

A water quality monitoring plan should include both tributary (Deal Ditch) and in-lake sampling efforts. Each sampling type is outlined below.

Tributary Sampling

The sites recommended to be sampled annually include those sites sampled during the 2017 study which include three sites along Deal Ditch. The three tributary sites are shown on Figure 6 in Section 3 and include Site 1 located at the crossing of County Road 875 E, Site 2 immediately downstream of the County Road 400 S crossing and Site 3 immediately upstream from County Road 430 S crossing. The frequency of sampling locations along the length of Deal Ditch is desirable because it would allow water quality to be tracked along the length of the stream.

Depending on the monitoring budget set by the PLCC it is recommended that tributary sampling take place during the spring, summer and early fall of each year. Recommended months for sampling are May, August and October with one base flow and one storm flow event collected during each sampling month. Water samples can be collected by a grab water sample and the parameters recommended for laboratory analysis include the following:

- Total phosphorus TP (PO4-P mg/L)
- Soluble reactive phosphorus SRP (PO4-P mg/L)
- Nitrate (NO3-N)
- *E. coli* (MPN/100ML)
- Total suspended solids (TSS mg/L)
- Ammonia (NH3-N mg/L)

Stream discharge could also be collected during each sampling event and would only need to be collected at Site 3 (the downstream most site) because this represents the overall discharge of Deal Ditch. Stream discharge is a beneficial parameter because it would allow the flow conditions/stream level/storm flow level to be compared between sampling events. Water quality parameters can change depending on stream flow conditions (base flow vs storm flow) so this would be a helpful parameter to be able to reference when interpreting the sampling results. A general cost estimate for tributary sampling if conducted by a third party group is provided in Table 44.

Table 44. Tributary water quality monitoring plan cost estimate by third party.

ITEM	Rate/Cost	UNIT	QUANTITY	TOTAL
Personnel Labor/Expenses (includes two people)	$150/hour + mileage ($75)	5 Hours per event	6 Sampling Events (storm and base flow event in each of the three months)	Labor $4500 Mileage $450
Laboratory Fees	$450	Per sampling event	6 Sampling Events (storm and base flow event in each of the three months	$2,700
Reporting/ Sampling Updates (one person). This is simple letter report with table of results.	$100	2 Hours per month of sampling	3 months of sampling	$600
			Total	**$8,250**

In-lake Sampling

In-lake sampling should occur on an annual basis and be completed at the same location sampled in 2017 which is shown on Figure 7 and located at the following coordinates latitude 41.575412 longitude -85.252038. It is recommended that sampling consist of a monthly secchi disk reading taken from April-November and a more comprehensive sampling effort which includes chemical analysis and a temperature/oxygen profile be completed during May, July and September. The May, July and September sampling efforts would collect the following parameters, with samples collected at both the epilimnion (approximately 1-2 feet below the water surface) and hypolimnion (approximately 1-2 feet above the lake bed). A secchi disk reading should also be taken during the May, July and September sampling events.

- Total phosphorus TP (PO4-P mg/L)
- Soluble reactive phosphorus SRP (PO4-P mg/L)
- Ammonia (NH3-N mg/L)

Included with the May, July and September sampling a temperature and dissolved oxygen profile should be completed at the sampling site. Temperature and dissolved oxygen readings should be collected at 1 meter intervals within the water column from the surface to bottom.

It is recommended that a PLCC representative complete the monthly secchi disk readings while an outside third party complete the more comprehensive sampling. A general cost estimate for a third party to complete three in-lake sampling events as describes above is provided in Table 45.

Table 45. In-lake water quality monitoring plan cost estimate.

ITEM	Rate/Cost	UNIT	QUANTITY	TOTAL
Personnel Labor/Expenses (includes two people)	$150/hour + mileage ($75)	4 Hours per event	3 Sampling Events	Labor $1,800 Mileage $225
Laboratory Fees	$150	Per sampling event	3 Sampling Events	$450
Reporting/ Sampling Updates (one person). This is simple letter report with table of results.	$100	2 Hours per month of sampling	3 months of sampling	$600
			Total	**$3,075**

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Section 6: Literature Cited

6 Literature Cited

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7 Glossary of Terms

Chlorophyll *a*. The plant pigments in algae consist of the chlorophylls (green color) and carotenoids (yellow color). Chlorophyll *a* is by far the most dominant chlorophyll pigment and occurs in great abundance. Thus, chlorophyll *a* is often used as a direct estimate of algal biomass. In general, chlorophyll *a* concentrations below 2 µg/L are considered low, while those exceeding 10 µg/L are considered high and indicative of poor water quality.

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.

Dissolved Oxygen (DO). DO is the dissolved gaseous form of oxygen. It is essential for respiration of fish and other aquatic organisms. Fish need at least 3 to 5 mg/L of DO. Coldwater fish such as trout generally require higher concentrations of DO than warmwater fish such as bass or bluegill. The Indiana Administrative Code (IAC) sets minimum DO concentrations at 4 mg/L, but all waters must have a daily average of 5 mg/L. 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. Conversely, dissolved oxygen is consumed by respiration of aquatic organisms, such as fish, and during bacterial decomposition of plant and animal matter.

***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 colonies/100 mL (MPN/100mL) in any one sample within a 30-day period or a geometric mean of 125 colonies per 100 mL for five samples collected in any 30-day period.

Light Transmission. Similar to the Secchi disk transparency, this measurement uses a light meter (photocell) to determine the <u>rate</u> at which light transmission is diminished in the upper portion of the lake's water column. Another important light transmission measurement is determination of the 1% light level. The 1% light level is the water depth to which one percent of the surface light penetrates. This is considered the lower limit of algal growth in lakes. The volume of water above the 1% light level is referred to as the ***photic zone***.

Nutrients. Scientists measure nutrients to predict the amount of algae growth and/or rooted plant (macrophyte) growth that is possible in a lake or stream. Algae and rooted plants are a natural and necessary part of aquatic ecosystems. Both will always occur in a healthy lake or stream. Complete elimination of algae and/or rooted plants is neither desirable nor even possible and should, therefore, never be the goal in managing a lake or stream. Algae and rooted plant growth can, however, reach nuisance levels and interfere with the aesthetic and recreational uses of a lake or stream. Scientists commonly measure nutrient concentrations in aquatic ecosystem evaluations to determine the potential for such nuisance growth.

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. This is an additional reason for examining nutrient levels in an aquatic ecosystem.

Phosphorus and nitrogen have several forms in water. The two common phosphorus forms are **soluble reactive phosphorus (SRP)** and **total phosphorus (TP)**. SRP is the dissolved form of phosphorus. It is the form that is "usable" by algae. Algae cannot directly digest and use particulate phosphorus. Total phosphorus is a measure of both dissolved and particulate forms of phosphorus. The most commonly measured nitrogen forms are **nitrate-nitrogen (NO_3)**, **ammonia-nitrogen (NH_3)**, and **total Kjeldahl nitrogen (TKN)**. Nitrate is a dissolved form of nitrogen that is commonly found in the upper layers of a lake or anywhere that oxygen is readily available. In contrast, ammonium-nitrogen is generally found where oxygen is lacking. ***Anoxia***, or a lack of oxygen, is common in the lower layers of a lake. Ammonium is a byproduct of decomposition generated by bacteria as they decompose organic material. Like SRP, ammonia is a dissolved form of nitrogen and the one utilized by algae for growth. The TKN measurement parallels the TP measurement to some extent. TKN is a measure of the **total organic nitrogen** (particulate) and ammonium-nitrogen in the water sample.

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 establishes a range of 6 to 9 pH units for the protection of aquatic life. pH concentrations in excess of 9 are considered acceptable when the concentration occurs as daily fluctuations associated with photosynthetic activity.

Plankton. Plankton are important members of the aquatic food web. Plankton include the algae (microscopic plants) and the zooplankton (tiny shrimp-like animals that eat algae). Plankton are collected by towing a net with a very fine mesh (63-micron openings = 63/1000 millimeter) up through the lake's water column from the one percent light level to the surface. Of the many different planktonic species present in the water, the blue-green algae are of particular interest. Blue-green algae are those that most often form nuisance blooms and their dominance in lakes may indicate poor water conditions.

Secchi Disk Transparency. This refers to the depth to which the black and white Secchi disk can be seen in the lake water. Water clarity, as determined by a Secchi disk, is affected by two primary factors: algae and suspended particulate matter. Particulates (for example, soil or dead leaves) may be introduced into the water by either runoff from the land or from sediments already on the bottom of the lake. Many processes may introduce sediments from runoff; examples include erosion from construction sites, agricultural land, and riverbanks. Bottom sediments may be resuspended by bottom feeding fish such as carp, or in shallow lakes, by motorboats or strong winds. In general, lakes possessing Secchi disk transparency depths greater than 15 feet (4.5 m) have outstanding clarity.

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 (USEPA, 1976). The Indiana Administrative Code (327 IAC 2-1-6) sets maximum temperature limits to protect aquatic life for Indiana streams according to the time of year. For example, temperatures during the summer months should not exceed 90 °F (32.2 °C).

Total Suspended Solids (TSS). A TSS measurement quantifies all particles suspended and dissolved in water. Closely related to turbidity, this parameter quantifies sediment particles and other solid compounds typically found in water. In general, the concentration of suspended solids is greater in streams during high flow events due to increased overland flow. The increased overland flow erodes and carries more soil and other particulates to the stream. The sediment in water originates from many sources, but a large portion of sediment entering streams comes from active construction sites or other disturbed areas such as unvegetated stream banks and poorly managed farm fields.

Suspended solids impact streams and lakes in a variety of ways. When suspended in the water column, solids can clog the gills of fish and invertebrates. As the sediment settles to the creek or lake 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.

Turbidity. Turbidity (measured in Nephelometric Turbidity Units) is a measure of particles suspended in the water itself. It is generally related to suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter, plankton, and other microscopic organisms. According to the Hoosier Riverwatch, the average turbidity of an Indiana stream is 11 NTU with a typical range of 4.5 to 17.5 NTU (Crighton and Hosier, 2004). Turbidity measurements >20 NTU have been found to cause undesirable changes in aquatic life (Walker, 1978). As part of their effort to make numeric nutrient criteria recommendations, the USEPA set 9.9 NTUs as a target for turbidity in stream ecosystems (USEPA, 2000b).

Pretty Lake Post-Construction Monitoring Report

APPENDIX A

TRIBUTARY SAMPLING DATASHEETS AND LABORATORY REPORTS

WATER QUALITY SAMPLING FIELD LOG SHEET

SITE NUMBER AND LOCATION: Site 1

DATE: 5/25/17 PROJECT NAME: ______

TIME: 1015

FIELD CREW: ______

WEATHER CONDITIONS: ______

OTHER OBSERVATIONS: ______

EQUIPMENT CALIBRATION (Date): ______

FIELD PARAMETERS	REPLICATE (if taken)	
pH: 6.04	pH: ____	RPD = ____
Temperature: 57.4	Temperature: ____	RPD = ____
Dissolved Oxygen: 5.49	Dissolved Oxygen: ____	RPD = ____
DO % Saturation: 56.1	DO % Saturation: ____	RPD = ____
Conductivity: 400	Conductivity: ____	RPD = ____
Calculated Flow: ____		

Relative Percent Difference (RPD)= $\frac{(sample_1 - sample_2)}{((sample_1 + sample_2)/2)}$

LAB PARAMETERS

E. Coli: ____

Ammonia: ____

Nitrate+Nitrite: ____

Kjeldahl Nitrogen: ____

Total Phosphorus: ____

Soluble Reactive Phosphorus: ____

Total Suspended Solids: ____

Turbidity: ____

Biological Oxygen Demand: ____

TSS May Pretty Lake

Site	Result
1	7
2	4
3	10
4	3

Field Cre[w] ____

Discharge Measurement

Site: 1
Project #:
Crew Members:
Physical Site Description:
GPS Coordinates:

Date: 5/25/17 Time:
Project Name:
Equipment:

If the stream is <2" deep:
Stream Width: ____ feet
Stream Depths: ____, ____, ____, ____, ____, ____, ____, ____, ____, ____ feet
U: ____, ____, ____, ____, ____, ____, ____, ____, ____, ____ ft/s
U_{max}: ____ ft/s

If the stream is >2" deep:
Stream Width (W): 8.5 feet
Interval Width (IW) (If W<15', then IW=W/5. If W>15, then IW=W*0.1): ____ feet

Segment	SI_0		SI_1		½ IW		$U_{0.4}$		$U_{0.8}$		$U_{0.2}$	
	Location	Depth (ft)	Location	Depth (ft)	Location	Depth (ft)	Set Depth	Rate (ft/s)	Set Depth	Rate (ft/s)	Set Depth	Rate (ft/s)
1	0	0	1.7	.9	0.85	.4		0				
2	1.7	.9	3.4	1.1	2.55	1.0		0.05				
3	3.4	1.1	5.1	1.2	4.25	1.2		0.15				
4	5.1	1.2	6.8	1.0	5.95	1.3		0.57				
5	6.8	1.0	8.5	0.2	7.65	.8		0.15				
6				.3								
7												
8												
9												
10												
11												
12												
13												
14												
15												

Field Crew Leader Signature: ____________________

WATER QUALITY SAMPLING FIELD LOG SHEET

SITE NUMBER AND LOCATION: 2

DATE: 5-25-17 PROJECT NAME: ____

TIME: 10:45

FIELD CREW: ____

WEATHER CONDITIONS: ____

OTHER OBSERVATIONS: ____

EQUIPMENT CALIBRATION (Date): ____

FIELD PARAMETERS	REPLICATE (if taken)	
pH: 6.53	pH: ____	RPD = ____
Temperature: 57.7	Temperature: ____	RPD = ____
Dissolved Oxygen: 5.55	Dissolved Oxygen: ____	RPD = ____
DO % Saturation: 54.7	DO % Saturation: ____	RPD = ____
Conductivity: 410	Conductivity: ____	RPD = ____
Calculated Flow: ____		

Relative Percent Difference (RPD)= $\frac{(sample_1 - sample_2)}{((sample_1 + sample_2)/2)}$

LAB PARAMETERS

E. Coli: ____

Ammonia: ____

Nitrate+Nitrite: ____

Kjeldahl Nitrogen: ____

Total Phosphorus: ____

Soluble Reactive Phosphorus: ____

Total Suspended Solids: ____

Turbidity: ____

Biological Oxygen Demand: ____

Field Crew Leader Signature: ____

Discharge Measurement

Site: 2 Date: 5/25/17 Time: ______
Project #: ______ Project Name: ______
Crew Members: ______ Equipment: ______
Physical Site Description: ______
GPS Coordinates: ______

If the stream is <2" deep:
Stream Width: _____ feet
Stream Depths: _____, _____, _____, _____, _____, _____, _____, _____, _____, _____ feet
U: _____, _____, _____, _____, _____, _____, _____, _____, _____, _____ ft/s
U_{max}: _____ ft/s

If the stream is >2" deep:
Stream Width (W): 8.0 feet
Interval Width (IW) (If W<15', then IW=W/5. If W>15, then IW=W*0.1): _____ feet

Segment	SI_0 Location	SI_0 Depth (ft)	SI_1 Location	SI_1 Depth (ft)	½ IW Location	½ IW Depth (ft)	$U_{0.4}$ Set Depth	$U_{0.4}$ Rate (ft/s)	$U_{0.8}$ Set Depth	$U_{0.8}$ Rate (ft/s)	$U_{0.2}$ Set Depth	$U_{0.2}$ Rate (ft/s)
1	0	.1	1.6	.4	.8	.3		0				
2	1.6	.4	3.2	.6	2.4	.5		0.3				
3	3.2	.6	4.8	.7	4.0	.8		1.87				
4	4.8	4.8	6.4	.6	5.6	.7		1.42				
5	6.4	.6	8.0	.2	7.2	.3		.11				
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												

Field Crew Leader Signature: ______

WATER QUALITY SAMPLING FIELD LOG SHEET

SITE NUMBER AND LOCATION: 3

DATE: 5/25/17 PROJECT NAME: ______

TIME: 11:15

FIELD CREW: ______

WEATHER CONDITIONS: ______

OTHER OBSERVATIONS: ______

EQUIPMENT CALIBRATION (Date): ______

FIELD PARAMETERS	REPLICATE (if taken)	
pH: 6.81	pH: ______	RPD = ______
Temperature: 57.5	Temperature: ______	RPD = ______
Dissolved Oxygen: 6.88	Dissolved Oxygen: ______	RPD = ______
DO % Saturation: 70.3	DO % Saturation: ______	RPD = ______
Conductivity: 416	Conductivity: ______	RPD = ______
Calculated Flow: ______		

Relative Percent Difference (RPD)= $\frac{(sample_1 - sample_2)}{((sample_1 + sample_2)/2)}$

LAB PARAMETERS

E. Coli: ____

Ammonia: ____

Nitrate+Nitrite: ____

Kjeldahl Nitrogen: ____

Total Phosphorus: ____

Soluble Reactive Phosphorus: ____

Total Suspended Solids: ____

Turbidity: ____

Biological Oxygen Demand: ____

Field Crew Leader Signature: ______

Discharge Measurement

Site: 3 | Date: 5/25/17 Time: 11:15
Project #: | Project Name:
Crew Members: | Equipment:
Physical Site Description:
GPS Coordinates:

If the stream is <2" deep:
Stream Width: ____ feet
Stream Depths: ____, ____, ____, ____, ____, ____, ____, ____, ____, ____ feet
U: ____, ____, ____, ____, ____, ____, ____, ____, ____, ____ ft/s
U_{max}: ____ ft/s

If the stream is >2" deep:
Stream Width (W): 7.0 feet
Interval Width (IW) (If W<15', then IW=W/5. If W>15, then IW=W*0.1): ____ feet

Segment	SI_0 Location	SI_0 Depth (ft)	SI_1 Location	SI_1 Depth (ft)	½ IW Location	½ IW Depth (ft)	$U_{0.4}$ Set Depth	$U_{0.4}$ Rate (ft/s)	$U_{0.8}$ Set Depth	$U_{0.8}$ Rate (ft/s)	$U_{0.2}$ Set Depth	$U_{0.2}$ Rate (ft/s)
1	0	0.1	1.4	.9	0.7	.4		.6				
2	1.4	.9	2.8	1.0	2.1	1.0		1.85				
3	2.8	1.0	4.2	.7	3.5	.9		1.2				
4	4.2	.7	5.6	.5	4.9	.5		.15				
5	5.6	.5	7.0	.2	6.3	.4		0				
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												

