Nine-Element Nonpoint Source Implementation Strategy (NPS-IS) for Indian Lake-Great Miami River HUC-12 (05080001 01 03)

Prepared for:

Indian Lake Watershed Project

Prepared by:

Civil & Environmental Consultants, Inc.
Toledo, Ohio

Version 1.0 Approved: January 7, 2022

This page intentionally left blank.

Acknowledgements

Version 1.0 prepared and written by:

Deanna Bobak
Civil & Environmental Consultants, Inc.
4841 Monroe Street, Suite 103
Toledo, OH 43623

Abigail Hastings
Watershed Coordinator
Indian Lake Watershed Project
324 County Road 11
Bellefontaine, OH 43311

The Indian Lake Watershed Project (ILWP) would like to acknowledge the collaboration of multiple partners in the preparation of this Nonpoint Source Implementation Strategy (NPS-IS) for the **Indian Lake-Great Miami River HUC-12 (05080001 01 03)**. The ILWP appreciates those individuals and organizations that contributed background information, insight into objectives and projects for inclusion in this NPS-IS, including the Auglaize Soil and Water Conservation District (SWCD), Logan SWCD, Hardin SWCD, the Natural Resources Conservation Service (NRCS) and Ohio Department of Natural Resources (ODNR). Thank you also to Rick Wilson, Ohio Environmental Protection Agency – Division of Surface Water, for guidance throughout the NPS-IS development process.

This product or publication was financed in part or totally through a grant from the United States Environmental Protection Agency through an assistance agreement with the Ohio Environmental Protection Agency. The contents and views, including any opinions, findings, conclusions or recommendations, contained in this product or publication are those of the authors and have not been subject to any Ohio Environmental Protection Agency or United States Environmental Protection Agency peer or administrative review and may not necessarily reflect the views of the Ohio Environmental Protection Agency or the United States Environmental Protection Agency and no official endorsement should be inferred.

Cover photo: Van Horn Creek; photo courtesy of Civil & Environmental Consultants, Inc.

Acronyms and Abbreviations

The acronyms and abbreviations below are commonly used by organizations working to restore Ohio's watersheds and are found throughout this NPS-IS document.

Numbers

§319	Section 319 of the Clean Water Act

A

ACPF	Agricultural Conservation Planning Framework
ALU	Aquatic Life Use

B

BMP	Best Management Practice

C

CAFF	Confined Animal Feeding Facility
CAFO	Confined Animal Feeding Operation
CDL	Cropland Data Layer
COVID-19	Coronavirus Disease-2019
CRP	Conservation Reserve Program

D

DEM	Digital Elevation Model
DO	Dissolved Oxygen

E

E. coli	*Escherichia coli*
ECBP	Eastern Corn Belt Plains
ECHO	Environmental Compliance History Online
EPT	*Ephemeroptera, Plecoptera and Trichoptera* – sensitive macroinvertebrate species
EQIP	Environmental Quality Incentives Program
EWH	Exceptional Warmwater Habitat

F

FLS	Federally Listed Species
FOTG	Field Office Technical Guide
FSA	Farm Service Agency

G

GIS	Geographic Information Systems

H

HAB	Harmful Algal Bloom
HSTS	Home Sewage Treatment System
HTF	Hypoxia Task Force
HUC	Hydrologic Unit Code

I

IBI	Index of Biotic Integrity
ICI	Invertebrate Community Index
ILWP	Indian Lake Watershed Project

M

MARB	Mississippi/Atchafalaya River Basin
MIwb	Modified Index of Well Being
MWH	Modified Warmwater Habitat

N

NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint Source
NPS-IS	Nonpoint Source-Implementation Strategy
NRCS	Natural Resources Conservation Service
NWI	National Wetland Inventory

O

OAC	Ohio Administrative Code
ODA	Ohio Department of Agriculture
ODH	Ohio Department of Health
ODNR	Ohio Department of Natural Resources
Ohio EPA	Ohio Environmental Protection Agency
OLEC	Ohio Lake Erie Commission
OpTIS	Operational Tillage Information System
ORB	Ohio River Basin
ORBA	Ohio River Basin Alliance
OSU	Ohio State University

P

PAD-US	Protected Areas Database of the United States
PCR	Primary Contact Recreation
PSS	Project Summary Sheet

Q

QHEI	Qualitative Habitat Evaluation Index

R

RM	River Mile

S

SNC	Significant Non-Compliance
STEPL	Spreadsheet Tool for Estimating Pollutant Loads
SWCD	Soil and Water Conservation District

T

TMDL	Total Maximum Daily Load

U

USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey

V

VRT	Variable Rate Technology

W

WAP	Watershed Action Plan
WPCLF	Water Pollution Control Loan Fund
WRP	Wetland Reserve Program
WQS	Water Quality Standards (Ohio Administrative Code 3745-1)
WWH	Warmwater Habitat

Table of Contents

Acknowledgements .... **i**
Acronyms and Abbreviations .... **ii**
Chapter 1: Introduction **1**
1.1 Report Background 1
1.2 Watershed Profile & History 4
1.3 Public Participation and Involvement 6
Chapter 2: HUC-12 Watershed Characterization and Assessment Summary **8**
2.1 Summary of HUC-12 Watershed Characterization 8
2.2 Summary of HUC-12 Biological Trends 17
2.3 Summary of HUC-12 Pollution Causes and Associated Sources 19
2.4 Additional Information for Determining Critical Areas and Developing Implementation Strategies 21
Chapter 3: Critical Area Conditions AND Restoration Strategies **22**
3.1 Overview of Critical Areas 22
3.2 Critical Area #1: Conditions, Goals & Objectives for Prioritized Agricultural Lands 23
3.3 Critical Area #2: Conditions, Goals & Objectives for Streambank and Riparian Restoration 30
3.4 Critical Area #3: Conditions, Goals & Objectives for Urban Nutrient Reduction 34
Chapter 4: Projects and Implementation Strategy **37**
4.1 Critical Area #1 Project and Implementation Strategy Overview Table 38
4.2 Critical Area #2 Project and Implementation Strategy Overview Table 39
4.3 Critical Area #3 Project and Implementation Strategy Overview Table 40
Chapter 5: Works Cited **45**

Table of Figures

Figure 1: Indian Lake-Great Miami River HUC-12 Overview 1
Figure 2: Great Miami Watershed 5
Figure 3: Location of the Indian Lake-Great Miami River HUC-12 6
Figure 4: Soils Classified by Particle Size 9
Figure 5: Municipalities 9
Figure 6: Land Use in the Headwaters Great Miami River HUC-10 11
Figure 7: Parks and Protected Lands 13
Figure 8: Wetlands within the Indian Lake-Great Miami River HUC-12 13
Figure 9: Indian Lake-Great Miami River HUC-12 Critical Area Overview 22
Figure 10: Indian Lake-Great Miami River HUC-12 Critical Area #1 23
Figure 11: Indian Lake-Great Miami River HUC-12 Critical Area #2 30
Figure 12: Indian Lake-Great Miami River HUC-12 Critical Area #3 34

Table of Tables

Table 1: Nine Elements for Watershed Plans and Implementation Projects 2
Table 2: Sub-watersheds in the Headwaters Great Miami River HUC-10..6
Table 3: Estimated Animal Counts in the Indian Lake-Great Miami River HUC-12..........................12
Table 4: Land Use Classifications in the Indian Lake-Great Miami River HUC-12............................12
Table 5: Parks and Protected Lands in Indian Lake-Great Miami River HUC-12.............................12
Table 6: Threatened and Endangered Species in Auglaize, Hardin and Logan Counties 14
Table 7: Historic Beach Water Quality Advisories in Indian Lake..15
Table 8: OpTIS Countywide Conservation Practice Averages for 2014-2018 for Counties in the Indian Lake Watershed...16
Table 9: Conservation Reserve Program (CRP) Contract Acreage by County.................................16
Table 10: Biological Indices Scores for Sites in Indian Lake-Great Miami River HUC-12.....................17
Table 11: Water Quality Standards for the Eastern Corn Belt Plains (ECBP) Ecoregion......................18
Table 12: QHEI Matrix with WWH and MWH Attribute Totals for Sites in the Indian Lake-Great Miami River HUC-12...19
Table 13: Causes and Sources of Impairments for Sampling Locations in the Indian Lake-Great Miami River HUC-12...20
Table 14: Estimated Nutrient Loadings from Contributing NPS Sources in the Indian Lake-Great Miami River HUC-12...20
Table 15: Indian Lake-Great Miami River HUC-12 Critical Area Descriptions 23
Table 16: Agricultural Conservation Planning Framework Results 24
Table 17: Critical Area #1 - Fish Community and Habitat Data 25
Table 18: Critical Area #1 - Macroinvertebrate Community Data 26
Table 19: Estimated Annual Nutrient Load Reductions from Each Objective 29
Table 20: Critical Area #2 - Fish Community and Habitat Data 31
Table 21: Critical Area #2 - Macroinvertebrate Community Data 32
Table 22: Indian Lake-Great Miami River HUC-12 (05080001 01 03) — Critical Area #1....................38
Table 23: Indian Lake-Great Miami River HUC-12 (05080001 01 03) — Critical Area #2....................39
Table 24: Indian Lake-Great Miami River HUC-12 (05080001 01 03) — Critical Area #3....................40
Table 25: Critical Area #3 – Project #1..41
Table 1: Critical Area #3 – Project #2..43

CHAPTER 1: INTRODUCTION

The **Indian Lake-Great Miami River Hydrologic Unit Code (HUC)-12 (05080001 01 03)** is located in northwest Logan County, southeast Auglaize County, and southwest Hardin County and contains an area of 27.38 square miles (Figure 1). The **Indian Lake-Great Miami River HUC-12** contains Indian Lake and several small tributaries, including Van Horn Creek and Blackhawk Run. The watershed is primarily agricultural (~45% cultivated crops and pasture combined), and a large percentage of the sub-watershed is covered by the open water of Indian Lake (~25%). The **Indian Lake-Great Miami River HUC-12** has been identified as an area of focus within the Ohio River Basin (ORB) due to the estimated loadings of total nitrogen that flows into the tributaries of the Ohio River, to the Mississippi River and its end-receiving waterbody, the Gulf of Mexico.