Field Crew Leader Signature: ____________

WATER QUALITY SAMPLING FIELD LOG SHEET

SITE NUMBER AND LOCATION: 4

DATE: 5/25/17 PROJECT NAME: ____

TIME: 11:45

FIELD CREW: ____

WEATHER CONDITIONS: ____

OTHER OBSERVATIONS: ____

EQUIPMENT CALIBRATION (Date): ____

FIELD PARAMETERS	REPLICATE (if taken)	
pH: 7.76	pH: ____	RPD = ____
Temperature: 64.1	Temperature: ____	RPD = ____
Dissolved Oxygen: 9.70	Dissolved Oxygen: ____	RPD = ____
DO % Saturation: 107	DO % Saturation: ____	RPD = ____
Conductivity: 335	Conductivity: ____	RPD = ____
Calculated Flow: ____		

Relative Percent Difference (RPD)= $\frac{(sample_1 - sample_2)}{((sample_1 + sample_2)/2)}$

LAB PARAMETERS

E. Coli: ____

Ammonia: ____

Nitrate+Nitrite: ____

Kjeldahl Nitrogen: ____

Total Phosphorus: ____

Soluble Reactive Phosphorus: ____

Total Suspended Solids: ____

Turbidity: ____

Biological Oxygen Demand: ____

Field Crew Leader Signature: ____

Discharge Measurement

Site: 4

Project #:

Crew Members:

Physical Site Description:

GPS Coordinates:

Date: 5-25-17 Time: 11:45

Project Name:

Equipment:

If the stream is <2" deep:

Stream Width:_____feet

Stream Depths: _____, _____, _____, _____, _____, _____, _____, _____, _____, _____feet

U: _____, _____, _____, _____, _____, _____, _____, _____, _____, _____ft/s

U_{max}:_____ft/s

If the stream is >2" deep:

Stream Width (W): 9.0 feet

Interval Width (IW) (If W<15', then IW=W/5. If W>15, then IW=W*0.1):_____feet

Segment	SI_0 Location	SI_0 Depth (ft)	SI_1 Location	SI_1 Depth (ft)	½ IW Location	½ IW Depth (ft)	$U_{0.4}$ Set Depth	$U_{0.4}$ Rate (ft/s)	$U_{0.8}$ Set Depth	$U_{0.8}$ Rate (ft/s)	$U_{0.2}$ Set Depth	$U_{0.2}$ Rate (ft/s)
1	0	.1	1.8	1.0	.9	.6		.12				
2	1.8	1.0	3.6	1.6	2.7	1.5		.32				
3	3.6	1.6	5.4	1.9	4.5	1.9		.52				
4	5.4	1.9	7.2	1.1	6.3	1.8		.48				
5	7.2	1.1	9.0	.2	8.1	.8		.1				
6												
7												
8												
9												
10												
11												
12												
13												
14												
15												

Field Crew Leader Signature: ____________

Environmental Labs, Inc.
635 Green Rd. P.O. Box 968
Madison, IN 47250
812 273 6699
Certified Lab # ~~M-39-01~~ **M-50-01**

Fecal Coliform / E. Coli

Order Number: 2017050635

Sample ID#: EX0517 007

Please use ink when completing this form:

Client Fills in:

Mail report to: Cardno #3289
Contact Name: Tom Estrem
Company:
Mailing Address: 708 Roosevelt Rd
City, State, Zip: Walkerton IN 46574
Phone: 574-229-8764
Email: tom.estrem@cardno.com

Sample Type (Check One)

____ Effluent (Waste Water)
____ Drinking Water
X Surface Water or Ditch Water
____ Other (Describe):

Sample Location: Site 1 A

Sample Collection Date: 5/25/17

Sample Collection Time: 1015

Sample Collected by: TLE

FAX results? ($2 / page) Yes (No)

FAX number:

Sample released by: TLE

Date and Time released: 5/25/17 1445

Sample received at lab by: DMN

Date and Time received at lab: 5/25/17 15:15

Sample Temperature upon receipt: °C

Comments:

Samples received on Friday will be charged a WEEKEND fee.

Lab Fills in:

____ Fecal Coliform Analysis **(6 hour Hold Time)**
Method Used: SM-9222D

Time in: ____ Date: ____ Init. ____

Time out: ____ Date: ____ Init. ____

Results: ____ cfu/ 100 mL

X E.Coli Analysis **(6 hour Hold Time)**
Method Used: SM-9223B

Time in: 15:30 Date: 5/25/17 Init. DMN

Time out: 15:30 Date: 5/26/17 Init. DMN

Results: >2419.6 MPN/ 100 mL

____ Satisfactory: At examination time, this sample is bacteriologically **safe** based on USEPA standards.

X Unsatisfactory: At examination time, this sample is bacteriologically **unsafe** based on USEPA standards. and is unsuitable for drinking, cooking, bathing or swimming.

Status of sample:
Please submit another sample. Test not valid due to: (please check)

____ Too long in transit
____ No collection date and/or time
____ Sample leaked or was broken in shipment
____ Insufficient volume
____ Residual Chlorine present
____ Sample Temp was above EPA Guidelines (> 10°C) upon receipt at lab
Notified by: ____ Date: ____

IMPORTANT SAMPLING INFORMATION

Each sample has a 6-HOUR HOLDING TIME. To avoid sample rejection due to holding time requirements, samples should be delivered to ELI Lab within 6 hours of sample collection.

Environmental Labs, Inc.
635 Green Rd. P.O. Box 968
Madison, IN 47250
812 273 6699
Certified Lab #: ~~M-39-01~~ **M-50-01**
Please use ink when completing this form:

Fecal Coliform / E. Coli

Order Number: **2017050635**

Sample ID#: EX0517 008

Client Fills in:

Mail report to:
Contact Name: Tom Estrem
Company: Cardno #3289
Mailing Address: 708 Roosevelt Rd.
City, State, Zip: Walkerton, IN 46574
Phone: 574-229-8764
Email: tom.estrem@cardno.com

Sample Type (Check One)

____ Effluent (Waste Water)
____ Drinking Water
X Surface Water or Ditch Water
____ Other (Describe):

Sample Location: Site 2A

Sample Collection Date: 5/25/17

Sample Collection Time: 1045

Sample Collected by: TLE

FAX results? ($2 / page) Yes (No)

FAX number:

Sample released by: TLE

Date and Time released: 5/25/17 1445

Sample received at lab by: DMN

Date and Time received at lab: 5/25/17 @ 15:15
Sample Temperature upon receipt: °C

Comments:

Samples received on Friday will be charged a WEEKEND fee.

Lab Fills in:

____ Fecal Coliform Analysis **(6 hour Hold Time)**
Method Used: SM-9222D

Time in: ____ Date: ____ Init. ____

Time out: ____ Date: ____ Init. ____

Results: ____ cfu/ 100 mL

X E.Coli Analysis **(6 hour Hold Time)**
Method Used: SM-9223B

Time in: 15:30 Date: 5/25/17 Init. DMN

Time out: 15:30 Date: 5/26/17 Init. DMN

Results: >2419.6 MPN/ 100 mL

____ Satisfactory: At examination time, this sample is bacteriologically **safe** based on USEPA standards.

X Unsatisfactory: At examination time, this sample is bacteriologically **unsafe** based on USEPA standards. and is unsuitable for drinking, cooking, bathing or swimming.

Status of sample:
Please submit another sample. Test not valid due to: (please check)

____ Too long in transit

____ No collection date and/or time

____ Sample leaked or was broken in shipment

____ Insufficient volume

____ Residual Chlorine present

____ Sample Temp was above EPA Guidelines (> 10°C) upon receipt at lab
Notified by: ____ Date: ____

IMPORTANT SAMPLING INFORMATION

Each sample has a 6-HOUR HOLDING TIME. To avoid sample rejection due to holding time requirements, samples should be delivered to ELI Lab within 6 hours of sample collection.

Environmental Labs, Inc.
635 Green Rd. P.O. Box 968
Madison, IN 47250
812 273 6699
Certified Lab #: ~~M-39-01~~ **M-50-01**
Please use ink when completing this form:

Fecal Coliform / E. Coli

Order Number: **2017050635**

Sample ID#: EX0517 009

Client Fills in:

Mail report to:
Contact Name: Cardno #3289
Company: Tom Estrem
Mailing Address: 708 Roosevelt Rd
City, State, Zip: Walkerton IN 46574
Phone: 574-229-8764
Email: tom.estrem@cardno.com

Sample Type (Check One)

____ Effluent (Waste Water)
____ Drinking Water
X Surface Water or Ditch Water
____ Other (Describe):

Sample Location: Site 3 A

Sample Collection Date: 5/25/17

Sample Collection Time: 1115

Sample Collected by: TLE

FAX results? ($2 / page) Yes (No)

FAX number:

Sample released by: TLE

Date and Time released: 5/25/17 1445

Sample received at lab by: DMN

Date and Time received at lab: 5/25/17 15:15
Sample Temperature upon receipt: °C

Comments:

Samples received on Friday will be charged a WEEKEND fee.

Lab Fills in:

____ Fecal Coliform Analysis **(6 hour Hold Time)**
Method Used: SM-9222D

Time in: ____ Date: ____ Init. ____

Time out: ____ Date: ____ Init. ____

Results: ____ cfu/ 100 mL

X E.Coli Analysis **(6 hour Hold Time)**
Method Used: SM-9223B

Time in: 15:30 Date: 5/25/17 Init. DMN

Time out: 15:30 Date: 5/26/17 Init. DMN

Results: 72419.6 MPN/ 100 mL

____ Satisfactory: At examination time, this sample is bacteriologically **safe** based on USEPA standards.

X Unsatisfactory: At examination time, this sample is bacteriologically **unsafe** based on USEPA standards. and is unsuitable for drinking, cooking, bathing or swimming.

Status of sample:
Please submit another sample. Test not valid due to: (please check)

____ Too long in transit

____ No collection date and/or time

____ Sample leaked or was broken in shipment

____ Insufficient volume

____ Residual Chlorine present

____ Sample Temp was above EPA Guidelines (> 10°C) upon receipt at lab
Notified by: ____ Date: ____

*****IMPORTANT SAMPLING INFORMATION*****

Each sample has a 6-HOUR HOLDING TIME. To avoid sample rejection due to holding time requirements, samples should be delivered to ELI Lab within 6 hours of sample collection.

Environmental Labs, Inc.
635 Green Rd. P.O. Box 968
Madison, IN 47250
812 273 6699
Certified Lab #: ~~M-39-01~~ M-50-01

Fecal Coliform / E. Coli

Order Number: 2017050635

Sample ID#: EX0517 010

Please use ink when completing this form:

Client Fills in:

Mail report to:
Contact Name: Tom Estrem
Company: Cardno #3289
Mailing Address: 708 Roosevelt Rd.
City, State, Zip: Walkerton, IN 46574
Phone: 574-229-8764
Email: tom.estrem@cardno.com

Sample Type (Check One)

____ Effluent (Waste Water)
____ Drinking Water
X Surface Water or Ditch Water
____ Other (Describe):

Sample Location: Site 4A

Sample Collection Date: 5/25/17

Sample Collection Time: 1145

Sample Collected by: TLE

FAX results? ($2 / page) Yes (No)

FAX number:

Sample released by: TLE

Date and Time released: 5/25/17 1445

Sample received at lab by: DMN

Date and Time received at lab: 5/25/17 15:15

Sample Temperature upon receipt: °C

Comments:

Samples received on Friday will be charged a WEEKEND fee.

Lab Fills in:

____ Fecal Coliform Analysis **(6 hour Hold Time)**
Method Used: SM-9222D

Time in: ____ Date: ____ Init. ____

Time out: ____ Date: ____ Init. ____

Results: ____ cfu/ 100 mL

X E.Coli Analysis **(6 hour Hold Time)**
Method Used: SM-9223B

Time in: 15:30 Date: 5/25/17 Init. DMN

Time out: 15:30 Date: 5/26/17 Init. DMN

Results: 31.8 MPN/ 100 mL

X Satisfactory: At examination time, this sample is bacteriologically **safe** based on USEPA standards.

____ Unsatisfactory: At examination time, this sample is bacteriologically **unsafe** based on USEPA standards. and is unsuitable for drinking, cooking, bathing or swimming.

Status of sample:
Please submit another sample. Test not valid due to: (please check)

____ Too long in transit
____ No collection date and/or time
____ Sample leaked or was broken in shipment
____ Insufficient volume
____ Residual Chlorine present
____ Sample Temp was above EPA Guidelines (> 10°C) upon receipt at lab
Notified by: ____ Date: ____

IMPORTANT SAMPLING INFORMATION

Each sample has a 6-HOUR HOLDING TIME. To avoid sample rejection due to holding time requirements, samples should be delivered to ELI Lab within 6 hours of sample collection.

Scientific Methods

Laboratory Report

Client: Cardno
Tom Estrem
708 Roosevelt Road
Walkerton, IN 46574

Report No. 20176

Sampling location: Yellow River
Sample collection date: May 25, 2017

Serotyping

SMI Lab#	Site#	# of Isolates	DNA phage	I	I/II	II	III	IV	%Human	%Animal
20176	1A	1	0	0	0	1	0	0	94	6
20177	2A	10	0	0	0	6	1	0	95	5
20178	3A	4	0	0	0	4	1	0	95	5
20179	4A	0	0	0	0	0	0	0	NA	NA

Note: Sample 20177 had 10 isolates but only 7 isolates produced results. Sample 20179 produced no isolates for testing.

SMI appreciates the opportunity to provide you with this analysis. Please feel free to contact us (574-277-4078) if you have any questions regarding this report.

Reviewed by: [signature] Date: June 13, 2017

Finalized by: [signature] Date: June 13, 2017

Laboratory Analysis

Instantly access all of your Data 24/7/365 by going to www.envirolabsinc.com and clicking on Client Data Support.

Environmental Laboratories, Inc.

635 Green Road, PO Box 968, Madison, IN 47250
Tel: 812.273.6699 Fax: 812.273.5788

Report To:

Tom Estrem
Cardno

708 Roosevelt Road

Walkerton, IN 46574

Order No.: 2017052242

PO No.:

Date Received: 05/26/2017

Report Date: 05/24/2018

Project Name: LARE MONITORING MAY

Order Number	Lab Id	Matrix	Location		Date Collected	Time Collected	Collected By	Description	Status
2017052242	P0517-566	Surface Water	SITE 1		5/24/2017	09:20	TE		Paid
	Test Name		Results	Units	Analyst		Detection Limit	Test Method	Analysis Date
	Solids, Suspended Total		3.00	mg/L	BG		1.0	SM-2540D	5/30/2017
	Comments:								

Order Number	Lab Id	Matrix	Location		Date Collected	Time Collected	Collected By	Description	Status
2017052242	P0517-567	Surface Water	SITE 2		5/24/2017	09:45	TE		Paid
	Test Name		Results	Units	Analyst		Detection Limit	Test Method	Analysis Date
	Solids, Suspended Total		3.00	mg/L	BG		1.0	SM-2540D	5/30/2017
	Comments:								

Order Number	Lab Id	Matrix	Location		Date Collected	Time Collected	Collected By	Description	Status
2017052242	P0517-568	Surface Water	SITE 3		5/24/2017	10:15	TE		Paid
	Test Name		Results	Units	Analyst		Detection Limit	Test Method	Analysis Date
	Solids, Suspended Total		21.0	mg/L	BG		1.0	SM-2540D	5/30/2017
	Comments:								

Order Number	Lab Id	Matrix	Location		Date Collected	Time Collected	Collected By	Description	Status
2017052242	P0517-569	Surface Water	SITE 4		5/24/2017	10:40	TE		Paid
	Test Name		Results	Units	Analyst		Detection Limit	Test Method	Analysis Date
	Solids, Suspended Total		3.00	mg/L	BG		1.0	SM-2540D	5/30/2017
	Comments:								

Order Number	Lab Id	Matrix	Location		Date Collected	Time Collected	Collected By	Description	Status
2017052242	P0517-570	Surface Water	SITE 1A		5/25/2017	10:15	TE		Paid
	Test Name		Results	Units	Analyst		Detection Limit	Test Method	Analysis Date
	Solids, Suspended Total		7.00	mg/L	BG		1.0	SM-2540D	5/30/2017
	Comments:								

Yellow Highlighted text is not Pretty Lake sites. Sits Identified as 1A, 2A, 3A and 4A correspond to Pretty Lake tributary sampling sites 1, 2, 3, 4.

Laboratory Analysis

Instantly access all of your Data 24/7/365 by going to www.envirolabsinc.com and clicking on Client Data Support.

Environmental Laboratories, Inc.

635 Green Road, PO Box 968, Madison, IN 47250
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Report To:

Tom Estrem
Cardno
708 Roosevelt Road
Walkerton, IN 46574

Order No.:	2017052242
PO No.:	
Date Received:	05/26/2017
Report Date:	05/24/2018
Project Name:	LARE MONITORING MAY

Order Number	Lab Id	Matrix	Location		Date Collected	Time Collected	Collected By	Description	Status
2017052242	P0517-571	Surface Water	SITE 2A		5/25/2017	10:45	TE		Paid
	Test Name		Results	Units	Analyst		Detection Limit	Test Method	Analysis Date
	Solids, Suspended Total		4.00	mg/L	BG		1.0	SM-2540D	5/30/2017
	Comments:								
Order Number	Lab Id	Matrix	Location		Date Collected	Time Collected	Collected By	Description	Status
2017052242	P0517-572	Surface Water	SITE 3A		5/25/2017	11:15	TE		Paid
	Test Name		Results	Units	Analyst		Detection Limit	Test Method	Analysis Date
	Solids, Suspended Total		10.0	mg/L	BG		1.0	SM-2540D	5/30/2017
	Comments:								
Order Number	Lab Id	Matrix	Location		Date Collected	Time Collected	Collected By	Description	Status
2017052242	P0517-573	Surface Water	SITE 4A		5/25/2017	11:45	TE		Paid
	Test Name		Results	Units	Analyst		Detection Limit	Test Method	Analysis Date
	Solids, Suspended Total		3.00	mg/L	BG		1.0	SM-2540D	5/30/2017
	Comments:								

Yellow Highlighted text is not Pretty Lake sites. Sits Identified as 1A, 2A, 3A and 4A correspond to Pretty Lake tributary sampling sites 1, 2, 3, 4.

Approved by:

Diana Dupraw, Ph.D., QC Officer

Whitney Wu, Ph.D., Lab Manager

Pretty Lake Post-Construction Monitoring Report

APPENDIX B

QHEI DATASHEETS

IDEM — OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Sample #	bioSample #	Stream Name	Location
		Deal Ditch	Site 1

Surveyor	Sample Date	County	Macro SampleType	Habitat Complete	QHEI Score:
TMM/BCL	11/13/17			☐	24

1-Substrate (20 points maximum)

Substrate Score: 0

Check 1 Predominant Pool & 1 Predominant Riffle

Check all that are present — P=Pool, R=Riffle

Predominant P	Predominant R	Substrate	Present P	Present R	Predominant P	Predominant R	Substrate	Present P	Present R
☐	☐	Bldrs/Slabs(10)	☐	☐	☐	☐	Hardpan(4)	☐	☑
☐	☐	Boulders(9)	☐	☐	☐	☐	Detritus(3)	☑	☑
☐	☐	Cobble(8)	☐	☐	☑	☑	Muck(2)	☐	☐
☐	☐	Gravel(7)	☐	☐	☐	☐	Silt(2)	☐	☐
☐	☐	Sand(6)	☐	☐	☐	☐	Sludge(1)	☐	☐
☐	☐	Bedrock(5)	☐	☐	☐	☐	Artificial(0)	☐	☐

NOTE: ignore sludge originating from point sources; score based on natural substrates

☐ >4 substrates present(2)

Comments:

Substrate Quality (check only 1, or check 2 and AVERAGE)

Substrate Origin
- ☐ Limestone(1)
- ☐ Tills(1)
- ☑ Wetlands(0)
- ☐ Hardpan(0)
- ☐ Sandstone(0)
- ☐ Rip/Rap(0)
- ☐ Lacustrine(0)
- ☐ Shale(-1)
- ☐ Coal fines(-2)

Silt Cover
- ☑ Silt heavy(-2)
- ☐ Silt moderate(-1)
- ☐ Silt normal(0)
- ☐ Silt free(1)

Embeddedness
- ☑ Extensive(-2)
- ☐ Moderate(-1)
- ☐ Low/Normal(0)
- ☐ None(1)

2-Instream Cover (20 points maximum

Instream Cover Score: 7

Type (check ALL that apply)
- ☐ Undercut banks(1)
- ☑ Overhanging vegetation(1)
- ☑ Shallows(in slow water)(1)
- ☑ Rootmats(1)
- ☐ Deep pools(2)
- ☐ Rootwads(1)
- ☐ Boulders(1)
- ☐ Oxbows(1)
- ☐ Aquatic macrophytes(1)
- ☑ Logs and woody debris(1)

Comments:

Amount (check only 1, or 2 and AVERAGE)
- ☐ Extensive >75% (11)
- ☐ Moderate 25-75% (7)
- ☑ Sparse 5-25% (3)
- ☐ Nearly absent <5% (1)

3-Channel Morphology (20) (check only one per category, OR two and AVERAGE)

Channel Score: 5

Sinuosity
- ☐ High (4)
- ☐ Moderate (3)
- ☑ Low (2)
- ☐ None (1)

Development
- ☐ Excellent (7)
- ☐ Good (5)
- ☐ Fair (3)
- ☑ Poor (1)

Channelization
- ☐ None (6)
- ☐ Recovered (4)
- ☐ Recovering (3)
- ☑ Recent or no recovery (1)

Stability
- ☐ High (3)
- ☐ Moderate (2)
- ☑ Low (1)

Modifications/Other
- ☐ Snagging
- ☐ Relocation
- ☑ Canopy Removal
- ☑ Dredging
- ☐ One side channel modifications
- ☐ Impound
- ☐ Islands
- ☐ Leveed
- ☐ Bank shaping

Comments:

4-Riparian Zone & Bank Erosion (10 points maximum)

Riparian Score: 5

Left/Right banks looking downstream (For each category, check only one per bank, OR two per bank and AVERAGE).

Riparian width — L R (per bank)
- ☐ ☐ Wide >50m (4)
- ☐ ☐ Moderate 10-50m (3)
- ☐ ☐ Narrow 5-10m (2)
- ☑ ☑ Very narrow <5m (1)
- ☐ ☐ None (0)

Erosion/Runoff-Floodplain quality (past 100 ft Riparian) — L R (most predominant per bank)
- ☐ ☐ Forest, Swamp (3)
- ☐ ☐ Shrub or Old field (2)
- ☐ ☐ Residential, Park, New field (1)
- ☑ ☑ Fenced pasture (1)
- ☐ ☐ Conservation Tillage (1)
- ☐ ☐ Urban or Industrial (0)
- ☐ ☐ Mining, Construction (0)
- ☐ ☐ Open Pasture/Rowcrop (0)

Bank Erosion — L R (per bank)
- ☑ ☑ None or little (3)
- ☐ ☐ Moderate (2)
- ☐ ☐ Heavy/Severe (1)

Comments:

5a-Pool/Glide Quality (12 points maximum

Pool/Glide Score:

Max pool depth (check one)
- ☐ >1m (6)
- ☐ 0.7-1m (4)
- ☐ 0.4-0.7m (2)
- ☐ 0.2-0.4m (1)
- ☑ <0.2m (pool=0)

Morphology (check only one, OR check two and AVERAGE)
- ☐ Pool width > riffle width (2)
- ☑ Pool width = riffle width (1)
- ☐ Pool width < riffle width (0)

Pool/Run/Riffle current velocity (check all that apply)
- ☐ Eddies (1)
- ☐ Fast (1)
- ☐ Moderate (1)
- ☐ Slow (1)
- ☐ Torrential (-1)
- ☐ Interstitial (-1)
- ☐ Intermittent (-2)
- ☑ No pool (0)

Comments:

5b-Riffle/Run Quality (8) (check only one per category, OR two and AVERAGE)

Riffle/Run Score: 0

Riffle/run depth (check one)
- ☐ Generally>10cm, Max>50cm (4)
- ☐ Generally>10cm, Max<50cm(3)
- ☐ Generally 5-10cm (1)
- ☑ Generally<5cm (riffle=0)

Riffle/run substrate
- ☐ Stable-e.g. cobble, boulder (2)
- ☐ Mod. stable-e.g. pea gravel (1)
- ☑ Unstable-e.g. sand, gravel (0)

Riffle/run embeddedness
- ☑ Extensive (-1)
- ☐ Moderate (0)
- ☐ Normal/Low (1)
- ☐ None (2)
- ☐ No riffle (0)

Comments:

6-Gradient (10 points maximum)

Gradient Score: 6

Average width: ____ Gradient: ____ (ft/mile) Drainage Area: ____ (square miles)

Comments:

IDEM OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Sample #	bioSample #	Stream Name	Location

Surveyor	Sample Date	County	Macro SampleType	Habitat Complete	QHEI Score:
				☐	

Impacts/Miscellaneous

Major Suspected Impacts (Check all that apply)

- ☐ None
- ☐ Industrial
- ☐ WWTP
- ☑ Agricultural
- ☑ Livestock
- ☐ Silviculture
- ☐ Construction
- ☐ Urban Runoff
- ☐ Suburban
- ☑ Channelization
- ☑ Riparian Removal
- ☐ Flow Alteration
- ☐ CSOs
- ☐ Mining
- ☐ Landfills
- ☐ Natural

Pollution Impact Comments:

trash/barrels in stream

Miscellaneous QHEI Information

Subjective rating (1-10): 2
Aesthetic rating (1-10): 2
Canopy Cover (% Open): 50

% Riffle: 25
% Run: 25
% Glide: 0
% Pool: 0

Is reach representative of stream? Yes

General QHEI Notes:

IDEM OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Sample # | bioSample # | Stream Name: Deal Ditch | Location: Site 2

Surveyor: TMM/BCL | Sample Date: 1/13/17 | County | Macro SampleType | Habitat Complete | **QHEI Score:** 40

1-Substrate (20 points maximum)

Substrate Score: 12

Check 1 Predominant Pool & 1 Predominant Riffle
Check all that are present
P=Pool, R=Riffle

Predominant P R		Present P R	Predominant P R		Present P R
☐ ☐	Bldrs/Slabs(10)	☐ ☐	☐ ☐	Hardpan(4)	☐ ☐
☐ ☐	Boulders(9)	☐ ☐	☐ ☐	Detritus(3)	☑ ☑
☐ ☐	Cobble(8)	☐ ☐	☐ ☐	Muck(2)	☑ ☑
☐ ☐	Gravel(7)	☐ ☐	☐ ☐	Silt(2)	☑ ☑
☑ ☑	Sand(6)	☐ ☐	☐ ☐	Sludge(1)	☐ ☐
☐ ☐	Bedrock(5)	☐ ☐	☐ ☐	Artificial(0)	☐ ☐

NOTE: ignore sludge originating from point sources; score based on natural substrates

☐ >4 substrates present(2)

Comments:

Substrate Quality (check only 1, or check 2 and AVERAGE)

Substrate Origin

- ☐ Limestone(1)
- ☑ Tills(1)
- ☐ Wetlands(0)
- ☐ Hardpan(0)
- ☐ Sandstone(0)
- ☐ Rip/Rap(0)
- ☐ Lacustrine(0)
- ☐ Shale(-1)
- ☐ Coal fines(-2)

Silt Cover

- ☐ Silt heavy(-2)
- ☐ Silt moderate(-1)
- ☑ Silt normal(0)
- ☐ Silt free(1)

Embeddedness

- ☐ Extensive(-2)
- ☑ Moderate(-1)
- ☐ Low/Normal(0)
- ☐ None(1)

2-Instream Cover (20 points maximum

Instream Cover Score: 7

Type (check ALL that apply)

- ☑ Undercut banks(1)
- ☑ Overhanging vegetation(1)
- ☑ Shallows(in slow water)(1)
- ☐ Rootmats(1)
- ☐ Deep pools(2)
- ☐ Rootwads(1)
- ☐ Boulders(1)
- ☐ Oxbows(1)
- ☐ Aquatic macrophytes(1)
- ☑ Logs and woody debris(1)

Comments:

Amount (check only 1, or 2 and AVERAGE)

- ☐ Extensive >75% (11)
- ☐ Moderate 25-75% (7)
- ☑ Sparse 5-25% (3)
- ☐ Nearly absent <5% (1)

3-Channel Morphology (20) (check only one per category, OR two and AVERAGE)

Channel Score: 7

Sinuosity

- ☐ High (4)
- ☐ Moderate (3)
- ☑ Low (2)
- ☐ None (1)

Development

- ☐ Excellent (7)
- ☐ Good (5)
- ☐ Fair (3)
- ☑ Poor (1)

Channelization

- ☐ None (6)
- ☐ Recovered (4)
- ☑ Recovering (3)
- ☐ Recent or no recovery (1)

Stability

- ☐ High (3)
- ☐ Moderate (2)
- ☑ Low (1)

Modifications/Other

- ☑ Snagging
- ☐ Relocation
- ☑ Canopy Removal
- ☐ Dredging
- ☐ One side channel modifications
- ☐ Impound
- ☐ Islands
- ☐ Leveed
- ☐ Bank shaping

Comments:

4-Riparian Zone & Bank Erosion (10 points maximum)

Riparian Score: 6

Left/Right banks looking downstream (For each category, check only one per bank, OR two per bank and AVERAGE).

Riparian width (per bank)

L	R	
☐	☐	Wide >50m (4)
☐	☐	Moderate 10-50m (3)
☐	☑	Narrow 5-10m (2)
☑	☑	Very narrow <5m (1)
☐	☐	None (0)

Erosion/Runoff-Floodplain quality (past 100 ft Riparian) (most predominant per bank)

L	R		L	R	
☐	☐	Forest, Swamp (3)	☐	☐	Conservation Tillage (1)
☐	☑	Shrub or Old field (2)	☐	☐	Urban or Industrial (0)
☑	☑	Residential, Park, New field (1)	☐	☐	Mining, Construction (0)
☐	☐	Fenced pasture (1)	☐	☐	Open Pasture/Rowcrop (0)

Bank Erosion (per bank)

L	R	
☐	☑	None or little (3)
☑	☐	Moderate (2)
☐	☐	Heavy/Severe (1)

Comments:

5a-Pool/Glide Quality (12 points maximum

Pool/Glide Score: 1

Max pool depth (check one)

- ☐ >1m (6)
- ☐ 0.7-1m (4)
- ☐ 0.4-0.7m (2)
- ☐ 0.2-0.4m (1)
- ☑ <0.2m (pool=0)

Morphology (check only one, OR check two and AVERAGE)

- ☐ Pool width > riffle width (2)
- ☐ Pool width = riffle width (1)
- ☑ Pool width < riffle width (0)

Pool/Run/Riffle current velocity (check all that apply)

- ☐ Eddies (1)
- ☐ Fast (1)
- ☐ Moderate (1)
- ☑ Slow (1)
- ☐ Torrential (-1)
- ☐ Interstitial (-1)
- ☐ Intermittent (-2)
- ☐ No pool (0)

Comments:

5b-Riffle/Run Quality (8) (check only one per category, OR two and AVERAGE)

Riffle/Run Score: 1

Riffle/run depth (check one)

- ☐ Generally>10cm, Max>50cm (4)
- ☐ Generally>10cm, Max<50cm(3)
- ☑ Generally 5-10cm (1)
- ☐ Generally<5cm (riffle=0)

Riffle/run substrate

- ☐ Stable-e.g. cobble, boulder (2)
- ☐ Mod. stable-e.g. pea gravel (1)
- ☑ Unstable-e.g. sand, gravel (0)

Comments:

Riffle/run embeddedness

- ☐ Extensive (-1)
- ☑ Moderate (0)
- ☐ Normal/Low (1)
- ☐ None (2)
- ☐ No riffle (0)

6-Gradient (10 points maximum)

Gradient Score: 6

Average width: | *Gradient:* (ft/mile) | *Drainage Area:* (square miles)

Comments:

IDEM **OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)**

Sample #	*bioSample #*	*Stream Name*	*Location*

Surveyor	*Sample Date*	*County*	*Macro SampleType*	☐ Habitat Complete	QHEI Score:

Impacts/Miscellaneous

Major Suspected Impacts (Check all that apply)

- ☐ None
- ☐ Industrial
- ☐ WWTP
- ☑ Agricultural
- ☐ Livestock
- ☐ Silviculture
- ☐ Construction
- ☐ Urban Runoff
- ☑ Suburban
- ☑ Channelization
- ☑ Riparian Removal
- ☐ Flow Alteration
- ☐ CSOs
- ☐ Mining
- ☐ Landfills
- ☐ Natural

Pollution Impact Comments:

Miscellaneous QHEI Information

Subjective rating (1-10):	3	% Riffle:	40
Aesthetic rating (1-10):	3	% Run:	40
		% Glide:	
Canopy Cover (% Open):	5	% Pool:	

Is reach representative of stream?

General QHEI Notes:

IDEM OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Sample #	bioSample #	Stream Name	Location
		Deal Ditch	Site 3

Surveyor	Sample Date	County	Macro SampleType	Habitat Complete	QHEI Score:
TMM/BCC	11/13/17			☐	44

1-Substrate (20 points maximum)

Substrate Score: 14

Check 1 Predominant Pool & 1 Predominant Riffle
Check all that are present — P=Pool, R=Riffle

Predominant P R		Present P R	Predominant P R		Present P R
☐ ☐	Bldrs/Slabs(10)	☐ ☐	☐ ☐	Hardpan(4)	☐ ☐
☐ ☐	Boulders(9)	☐ ☐	☐ ☐	Detritus(3)	☐ ☐
☐ ☐	Cobble(8)	☐ ☐	☐ ☐	Muck(2)	☐ ☐
☐ ☑	Gravel(7)	☑ ☐	☐ ☐	Silt(2)	☑ ☑
☑ ☐	Sand(6)	☐ ☑	☐ ☐	Sludge(1)	☐ ☐
☐ ☐	Bedrock(5)	☐ ☐	☐ ☐	Artificial(0)	☑ ☑

NOTE: ignore sludge originating from point sources; score based on natural substrates

☐ >4 substrates present(2)

Comments:

Substrate Quality (check only 1, or check 2 and AVERAGE)

Substrate Origin
- ☐ Limestone(1)
- ☑ Tills(1)
- ☐ Wetlands(0)
- ☐ Hardpan(0)
- ☐ Sandstone(0)
- ☐ Rip/Rap(0)
- ☐ Lacustrine(0)
- ☐ Shale(-1)
- ☐ Coal fines(-2)

Silt Cover
- ☐ Silt heavy(-2)
- ☐ Silt moderate(-1)
- ☑ Silt normal(0)
- ☐ Silt free(1)

Embeddedness
- ☐ Extensive(-2)
- ☐ Moderate(-1)
- ☑ Low/Normal(0)
- ☐ None(1)

2-Instream Cover (20 points maximum

Instream Cover Score: 6

Type (check ALL that apply)
- ☐ Undercut banks(1)
- ☑ Overhanging vegetation(1)
- ☑ Shallows(in slow water)(1)
- ☐ Rootmats(1)
- ☐ Deep pools(2)
- ☐ Rootwads(1)
- ☐ Boulders(1)
- ☐ Oxbows(1)
- ☐ Aquatic macrophytes(1)
- ☑ Logs and woody debris(1)

Comments:

Amount (check only 1, or 2 and AVERAGE)
- ☐ Extensive >75% (11)
- ☐ Moderate 25-75% (7)
- ☑ Sparse 5-25% (3)
- ☐ Nearly absent <5% (1)

3-Channel Morphology (20) (check only one per category, OR two and AVERAGE)

Channel Score: 8

Sinuosity
- ☐ High (4)
- ☐ Moderate (3)
- ☑ Low (2)
- ☐ None (1)

Development
- ☐ Excellent (7)
- ☐ Good (5)
- ☑ Fair (3)
- ☑ Poor (1)

Channelization
- ☐ None (6)
- ☐ Recovered (4)
- ☑ Recovering (3)
- ☐ Recent or no recovery (1)

Stability
- ☐ High (3)
- ☑ Moderate (2)
- ☐ Low (1)

Modifications/Other
- ☐ Snagging
- ☐ Relocation
- ☑ Canopy Removal
- ☑ Dredging
- ☑ One side channel modifications
- ☐ Impound
- ☐ Islands
- ☐ Leveed
- ☑ Bank shaping

Comments:

4-Riparian Zone & Bank Erosion (10 points maximum)

Riparian Score: 6

Left/Right banks looking downstream (For each category, check only one per bank, OR two per bank and AVERAGE).