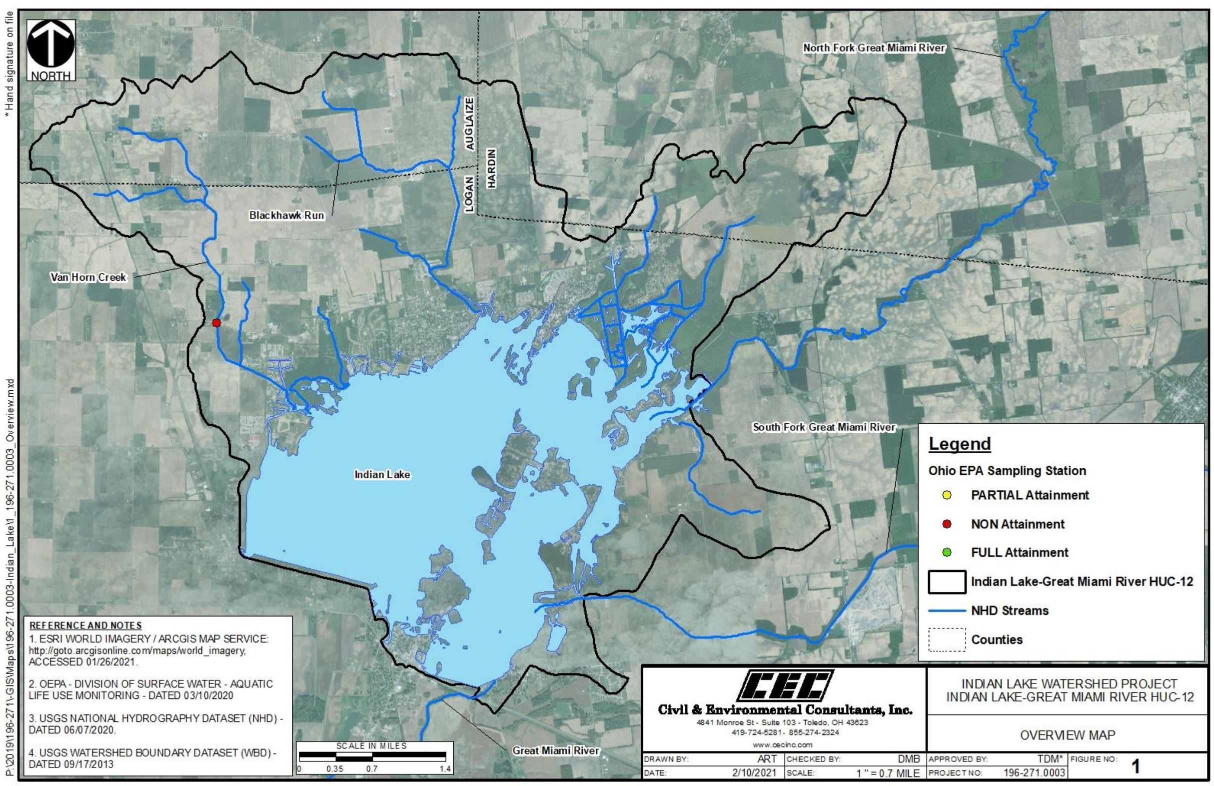

Figure 1: Indian Lake-Great Miami River HUC-12 Overview

1.1 Report Background

While watershed plans could be all-inclusive inventories, the US Environmental Protection Agency (USEPA) identified nine critical elements to include in strategic planning documents for impaired waters (Table 1). To ease implementation of projects addressing nonpoint source (NPS) management and habitat restoration, current federal and state NPS and habitat restoration funding opportunities require strategic watershed plans incorporate these nine key elements, concisely to HUC-12 watersheds.
The Ohio Environmental Protection Agency (Ohio EPA) has historically supported watershed-based planning in many forms (Ohio EPA, 2016b).

Table 1: Nine Elements for Watershed Plans and Implementation Projects

Element	Description
a	Identification of causes of impairment and pollutant sources or groups of similar sources that need to be controlled to achieve load reductions
b	Load reductions expected from management measures described under element (c) below
c	Description of the NPS measures that need to be implemented to achieve load reductions estimated under element (b) above and an identification of the critical areas in which those measures will be needed to implement this plan
d	An estimate of the amounts of technical and financial assistance needed, associated costs and/or sources and authorities that will be relied upon to implement this plan
e	An information/education component that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing and implementing the NPS management measures that will be implemented
f	A schedule for implementing the NPS measures identified in this plans that is reasonably expeditious
g	A description of interim, measurable milestones for determining whether NPS management measures or other control actions are being implemented
h	A set of criteria that can be used to determine whether loading reductions are being achieved over time and substantial progress is being made toward attaining water quality standards
i	A monitoring component to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under element (h) above

(Source: USEPA, 2008)

In 1997, Ohio EPA issued guidance for the development of Watershed Action Plans (WAPs), which typically covered larger watersheds (HUC-10 to HUC-8 size). The WAPs included an outline and checklist to ensure USEPA's nine elements were included within each plan. The USEPA issued new guidance in 2013 and concluded Ohio's interpretation for WAP development did not adequately address critical areas, nor did it include an approach that detailed the nine elements at the project level (Ohio EPA, 2016b). In response, Ohio EPA developed a new template for watershed planning in the form of a Nonpoint Source-Implementation Strategy (NPS-IS), ensuring NPS pollution is addressed at a finer resolution and that individual projects listed within each plan include each of the nine elements. The first NPS-IS plans were approved in 2017. Over time, these plans have evolved to not only address in-stream (near-field) water quality impairment from NPS pollution, but they also address reductions in nutrient loadings to larger bodies of water (far-field).

Hypoxia Task Force

The State of Ohio is an active participant in the Mississippi River/Gulf of Mexico Hypoxia Task Force (HTF), a multi-state agency effort established in 1997 to understand the causes and effects of eutrophication in the Gulf of Mexico and coordinate activities throughout the Mississippi/Atchafalaya River Basin (MARB) to reduce the size, severity and duration and ameliorate the effects of hypoxia within the Gulf (USEPA, 2020). The 2007 Mississippi River Basin Science Advisory Committee recommended a reduction in total nitrogen and total phosphorus from baseline values calculated from 1980 to 1996 by 45% to reduce the hypoxic zone within the Gulf of Mexico to a five year running average of 5,000 km^2 (USEPA, 2007). The HTF has accepted this recommendation and outlined an interim goal to reduce nutrient loading from major sources of nitrogen and phosphorus in the MARB by

20% by 2025 and 45% by 2035 (HTF, 2014; USEPA, 2017). Ohio EPA's *Nutrient Mass Balance Study for Ohio's Major Rivers* (2020) has identified high nitrogen and phosphorus loads within the Ohio portion of the ORB, particularly from the Scioto River and Great Miami River watersheds, citing 82% and 83% of the nitrogen load and 69% and 66%, respectively, of the phosphorus load in these two watersheds is from NPS contributions (Ohio EPA, 2020c).

Through the *State of Ohio's Domestic Action Plan*, state agencies modeled and estimated nutrient loads for NPS classifications (agricultural, home sewage treatment system (HSTS) and urban contributions) at the HUC-12 level within the northwestern portion of the state, underlining the state's commitment to nutrient reduction from all landscapes (OLEC, 2020). While this level of modeling has not yet occurred within the ORB, approximate loads from agricultural and urban landscapes, based upon nutrient loss literature and *Mass Balance* results, have been estimated for select HUC-12s within the ORB, including those in the Upper Scioto, Great Miami River, Little Miami River and Paint Creek watersheds as a beginning step in setting reduction targets to make progress towards HTF goals (Ohio EPA, 2021a).

Indian Lake Watershed Project Watershed Action Plan

The Indian Lake Watershed Project (ILWP) Long-Range Plan was originally developed in 1995-96 by the Ohio State University (OSU) Extension in collaborative efforts with the ILWP Joint Board of Supervisors (ILWP, 2009). The original plan guided the ILWP's growth and development over a ten year timespan, and modifications to the original plan were incorporated in the *Indian Lake WAP*, endorsed in 2010. This plan outlines seven water quality goals for Indian Lake and its watershed:

- Restore and maintain the chemical, physical and biological integrity of Indian Lake and its tributaries;
- Promote the reduction of NPS pollution from all potential sources that may include agriculture, commercial, residential and recreational;
- Develop and offer youth and adult educational opportunities regarding water quality and other relevant watershed management topics;
- Foster cooperation among agriculture, commercial, residential and recreational interests in order to enable coordinated actions toward a common goal;
- Assist area decision makers in the development and coordination of sound water quality and watershed management policies;
- Ensure downstream users that the water quality at the headwaters of the Great Miami River meet the Ohio EPA chemical, physical and biological integrity requirements; and,
- Protect the underground aquifer's water quality by preventing contaminated recharge to occur.

The *Indian Lake WAP* will be updated by the concurrent development of a NPS-IS for each of the three HUC-12 watersheds that are encompassed in the Indian Lake watershed: the *North Fork Great Miami River HUC-12,* the *South Fork Great Miami River HUC-12,* and the **Indian Lake-Great Miami River HUC-12**.

Indian Lake-Great Miami River HUC-12 NPS-IS

The development of NPS-IS in watersheds contained within the ORB is critical to the efforts focused on implementing the HTF's goal to reduce nutrient loadings from major sources of nitrogen and phosphorus to the Gulf of Mexico, as well as to meet state water quality standards and local goals. Development of NPS-IS within Ohio's portion of the ORB also aligns with goals established by the Ohio River Basin Alliance (ORBA) for abundant clean water and healthy and productive ecosystems in the Ohio River (USACE, 2020). The *Indian Lake-Great Miami River HUC-12 NPS-IS* will address NPS pollution by accounting for both near-field (within stream/watershed) and far-field (loadings to the Ohio River) effects. The *Indian Lake-Great Miami River HUC-12 NPS-IS,* along with the development of NPS-IS for the two other HUC-12s contained within the watershed, serves as an update to the *Indian Lake WAP*. The development of this NPS-IS is sponsored by the ILWP in collaboration with local partners through funding from a sub-grant from the Ohio EPA from the HTF.

Removal of NPS impairments and reduction in overall sediment and nutrient loss and restoration of streambanks, floodplains and wetlands within the **Indian Lake-Great Miami River HUC-12** is crucial to the attainment of aquatic life use (ALU) standards both within the Indian Lake watershed and on a greater scale within the context of the Ohio River watershed, the Mississippi River and its end-receiving waterbody, the Gulf of Mexico. Within the **Indian Lake-Great Miami River HUC-12**, one biological sample location was established in Van Horn Creek during the sampling study conducted in 2008-2009. Van Horn Creek was found to be in *Non-Attainment* of its Warmwater Habitat (WWH) designation due to habitat alterations from channelization. Land use activities have the potential to be substantial stressors on aquatic life through changes in habitat attributes and contributions of high nutrient loadings that could potentially threaten water quality both within Indian Lake, but also larger, end-receiving waterbodies. This NPS-IS will be used to strategically identify and outline key projects that should be implemented within the **Indian Lake-Great Miami River HUC-12** to address management of NPS pollution to not only attain Water Quality Standards (WQS) within the sub-watershed boundaries, but to also make progress towards far-field watershed goals on a larger scale within the greater ORB, MARB and Gulf of Mexico.

1.2 Watershed Profile & History

The land area contained within the **Indian Lake-Great Miami River HUC-12** is contained within the headwaters section of the Great Miami watershed (05080001) (Figure 2). The Great Miami River is located in southwestern Ohio and is approximately 160 miles in length[1], flowing from its headwaters in northwestern Logan County at the outlet of Indian Lake southwesterly to empty into the Ohio River west of Cincinnati. The Great Miami River drains an area of 3,802 square miles and is divided into 20 sub-basins at the HUC-10 level, including tributary watersheds for the Stillwater River, Mad River, Twin Creek, Fourmile Creek and Indian Creek. The headwaters section of the Great Miami River includes the North Fork Great Miami River, the South Fork Great Miami River, and Indian Lake.

[1] The *Ohio Gazetteer of Streams* (ODNR, 2001) lists the Great Miami River as 170 miles in length; however, the *River Mile Index* (Ohio EPA, 2021c) shows the Great Miami River with a length of ~159.7 miles. Biological sampling stations utilize the river mile (RM) locations in the *River Mile Index*.