Riparian width — L R (per bank)
- ☐ ☐ Wide >50m (4)
- ☐ ☐ Moderate 10-50m (3)
- ☐ ☐ Narrow 5-10m (2)
- ☑ ☐ Very narrow <5m (1)
- ☐ ☑ None (0)

Erosion/Runoff-Floodplain quality (past 100 ft Riparian) — L R (most predominant per bank)
- ☐ ☐ Forest, Swamp (3)
- ☐ ☐ Shrub or Old field (2)
- ☑ ☑ Residential, Park, New field (1)
- ☐ ☐ Fenced pasture (1)
- ☐ ☐ Conservation Tillage (1)
- ☐ ☐ Urban or Industrial (0)
- ☐ ☐ Mining, Construction (0)
- ☐ ☐ Open Pasture/Rowcrop (0)

Bank Erosion — L R (per bank)
- ☑ ☐ None or little (3)
- ☐ ☑ Moderate (2)
- ☐ ☐ Heavy/Severe (1)

Comments:

5a-Pool/Glide Quality (12 points maximum)

Pool/Glide Score: 4

Max pool depth (check one)
- ☐ >1m (6)
- ☐ 0.7-1m (4)
- ☐ 0.4-0.7m (2)
- ☑ 0.2-0.4m (1)
- ☐ <0.2m (pool=0)

Morphology (check only one, OR check two and AVERAGE)
- ☑ Pool width > riffle width (2)
- ☐ Pool width = riffle width (1)
- ☐ Pool width < riffle width (0)

Pool/Run/Riffle current velocity (check all that apply)
- ☐ Eddies (1)
- ☐ Fast (1)
- ☐ Moderate (1)
- ☑ Slow (1)
- ☐ Torrential (-1)
- ☐ Interstitial (-1)
- ☐ Intermittent (-2)
- ☐ No pool (0)

Comments:

5b-Riffle/Run Quality (8) (check only one per category, OR two and AVERAGE)

Riffle/Run Score: 0

Riffle/run depth (check one)
- ☐ Generally>10cm, Max>50cm (4)
- ☐ Generally>10cm, Max<50cm(3)
- ☐ Generally 5-10cm (1)
- ☑ Generally<5cm (riffle=0)

Riffle/run substrate
- ☐ Stable-e.g. cobble, boulder (2)
- ☐ Mod. stable-e.g. pea gravel (1)
- ☑ Unstable-e.g. sand, gravel (0)

Comments:

Riffle/run embeddedness
- ☐ Extensive (-1)
- ☑ Moderate (0)
- ☑ Normal/Low (1)
- ☐ None (2)
- ☐ No riffle (0)

6-Gradient (10 points maximum)

Gradient Score: 6

Average width: ______ Gradient: ______ (ft/mile) Drainage Area: ______ (square miles)

Comments:

IDEM **OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)**

Sample #	bioSample #	Stream Name	Location

Surveyor	Sample Date	County	Macro SampleType	☐ Habitat Complete	QHEI Score:

Impacts/Miscellaneous

Major Suspected Impacts (Check all that apply)

- ☐ None
- ☐ Industrial
- ☐ WWTP
- ☐ Agricultural
- ☐ Livestock
- ☐ Silviculture
- ☐ Construction
- ☐ Urban Runoff
- ☑ Suburban
- ☐ Channelization
- ☑ Riparian Removal
- ☑ Flow Alteration
- ☐ CSOs
- ☐ Mining
- ☐ Landfills
- ☑ Natural

Pollution Impact Comments:

Miscellaneous QHEI Information

Subjective rating (1-10): 3
Aesthetic rating (1-10): 3
Canopy Cover (% Open): 85

% Riffle: 40
% Run: 40
% Glide: 0
% Pool: 20

Is reach representative of stream?

General QHEI Notes:

IDEM OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Sample # | bioSample # | Stream Name: Lake Outlet Stream | Location: Site 4

Surveyor: TMM/BCL | Sample Date: 11/13/17 | County | Macro Sample Type | Habitat Complete | **QHEI Score:** 34

1-Substrate (20 points maximum)

Substrate Score: 11

Check 1 Predominant Pool & 1 Predominant Riffle
Check all that are present — P=Pool, R=Riffle

Predominant P R	Present P R		Predominant P R	Present P R	
☐ ☐	☐ ☐	Bldrs/Slabs(10)	☐ ☐	☐ ☐	Hardpan(4)
☐ ☐	☐ ☐	Boulders(9)	☑ ☑	☑ ☑	Detritus(3)
☐ ☐	☐ ☐	Cobble(8)	☐ ☐	☑ ☑	Muck(2)
☐ ☐	☐ ☐	Gravel(7)	☑ ☑	☑ ☑	Silt(2)
☑ ☑	☐ ☐	Sand(6)	☐ ☐	☐ ☐	Sludge(1)
☐ ☐	☐ ☐	Bedrock(5)	☐ ☐	☐ ☐	Artificial(0)

NOTE: Ignore sludge originating from point sources; score based on natural substrates

☐ >4 substrates present(2)

Comments:

Substrate Quality (check only 1, or check 2 and AVERAGE)

Substrate Origin
- ☐ Limestone(1) ☐ Hardpan(0) ☑ Lacustrine(0)
- ☐ Tills(1) ☐ Sandstone(0) ☐ Shale(-1)
- ☑ Wetlands(0) ☐ Rip/Rap(0) ☐ Coal fines(-2)

Silt Cover
- ☐ Silt heavy(-2)
- ☑ Silt moderate(-1)
- ☐ Silt normal(0)
- ☐ Silt free(1)

Embeddedness
- ☐ Extensive(-2)
- ☑ Moderate(-1)
- ☐ Low/Normal(0)
- ☐ None(1)

2-Instream Cover (20 points maximum

Instream Cover Score: 3

Type (check ALL that apply)
- ☐ Undercut banks(1)
- ☐ Overhanging vegetation(1)
- ☑ Shallows(in slow water)(1)
- ☐ Rootmats(1)
- ☐ Deep pools(2)
- ☐ Rootwads(1)
- ☐ Boulders(1)
- ☐ Oxbows(1)
- ☐ Aquatic macrophytes(1)
- ☑ Logs and woody debris(1)

Comments:

Amount (check only 1, or 2 and AVERAGE)
- ☐ Extensive >75% (11)
- ☐ Moderate 25-75% (7)
- ☐ Sparse 5-25% (3)
- ☑ Nearly absent <5% (1)

3-Channel Morphology (20) (check only one per category, OR two and AVERAGE)

Channel Score: 6

Sinuosity	Development	Channelization	Stability	Modifications/Other	
☐ High (4)	☐ Excellent (7)	☐ None (6)	☐ High (3)	☐ Snagging	☐ Impound
☐ Moderate (3)	☐ Good (5)	☐ Recovered (4)	☐ Moderate (2)	☐ Relocation	☐ Islands
☐ Low (2)	☐ Fair (3)	☑ Recovering (3)	☑ Low (1)	☑ Canopy Removal	☐ Leveed
☑ None (1)	☑ Poor (1)	☐ Recent or no recovery (1)		☑ Dredging	☑ Bank shaping

Comments: ☐ One side channel modifications

4-Riparian Zone & Bank Erosion (10 points maximum)

Riparian Score: 5

Left/Right banks looking downstream (For each category, check only one per bank, OR two per bank and AVERAGE).

Riparian width (L R, per bank)
- ☐ ☐ Wide >50m (4)
- ☐ ☐ Moderate 10-50m (3)
- ☐ ☐ Narrow 5-10m (2)
- ☐ ☑ Very narrow <5m (1)
- ☑ ☐ None (0)

Erosion/Runoff-Floodplain quality (past 100 ft Riparian) (L R, most predominant per bank)
- ☐ ☐ Forest, Swamp (3)
- ☐ ☐ Shrub or Old field (2)
- ☑ ☑ Residential, Park, New field (1)
- ☐ ☐ Fenced pasture (1)
- ☐ ☐ Conservation Tillage (1)
- ☐ ☐ Urban or Industrial (0)
- ☐ ☐ Mining, Construction (0)
- ☐ ☐ Open Pasture/Rowcrop (0)

Bank Erosion (L R, per bank)
- ☐ ☑ None or little (3)
- ☑ ☐ Moderate (2)
- ☐ ☐ Heavy/Severe (1)

Comments:

5a-Pool/Glide Quality (12 points maximum

Pool/Glide Score: 3

Max pool depth (check one)
- ☐ >1m (6)
- ☐ 0.7-1m (4)
- ☐ 0.4-0.7m (2)
- ☑ 0.2-0.4m (1)
- ☐ <0.2m (pool=0)

Morphology (check only one, OR check two and AVERAGE)
- ☐ Pool width > riffle width (2)
- ☑ Pool width = riffle width (1)
- ☐ Pool width < riffle width (0)

Pool/Run/Riffle current velocity (check all that apply)
- ☐ Eddies (1)
- ☐ Fast (1)
- ☐ Moderate (1)
- ☑ Slow (1)
- ☐ Torrential (-1)
- ☐ Interstitial (-1)
- ☐ Intermittent (-2)
- ☐ No pool (0)

Comments:

5b-Riffle/Run Quality (8) (check only one per category, OR two and AVERAGE)

Riffle/Run Score: 0

Riffle/run depth (check one)
- ☐ Generally>10cm, Max>50cm (4)
- ☐ Generally>10cm, Max<50cm(3)
- ☐ Generally 5-10cm (1)
- ☑ Generally<5cm (riffle=0)

Riffle/run substrate
- ☐ Stable-e.g. cobble, boulder (2)
- ☐ Mod/stable-e.g. pea gravel (1)
- ☑ Unstable-e.g. sand, gravel (0)

Comments:

Riffle/run embeddedness
- ☑ Extensive (-1)
- ☐ Moderate (0)
- ☐ Normal/Low (1)
- ☐ None (2)
- ☐ No riffle (0)

6-Gradient (10 points maximum)

Gradient Score: 6

Average width: | Gradient: (ft/mile) | Drainage Area: (square miles)

Comments:

IDEM OWQ Biological Studies QHEI (Qualitative Habitat Evaluation Index)

Sample #	bioSample #	Stream Name	Location

Surveyor	Sample Date	County	Macro SampleType	Habitat Complete	QHEI Score:
				☐	

Impacts/Miscellaneous

Major Suspected Impacts (Check all that apply)

- ☐ None
- ☐ Industrial
- ☐ WWTP
- ☐ Agricultural
- ☐ Livestock
- ☐ Silviculture
- ☐ Construction
- ☐ Urban Runoff
- ☑ Suburban
- ☐ Channelization
- ☐ Riparian Removal
- ☐ Flow Alteration
- ☐ CSOs
- ☐ Mining
- ☐ Landfills
- ☐ Natural

Pollution Impact Comments:

Miscellaneous QHEI Information

Subjective rating (1-10): 2

Aesthetic rating (1-10): 1

Canopy Cover (% Open): 90

% Riffle:

% Run: 80

% Glide:

% Pool: 20

Is reach representative of stream?

General QHEI Notes:

Pretty Lake Post-Construction Monitoring Report

APPENDIX C

MACROINVERTEBRATE LABORATORY BENCH SHEETS

Macroinvertebrates

(Copy this sheet as new worksheet for multiple sites)

Stream Site	Deal Ditch, Site 1
Analyst	TM
Date Collected	11/13/2017
Date Counted	3/7/2018

Moderately Impaired

mIBI Metric		**Metric Score**
HBI	6.34	0
No. Taxa (family)	10	2
Total Count (# individuals)	84	2
% Dominant Taxa	46.4	2
EPT Index (# families)	1	0
EPT Count (# individuals)	1	0
EPT Count/Total Count	0.01	0
EPT Abun./Chir. Abun.	9999.00	8
Chironomid Count	0	8
mIBI Score		2.4

Taxa (Scientific Name)

Order	Family	#	EPT	# w/t	Tolerance (t)	# x t	%
Acarina	Hydrachnidae			0		0	0.00
Amphipoda	Crangonyctidae	26		26	4	104	30.95
Amphipoda	Gammaridae	4		4	4	16	4.76
Amphipoda	Haustoriidae			0	4	0	0.00
Amphipoda	Talitridae			0	8	0	0.00
Araneae	Pisauridae			0		0	0.00
Bivalvia	*Corbicula fluminea*			0	3.2	0	0.00
Bivalvia	Sphaeriidae			0	8	0	0.00
Coleoptera	Amphizoidae			0		0	0.00
Coleoptera	Chrysomelidae			0		0	0.00
Coleoptera	Curculionidae			0		0	0.00
Coleoptera	Cyrinidae			0		0	0.00
Coleoptera	Dytiscidae			0	5	0	0.00
Coleoptera	Elmidae	1		1	4	4	1.19
Coleoptera	Gyrinidae			0	5	0	0.00
Coleoptera	Haliplidae			0	7	0	0.00
Coleoptera	Helodidae			0		0	0.00
Coleoptera	Hydrophilidae			0	5	0	0.00
Coleoptera	Noteridae			0		0	0.00
Coleoptera	Psephenidae			0	4	0	0.00
Coleoptera	Staphylinidae			0	8	0	0.00
Decopoda	Astacidae			0	8	0	0.00
Decopoda	Palaemonidae			0		0	0.00
Diptera	Brachyera pupae			0		0	0.00
Diptera	Ceratopognidae			0	6	0	0.00
Diptera	Chironomidae			0	6	0	0.00
Diptera	Culicidae			0	8	0	0.00
Diptera	Dolichopodidae			0	4	0	0.00
Diptera	Empididae			0	6	0	0.00
Diptera	Ephydridae			0	6	0	0.00
Diptera	Nematocera pupae			0		0	0.00
Diptera	Ptychopteridae			0	7	0	0.00
Diptera	Simuliidae			0	6	0	0.00
Diptera	Stratiomyidae			0		0	0.00
Diptera	Syrphidae			0	10	0	0.00
Diptera	Tabanidae			0	6	0	0.00
Diptera	Tipulidae			0	3	0	0.00
Ephemeroptera	Baetidae			0	4	0	0.00
Ephemeroptera	Caenidae			0	7	0	0.00
Ephemeroptera	Ephemerellidae			0	1	0	0.00
Ephemeroptera	Heptageniidae			0	4	0	0.00
Ephemeroptera	Neoephemeridae			0	7	0	0.00
Ephemeroptera	Siphlonuridae			0	7	0	0.00
Ephemeroptera	Tricorythidae			0	4	0	0.00
Gastropoda	Ancylidae			0	6	0	0.00
Gastropoda	Lymnaeidae	9		9	6.9	62.1	10.71
Gastropoda	Physidae	1		1	8	8	1.19
Gastropoda	Planorbidae	1		1	7	7	1.19
Gastropoda	Pleuroceridae			0		0	0.00
Gastropoda	Viviparidae			0	6	0	0.00
Hemiptera	Belostomatidae	1		0		0	1.19
Hemiptera	Corixidae			0	10	0	0.00
Hemiptera	Gerridae			0	5	0	0.00
Hemiptera	Herbridae			0		0	0.00
Hemiptera	Hydrometridae			0		0	0.00
Hemiptera	Mesoveliidae			0		0	0.00
Hemiptera	Naucoridae			0		0	0.00
Hemiptera	Nepidae			0		0	0.00
Hemiptera	Notonectidae			0		0	0.00
Hemiptera	Pleidae			0		0	0.00
Hemiptera	Veliidae			0		0	0.00
Hirudinea				0	10	0	0.00
Hirudinea	Glossiphoniidae			0	8	0	0.00
Isopoda	Asillidae	39		39	8	312	46.43
Lepidoptera	Langessa			0		0	0.00
Megaloptera	Nigronia			0		0	0.00
Megaloptera	Sialidae			0	4	0	0.00
Nematomorpha				0		0	0.00
Odonata	Aeshnidae			0	3	0	0.00
Odonata	Agrionidae			0	5	0	0.00
Odonata	Coenagrionidae			0	6.1	0	0.00
Odonata	Corduliidae			0	5	0	0.00
Odonata	Gomphidae			0	1	0	0.00
Odonata	Lestidae			0	9	0	0.00
Odonata	Libellulidae			0	9	0	0.00
Odonata	Petaluridae			0		0	0.00
Oligochaeta				0	5	0	0.00
Platyhelminthes	Planaria			0	1	0	0.00
Plecoptera	Chloroperlidae			0		0	0.00
Plecoptera	Perlidae			0	1	0	0.00
Plecoptera	Perlodidae			0	2	0	0.00
Trichoptera	Beraeidtae			0		0	0.00
Trichoptera	Brachycentridae			0	1	0	0.00
Trichoptera	Helicopsychidae			0	3	0	0.00
Trichoptera	Hydropsychidae			0	4	0	0.00
Trichoptera	Hydroptilidae			0	4	0	0.00
Trichoptera	Limnephilidae			0	4	0	0.00
Trichoptera	Odontoceridae			0	0	0	0.00
Trichoptera	Polycentropodidae			0		0	0.00
Trichoptera	Philopotamidae	1	1	1	3	3	1.19
Trichoptera	glossosomatidae			0		0	0.00
Collembola		1		1	10	10	1.19
TOTALS		**84**	**1**	**83**		**526.1**	100.00

Macroinvertebrates
(Copy this sheet as new worksheet for multiple sites)

Stream Site	Deal Ditch, Site 2
Analyst	TM
Date Collected	11/13/2017
Date Counted	3/7/2018

Severely Impaired

mIBI Metric		Metric Score
HBI	5.51	2
No. Taxa (family)	12	4
Total Count (# individuals)	105	2
% Dominant Taxa	49.5	2
EPT Index (# families)	2	0
EPT Count (# individuals)	9	0
EPT Count/Total Count	0.09	0
EPT Abun./Chir. Abun.	0.17	0
Chironomid Count	52	6
mIBI Score		1.8

Taxa (Scientific Name)

Order	Family	#	EPT	# w/t	Tolerance (t)	# x t	%
Acarina	Hydrachnidae			0		0	0.00
Amphipoda	Crangonyctidae	13		13	4	52	12.38
Amphipoda	Gammaridae			0	4	0	0.00
Amphipoda	Haustoriidae			0	4	0	0.00
Amphipoda	Talitridae			0	8	0	0.00
Araneae	Pisauridae			0		0	0.00
Bivalvia	*Corbicula fluminea*			0	3.2	0	0.00
Bivalvia	Sphaeriidae	1		1	8	8	0.95
Coleoptera	Amphizoidae			0		0	0.00
Coleoptera	Chrysomelidae			0		0	0.00
Coleoptera	Curculionidae			0		0	0.00
Coleoptera	Cyrinidae			0		0	0.00
Coleoptera	Dytiscidae			0	5	0	0.00
Coleoptera	Elmidae	8		8	4	32	7.62
Coleoptera	Gyrinidae			0	5	0	0.00
Coleoptera	Haliplidae			0	7	0	0.00
Coleoptera	Helodidae			0		0	0.00
Coleoptera	Hydrophilidae			0	5	0	0.00
Coleoptera	Noteridae			0		0	0.00
Coleoptera	Psephenidae			0	4	0	0.00
Coleoptera	Staphylinidae			0	8	0	0.00
Decopoda	Astacidae			0	8	0	0.00
Decopoda	Palaemonidae			0		0	0.00
Diptera	Brachyera pupae			0		0	0.00
Diptera	Ceratopognidae			0	6	0	0.00
Diptera	Chironomidae	52		52	6	312	49.52
Diptera	Culicidae	2		2	8	16	1.90
Diptera	Dolichopodidae			0	4	0	0.00
Diptera	Empididae	1		1	6	6	0.95
Diptera	Ephydridae			0	6	0	0.00
Diptera	Nematocera pupae			0		0	0.00
Diptera	Ptychopteridae			0	7	0	0.00
Diptera	Simuliidae			0	6	0	0.00
Diptera	Stratiomyidae			0		0	0.00
Diptera	Syrphidae			0	10	0	0.00
Diptera	Tabanidae	1		1	6	6	0.95
Diptera	Tipulidae	5		5	3	15	4.76
Ephemeroptera	Baetidae			0	4	0	0.00
Ephemeroptera	Caenidae			0	7	0	0.00
Ephemeroptera	Ephemerellidae			0	1	0	0.00
Ephemeroptera	Heptageniidae			0	4	0	0.00
Ephemeroptera	Neoephemeridae			0	7	0	0.00
Ephemeroptera	Siphlonuridae			0	7	0	0.00
Ephemeroptera	Tricorythidae			0	4	0	0.00
Gastropoda	Ancylidae			0	6	0	0.00
Gastropoda	Lymnaeidae	8		8	6.9	55.2	7.62
Gastropoda	Physidae	5		5	8	40	4.76
Gastropoda	Planorbidae			0	7	0	0.00
Gastropoda	Pleuroceridae			0		0	0.00
Gastropoda	Viviparidae			0	6	0	0.00
Hemiptera	Belostomatidae			0		0	0.00
Hemiptera	Corixidae			0	10	0	0.00
Hemiptera	Gerridae			0	5	0	0.00
Hemiptera	Herbridae			0		0	0.00
Hemiptera	Hydrometridae			0		0	0.00
Hemiptera	Mesoveliidae			0		0	0.00
Hemiptera	Naucoridae			0		0	0.00
Hemiptera	Nepidae			0		0	0.00
Hemiptera	Notonectidae			0		0	0.00
Hemiptera	Pleidae			0		0	0.00
Hemiptera	Veliidae			0		0	0.00
Hirudinea				0	10	0	0.00
Hirudinea	Glossiphoniidae			0	8	0	0.00
Isopoda	Asillidae			0	8	0	0.00
Lepidoptera	Langessa			0		0	0.00
Megaloptera	Nigronia			0		0	0.00
Megaloptera	Sialidae			0	4	0	0.00
Nematomorpha				0		0	0.00
Odonata	Aeshnidae			0	3	0	0.00
Odonata	Agrionidae			0	5	0	0.00
Odonata	Coenagrionidae			0	6.1	0	0.00
Odonata	Corduliidae			0	5	0	0.00
Odonata	Gomphidae			0	1	0	0.00
Odonata	Lestidae			0	9	0	0.00
Odonata	Libellulidae			0	9	0	0.00
Odonata	Petaluridae			0		0	0.00
Oligochaeta				0	5	0	0.00
Platyhelminthes	Planaria			0	1	0	0.00
Plecoptera	Chloroperlidae			0		0	0.00
Plecoptera	Perlidae			0	1	0	0.00
Plecoptera	Perlodidae			0	2	0	0.00
Trichoptera	Beraeidtae			0		0	0.00
Trichoptera	Brachycentridae			0	1	0	0.00
Trichoptera	Helicopsychidae			0	3	0	0.00
Trichoptera	Hydropsychidae	2	2	2	4	8	1.90
Trichoptera	Hydroptilidae			0	4	0	0.00
Trichoptera	Limnephilidae	7	7	7	4	28	6.67
Trichoptera	Odontoceridae			0	0	0	0.00
Trichoptera	Polycentropodidae			0		0	0.00
Trichoptera	glossosomatidae			0		0	0.00
TOTALS		**105**	**9**	**105**		**578.2**	100.00

Macroinvertebrates
(Copy this sheet as new worksheet for multiple sites)

Stream Site	Deal Ditch, Site 3
Analyst	TM
Date Collected	11/13/2017
Date Counted	3/7/2018

Moderately Impaired

mIBI Metric		Metric Score
HBI	5.36	2
No. Taxa (family)	14	4
Total Count (# individuals)	140	4
% Dominant Taxa	47.1	2
EPT Index (# families)	2	0
EPT Count (# individuals)	8	0
EPT Count/Total Count	0.06	0
EPT Abun./Chir. Abun.	0.12	0
Chironomid Count	66	6
mIBI Score		2.0

Taxa (Scientific Name)

Order	Family	#	EPT	# w/t	Tolerance (t)	# x t	%
Acarina	Hydrachnidae			0		0	0.00
Amphipoda	Crangonyctidae	9		9	4	36	6.43
Amphipoda	Gammaridae			0	4	0	0.00
Amphipoda	Haustoriidae			0	4	0	0.00
Amphipoda	Talitridae			0	8	0	0.00
Araneae	Pisauridae			0		0	0.00
Bivalvia	*Corbicula fluminea*			0	3.2	0	0.00
Bivalvia	Sphaeriidae	2		2	8	16	1.43
Coleoptera	Amphizoidae			0		0	0.00
Coleoptera	Chrysomelidae			0		0	0.00
Coleoptera	Curculionidae			0		0	0.00
Coleoptera	Cyrinidae			0		0	0.00
Coleoptera	Dytiscidae			0	5	0	0.00
Coleoptera	Elmidae	29		29	4	116	20.71
Coleoptera	Gyrinidae			0	5	0	0.00
Coleoptera	Haliplidae			0	7	0	0.00
Coleoptera	Helodidae			0		0	0.00
Coleoptera	Hydrophilidae			0	5	0	0.00
Coleoptera	Noteridae			0		0	0.00
Coleoptera	Psephenidae			0	4	0	0.00
Coleoptera	Staphylinidae			0	8	0	0.00
Decopoda	Astacidae			0	8	0	0.00
Decopoda	Palaemonidae			0		0	0.00
Diptera	Brachyera pupae			0		0	0.00
Diptera	Ceratopognidae	3		3	6	18	2.14
Diptera	Chironomidae	66		66	6	396	47.14
Diptera	Culicidae	4		4	8	32	2.86
Diptera	Dolichopodidae			0	4	0	0.00
Diptera	Empididae			0	6	0	0.00
Diptera	Ephydridae			0	6	0	0.00
Diptera	Nematocera pupae			0		0	0.00
Diptera	Ptychopteridae			0	7	0	0.00
Diptera	Simuliidae	1		1	6	6	0.71
Diptera	Stratiomyidae			0		0	0.00
Diptera	Syrphidae			0	10	0	0.00
Diptera	Tabanidae			0	6	0	0.00
Diptera	Tipulidae	8		8	3	24	5.71
Ephemeroptera	Baetidae			0	4	0	0.00
Ephemeroptera	Caenidae			0	7	0	0.00
Ephemeroptera	Ephemerellidae			0	1	0	0.00
Ephemeroptera	Heptageniidae			0	4	0	0.00
Ephemeroptera	Neoephemeridae			0	7	0	0.00
Ephemeroptera	Siphlonuridae			0	7	0	0.00
Ephemeroptera	Tricorythidae			0	4	0	0.00
Gastropoda	Ancylidae			0	6	0	0.00
Gastropoda	Lymnaeidae			0	6.9	0	0.00
Gastropoda	Physidae			0	8	0	0.00
Gastropoda	Planorbidae			0	7	0	0.00
Gastropoda	Pleuroceridae			0		0	0.00
Gastropoda	Viviparidae			0	6	0	0.00
Hemiptera	Belostomatidae			0		0	0.00
Hemiptera	Corixidae			0	10	0	0.00
Hemiptera	Gerridae			0	5	0	0.00
Hemiptera	Herbridae			0		0	0.00
Hemiptera	Hydrometridae			0		0	0.00
Hemiptera	Mesoveliidae			0		0	0.00
Hemiptera	Naucoridae			0		0	0.00
Hemiptera	Nepidae			0		0	0.00
Hemiptera	Notonectidae			0		0	0.00
Hemiptera	Pleidae			0		0	0.00
Hemiptera	Veliidae			0		0	0.00
Hirudinea		1		1	10	10	0.71
Hirudinea	Glossiphoniidae			0	8	0	0.00
Isopoda	Asillidae	7		7	8	56	5.00
Lepidoptera	Langessa			0		0	0.00
Megaloptera	Nigronia			0		0	0.00
Megaloptera	Sialidae			0	4	0	0.00
Nematomorpha				0		0	0.00
Odonata	Aeshnidae	1		1	3	3	0.71
Odonata	Agrionidae			0	5	0	0.00
Odonata	Coenagrionidae			0	6.1	0	0.00
Odonata	Corduliidae			0	5	0	0.00
Odonata	Gomphidae			0	1	0	0.00
Odonata	Lestidae			0	9	0	0.00
Odonata	Libellulidae			0	9	0	0.00
Odonata	Petaluridae			0		0	0.00
Oligochaeta		1		1	5	5	0.71
Platyhelminthes	Planaria			0	1	0	0.00
Plecoptera	Chloroperlidae			0		0	0.00
Plecoptera	Perlidae			0	1	0	0.00
Plecoptera	Perlodidae			0	2	0	0.00
Trichoptera	Beraeidtae			0		0	0.00
Trichoptera	Brachycentridae			0	1	0	0.00
Trichoptera	Helicopsychidae			0	3	0	0.00
Trichoptera	Hydropsychidae	5	5	5	4	20	3.57
Trichoptera	Hydroptilidae			0	4	0	0.00
Trichoptera	Limnephilidae	3	3	3	4	12	2.14
Trichoptera	Odontoceridae			0	0	0	0.00
Trichoptera	Polycentropodidae			0		0	0.00
Trichoptera	Philopotamidae			0	3	0	0.00
Trichoptera	glossosomatidae			0		0	0.00
Collembola				0	10	0	0.00
TOTALS		**140**	**8**	**140**		**750.0**	100.00

Macroinvertebrates
(Copy this sheet as new worksheet for multiple sites)

Stream Site	Deal Ditch, Site 4
Analyst	TM
Date Collected	11/13/2017
Date Counted	3/7/2018

Slightly Impaired

mIBI Metric		Metric Score
HBI	4.92	4
No. Taxa (family)	16	6
Total Count (# individuals)	35	0
% Dominant Taxa	22.9	6
EPT Index (# families)	6	6
EPT Count (# individuals)	11	0
EPT Count/Total Count	0.31	4
EPT Abun./Chir. Abun.	9999.00	8
Chironomid Count	0	8
mIBI Score		4.7

Taxa (Scientific Name)

Order	Family	#	EPT	# w/t	Tolerance (t)	# x t	%
Acarina	Hydrachnidae			0		0	0.00
Amphipoda	Crangonyctidae	4		4	4	16	11.43
Amphipoda	Gammaridae	8		8	4	32	22.86
Amphipoda	Haustoriidae			0	4	0	0.00
Amphipoda	Talitridae			0	8	0	0.00
Araneae	Pisauridae			0		0	0.00
Bivalvia	*Corbicula fluminea*			0	3.2	0	0.00
Bivalvia	Sphaeriidae			0	8	0	0.00
Coleoptera	Amphizoidae			0		0	0.00
Coleoptera	Chrysomelidae			0		0	0.00
Coleoptera	Curculionidae			0		0	0.00
Coleoptera	Cyrinidae			0		0	0.00
Coleoptera	Dytiscidae			0	5	0	0.00
Coleoptera	Elmidae			0	4	0	0.00
Coleoptera	Gyrinidae			0	5	0	0.00
Coleoptera	Haliplidae			0	7	0	0.00
Coleoptera	Helodidae			0		0	0.00
Coleoptera	Hydrophilidae			0	5	0	0.00
Coleoptera	Noteridae			0		0	0.00
Coleoptera	Psephenidae			0	4	0	0.00
Coleoptera	Staphylinidae			0	8	0	0.00
Decopoda	Astacidae			0	8	0	0.00
Decopoda	Palaemonidae			0		0	0.00
Diptera	Brachyera pupae			0		0	0.00
Diptera	Ceratopognidae	2		2	6	12	5.71
Diptera	Chironomidae			0	6	0	0.00
Diptera	Culicidae	2		2	8	16	5.71
Diptera	Dolichopodidae			0	4	0	0.00
Diptera	Empididae			0	6	0	0.00
Diptera	Ephydridae			0	6	0	0.00
Diptera	Nematocera pupae			0		0	0.00
Diptera	Ptychopteridae			0	7	0	0.00
Diptera	Simuliidae			0	6	0	0.00
Diptera	Stratiomyidae			0		0	0.00
Diptera	Syrphidae			0	10	0	0.00
Diptera	Tabanidae			0	6	0	0.00
Diptera	Tipulidae			0	3	0	0.00
Ephemeroptera	Baetidae			0	4	0	0.00
Ephemeroptera	Caenidae			0	7	0	0.00
Ephemeroptera	Ephemerellidae	1	1	1	1	1	2.86
Ephemeroptera	Heptageniidae			0	4	0	0.00
Ephemeroptera	Neoephemeridae			0	7	0	0.00
Ephemeroptera	Siphlonuridae			0	7	0	0.00
Ephemeroptera	Tricorythidae			0	4	0	0.00
Gastropoda	Ancylidae			0	6	0	0.00
Gastropoda	Lymnaeidae	1		1	6.9	6.9	2.86
Gastropoda	Physidae			0	8	0	0.00
Gastropoda	Planorbidae	1		1	7	7	2.86
Gastropoda	Pleuroceridae			0		0	0.00
Gastropoda	Viviparidae			0	6	0	0.00
Hemiptera	Belostomatidae			0		0	0.00
Hemiptera	Corixidae			0	10	0	0.00
Hemiptera	Gerridae			0	5	0	0.00
Hemiptera	Herbridae			0		0	0.00
Hemiptera	Hydrometridae			0		0	0.00
Hemiptera	Mesoveliidae			0		0	0.00
Hemiptera	Naucoridae			0		0	0.00
Hemiptera	Nepidae			0		0	0.00
Hemiptera	Notonectidae			0		0	0.00
Hemiptera	Pleidae			0		0	0.00
Hemiptera	Veliidae			0		0	0.00
Hirudinea		1		1	10	10	2.86
Hirudinea	Glossiphoniidae			0	8	0	0.00
Isopoda	Asillidae			0	8	0	0.00
Lepidoptera	Langessa			0		0	0.00
Megaloptera	Nigronia			0		0	0.00
Megaloptera	Sialidae			0	4	0	0.00
Nematomorpha				0		0	0.00
Odonata	Aeshnidae			0	3	0	0.00
Odonata	Agrionidae			0	5	0	0.00
Odonata	Coenagrionidae	3		3	6.1	18.3	8.57
Odonata	Corduliidae			0	5	0	0.00
Odonata	Gomphidae			0	1	0	0.00
Odonata	Lestidae			0	9	0	0.00
Odonata	Libellulidae			0	9	0	0.00
Odonata	Petaluridae			0		0	0.00
Oligochaeta		1		1	5	5	2.86
Platyhelminthes	Planaria			0	1	0	0.00
Plecoptera	Chloroperlidae			0		0	0.00
Plecoptera	Perlidae			0	1	0	0.00
Plecoptera	Perlodidae			0	2	0	0.00
Trichoptera	Beraeidtae			0		0	0.00
Trichoptera	Brachycentridae			0	1	0	0.00
Trichoptera	Helicopsychidae	1	1	1	3	3	2.86
Trichoptera	Hydropsychidae	3	3	3	4	12	8.57
Trichoptera	Hydroptilidae			0	4	0	0.00
Trichoptera	Limnephilidae	1	1	1	4	4	2.86
Trichoptera	Odontoceridae			0	0	0	0.00
Trichoptera	Polycentropodidae	2	2	0		0	5.71
Trichoptera	Philopotamidae	3	3	3	3	9	8.57
Trichoptera	glossosomatidae			0		0	0.00
Collembola		1		1	10	10	2.86
TOTALS		**35**	**11**	**33**		**162.2**	100.00

Pretty Lake Post-Construction Monitoring Report

APPENDIX D

IN-LAKE SAMPLING DATASHEETS AND LABORATORY REPORTS

Dissolved Oxygen and Temperature Profile. Light Extinction Profile

S 13'.4"

Project	Pretty Lake
Date	9/6/2017
Waterbody	Pretty Lake, Middle of Lake

Depth (m)	Light Trans.	D.O. (mg/L)	D.O. (%)	TEMP
0	-342	8.83	105.3	70.5
1	-215	8.82	103.2	70.5
2	-134	8.79	102.7	70.4
3	-92.7	8.79	102.4	70.2
4	-62.9	8.75	102.0	70.1
5	-48.5	8.73	101.6	70.0
6	-34.9	7.92	91.7	69.6
7	-24.8	2.20	24.2	65.0
8	-18.5 (26')	0.43	4.4	58.4
9	-14.5	0.27	2.6	55.4
10	-8.4 (32')	0.18	1.7	52.5
11		0.12	1.1	49.9
12		0.11	1.0	48.5
13		0.28	2.5	47.4
14		0.16	1.4	46.4
15		0.13	1.1	46.2
16		0.12	1.1	45.8
17		0.12	1.1	45.4
18		0.13	1.2	45.1
19		0.13	1.1	44.9
20		0.13	1.1	44.8
21		0.12	1.1	44.7
22		0.11	1.0	44.7
23		0.11	1.0	44.7
24		0.11	0.9	44.6
25				
26				
27				
100'		0.11	0.9	44.4

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September 13, 2017

Analytical Report for Service Request No: K1709407

Tom Estrem
Cardno, Inc.
708 Roosevelt Road
Walkerton, IN 46574

RE: Pretty Lake

Dear Tom,

Enclosed are the results of the sample(s) submitted to our laboratory September 07, 2017
For your reference, these analyses have been assigned our service request number **K1709407.**

Analyses were performed according to our laboratory's NELAP-approved quality assurance program. The test results meet requirements of the current NELAP standards, where applicable, and except as noted in the laboratory case narrative provided. For a specific list of NELAP-accredited analytes, refer to the certifications section at www.alsglobal.com. All results are intended to be considered in their entirety, and ALS Group USA Corp. dba ALS Environmental (ALS) is not responsible for use of less than the complete report. Results apply only to the items submitted to the laboratory for analysis and individual items (samples) analyzed, as listed in the report.