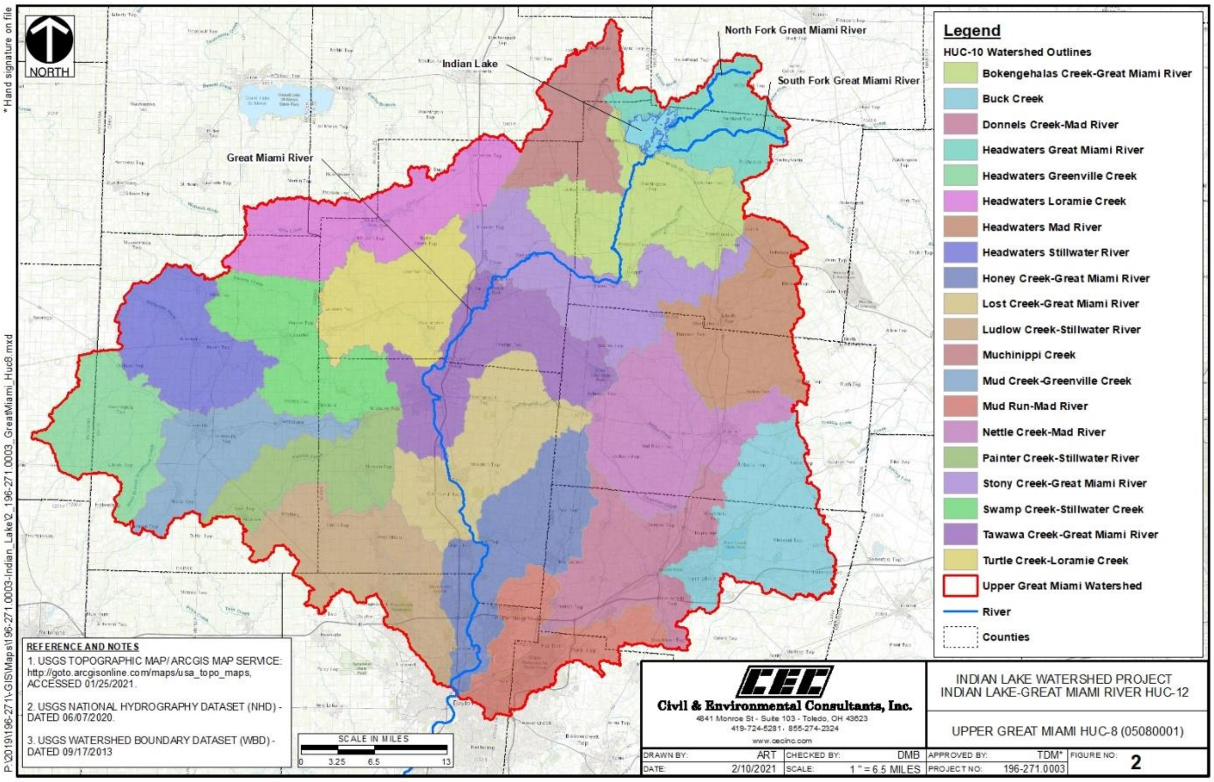

Figure 2: Great Miami Watershed

Indian Lake

The region of Indian Lake was originally a cluster of five natural lakes situated along the Great Miami River created by retreating continental glaciers (ODNR, 2021a). The resulting shallow, marshy lakes in this area covered an area of 640 acres. Old Indian Lake was one of these kettle lakes and was developed in 1851 as a feeder lake for the Miami and Erie Canal in order to maintain the required four-foot water depth throughout the canal system. Construction of a bulkhead where the Great Miami River begins was completed in 1860 and the lake became known as Lewiston Reservoir. At the time, the reservoir spanned more than 6,000 acres with 29 miles of shoreline. With the use of canal systems declining, the Ohio General Assembly dedicated the lake as a recreation area, changing the name to Indian Lake in 1898 (ODNR, 2021a). Today, Indian Lake is a highly used recreation area that covers approximately 5,147 acres and forms the headwaters of the Great Miami River (ILWP, 2009).

The watershed draining directly to Indian Lake is contained within the *Headwaters Great Miami River HUC-10.* The HUC-10 has a drainage area of 100.43 square miles or 64,272 acres (Figure 3). Land use within the *Headwaters Great Miami River HUC-10* is mainly agricultural, with most of the land area remaining unincorporated. One small municipality, Belle Center, is contained within the HUC-10 and supports approximately 810 people (US Census Bureau, 2010). The *Headwaters Great Miami River HUC-10* is further divided into three HUC-12 watersheds (Table 2). The **Indian Lake-Great Miami River HUC-**

12 fully contains Van Horn Creek, a 3.6 mile-long stream[2] flowing into the northwest section of Indian Lake (Ohio EPA, 2020c). Water quality within this headwaters region affects not only Indian Lake, but also downstream segments of the Great Miami River and end receiving waterbodies.

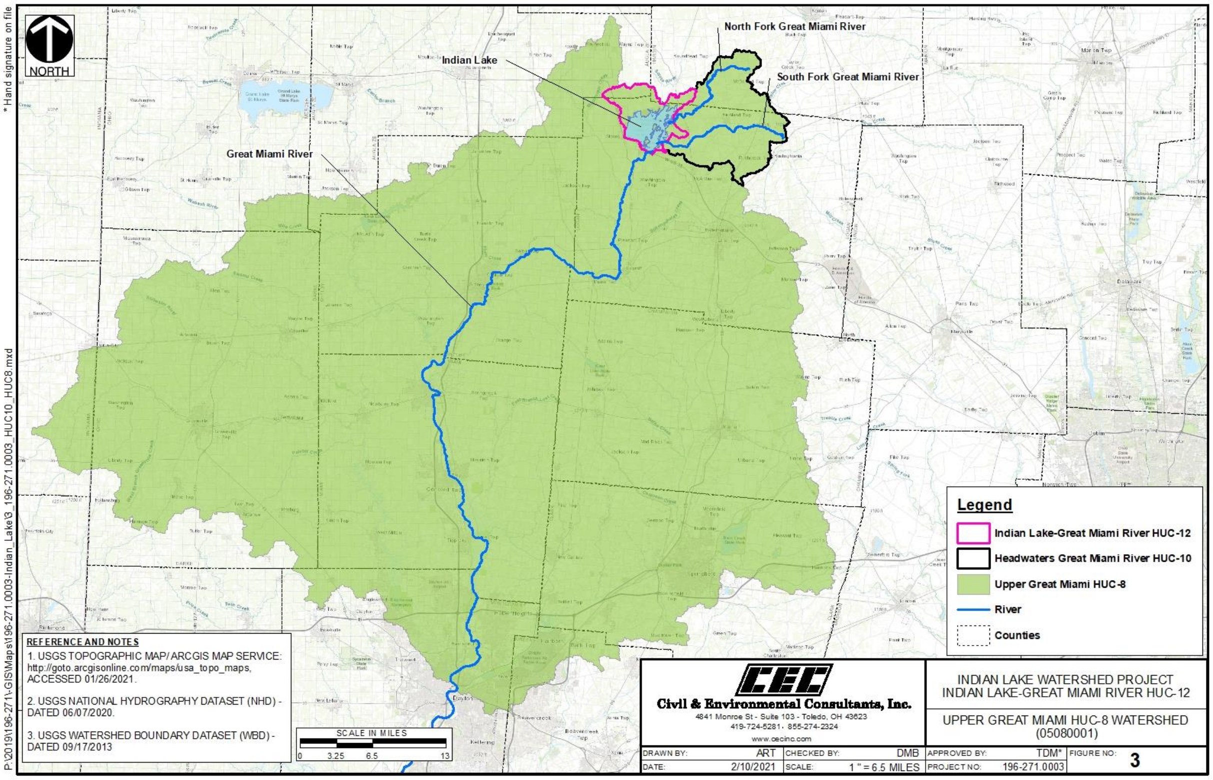

Figure 3: Location of the Indian Lake-Great Miami River HUC-12

Table 2: Sub-watersheds in the Headwaters Great Miami River HUC-10

Headwaters Great Miami River HUC-10 (05080001 01)		
HUC-12	**Area (Square miles)**	**Area (Acres)**
North Fork Great Miami River HUC-12 (01)	21.70	13,887
South Fork Great Miami River HUC-12 (02)	51.35	32,862
Indian Lake-Great Miami River HUC-12 (03)	27.38	17,523

(Source: Ohio EPA, 2020a)

1.3 Public Participation and Involvement

Watershed planning is best accomplished by collaboration and input from a diverse group of entities, including governmental agencies, private businesses, academia, non-profit groups, neighborhood organizations and the public at large. The ILWP was established in 1990, when the United States Department of Agriculture (USDA) designated Indian Lake as a high priority watershed through its

[2] The *Ohio Gazetteer of Streams* (ODNR, 2001) lists Van Horn Creek as 0.4 miles in length; however, the *River Mile Index* (Ohio EPA, 2020c) shows Van Horn Creek with a length of ~3.6 miles. Biological sampling stations utilize the river mile locations in the *River Mile Index*.

Hydrologic Unit Program. Indian Lake was Ohio's first watershed to be enrolled in this program (ILWP, 2009). The ILWP employs a full-time Watershed Coordinator dedicated to protecting the water quality of Indian Lake and the surrounding watershed, including the **Indian Lake-Great Miami River HUC-12**. The Watershed Coordinator facilitates the meetings of the ILWP, and through this organization, contributes to watershed-wide activities, including: the development of a microcystin monitoring program, the deployment of floating wetlands in Indian Lake and the facilitation of public outreach and educational programs.

The ILWP frequently partners with and garners participation from many organizational stakeholders, including, the:

- Indian Lake Chamber of Commerce;
- Indian Lake Development Corporation;
- Ohio EPA;
- Ohio State University (OSU) Extension;
- Ohio Department of Natural Resources (ODNR) and the Indian Lake State Park;
- University of Dayton;
- Wright State University;
- Ohio Farm Bureau Federation;
- Pheasants Forever;
- USDA-Natural Resources Conservation Service (NRCS);
- Farm Service Agency (FSA); and
- County agencies, including the Health Departments, Soil and Water Conservation Districts (SWCDs), Engineer's Offices, and County Commissioners from Logan, Hardin and Auglaize counties.

Input and feedback was solicited from these stakeholders to help guide and formulate critical areas and potential projects within the **Indian Lake-Great Miami River HUC-12**. Chapters 1, 2 and 3 were primarily prepared using the *2020 Ohio Integrated Report* (Ohio EPA, 2020a), *Total Maximum Daily Loads (TMDL) for the Great Miami River Watershed* (Ohio EPA, 2012), *Biological and Water Quality Study of the Upper Great Miami River and Selected Tributaries 2008* (Ohio EPA, 2011) and the *Indian Lake Watershed Action Plan* (ILWP, 2009*)*. Project information for Chapter 4 was compiled by collaborative outreach with organizational stakeholders, community partners and local landowners, when possible. The *Indian Lake-Great Miami River HUC-12 NPS-IS* was developed during the Coronavirus Disease-19 (COVID-19) pandemic occurring in 2020-2021, limiting in-person meetings and gatherings. Organizational stakeholder input was solicited and received through interpersonal electronic communications, virtual meetings and phone calls. An organizational stakeholder meeting was held on February 4, 2021, and private landowner surveys soliciting project needs and interest were sent to 700 individuals across the entire Indian Lake watershed (North Fork, South Fork and Indian Lake sub-watersheds) in spring 2021. Landowner outreach was conducted on an individual basis, and project site visits were made in late 2021 in order to outline project components.

CHAPTER 2: HUC-12 WATERSHED CHARACTERIZATION AND ASSESSMENT SUMMARY

2.1 Summary of HUC-12 Watershed Characterization

2.1.1 Physical and Natural Features

The *Headwaters Great Miami River HUC-10* is comprised of three HUC-12 watersheds; this document focuses on the #03 hydrologic unit—the **Indian Lake-Great Miami River HUC-12**. The largest waterbody within this sub-watershed is Indian Lake, covering approximately 5,147 acres of open water (ILWP, 2009). Two named tributaries drain to Indian Lake in the sub-watershed. Van Horn Creek, a 3.6 mile-long stream, rises in southeastern Auglaize County, drains an area of approximately 3.4 square miles and has an average fall of 2.5 feet per mile (Ohio EPA, 2020c; USGS, 2021; ODNR, 2001). Blackhawk Run is ~3.3 miles long, drains a 5.61-acre area and has an average fall of 2.5 feet per mile. Both tributaries are designated as WWH (Ohio EPA, 2011). In total, the **Indian Lake-Great Miami River HUC-12** drains an area of 27.38 square miles (17,522.56 acres) and contains 44.4 miles (234,401 linear feet) of stream segments (Ohio EPA, 2020a).

The **Indian Lake-Great Miami River HUC-12** is located in the Eastern Corn Belt Plains (ECBP) ecoregion (Ohio EPA, 2011). The ECBP consists of a rolling till plain with local end moraines (USEPA, 2013). Wisconsinan glacial deposits are extensive across the ecoregion and supported beech forests prior to settlement. Most of the Upper Great Miami watershed lies within the Clayey High Till Plains, a transitional area between the Loamy High Till Plains, an area of loamy, limy glacial deposits with relatively good drainage and recharge by groundwater, and the Maumee Lake Plains, an area of poorly drained, clay-rich soils and low gradient streams. In the Clayey High Till Plains, soils are poorly drained and subject to high amounts of artificial drainage. Streams are channelized and maintained without riparian cover, and exceptional fish communities are rare in the turbid, low gradient streams of the region (Ohio EPA, 2011).

Bedrock in the Upper Great Miami watershed is mainly Silurian dolomite overlain by glacial drift in thicknesses up to 260 feet (ODNR, 2021b). Soils in the Headwaters Great Miami River watershed are primarily clay-rich, high in lime and derived from glacial material (ILWP, 2009). Eight major soil associations occur throughout the watershed. The two most extensive soil associations include the Blount-Morley and the St. Clair-Nappannee, both of which are characterized as finer-grained soils with the highest slope and erosion potential across the watershed (Figure 4). These soils cover 47% of the Indian Lake watershed and are moderately productive for row crop and small grain production (ILWP, 2009). The watershed's soils have low permeability, making most unsuitable for septic system development. Development across much of the watershed is also unsuitable due to other soil conditions, such as the presence of wetlands and prime farmland (ILWP, 2009).

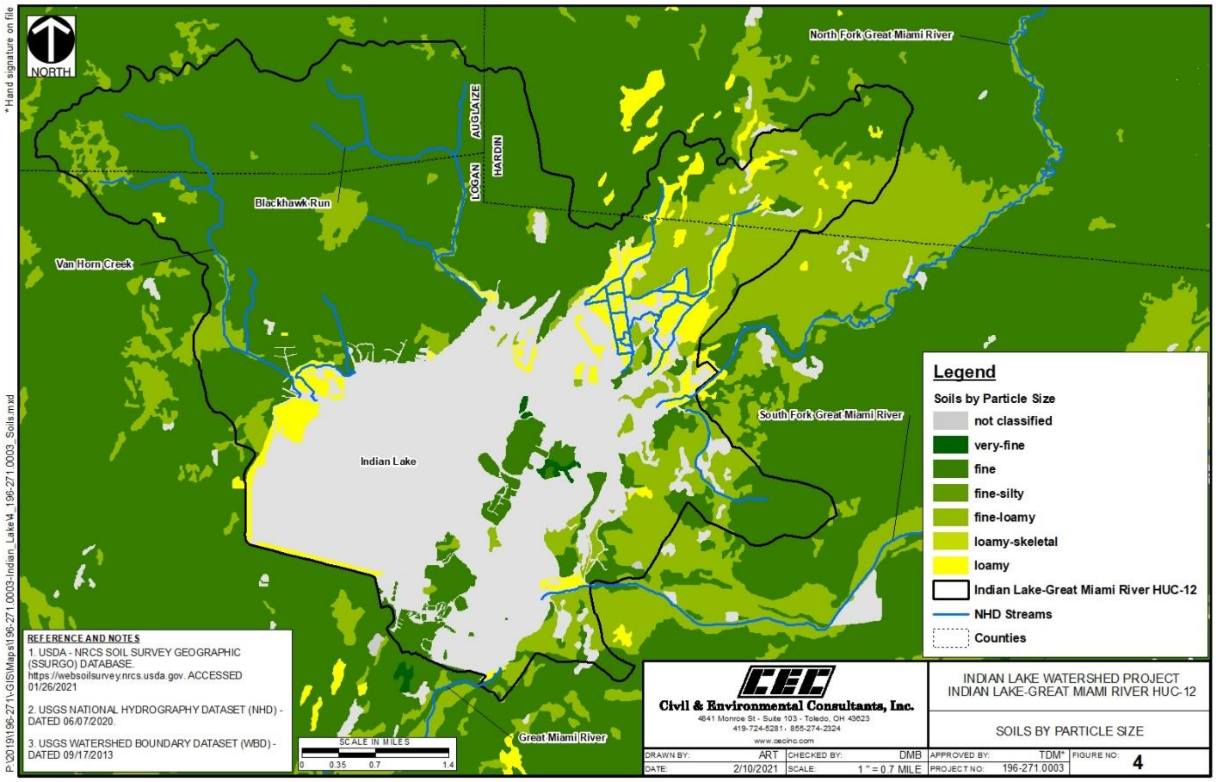

Figure 4: Soils Classified by Particle Size

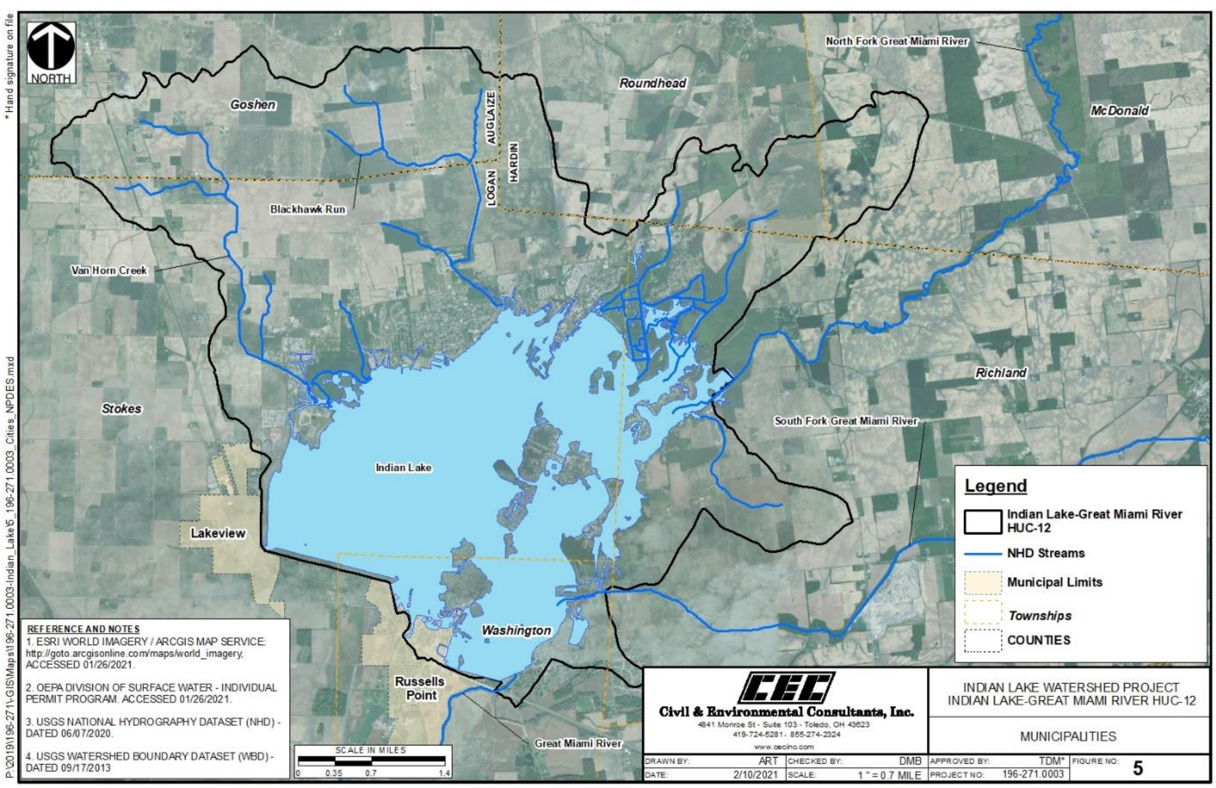

Figure 5: Municipalities

Urban land use within the **Indian Lake-Great Miami River HUC-12** occurs at a much higher rate (~10%) than in the North Fork Great Miami River HUC-12 (< 1%) and the South Fork Great Miami River HUC-12 (3%). Several islands within Indian Lake have been connected by roads and bridges allowing for the expansion and development of single family homes and condominiums (ILWP, 2009). In addition, many areas surrounding Indian Lake are becoming rapidly being developed to accommodate single family housing or overnight camping sites. The sub-watershed spans six townships: Goshen Township in Auglaize County, Roundhead and McDonald Townships in Hardin County, and Stokes, Washington and Richland Townships in Logan County (Figure 5). A small area of Russells Point is located within the boundaries of the sub-watershed, to the southwest of Indian Lake. Currently, no National Pollutant Discharge Elimination System (NPDES)-permitted facilities are located within the sub-watershed (Ohio EPA, 2021).

The Indian Lake Sanitary Sewer District was formed in the late 1930s and was originally comprised of the Russells Point and Orchard Island Areas (Logan County, 2021). In the 1940s and 1950s, the Village of Lakeview and the chain of islands referred to as the "Indian Isles" (Minnewauken, Tecumseh, Miami, Sunset, Sunrise, Cranetown, Seminole, Shawnee and Lake Ridge Islands) were added. The 1980s and 1990s saw the addition of Chippewa Park, Island View, Avondale, Sassafras Point, Turkeyfoot, King's Landing, Indian Lake Shores, Five Parks Allotment, Five Parks Addition, Waterbury, Smith Addition, Dunn's Pond, Bergs, Putterbaugh, Tracey Farm Addition, Long Island, O'Connor's Point, Blue Heron Cove, North Fork Area and the Village of Belle Center. The sanitary system runs to the Indian Lake Water Pollution Control Facility (located south of the Indian Lake watershed) and services over 14,000 customers (Ohio EPA, 2016a). Despite the large number of residences and businesses connected to sanitary sewer around Indian Lake, 1,002 HSTS were estimated to be within the **Indian Lake-Great Miami River HUC-12** by National Small Flows Clearinghouse Data from 1992 and 1998 (Tetra Tech, 2018). Studies conducted by the Ohio Department of Health (ODH) across Ohio have shown an average HSTS failure rate of 31% (ODH, 2013).