Please contact me if you have any questions. My extension is 3364. You may also contact me via email at howard.holmes@alsglobal.com.

Respectfully submitted,

ALS Group USA, Corp. dba ALS Environmental

Howard Holmes
Project Manager

ALS Environmental
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Table of Contents

Acronyms

ASTM	American Society for Testing and Materials
A2LA	American Association for Laboratory Accreditation
CARB	California Air Resources Board
CAS Number	Chemical Abstract Service registry Number
CFC	Chlorofluorocarbon
CFU	Colony-Forming Unit
DEC	Department of Environmental Conservation
DEQ	Department of Environmental Quality
DHS	Department of Health Services
DOE	Department of Ecology
DOH	Department of Health
EPA	U. S. Environmental Protection Agency
ELAP	Environmental Laboratory Accreditation Program
GC	Gas Chromatography
GC/MS	Gas Chromatography/Mass Spectrometry
LOD	Limit of Detection
LOQ	Limit of Quantitation
LUFT	Leaking Underground Fuel Tank
M	Modified
MCL	Maximum Contaminant Level is the highest permissible concentration of a substance allowed in drinking water as established by the USEPA.
MDL	Method Detection Limit
MPN	Most Probable Number
MRL	Method Reporting Limit
NA	Not Applicable
NC	Not Calculated
NCASI	National Council of the Paper Industry for Air and Stream Improvement
ND	Not Detected
NIOSH	National Institute for Occupational Safety and Health
PQL	Practical Quantitation Limit
RCRA	Resource Conservation and Recovery Act
SIM	Selected Ion Monitoring
TPH	Total Petroleum Hydrocarbons
tr	Trace level is the concentration of an analyte that is less than the PQL but greater than or equal to the MDL.

Inorganic Data Qualifiers

*	The result is an outlier. See case narrative.
#	The control limit criteria is not applicable. See case narrative.
B	The analyte was found in the associated method blank at a level that is significant relative to the sample result as defined by the DOD or NELAC standards.
E	The result is an estimate amount because the value exceeded the instrument calibration range.
J	The result is an estimated value.
U	The analyte was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL. *DOD-QSM 4.2 definition* : Analyte was not detected and is reported as less than the LOD or as defined by the project. The detection limit is adjusted for dilution.
i	The MRL/MDL or LOQ/LOD is elevated due to a matrix interference.
X	See case narrative.
Q	See case narrative. One or more quality control criteria was outside the limits.
H	The holding time for this test is immediately following sample collection. The samples were analyzed as soon as possible after receipt by the laboratory.

Metals Data Qualifiers

#	The control limit criteria is not applicable. See case narrative.
J	The result is an estimated value.
E	The percent difference for the serial dilution was greater than 10%, indicating a possible matrix interference in the sample.
M	The duplicate injection precision was not met.
N	The Matrix Spike sample recovery is not within control limits. See case narrative.
S	The reported value was determined by the Method of Standard Additions (MSA).
U	The analyte was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL. *DOD-QSM 4.2 definition* : Analyte was not detected and is reported as less than the LOD or as defined by the project. The detection limit is adjusted for dilution.
W	The post-digestion spike for furnace AA analysis is out of control limits, while sample absorbance is less than 50% of spike absorbance.
i	The MRL/MDL or LOQ/LOD is elevated due to a matrix interference.
X	See case narrative.
+	The correlation coefficient for the MSA is less than 0.995.
Q	See case narrative. One or more quality control criteria was outside the limits.

Organic Data Qualifiers

*	The result is an outlier. See case narrative.
#	The control limit criteria is not applicable. See case narrative.
A	A tentatively identified compound, a suspected aldol-condensation product.
B	The analyte was found in the associated method blank at a level that is significant relative to the sample result as defined by the DOD or NELAC standards.
C	The analyte was qualitatively confirmed using GC/MS techniques, pattern recognition, or by comparing to historical data.
D	The reported result is from a dilution.
E	The result is an estimated value.
J	The result is an estimated value.
N	The result is presumptive. The analyte was tentatively identified, but a confirmation analysis was not performed.
P	The GC or HPLC confirmation criteria was exceeded. The relative percent difference is greater than 40% between the two analytical results.
U	The analyte was analyzed for, but was not detected ("Non-detect") at or above the MRL/MDL. *DOD-QSM 4.2 definition* : Analyte was not detected and is reported as less than the LOD or as defined by the project. The detection limit is adjusted for dilution.
i	The MRL/MDL or LOQ/LOD is elevated due to a chromatographic interference.
X	See case narrative.
Q	See case narrative. One or more quality control criteria was outside the limits.

Additional Petroleum Hydrocarbon Specific Qualifiers

F	The chromatographic fingerprint of the sample matches the elution pattern of the calibration standard.
L	The chromatographic fingerprint of the sample resembles a petroleum product, but the elution pattern indicates the presence of a greater amount of lighter molecular weight constituents than the calibration standard.
H	The chromatographic fingerprint of the sample resembles a petroleum product, but the elution pattern indicates the presence of a greater amount of heavier molecular weight constituents than the calibration standard.
O	The chromatographic fingerprint of the sample resembles an oil, but does not match the calibration standard.
Y	The chromatographic fingerprint of the sample resembles a petroleum product eluting in approximately the correct carbon range, but the elution pattern does not match the calibration standard.
Z	The chromatographic fingerprint does not resemble a petroleum product.

ALS Group USA Corp. dba ALS Environmental (ALS) - Kelso
State Certifications, Accreditations, and Licenses

Agency	Web Site	Number
Alaska DEH	http://dec.alaska.gov/eh/lab/cs/csapproval.htm	UST-040
Arizona DHS	http://www.azdhs.gov/lab/license/env.htm	AZ0339
Arkansas - DEQ	http://www.adeq.state.ar.us/techsvs/labcert.htm	88-0637
California DHS (ELAP)	http://www.cdph.ca.gov/certlic/labs/Pages/ELAP.aspx	2795
DOD ELAP	http://www.denix.osd.mil/edqw/Accreditation/AccreditedLabs.cfm	L14-51
Florida DOH	http://www.doh.state.fl.us/lab/EnvLabCert/WaterCert.htm	E87412
Hawaii DOH	http://health.hawaii.gov/	-
ISO 17025	http://www.pjlabs.com/	L16-57
Louisiana DEQ	http://www.deq.louisiana.gov/page/la-lab-accreditation	03016
Maine DHS	http://www.maine.gov/dhhs/	WA01276
Minnesota DOH	http://www.health.state.mn.us/accreditation	053-999-457
Nevada DEP	http://ndep.nv.gov/bsdw/labservice.htm	WA01276
New Jersey DEP	http://www.nj.gov/dep/enforcement/oqa.html	WA005
New York - DOH	https://www.wadsworth.org/regulatory/elap	12060
North Carolina DEQ	https://deq.nc.gov/about/divisions/water-resources/water-resources-data/water-sciences-home-page/laboratory-certification-branch/non-field-lab-certification	605
Oklahoma DEQ	http://www.deq.state.ok.us/CSDnew/labcert.htm	9801
Oregon – DEQ (NELAP)	http://public.health.oregon.gov/LaboratoryServices/EnvironmentalLaboratoryAccreditation/Pages/index.aspx	WA100010
South Carolina DHEC	http://www.scdhec.gov/environment/EnvironmentalLabCertification/	61002
Texas CEQ	http://www.tceq.texas.gov/field/qa/env_lab_accreditation.html	T104704427
Washington DOE	http://www.ecy.wa.gov/programs/eap/labs/lab-accreditation.html	C544
Wyoming (EPA Region 8)	https://www.epa.gov/region8-waterops/epa-region-8-certified-drinking-water-	-
Kelso Laboratory Website	www.alsglobal.com	NA

Analyses were performed according to our laboratory’s NELAP-approved quality assurance program. A complete listing of specific NELAP-certified analytes, can be found in the certification section at www.ALSGlobal.com or at the accreditation bodies web site.
Please refer to the certification and/or accreditation body's web site if samples are submitted for compliance purposes. The states highlighted above, require the analysis be listed on the state certification if used for compliance purposes and if the method/anlayte is offered by that state.

Chain of Custody

ALS Environmental—Kelso Laboratory
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ALS

1317 South 13th, Kelso, WA 98626 (360) 577-7222 FAX (360) 636-1068

SR# K1709407
PAGE 1 OF 1

Project Name: Pretty Lake Project Number:

Project Manager: Tom Estrem Company: Cardno

Company/Address: 708 Roosevelt Rd Phone: 574-229-8764

City, State, Zip: Walkerton, IN 46574 FAX:

Sampler's Signature: [signature]

Sample I.D.	Date	Time	LAB ID	Matrix	Number of Containers	Chlorophyll A					REMARKS
Site 1	9/6/13	1100		water	1	X					

Analysis Requested

TURNAROUND REQUIREMENTS

___ 24 hr X 48 hr ___ 5 day

___ Standard (21 days)

___ Provide FAX Preliminary Results

Requested Report Date: ___

Invoice Information

P.O. # ___

Bill to: Same as above

REPORT REQUIREMENTS

X I. Routine Report: Results, Method Blank, Surrogate, as required

___ II. Report Dup., MS, MSD as required

___ III. Data Validation Report (includes raw data)

___ IV. CLP Deliverable Report

___ V. EDD

Comments/Special Instructions:

RELINQUISHED BY:	RECEIVED BY:	RELINQUISHED BY:	RECEIVED BY:
Signature: [signature]	Signature: [signature]	Signature:	Signature:
Printed Name: Thomas Estrem	Printed Name: SWOLF	Printed Name:	Printed Name:
Firm: Cardno	Firm: ALS	Firm:	Firm:
Date/Time: 9/6/17 1500	Date/Time: 9/7/17 0920	Date/Time:	Date/Time:

ALS

PC HH

Cooler Receipt and Preservation Form

Client Cardno   Service Request K17 09407

Received: 9/7/17 Opened: 9/7/17 By: [illegible] Unloaded: 9/7/17 By: [illegible]

1. Samples were received via? *USPS* *Fed Ex* *UPS* (circled) *DHL* *PDX* *Courier* *Hand Delivered*
2. Samples were received in: (circle) *Cooler* (circled) *Box* *Envelope* *Other* ____ NA
3. Were custody seals on coolers? NA Y N (circled) If yes, how many and where? ____
   If present, were custody seals intact? Y N If present, were they signed and dated? Y N

Raw Cooler Temp	Corrected. Cooler Temp	Raw Temp Blank	Corrected Temp Blank	Corr. Factor	Thermometer ID	Cooler/COC ID NA	Tracking Number NA	Filed
6.9	6.9	—	—	0	380		1Z6T1590 01 9430	7/147

4. Packing material: *Inserts* *Baggies* *Bubble Wrap* (circled) *Gel Packs* (circled, "thawed") *Wet Ice* *Dry Ice* *Sleeves* ____
5. Were custody papers properly filled out (ink, signed, etc.)? NA Y (circled) N
6. Were samples received in good condition (temperature, unbroken)? *Indicate in the table below.* NA Y (circled) N
   If applicable, tissue samples were received: *Frozen* *Partially Thawed* *Thawed*
7. Were all sample labels complete (i.e analysis, preservation, etc.)? NA Y (circled) N
8. Did all sample labels and tags agree with custody papers? *Indicate major discrepancies in the table on page 2.* NA Y (circled) N
9. Were appropriate bottles/containers and volumes received for the tests indicated? NA Y (circled) N
10. Were the pH-preserved bottles (*see SMO GEN SOP*) received at the appropriate pH? *Indicate in the table below* NA (circled) Y N
11. Were VOA vials received without headspace? *Indicate in the table below.* NA (circled) Y N
12. Was C12/Res negative? NA (circled) Y N

Sample ID on Bottle	Sample ID on COC	Identified by:

Sample ID	Bottle Count Bottle Type	Out of Temp	Head-space	Broke	pH	Reagent	Volume added	Reagent Lot Number	Initials	Time
All		X								

SHORT HOLD TIME

RUSH

Notes, Discrepancies, & Resolutions: ____

7/25/16

Page ____ *of* ____

General Chemistry

ALS Environmental—Kelso Laboratory
1317 South 13th Avenue, Kelso, WA 98626
Phone (360)577-7222 Fax (360)636-1068
www.alsglobal.com

Client: Cardno, Inc. (formerly CARDNO ENTRIX)
Project: Pretty Lake
Sample Matrix: Water

Service Request: K1709407
Date Collected: 09/6/17
Date Received: 09/7/17

Analysis Method: SM 10200 H
Prep Method: Method

Units: mg/m3
Basis: NA

Chlorophyll A

Sample Name	Lab Code	Result	MRL	MDL	Dil.	Date Analyzed	Date Extracted	Q
Site 1	K1709407-001	**2.7**	1.1	0.5	1	09/08/17 16:15	9/8/17	
Method Blank	K1709407-MB1	ND U	0.60	0.30	1	09/08/17 16:15	9/8/17	
Method Blank	K1709407-MB2	ND U	0.60	0.30	1	09/08/17 16:15	9/8/17	

Client:	Cardno, Inc. (formerly CARDNO ENTRIX)	**Service Request:**	K1709407
Project:	Pretty Lake	**Date Analyzed:**	09/08/17
Sample Matrix:	Water	**Date Extracted:**	NA

Duplicate Lab Control Sample Summary
General Chemistry Parameters

Analysis Method:	SM 10200 H	**Units:**	mg/m3
Prep Method:	None	**Basis:**	NA
		Analysis Lot:	561169

	Lab Control Sample K1709407-LCS1			Duplicate Lab Control Sample K1709407-DLCS1					
Analyte Name	**Result**	**Spike Amount**	**% Rec**	**Result**	**Spike Amount**	**% Rec**	**% Rec Limits**	**RPD**	**RPD Limit**
Chlorophyll A	4080	4080	100	4080	4080	100	88-113	<1	20

ALS Group USA, Corp.
dba ALS Environmental

QA/QC Report

Client:	Cardno, Inc. (formerly CARDNO ENTRIX)	**Service Request:**	K1709407
Project:	Pretty Lake	**Date Analyzed:**	09/08/17
Sample Matrix:	Water	**Date Extracted:**	NA

Duplicate Lab Control Sample Summary
General Chemistry Parameters

Analysis Method:	SM 10200 H	**Units:**	mg/m3
Prep Method:	None	**Basis:**	NA
		Analysis Lot:	561169

	Lab Control Sample K1709407-LCS2			Duplicate Lab Control Sample K1709407-DLCS2					
Analyte Name	**Result**	**Spike Amount**	**% Rec**	**Result**	**Spike Amount**	**% Rec**	**% Rec Limits**	**RPD**	**RPD Limit**
Chlorophyll A	4110	4080	101	4160	4080	102	88-113	1	20

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Algae Analysis
Report and Data Set

Customer ID: 303

Tracking Code: 170001-303 | **Sample ID:** Lake Galbraith | **Replicate:** 1

Customer ID: 303 | **Sample Date:** 9/7/2017 | **Sample Level:** Composite

Job ID: 1 | **Station:** . | **Sample Depth:** 0

System Name: Lake Galbraith | **Site:** . | **Preservative:** Glutaraldehyde

Report Notes: Time: 1000

Division: Bacillariophyta

Taxa ID	Genus	Species	Subspecies	Variety	Form	Morph	Structure	Count NU/ml	Relative Count	Algal Cell Count Cells/ml	Relative Algal Cell Count
1010	*Achnanthes*	*spp*	.	.	.	.	Vegetative	42.346	0.21	42.346	0.03
9707	*Fragilaria*	*sp. 1*	.	(large) Job 07	.	.	Vegetative	2.556	0.01	140.184	0.09

Summary for Division ~ Bacillariophyta (2 detail records) **Sum Total Bacillariophyta** 44.903 | 0.22 | 182.530 | 0.12

Division: Chlorophyta

Taxa ID	Genus	Species	Subspecies	Variety	Form	Morph	Structure	Count NU/ml	Relative Count	Algal Cell Count Cells/ml	Relative Algal Cell Count
2080	*Chlamydomonas*	*spp*	.	.	.	.	Vegetative	84.692	0.41	84.692	0.05
2550	*Tetraedron*	*spp*	.	.	.	.	Vegetative	42.346	0.21	42.346	0.03

Summary for Division ~ Chlorophyta (2 detail records) **Sum Total Chlorophyta** 127.039 | 0.62 | 127.039 | 0.08

Division: Chrysophyta

Taxa ID	Genus	Species	Subspecies	Variety	Form	Morph	Structure	Count NU/ml	Relative Count	Algal Cell Count Cells/ml	Relative Algal Cell Count
1652	*.	*spp*	.	.	.	.	Vegetative	42.346	0.21	42.346	0.03

1000035	**Chrysocapsaceae*	*spp*	.	.	.	>1 um spherical	Vegetative	42.346	0.21	42.346	0.03

Summary for Division ~ Chrysophyta (2 detail records) **Sum Total Chrysophyta** 84.692 0.41 84.692 0.05

Division: Cyanophyta

Taxa ID	Genus	Species	Subspecies	Variety	Form	Morph	Structure	Count NU/ml	Relative Count	Algal Cell Count Cells/ml	Relative Algal Cell Count
4023	*Cylindrospermopsis*	*raciborskii*	.	.	.	straight	Vegetative	973.962	4.75	6,507.822	4.17
4110	*Dactylococcopsis*	*spp*	.	.	.	.	Vegetative	11,115.875	54.23	11,115.875	7.12
4648	*Lyngbya*	*spp*	.	.	.	<5 um filament diameter	Vegetative	1,143.347	5.58	20,117.421	12.89
4155	*Lyngbya*	*lagerheimia*	.	minor	.	.	Vegetative	169.385	0.83	1,355.078	0.87
4160	*Merismopedia*	*spp*	.	.	.	.	Vegetative	550.501	2.69	8,107.385	5.19
131148	*Planktothrix*	*spp*	.	.	.	.	Vegetative	762.231	3.72	39,724.986	25.44
4460	*Pseudanabaena*	*spp*	.	.	.	.	Vegetative	4,552.215	22.21	67,828.009	43.44
4320	*Synechococcus*	*spp*	.	.	.	.	Vegetative	169.385	0.83	169.385	0.11
4285	*Synechocystis*	*spp*	.	.	.	>1 um spherical	Vegetative	254.077	1.24	254.077	0.16