The Health Departments that operate within the watershed are focused on compliance with the Ohio Administrative Code related to HSTS operation and protection of water pollution. The Auglaize County Health Department performs inspections, enforces sewage regulations and provides education to homeowners (Auglaize County Health Department, 2021). The Logan County Health District also ensures protection of local waterways and offers homeowner assistance. The Logan County Health Department received $84,000 in 2018 and $150,000 in 2021 to help address failing septic systems or provide assistance in connection to sanitary sewers (Ohio EPA, 2018a; Ohio EPA, 2021b). The Logan County Health District also allows alternative technologies, such as constructed wetlands, on an experimental basis, as a means of providing additional options for landowners (LCHD, 2021). Though the amount of NPS pollution from HSTS in the **Indian Lake-Great Miami River HUC-12** is relatively small, repair or replacement of failing HSTS or connection to sanitary sewer lines reduces the potential for NPS pollution from this source.

Specific landmarks and features within this watershed include:

- Indian Lake State Park;
- Tilton Hilton;
- Smugglers' Cove Recreational Vehicle (RV) Family Camping;
- Geronimo Campgrounds;
- Welcome Woods RV and Tent;
- Indian Lake Community Church Fellowship Hall;
- Spend A Day Marina; and,
- Indian Hallow Campground and Vacation Cottages.

2.1.2 Land Use and Protection

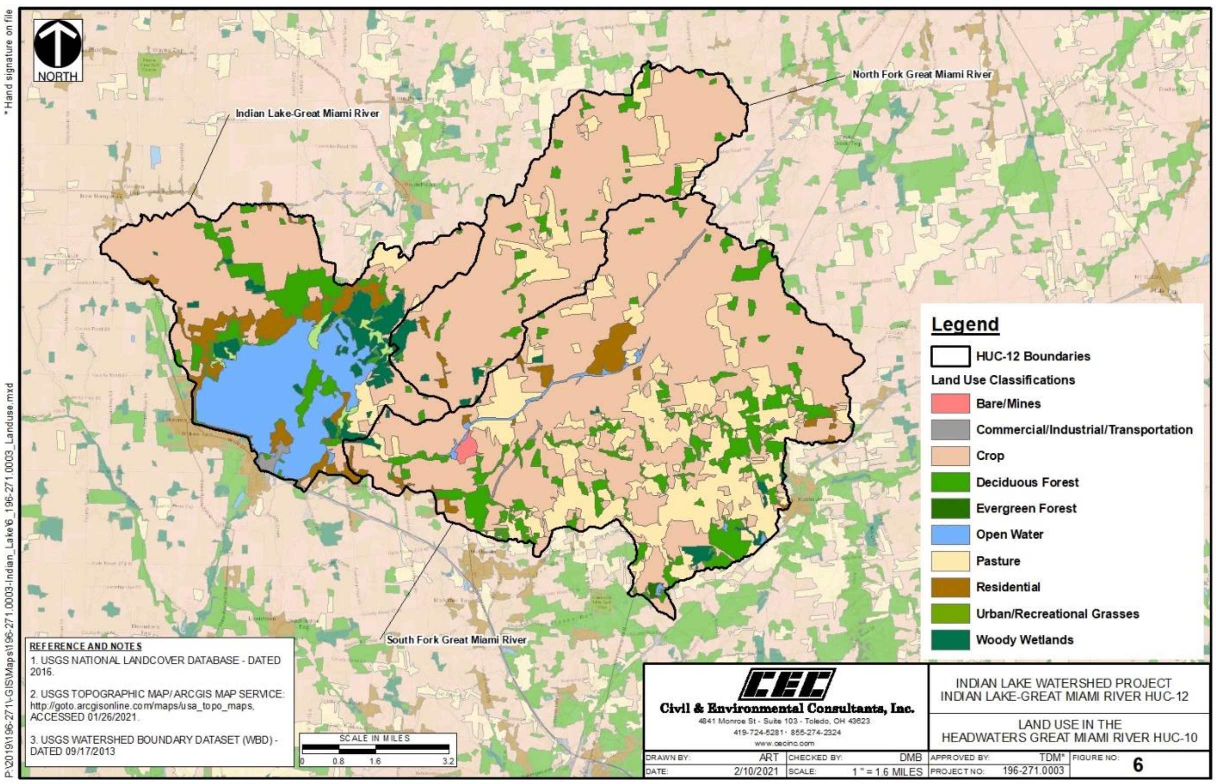

Figure 6: Land Use in the Headwaters Great Miami River HUC-10

Land use within the **Indian Lake-Great Miami River HUC-12** is the most diverse within the entire Indian Lake watershed. Like the greater Indian Lake watershed, the largest land use type within the sub-watershed maintains the rural activities of cultivated croplands (~42%) and pasture (~3%) (Figure 6). The USDA Census of Agriculture (2017) lists soybeans as the largest field crop harvested in Auglaize, Hardin and Logan Counties (≥ 45%), while corn accounts for 35-44% of crops (USDA, 2019). Wheat accounts for 5-9% of fields in Auglaize County, but less than 5% in Hardin and Logan. In general, livestock operations are small, though Auglaize and Hardin counties did realize a slight increase in inventory of dairy cattle in 2017 over 2012. No Concentrated Animal Feeding Operations (CAFOs) or Ohio Department of Agriculture (ODA)-permitted Confined Animal Feeding Facilities (CAFFs) are located within the sub-watershed. An estimate of the animals existing in the **Indian Lake-Great Miami River HUC-12** is listed in Table 3.

Table 3: Estimated Animal Counts in the Indian Lake-Great Miami River HUC-12

Livestock Type	Animal Units	Livestock Type	Animal Units
Beef	124	Horse	16
Dairy	78	Chicken	997
Swine	1,157	Turkey	3
Sheep	26	Duck	3

(Source: USDA Census of Agriculture, 2012, as presented in the STEPL Input Data Server (Tetra Tech, 2017)

Open water constitutes 25% of the land acres in the **Indian Lake-Great Miami River HUC-12** (Table 4). Approximately 11% of land in the sub-watershed is forested. The forested stands are mainly concentrated in pockets around Indian Lake, but fragmented stands are scattered throughout the northern portion of the sub-watershed. Concentrated woody wetlands are found within Indian Lake State Park. The State Park is one of two protected lands listed within the United States Geological Survey's (USGS) Protected Areas Database of the United States (PAD-US) (Figure 7). Historically, the northeastern section was known as the "Game Preserve", but is currently fragmented by ongoing dredging (ODNR, 2021). Extensive wetland areas are shown in the National Wetland Inventory (NWI) extending from Indian Lake to the northeast and southeast (USFWS, 2020)(Figure 8). One wetland area consisting of 105 acres is under private conservation easement (Table 5).

Table 4: Land Use Classifications in the Indian Lake-Great Miami River HUC-12

Land Use	Indian Lake-Great Miami River HUC-12 (05080001 01 03)		
	Area (mi^2)	Area (acres)	% Watershed Area
Commercial/Industrial/Transportation	0.21	137	0.78%
Crop	11.45	7,321	41.81%
Deciduous Forest	3.05	1,954	11.15%
Herbaceous Wetlands	0.43	278	1.59%
Open Water	6.85	4,386	25.02%
Pasture	0.83	529	3.02%
Residential	2.54	1,626	9.27%
Woody Wetlands	2.02	1,292	7.37%
Total	**27.38**	**17,523**	**100.00%**

(Source: Homer et al., 2020)

Table 5: Parks and Protected Lands in Indian Lake-Great Miami River HUC-12

Name	Acreage	Description
Indian Lake State Park	6,473	State Park; managed by ODNR
Private lands	105	Conservation easement through the WRP

(Source: USGS, 2019)