Summary for Division ~ Cyanophyta (9 detail records) **Sum Total Cyanophyta** 19,690.978 96.06 155,180.037 99.39

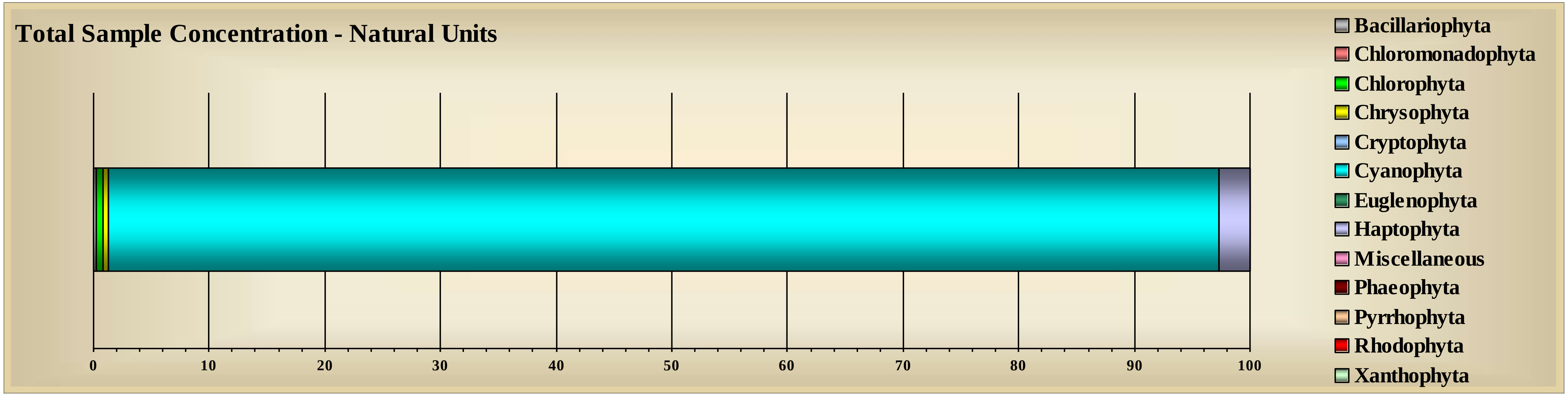
Division: Haptophyta

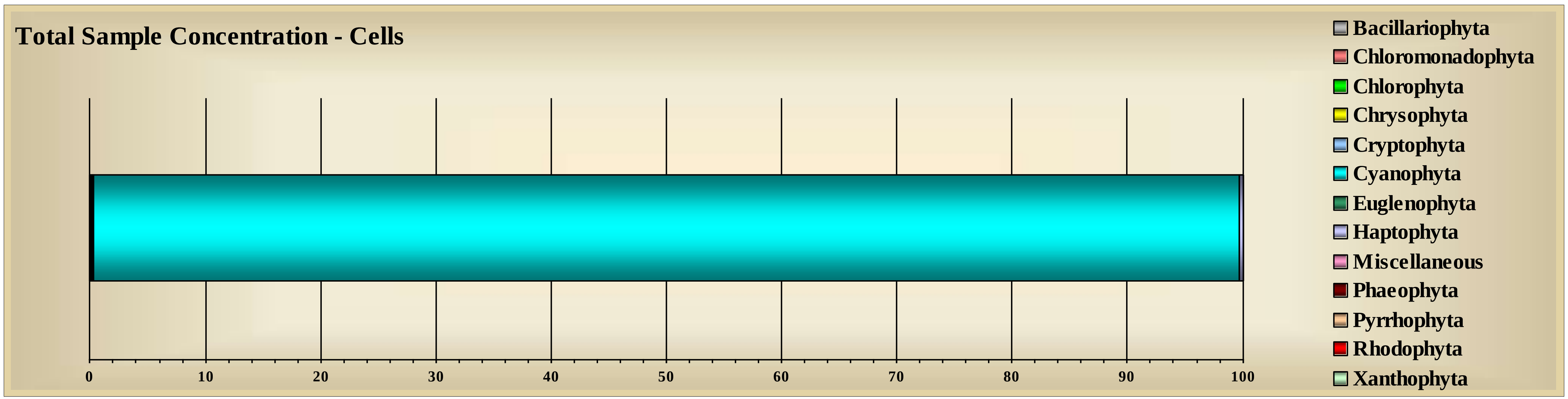
Taxa ID	Genus	Species	Subspecies	Variety	Form	Morph	Structure	Count NU/ml	Relative Count	Algal Cell Count Cells/ml	Relative Algal Cell Count
1730	*Chrysochromulina*	*spp*	.	.	.	.	Vegetative	550.501	2.69	550.501	0.35

Summary for Division ~ Haptophyta (1 detail record) **Sum Total Haptophyta** 550.501 2.69 550.501 0.35

Total Sample Concentration	Total Sample Cell Concentration
20,498.112	**156,124.799**
NU/ml	**Cells**/ml

SUMMARY GRAPHICS





Tracking Code: 170002-303 | **Sample ID:** Pretty Lake | **Replicate:** 1
Customer ID: 303 | **Sample Date:** 9/6/2017 | **Sample Level:** Composite
Job ID: 1 | **Station:** . | **Sample Depth:** 0
System Name: Pretty Lake | **Site:** . | **Preservative:** Glutaraldehyde
Report Notes: Time: 1230

Division: Bacillariophyta

Taxa ID	Genus	Species	Subspecies	Variety	Form	Morph	Structure	Count NU/ml	Relative Count	Algal Cell Count Cells/ml	Relative Algal Cell Count
1010	*Achnanthes*	*spp*	.	.	.	.	Vegetative	84.692	0.38	84.692	0.11
9853	*Cyclotella*	*sp. 2*	.	(large) Job 07	.	.	Vegetative	84.692	0.38	84.692	0.11
9707	*Fragilaria*	*sp. 1*	.	(large) Job 07	.	.	Vegetative	889.270	4.02	6,954.091	8.97
1330	*Tabellaria*	*spp*	.	.	.	.	Vegetative	42.346	0.19	169.385	0.22
Summary for Division ~ Bacillariophyta (4 detail records)						**Sum Total**	**Bacillariophyta**	1,101.001	4.98	7,292.861	9.40

Division: Chlorophyta

Taxa ID	Genus	Species	Subspecies	Variety	Form	Morph	Structure	Count NU/ml	Relative Count	Algal Cell Count Cells/ml	Relative Algal Cell Count
2683	**Chlorococcaceae*	*spp*	.	.	.	2-9.9 um spherical	Vegetative	169.385	0.77	169.385	0.22
2080	*Chlamydomonas*	*spp*	.	.	.	.	Vegetative	423.462	1.92	423.462	0.55
2350	*Oedogonium*	*spp*	.	.	.	.	Vegetative	2.556	0.01	12.071	0.02
Summary for Division ~ Chlorophyta (3 detail records)						**Sum Total**	**Chlorophyta**	595.403	2.69	604.918	0.78

Division: Chrysophyta

Taxa ID	Genus	Species	Subspecies	Variety	Form	Morph	Structure	Count NU/ml	Relative Count	Algal Cell Count Cells/ml	Relative Algal Cell Count
1652	*.	*spp*	.	.	.	.	Vegetative	127.039	0.57	127.039	0.16
1120	*Dinobryon*	*spp*	.	.	.	.	Vegetative	169.385	0.77	813.047	1.05
1123	*Dinobryon*	*spp*	.	.	.	.	Monad	127.039	0.57	127.039	0.16
1180	*Mallomonas*	*spp*	.	.	.	.	Vegetative	42.346	0.19	42.346	0.05
1620	*Syncrypta*	*spp*	.	.	.	.	Vegetative	42.346	0.19	338.770	0.44
1323	*Synura*	*spp*	.	.	.	.	Vegetative	84.692	0.38	84.692	0.11

Summary for Division ~ Chrysophyta (6 detail records) **Sum Total Chrysophyta** 592.847 2.68 1,532.932 1.98

Division: Cryptophyta

Taxa ID	Genus	Species	Subspecies	Variety	Form	Morph	Structure	Count NU/ml	Relative Count	Algal Cell Count Cells/ml	Relative Algal Cell Count
3010	*Cryptomonas*	*spp*	.	.	.	.	Vegetative	42.346	0.19	42.346	0.05
3043	*Rhodomonas*	*minuta*	.	nannoplanctica	.	.	Vegetative	127.039	0.57	127.039	0.16

Summary for Division ~ Cryptophyta (2 detail records) **Sum Total Cryptophyta** 169.385 0.77 169.385 0.22

Division: Cyanophyta

Taxa ID	Genus	Species	Subspecies	Variety	Form	Morph	Structure	Count NU/ml	Relative Count	Algal Cell Count Cells/ml	Relative Algal Cell Count
4050	*Aphanocapsa*	*spp*	.	.	.	.	Vegetative	84.692	0.38	6,097.851	7.86
4023	*Cylindrospermopsis*	*raciborskii*	.	.	.	straight	Vegetative	42.346	0.19	211.731	0.27
4010	*Dolichospermum*	*spp*	.	.	.	.	Vegetative	84.692	0.38	1,863.232	2.40
4480	*Gloeotrichia*	*spp*	.	.	.	.	Vegetative	42.346	0.19	211.731	0.27

4649	*Lyngbya*	*spp*	.	.	.	>=5 um filament dia meter	Vegetative	42.346	0.19	2,011.444	2.59
4267	*Microcystis*	*spp*	.	.	.	.	Vegetative	1,524.463	6.90	1,524.463	1.97
4260	*Microcystis*	*spp*	.	.	.	.	Vegetative	42.346	0.19	6,690.698	8.63
4460	*Pseudanabaena*	*spp*	.	.	.	.	Vegetative	254.077	1.15	2,286.694	2.95
4285	*Synechocystis*	*spp*	.	.	.	>1 um spherical	Vegetative	2,921.887	13.22	2,921.887	3.77
4094	*Woronichinia*	*spp*	.	.	.	.	Vegetative	14,355.358	64.94	14,355.358	18.51
4090	*Woronichinia*	*spp*	.	.	.	.	Vegetative	127.039	0.57	29,642.328	38.23

Summary for Division ~ Cyanophyta (11 detail records) **Sum Total Cyanophyta** 19,521.593 | 88.30 | 67,817.418 | 87.46

Division: Haptophyta

Taxa ID	Genus	Species	Subspecies	Variety	Form	Morph	Structure	Count NU/ml	Relative Count	Algal Cell Count Cells/ml	Relative Algal Cell Count
1730	*Chrysochromulina*	*spp*	.	.	.	.	Vegetative	84.692	0.38	84.692	0.11

Summary for Division ~ Haptophyta (1 detail record) **Sum Total Haptophyta** 84.692 | 0.38 | 84.692 | 0.11

Division: Pyrrhophyta

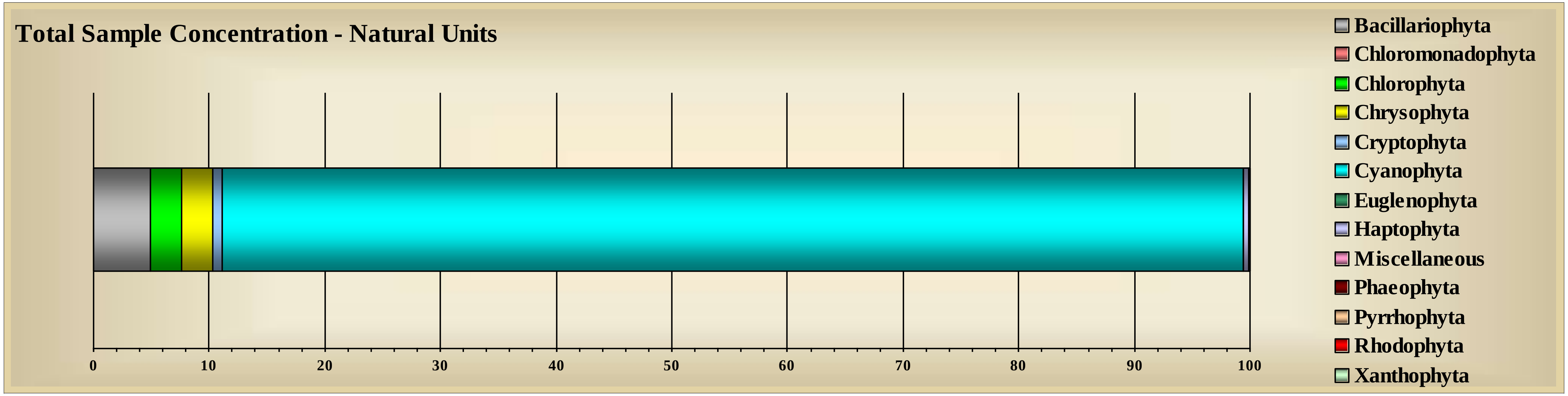
Taxa ID	Genus	Species	Subspecies	Variety	Form	Morph	Structure	Count NU/ml	Relative Count	Algal Cell Count Cells/ml	Relative Algal Cell Count
6010	*Ceratium*	*spp*	.	.	.	.	Vegetative	42.346	0.19	42.346	0.05

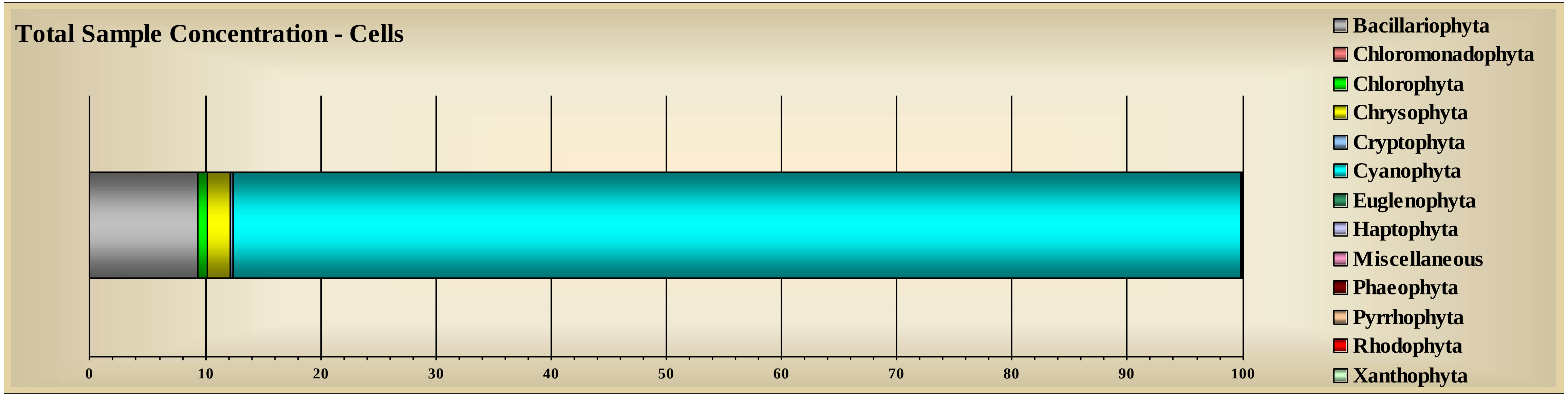
Summary for Division ~ Pyrrhophyta (1 detail record) **Sum Total Pyrrhophyta** 42.346 | 0.19 | 42.346 | 0.05

Total Sample Concentration
22,107.268
NU/ml

Total Sample Cell Concentration
77,544.552
Cells/ml

S U M M A R Y G R A P H I C S





Species List

Division: Bacillariophyta

Taxa ID	Genus	Species	Subspecies	Variety	Form	PhysiState	Structure	Authority
1010	Achnanthes	spp	.	.	.		Vegetative	(Greg.) Hust.
9853	Cyclotella	sp. 2	.	(large) Job 07	.		Vegetative	(Kutzing) de Brebisson
9707	Fragilaria	sp. 1	.	(large) Job 07	.		Vegetative	Lyngbye
1330	Tabellaria	spp	.	.	.		Vegetative	(Ehrenberg) Grunow

Division: Chlorophyta

Taxa ID	Genus	Species	Subspecies	Variety	Form	PhysiState	Structure	Authority
2683	*Chlorococcaceae	spp	.	.	.		Vegetative	N/A
2080	Chlamydomonas	spp	.	.	.		Vegetative	Ehrenberg
2350	Oedogonium	spp	.	.	.		Vegetative	De Bary
2550	Tetraedron	spp	.	.	.		Vegetative	(Reinsch) De Toni

Division: Chrysophyta

Taxa ID	Genus	Species	Subspecies	Variety	Form	PhysiState	Structure	Authority
1652	*.	spp	.	.	.		Vegetative	Cienkowski .
1000035	*Chrysocapsaceae	spp	.	.	.		Vegetative	N/A
1120	Dinobryon	spp	.	.	.		Vegetative	Ehrenberg
1123	Dinobryon	spp	.	.	.		Monad	Ehrenberg
1180	Mallomonas	spp	.	.	.		Vegetative	Perty
1620	Syncrypta	spp	.	.	.		Vegetative	Ehrenberg 1834
1323	Synura	spp	.	.	.		Vegetative	Ehrenberg

Division: Cryptophyta

Taxa ID	Genus	Species	Subspecies	Variety	Form	PhysiState	Structure	Authority
3010	Cryptomonas	spp	.	.	.		Vegetative	Ehrenberg .