NOTES
WRP Wetlands Reserve Program
ODNR Ohio Department of Natural Resources

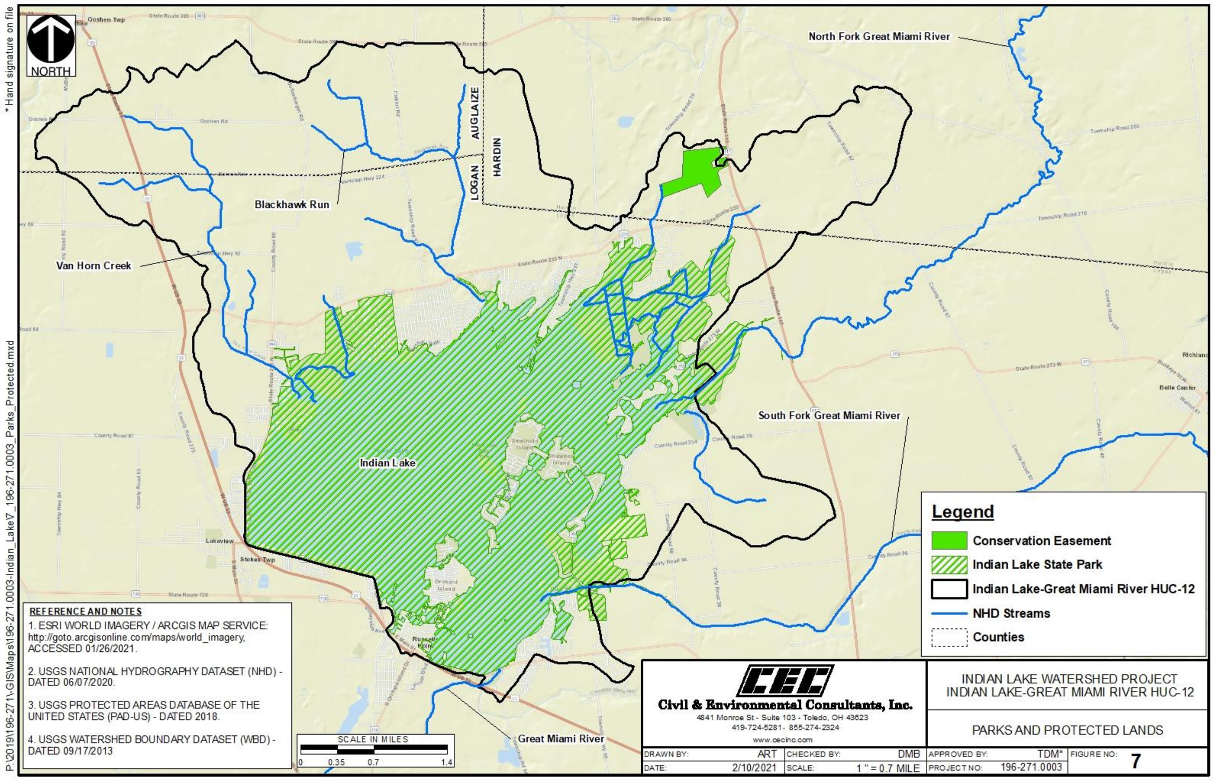

Figure 7: Parks and Protected Lands

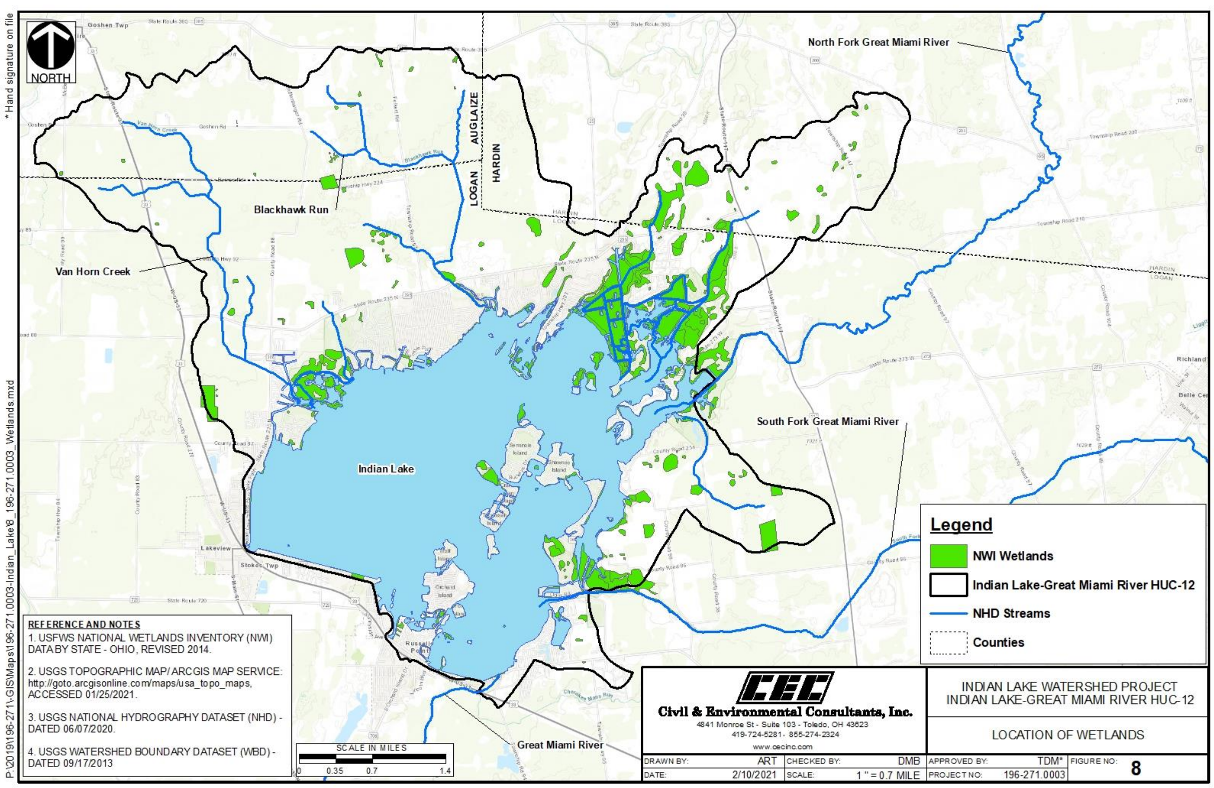

Figure 8: Wetlands within the Indian Lake-Great Miami River HUC-12

The on-going protection of the State Park may provide necessary habitat for threatened or endangered species listed in Auglaize and Logan counties by the United States Fish and Wildlife Service (USFWS) (Table 6). While threatened and endangered mussels may be found in Logan County, it is unlikely that they will be found within the Van Horn Creek and Blackhawk Run. Neither tributary is currently listed in Appendix A of the *Ohio Mussel Survey Protocol*, indicating that mussels may be present, but the Federally Listed Species (FLS) on USFWS's listing are not expected to be found (ODNR, 2020).

Table 6: Threatened and Endangered Species in Auglaize, Hardin and Logan Counties

Species	Status	Habitat Characteristics
Indiana bat[1] (Myotis sodalis)	Endangered	Hibernates in caves and mines and forages in small stream corridors with well-developed riparian woods, as well as upland forests
Northern long-eared bat[1] (Myotis septentrionalis)	Threatened	Hibernates in caves and mines and swarms in surrounding wooded areas in autumn; roosts and forages in upland forests during late spring and summer
Eastern massasauga[2] (Sistrurus catenatus)	Threatened	Wetlands and adjacent uplands
Copperbelly watersnake[3] (Nerodia erythrogaster neglecta)	Threatened	Wooded and permanently wet areas including oxbows, sloughs, brushy ditches and floodplain woods
Clubshell[3] (Pleurobema clava)	Endangered	Found in coarse sand and gravel areas of runs and riffles within streams and small rivers
Rayed bean[2] (Villosa fabalis)	Endangered	Smaller, headwater creeks, but they are sometimes found in large rivers

(Source: USFWS, 2018)

NOTES
1 Listed in all three counties
2 Listed in Hardin and Logan County
3 Listed in Hardin County only

Van Horn Creek and Blackhawk Run are direct tributaries to Indian Lake, which is regularly monitored to ensure recreational standards are met. Three beach areas in Indian Lake have enacted advisories related to high bacterial levels since 2013 (Table 7). While bacterial sampling conducted by Ohio EPA in 2008 and 2009 indicated *Non-Attainment* of the Primary Contact Recreation (PCR) use for elevated levels of *Escherichia coli* (*E. coli)*, neither tributary within the **Indian Lake-Great Miami River HUC-12** was sampled, despite their PCR use designation. The *Non-Attainment* status in streams outside of the sub-watershed was attributed to agricultural runoff and failing HSTS. However, no advisories within Indian Lake have been issued related to toxins associated with Harmful Algal Blooms (HABs). Since 2014, the ILWP has sampled the lake for microcystin during the recreational season. To date, all samples have fallen below the Ohio EPA Recreational Advisory Level of 6.0 ug/L (micrograms per liter), with the highest recorded value at 1.5 ug/L.

Table 7: Historic Beach Water Quality Advisories in Indian Lake

Beach Site	Year	Days Under Advisory	Type of Advisory
Camp	2020	12	High bacterial levels
	2019	2	High bacterial levels
	2018	3	High bacterial levels
	2017	6	High bacterial levels
	2015	6	High bacterial levels
Fox Island	2020	10	High bacterial levels
	2019	6	High bacterial levels
	2017	6	High bacterial levels
	2016	7	High bacterial levels
	2015	6	High bacterial levels
Oldfield	2020	10	High bacterial levels
	2019	2	High bacterial levels
	2015	6	High bacterial levels
	2013	4	High bacterial levels

(Source: ODH, 2021)

The ODNR actively manages Indian Lake for noxious weeds (Eurasian water milfoil) through both physical and chemical means. In 2021, Indian Lake experienced a significant increase in aquatic vegetation growth, prompting the purchase of an additional weed harvester by the ILWP to physically remove the weeds from the bottom of the lake. The exceptional lake clarity in 2021 was prompted by little spring precipitation, which typically brings an influx of sediments into the lake. Clear waters, coupled with excessive nutrients in the system, created an ideal growth situation for the noxious weed. The ODNR is carefully monitoring the situation to find balance between harvesting to open up recreational channels and removing too much vegetation which absorbs nutrients and helps prevent HABs within the lake (ODNR, 2021a).

Weed harvester.
Photo from the ILWP website.

Most land within the **Indian Lake-Great Miami River HUC-12** is privately owned; therefore, knowledge of conservation practices may be limited. From the early 1990s to 2009, the ILWP has partnered with many stakeholder groups to administer more than $2.3 million towards conservation practices. Over the last three years, the NRCS has provided over $600,000 for the planting of cover crops and nutrient management techniques, mainly within the Hardin County portion of the Indian Lake watershed. These efforts have led to some of the success in combatting the formation of HABs within Indian Lake. While some of those early conservation efforts are still ongoing, the ILWP recognizes the need to continue conservation work to engage new landowners or re-engage landowners who may have abandoned practices over time.

Some current conservation practices, such as the use of conservation tillage, can be estimated from remote sensing techniques used within the Operational Tillage Information System (OpTIS). From 2014-2018, OpTIS estimated an average of 37.9% of crop fields in the Upper Great Miami watershed were under no-till conditions, 51.9% were under some form of reduced tillage and 10.2% were under traditional tillage regimes (Dagan, 2019). OpTIS also estimated cover crop usage across the Upper Great Miami River watershed to average 3.0% of fields utilized a winter commodity crop, while 2.5% utilized a winter cover crop over the same five-year period. County-wide estimations were not consistently above or below these HUC-8 averages (Table 8).

Summary data provided by Ohio EPA regarding the use of the Environmental Quality Incentives Program (EQIP) within the **North Fork Great Miami River HUC-12** indicated no practices were certified after March 30, 2017 (USDA-NRCS, 2018). Additional data provided by the FSA on current contracts within the counties of the Indian Lake watershed are found in Table 9.

Table 8: OpTIS Countywide Conservation Practice Averages for 2014-2018 for Counties in the Indian Lake Watershed

	Upper Great Miami HUC-8	Auglaize	Hardin	Logan
Practice	% Usage	% Usage	% Usage	% Usage
No-till conditions	37.9	28.7	31.0	44.7
Reduced till conditions	51.9	54.9	51.3	47.0
Conventional till	10.2	16.3	17.7	5.7
Winter commodity cover crop	3.0	5.2	3.2	2.0
Winter cover crop	2.5	3.3	1.7	2.0

(Source: Dagan, 2019; provided by The Nature Conservancy in 2021)

Table 9: Conservation Reserve Program (CRP) Contract Acreage by County

	Auglaize	Hardin	Logan
Practice	Acres*	Acres*	Acres*
Establishment of Permanent Introduced Grasses and Legumes	44.31	248.01	59.43
Vegetative Cover – Grass – Already Established	--	11.30	17.00
Wildlife Food Plot	1.00	2.00	--
Shelterbelt Establishment	2.28	5.00	--
Establishment of Permanent Native Grasses	130.09	541.36	673.65
Filter Strips	1,839.95	1,784.58	448.26
Riparian Buffer	160.11	18.94	36.60
Wetland Restoration	25.69	35.46	50.00
Wetland Restoration, Non-Floodplain	407.74	168.69	42.98
Rare and Declining Habitat	46.01	55.20	25.71
Farmable Wetland Program	--	28.10	--
Tree Planting	--	10.30	34.70
Upland Habitat Buffers	205.93	238.74	86.46
Wildlife Habitat for Pheasants	1,098.90	3,065.43	1,556.42
Hardwood Tree Planting	11.84	64.65	91.70
Pollinator Habitat	20.01	85.54	138.94
Permanent Wildlife Habitat, Noneasement	64.62	299.70	3.00
Grassland Wildlife Plan	155.97	--	23.01

Field Windbreak Establishment, Noneasement	115.48	79.08	--
Grass Waterways, Noneasement	295.45	403.70	347.80
Shallow Water Areas for Wildlife	--	--	7.01

(Source: USDA-NRCS, 2018)

NOTES
**Acres reported at the county level and may not necessarily fall within the Indian Lake watershed boundaries.*

2.2 Summary of HUC-12 Biological Trends

Ohio EPA sampled the Upper Great Miami River watershed in 2008 and 2009 as part of a TMDL study for the Great Miami River. TMDL targets were established for habitat within the **Indian Lake-Great Miami River HUC-12**. In total, eleven locations were sampled within the headwaters section of the Great Miami River, one of which is located within the **Indian Lake-Great Miami River HUC-12**. Van Horn Creek was the only stream within the *Headwaters Great Miami River HUC-10* to not attain WQS. A summary of sample locations is provided in Table 10. For reference, WQS for the ECBP ecoregion are presented in Table 11.

Table 10: Biological Indices Scores for Sites in Indian Lake-Great Miami River HUC-12

Indian Lake-Great Miami River HUC-12 (05080001 01 03)							
River Mile	Drainage Area (mi^2)	IBI	MIwb[a]	ICI[b]	QHEI	Attainment Status	Location
Van Horn Creek (WWH)							
0.97[H]	2.8	34*	N/A	F*	60.5	Non	State Route 366

(Source: Ohio EPA, 2011)

NOTES
IBI Index of Biotic Integrity
a The Modified Index of Well Being (MIwb) is not applicable to headwater sites (drainage ≤20 mi2).
ICI Invertebrate Community Index
b Narrative evaluation used in lieu of ICI (E=Exceptional; G=Good; MG=Marginally Good; H Fair =High Fair; F=Fair; L Fair=Low Fair; P=Poor; VP=Very Poor).
QHEI Qualitative Habitat Evaluation Index
H Headwaters site
ns Nonsignificant departure from ecoregion biocriteria (≤4 IBI or ICI units, ≤0.5 MIwb units).
** Significant departure from applicable biocriteria (>4 IBI or ICI units, or >0.5 MIwb units). Underlined scores are in the poor to very poor range.*
N/A Not applicable
WWH Warmwater Habitat

Table 11: Water Quality Standards for the Eastern Corn Belt Plains (ECBP) Ecoregion

ECBP Ecoregion	EWH WQS			WWH WQS			MWH WQS		
	Headwaters	Wading	Boat	Headwaters	Wading	Boat	Headwaters	Wading	Boat
IBI	50	50	48	40	40	40	24	24	24
MIwb	N/A	9.4	9.6	N/A	8.3	8.5	N/A	6.2	5.8
ICI	46	46	46	36	36	36	22	22	22
QHEI[a]	75	75	75	55	60	60	43.5	43.5	43.5

(Source: Ohio EPA, 2011)

NOTES

EWH *Exceptional Warmwater Habitat*
WWH *Warmwater Habitat*
MWH *Modified Warmwater Habitat*
WQS *Water Quality Standards*
a *QHEI is not criteria included in Ohio WQS; however, it has been shown to be highly correlated with the health of aquatic communities. In general, sites scoring 60 or above (or above 55 for headwaters sites) support healthy aquatic assemblages indicative of WWH (Ohio EPA, 2013). Sites scoring 75 or above support EWH assemblages (Ohio EPA, 1999).*
N/A *MIwb not applicable to headwaters sampling locations with drainage areas ≤ 20 mi2.*

Fishes (Modified Index of Well-Being (MIwb] & Index of Biotic Integrity [IBI])

In general, fish assemblages within the headwaters section of the Great Miami River performed well. In 2008-2009, ten of eleven sites were in *Full Attainment* of biological water quality standards; however, Van Horn Creek was the only site to not achieve attainment. Fish communities in Van Horn Creek did not meet the standards for the WWH designation. Van Horn Creek is one stream within the Indian Lake watershed that does not have a strong connection to groundwater; therefore, habitat alterations resulting from agricultural drainage maintenance activities increase the impact to flow regimes and aquatic communities, especially in times of infrequent precipitation and lower baseflow. Target reference levels for nutrients were generally met; however, dissolved oxygen (DO) levels dropped below WWH criteria in late summer as flows diminished (Ohio EPA, 2011).

Macroinvertebrates (Invertebrate Community Index [ICI])

Generally, benthic communities within the headwaters section of the Great Miami River met attainment thresholds; however, benthic communities within Van Horn Creek were of fair quality, scoring below the WWH criteria. Community diversity was low, yielding only five facultative *Ephemeroptera, Plecoptera and Trichoptera* (EPT) taxa and five pollution sensitive species. Residual pesticide contamination within the sediments of Van Horn Creek is also present, though impacts to the benthic community is thought to be negligible (Ohio EPA, 2011).

Habitat (via Qualitative Habitat Evaluation Index [QHEI])

Ohio EPA sampling crews documented various water quality and habitat attributes during the QHEI assessment in the summer of 2008 (Table 12). Habitat in the Indian Lake watershed is generally favorable, and habitat in Van Horn Creek was similar, scoring 60.5 (Ohio EPA, 2011). Strong correlations exist between habitat attributes and a stream's ability to support healthy aquatic assemblages (Ohio

EPA, 1999). The presence of certain attributes are shown to have a larger negative impact on fish and macroinvertebrate communities. Streams designated as WWH should exhibit no more than four total Modified Warmwater Habitat (MWH) attributes; additionally, no more than one of those four should be of high-influence (Ohio EPA, 2013). Within the boundaries of the **Indian Lake-Great Miami River HUC-12**, Van Horn Creek exhibited two high-influence MWH attributes related to historical channelization. Van Horn Creek also demonstrated a total of five moderate-influence MWH attributes, including heavy/moderate silt cover, fair/poor development, low current, and high embeddedness. Continued excessive sedimentation and associated nutrient loss from land use practices within the sub-watershed's boundaries is a concern for maintenance of water quality both within the stream and within Indian Lake.

Table 12: QHEI Matrix with WWH and MWH Attribute Totals for Sites in the Indian Lake-Great Miami River HUC-12

Indian Lake-Great Miami River HUC-12 (05080001 01 03)																																
Key QHEI Components			WWH Attributes											MWH Attributes																		
														High Influence						Moderate Influence												
River Mile	QHEI Score	Gradient (ft/mi)	Not Channelized or Recovered	Boulder/Cobble/Gravel Substrate	Silt Free Substrates	Good/Excellent Development	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low/Normal Embeddedness	Max Depth >40 cm	Low/No Riffle/Run Embeddedness	WWH Attributes	Channelized/No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth <40 cm	High-Influence MWH Attributes	Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrate (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1 or 2 Cover Types	Intermediate/Poor Pools	No Fast Current	High/Moderate Embeddedness	High/Moderate Riffle Embeddedness	No Riffle	Moderate-Influence MWH Attributes
Van Horn Creek (WWH)																																
0.97^H	60.5	9.8		•				•		•	•	•	5	•		•			2	•	•			•				•	•			5

(Source: Ohio EPA, 2011)

NOTES
QHEI *Qualitative Habitat Evaluation Index*
WWH *Warmwater Habitat*
MWH *Modified Warmwater Habitat*
H *Headwaters site*

2.3 Summary of HUC-12 Pollution Causes and Associated Sources

As shown in the 2011 *Biological and Water Quality Study of the Upper Great Miami River and Selected Tributaries 2008*, one biological sampling site in the **Indian Lake-Great Miami River HUC-12** is not meeting attainment of the WWH designation due to underperforming fish and macroinvertebrate communities (Table 13). Near-field impairment in Van Horn Creek is primarily driven by habitat alteration, a result of agricultural drainage maintenance activities. In addition to habitat alterations, the resulting excessive sedimentation that accompanies channelization is a potential threat that may cause additional stress to aquatic communities. Loss of sediment from the surrounding landscape also implies loss of nutrients, including nitrogen and phosphorus, as a fraction of these nutrients introduced to the landscape through fertilization techniques and other sources bind to soil particles. As soil particles are lost to local waterways, nutrients can become available for microorganism uptake, and in situations where nutrients concentrate and are overabundant, such as inland lakes like Indian Lake, the risk of HAB formation increases. In addition to adsorbed nutrients, water soluble factions, particularly nitrates from the nitrification process, are prone to leaching or denitrification in saturated soil conditions (OSU Extension, 2018). Actions taken to manage nutrient-laden water by retaining it and promoting assimilation help reduce the influx of nutrients to local waterways.

Table 13: Causes and Sources of Impairments for Sampling Locations in the Indian Lake-Great Miami River HUC-12

Indian Lake-Great Miami River HUC-12 (05080001 01 03)				
River Mile	**Primary Cause(s)**	**Primary Source(s)**	**Attainment Status**	**Location**
Van Horn Creek (WWH)				
0.97[H]	Habitat alterations	Channelization	Non	State Route 366

(Source: Ohio EPA, 2011)

NOTES
WWH Warmwater Habitat
H Headwaters site

While no near-field impairments currently exist in this sub-watershed, the presence and persistence of the hypoxic zone within the Gulf of Mexico has shown the need for reduced NPS pollution, particularly in regards to nitrogen, and to a lesser extent phosphorus, throughout the entire MARB, of which the Ohio River is a main tributary. Nitrogen loss within the **Indian Lake-Great Miami River HUC-12** contributes to this far-field impairment. Ohio EPA has estimated nitrogen loadings from individual sub-watersheds in targeted areas of the ORB. These estimates include a breakdown of estimated loads from contributing sources of NPS pollutants, including agricultural lands/activities and developed/urban lands (Table 14). Efforts to reduce nutrients from each of these contributing sources will focus on reaching the 20% reduction goal by 2025, as outlined by the HTF in 2014.

Table 14: Estimated Nutrient Loadings from Contributing NPS Sources in the Indian Lake-Great Miami River HUC-12

	Agricultural Load (lbs/yr)		**Developed/Urban Load (lbs/yr)**	
	Total Nitrogen	**Total Phosphorus**	**Total Nitrogen**	**Total Phosphorus**
Current Estimates*	110,000	7,000	13,000	790
Target Loadings	88,000	5,600	10,400	630

(Source: Ohio EPA, 2021a)

NOTES
**Estimated using two significant figures*

2.4 Additional Information for Determining Critical Areas and Developing Implementation Strategies

Assessment data from the 2008-2009 study and data referenced in the 2011 *Biological and Water Quality Study of the Upper Great Miami River, 2008, Technical Report EAS/2013-05-06*, the *Total Maximum Daily Loads for the Great Miami River (upper) Watershed* and the *2020 Integrated Report* were used in the development of this NPS-IS (Ohio EPA, 2011; Ohio EPA, 2012; Ohio EPA, 2020a). Additional information was gleaned from the *Indian Lake WAP* (ILWP, 2009). Any additional documents and/or studies created by outside organizations that were used as supplemental information to develop this NPS-IS are referenced in Chapter 5 (Works Cited), as appropriate.

CHAPTER 3: CRITICAL AREA CONDITIONS AND RESTORATION STRATEGIES

3.1 Overview of Critical Areas

Only one sampling site is located within the **Indian Lake-Great Miami River HUC-12** in Van Horn Creek, which is currently in *Non-Attainment* of its WWH designation due to habitat alterations from channelization. Restoration of NPS impairments, reduction in overall sediment and nutrient loss and restoration of streambanks, floodplains and wetlands within the **Indian Lake-Great Miami River HUC-12** is crucial to the attainment of ALU standards both within the Indian Lake watershed and on a greater scale within the context of the Ohio River watershed, the Mississippi River and its end-receiving waterbody, the Gulf of Mexico. Three critical areas have been identified within the **Indian Lake-Great Miami River HUC-12**. Two critical areas will address far-field impacts of nutrients and sediments flowing to the Ohio River, Mississippi River and Gulf of Mexico, the end receiving waterbody of drainage from the **Indian Lake-Great Miami River HUC-12**, while a third critical area will address habitat alterations and channelization effects that contribute to near-field impairment (Figure 9).