3043	Rhodomonas	minuta	.	nannoplanctica	.		Vegetative	Skuja

Division: Cyanophyta

Taxa ID	Genus	Species	Subspecies	Variety	Form	PhysiState	Structure	Authority
4050	Aphanocapsa	spp	.	.	.		Vegetative	W. and G. S. West
4023	Cylindrospermopsis	raciborskii	.	.	.		Vegetative	(Wolosz.) Seena. and Subbar.
4110	Dactylococcopsis	spp	.	.	.		Vegetative	Lemmermann
4010	Dolichospermum	spp	.	.	.		Vegetative	Bory
4480	Gloeotrichia	spp	.	.	.		Vegetative	(J. Smith) P. Richter
4648	Lyngbya	spp	.	.	.		Vegetative	.
4649	Lyngbya	spp	.	.	.		Vegetative	.
4155	Lyngbya	lagerheimia	.	minor	.		Vegetative	.
4160	Merismopedia	spp	.	.	.		Vegetative	Thompson
4260	Microcystis	spp	.	.	.		Vegetative	(Kutzing) Lemmermann
4267	Microcystis	spp	.	.	.		Vegetative	(Kutzing) Lemmermann
131148	Planktothrix	spp	.	.	.		Vegetative	(Gomont) Anag. and Komar
4460	Pseudanabaena	spp	.	.	.		Vegetative	Lauterborn
4320	Synechococcus	spp	.	.	.		Vegetative	(Nageli) Elenkin .
4285	Synechocystis	spp	.	.	.		Vegetative	N/A
4090	Woronichinia	spp	.	.	.		Vegetative	Lemmermann
4094	Woronichinia	spp	.	.	.		Vegetative	Lemmermann

Division: Haptophyta

Taxa ID	Genus	Species	Subspecies	Variety	Form	PhysiState	Structure	Authority
1730	Chrysochromulina	spp	.	.	.		Vegetative	Lackey

Division: Pyrrhophyta

Taxa ID	Genus	Species	Subspecies	Variety	Form	PhysiState	Structure	Authority
6010	Ceratium	spp	.	.	.		Vegetative	Dujardin

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Zooplankton Analysis

Report and Data Set

Customer ID: 303

Tracking Code: 170003-303
Customer ID: 303
Job ID: 1
System Name: Lake Galbraith
Report Notes: Time: 1000

Sample ID: Lake Galbraith
Sample Date: 9/7/2017
Station: .
Site: .

Replicate: 1
Sample Level: Composite
Sample Depth: 4.27
Preservative: Ethanol

Phylum: Arthropoda

Order: ^Copepoda

Taxa ID	Genus	Species	Subspecies	Variety	Morph	Structure	Concentration Animals / ml	Relative Concentration
1000303	*.	*spp*	.	.	.	nauplius	0.157	2.00
Summary for Order ~ ^Copepoda (1 detail record)					**Sum Total**	**^Copepoda**	0.157	2.00

Order: Calanoida

Taxa ID	Genus	Species	Subspecies	Variety	Morph	Structure	Concentration Animals / ml	Relative Concentration
128120	*Diaptomus*	*spp*	.	.	.	Whole Animal	0.236	3.00
1000344	*.	*spp*	.	.	CI-CIV	Whole Animal	0.708	9.00
Summary for Order ~ Calanoida (2 detail records)					**Sum Total**	**Calanoida**	0.944	12.00

Order: Cyclopoida

Taxa ID	Genus	Species	Subspecies	Variety	Morph	Structure	Concentration Animals / ml	Relative Concentration
1000248	*.	*spp*	.	.	CI-CV	Whole Animal	0.787	10.00
128191	*Cyclops*	*spp*	.	.	.	Whole Animal	0.157	2.00
Summary for Order ~ Cyclopoida (2 detail records)					**Sum Total**	**Cyclopoida**	0.944	12.00

Phylum: Rotifera

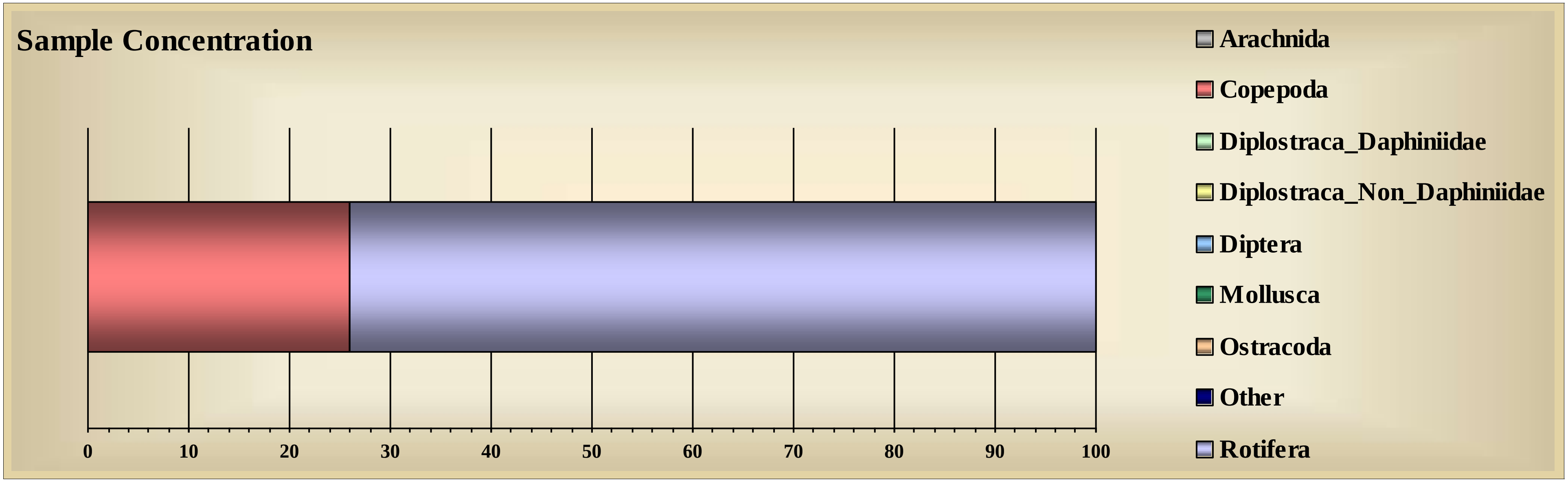
Order: Ploima

Taxa ID	Genus	Species	Subspecies	Variety	Morph	Structure	Concentration Animals / ml	Relative Concentration
1000422	*Keratella*	*spp*	.	.	.	Whole Animal	0.079	1.00
131841	*Asplanchna*	*spp*	.	.	.	Whole Animal	5.745	73.00
Summary for Order ~ Ploima (2 detail records)						**Sum Total Ploima**	5.824	74.00

Total Sample Concentration

7.870

SUMMARY GRAPHICS



Tracking Code: 170004-303
Customer ID: 303
Job ID: 1
System Name: Pretty Lake
Report Notes: Time: 1230

Sample ID: Pretty Lake
Sample Date: 9/6/2017
Station: .
Site: .

Replicate: 1
Sample Level: Composite
Sample Depth: 12.19
Preservative: Ethanol

Phylum: Arthropoda

Order: ^Copepoda

Taxa ID	Genus	Species	Subspecies	Variety	Morph	Structure	Concentration Animals / ml	Relative Concentration
1000303	*.	*spp*	.	.	.	nauplius	0.731	11.71
Summary for Order ~ ^Copepoda (1 detail record)					**Sum Total**	**^Copepoda**	0.731	11.71

Order: Calanoida

Taxa ID	Genus	Species	Subspecies	Variety	Morph	Structure	Concentration Animals / ml	Relative Concentration
1000344	*.	*spp*	.	.	CI-CIV	Whole Animal	1.125	18.02
128120	*Diaptomus*	*spp*	.	.	.	Whole Animal	0.562	9.01
Summary for Order ~ Calanoida (2 detail records)					**Sum Total**	**Calanoida**	1.687	27.03

Order: Cyclopoida

Taxa ID	Genus	Species	Subspecies	Variety	Morph	Structure	Concentration Animals / ml	Relative Concentration
128191	*Cyclops*	*spp*	.	.	.	Whole Animal	0.225	3.60
1000248	*.	*spp*	.	.	CI-CV	Whole Animal	2.699	43.24
Summary for Order ~ Cyclopoida (2 detail records)					**Sum Total**	**Cyclopoida**	2.924	46.85

Phylum: Arthropoda

Order: Diplostraca

Taxa ID	Genus	Species	Subspecies	Variety	Morph	Structure	Concentration Animals / ml	Relative Concentration
128157	*Daphnia*	*spp*	.	.	.	Whole Animal	0.450	7.21
Summary for Order ~ Diplostraca (1 detail record)						**Sum Total Diplostraca**	0.450	7.21

Phylum: Arthropoda

Order: Diplostraca

Taxa ID	Genus	Species	Subspecies	Variety	Morph	Structure	Concentration Animals / ml	Relative Concentration
128182	*Diaphanosoma*	*spp*	.	.	.	Whole Animal	0.281	4.50
Summary for Order ~ Diplostraca (1 detail record)						**Sum Total Diplostraca**	0.281	4.50

Phylum: Rotifera

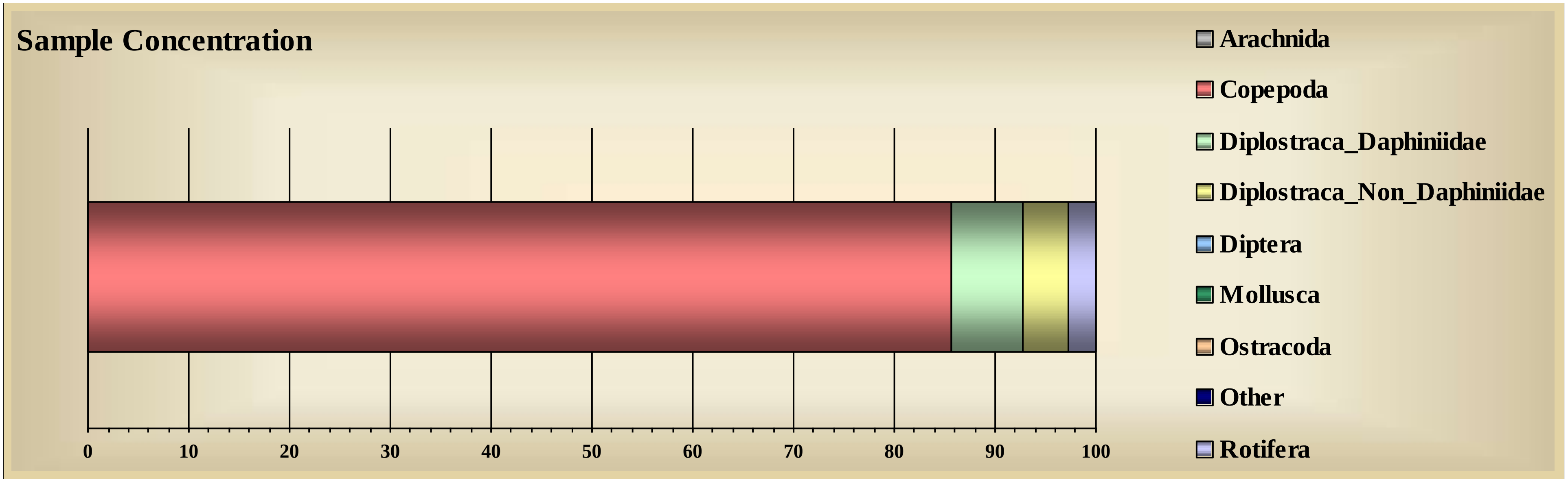
Order: Ploima

Taxa ID	Genus	Species	Subspecies	Variety	Morph	Structure	Concentration Animals / ml	Relative Concentration
131845	*Kellicottia*	*spp*	.	.	.	Whole Animal	0.056	0.90
131841	*Asplanchna*	*spp*	.	.	.	Whole Animal	0.056	0.90
131842	*Brachionus*	*spp*	.	.	.	Whole Animal	0.056	0.90
Summary for Order ~ Ploima (3 detail records)						**Sum Total Ploima**	0.169	2.70

Total Sample Concentration

6.242

SUMMARY GRAPHICS



Species List

Order: ^Copepoda

Taxa ID	Genus	Species	Subspecies	Variety	Form	Morph	Structure	Authority
1000303	*.	spp	.	.	.	.	nauplius	Esterley 1911

Order: Calanoida

Taxa ID	Genus	Species	Subspecies	Variety	Form	Morph	Structure	Authority
1000344	*.	spp	.	.	.	CI-CIV	Whole Animal	Sars, 1903
128120	Diaptomus	spp	.	.	.	.	Whole Animal	Herrick

Order: Cyclopoida

Taxa ID	Genus	Species	Subspecies	Variety	Form	Morph	Structure	Authority
1000248	*.	spp	.	.	.	CI-CV	Whole Animal	Burmeister, 1834
128191	Cyclops	spp	.	.	.	.	Whole Animal	Muller, 1785

Order: Diplostraca

Taxa ID	Genus	Species	Subspecies	Variety	Form	Morph	Structure	Authority
128157	Daphnia	spp	.	.	.	.	Whole Animal	O. F. Mueller, 1785
128182	Diaphanosoma	spp	.	.	.	.	Whole Animal	Fischer, 1850

Order: Ploima

Taxa ID	Genus	Species	Subspecies	Variety	Form	Morph	Structure	Authority
1000422	Keratella	spp	.	.	.	.	Whole Animal	(Ehrenberg 1834)
131841	Asplanchna	spp	.	.	.	.	Whole Animal	Gosse 1850
131842	Brachionus	spp	.	.	.	.	Whole Animal	Gosse 1851
131845	Kellicottia	spp	.	.	.	.	Whole Animal	Kellicott 1879

Pretty Lake Post-Construction Monitoring Report

APPENDIX E

HISTORICAL WATER QUALITY DATASET

Appendix E. Pretty Lake Historical Water Quality Dataset

Date	Secchi (ft)	Percent Oxic	epi pH	1% Light Level	TN	NH3	NO3	Mean TP (mg/L)	SRP	Plankton	Chl a	% Light @ 3'	TSI	Carlson TSI	Source
08/01/30		36.3%													Scott, 1930
08/01/63		37.5%													Wetzel, 1966
09/01/63		35.0%													Wetzel, 1966
10/01/63		47.5%													Wetzel, 1966
11/01/63		48.8%													Wetzel, 1966
06/22/64	10.83	100.0%	8.73	36.1								50.0%			McGinty, 1966
07/01/70		32.5%													IDNR, 1970 cited in EarthSource
08/31/72	10.00	31.3%						0.300					25		IDEM, 1986
07/31/73	11.00	56.3%	9.00												Peterson, 1974
01/01/74			8.10					0.040							IDNR, 1974
08/06/79	18.50	75.0%	9.00												Peterson, 1980
09/01/83	12.6	36.3%	9.20												IDNR, 1984
08/07/85	17.00	50.0%	9.00												Ledet, 1986
07/01/88	14.8	48.8%	8.50			0.242	0.385		0.010						Indiana University, 1988
08/22/88	9.00	48.8%						0.005							Grant, 1989
07/01/89	9.19	95.5%	--	--	1.487	0.216	0.472	0.013	0.005	2806	--	54.0	7	41	CLP, 1989
09/15/89	12.4	32.8%			1.7	0.130	0.200	0.680	0.030		3.1		13		Earthsource, 1991
10/05/89	13.1	32.8%			0.5	0.500	0.900	0.190	0.020		3.5		13		Earthsource, 1991
07/27/93	11.48	65.9%	8.50	28	0.5965	0.226	0.045	0.070	0.048	4437	2.1	60.0	22	39	CLP, 1993
06/17/96	19.00	100.0%	9.20												Ledet, 1998
08/26/97	11.15	32.0%	8.61	28	0.75	0.165	0.022	0.043	0.028	7483	3.04	48	21	42	CLP, 1997
05/21/00	17.0														Volunteer monitor
06/17/00	17.0														Volunteer monitor
05/19/01	16.5														Volunteer monitor
06/23/01	13.5														Volunteer monitor
08/29/01	12.5														Volunteer monitor
09/12/01	11.0														Volunteer monitor
10/04/01	16.0														Volunteer monitor
07/05/02	14.0														Volunteer monitor
07/14/02	14.8														Volunteer monitor
08/03/02	14.5														Volunteer monitor
08/12/02	15.75	78.7%	8.35	28	0.7085	0.100	0.173	0.026	0.016	8983	1.0	55.0	16		CLP, 2002
08/29/02	16.5														Volunteer monitor
09/30/02	12.9														Volunteer monitor
07/02/03	14.8														Volunteer monitor
06/15/04	13.6														Volunteer monitor
06/19/04	14.2														Volunteer monitor
07/13/04	14.5														Volunteer monitor
07/04/05	15.5														Volunteer monitor
07/27/06	11.5	83.0%	8.70	23		0.586	0.018	0.019	0.010	901	0.14	16.4%	15		Cardno, 2007 Diagnostic Study
07/30/07	15.5														Cardno, 2008 AVMP
06/21/10	14.0	70ft%	9.20												Koza, 2011 IDNR Fishereis
08/09/10	14.4	73.0%	8.60	26.6		0.028	0.118	0.018	0.010	3118		20.5	37	41	CLP, 2010
09/07/11								0.140							Lagrange County Lakes Council
05/30/12								0.150							Lagrange County Lakes Council
07/02/12	6.9	100.0%	8.40			0.018	0.062	0.013	0.010		2.12			43	CLP, 2012
09/12/12								0.170							Lagrange County Lakes Council
05/07/13								0.170							Lagrange County Lakes Council
06/27/13								0.670							Lagrange County Lakes Council
07/25/13								0.230							Lagrange County Lakes Council
07/26/13	26.0														Aquatic Weed Control, 2013 AVMP Update
08/22/13								0.280							Lagrange County Lakes Council
09/26/13								0.130							Lagrange County Lakes Council
10/24/13								1.070							Lagrange County Lakes Council
06/26/14								0.180							Lagrange County Lakes Council
07/24/14								0.250							Lagrange County Lakes Council
07/30/14	18.2														Aquatic Weed Control, 2014 AVMP Update
08/28/14								0.190							Lagrange County Lakes Council
07/29/15	12.90														Aquatic Weed Control, 2015 AVMP Update
08/01/15								0.080							Lagrange County Lakes Council
09/09/15								0.070							Lagrange County Lakes Council
07/21/16								0.050							Lagrange County Lakes Council
07/26/16	13.50														Aquatic Weed Control, 2016 AVMP Update
08/22/16								0.070							Lagrange County Lakes Council
09/16/16								0.060							Lagrange County Lakes Council
07/30/17								0.070							Lagrange County Lakes Council
08/01/17	15.00														Aquatic Weed Control, 2017-unpublished
08/30/17								0.060							Lagrange County Lakes Council
09/06/17	13.10	25.0%	8.25	32.8		0.149	0.182	0.066	0.059	15068	2.7	65	21	40	Cardno, 2018
09/27/17								0.060							Lagrange County Lakes Council
Average all years	14.08	0.56	8.71	28.93	0.96	0.21	0.164	0.031	0.02	6113.71	2.22	37.90	17		