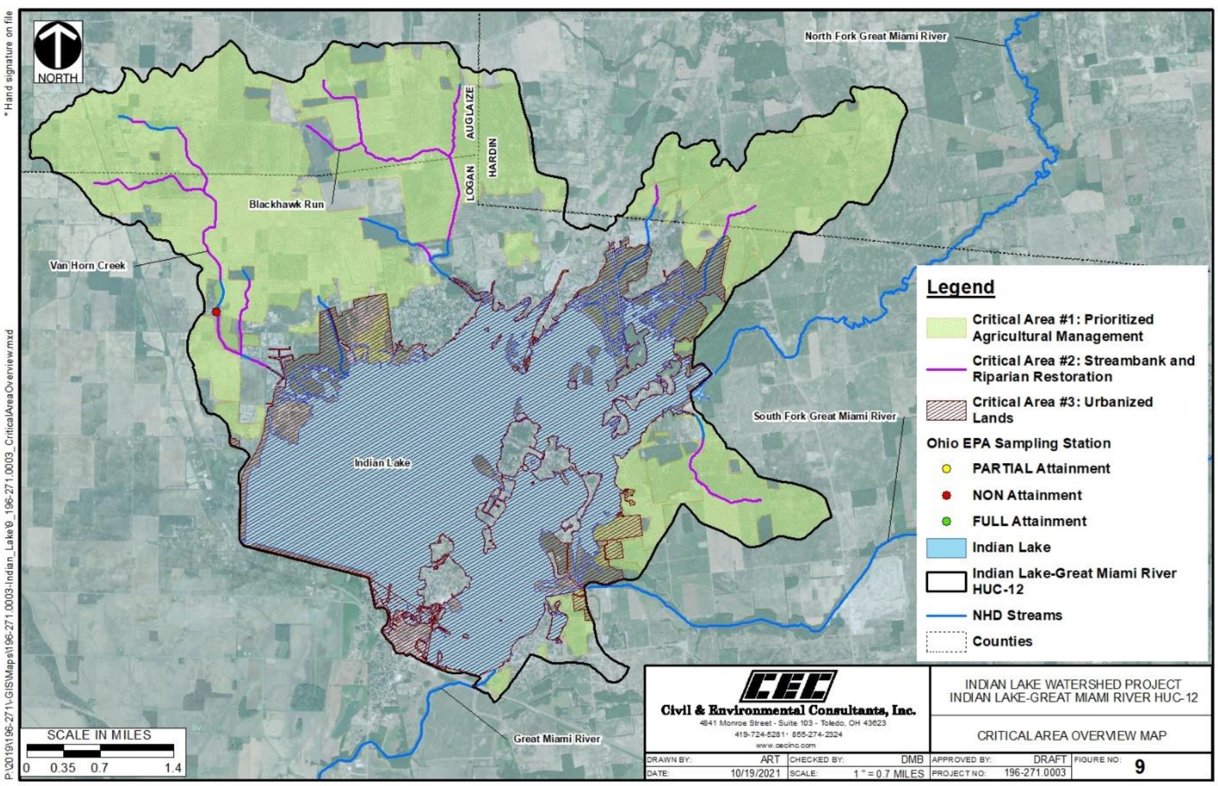

Figure 9: Indian Lake-Great Miami River HUC-12 Critical Area Overview

Many agricultural BMP implementation activities nested within this sub-watershed also simultaneously benefit near-field effects in Van Horn Creek and other Indian Lake tributaries through sediment reduction. Because many of these BMPs offer dual benefits of nutrient and sediment reduction and agricultural land prioritization is not substantially different for nutrient and sediment reduction within this sub-watershed, the critical areas for these land use categories address both near-field and far-field impacts (Table 15). Subsequently, the critical area designated for near-field impairment offers benefits to far-field receiving waterbodies through sediment (and associated nutrient) reduction opportunities. Additional critical areas may be developed in subsequent versions of this NPS-IS.

Table 15: Indian Lake-Great Miami River HUC-12 Critical Area Descriptions

Critical Area Number	Critical Area Description	NPS Pollutant Addressed	Focus Area
1	Prioritized Agricultural Land Management	Sediment and nutrients	Far-field (with near-field effects)
2	Streambank and Riparian Restoration	Sediment and nutrients	Near-field
3	Urban Nutrient Reduction	Sediment and nutrients	Far-field (with near-field effects)

3.2 Critical Area #1: Conditions, Goals & Objectives for Prioritized Agricultural Lands

3.2.1 Detailed Characterization

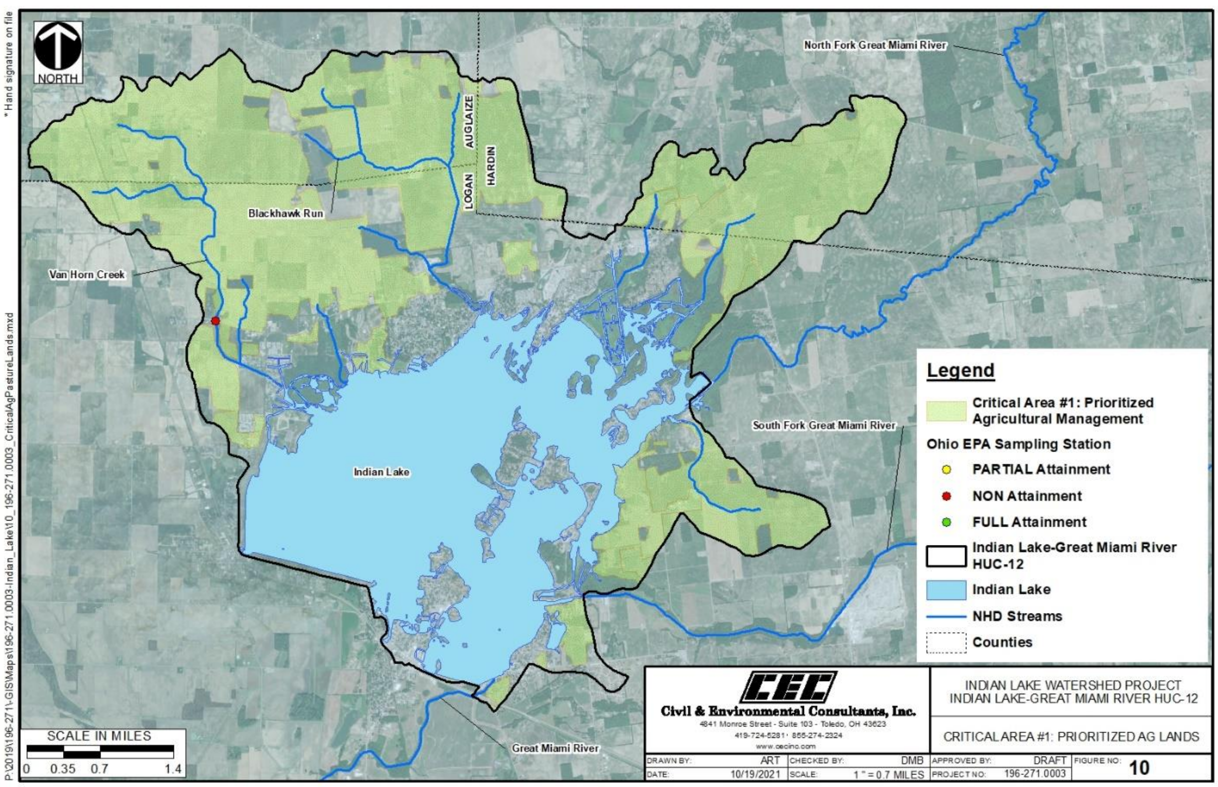

Figure 10: Indian Lake-Great Miami River HUC-12 Critical Area #1

Ohio's *Nutrient Mass Balance Study* (Ohio EPA, 2020c) estimated 83% of the nitrogen nutrient loading and 66% of the phosphorus nutrient loading to the Ohio River via the Great Miami River was primarily from nonpoint sources, related to land use activities, with much smaller contributions from failing HSTS and NPDES-permitted facilities. Given the dominance of agricultural land use throughout the greater

Miami River watershed, the use of BMPs are recommended for agricultural operations to minimize nutrient and associated sediment loss to local waterways and drainage ditches through surface and tile flow. While BMPs are encouraged on all agricultural lands, certain lands are more prone to nutrient loss than others and are prioritized for BMP implementation. Lands maintained under conventional agricultural production or managed as pasture are prone to contribute excessive sediment and nutrient loadings to adjacent waterways that eventually flow to the ORB. Lands that are proximal to streams and ditches or do not currently implement specific BMPs are most vulnerable to excessive nutrient and sediment loss, and these lands are also prioritized as critical within this watershed. *Critical Area #1* contains prioritized agricultural lands throughout the **Indian Lake-Great Miami River HUC-12** (Figure 10).

An Agricultural Conservation Planning Framework (ACPF) database was assembled for the **Indian Lake-Great Miami River HUC-12**. The Geographic Information System (GIS)-based tool utilizes input data including a high resolution digital elevation model (DEM), the National Cropland Data Layer (CDL), parcel boundary details and detailed soil surveys to identify potential areas for conservation practices. Results from this tool informed the prioritization of critical lands and objective building (Table 18). The ACPF identified 1,233 acres of high-runoff risk fields (very high + high), which accounts for approximately 17% of all croplands within the sub-watershed.

Table 16: Agricultural Conservation Planning Framework Results

Indian Lake-Great Miami River HUC-12 (05080001 01 03)			
Critical Runoff Risk (acres)*			
Very High	**High**	**Moderate**	**Low**
61	1,172	4,161	4,736
Best Management Practice	**Number of Potential Locations**	**Total Size**	**Treated Acreage**
Grassed waterways	1	469 miles	--
Saturated buffers	36	11.48 miles	3,178
Drainage water management structures	77	--	3,036
Bioreactors	64	--	3,246
Nutrient removal wetlands	1	56 acres (pool) 194 (vegetated buffer)	3,023^
Water and Sediment Control Basins (WASCOBs)	3	--	16

(Source: ACPF model run by The Nature Conservancy)

NOTES

* *The ACPF model analyzes drainage area based upon high-resolution imagery. Watershed boundaries may be redrawn based upon drainage patterns and extend beyond current USGS HUC-12 boundaries; therefore, acreage may not be equal to acreage calculated for the USGS HUC-12s.*

^ *Treated wetland acres may overlap, based on placement of nutrient removal wetlands or may contain acreage outside of the HUC-12 watershed boundaries.*

Of the 7,850 agricultural acres in the **Indian Lake-Great Miami River HUC-12**, prioritized lands are operations that meet one or more of the following criteria:

- Lands directly adjacent to streams or drainage waterways;
- Lands in need of surface water management for runoff or erosion;
- Lands with uncontrolled or unfiltered subsurface drainage water; and,
- Lands without a current (<3 years) nutrient management plan or soil test.

3.2.2 Detailed Biological Conditions

Fish community data for the sampling site in **Indian Lake-Miami River HUC-12** is summarized below (Table 17). Analysis of the abundance, diversity and pollution tolerance of existing fish species found by Ohio EPA at each sampling location, in relation to the corresponding QHEI score, aids in the identification of causes and sources of impairment. Van Horn Creek is one stream within the Indian Lake watershed that does not have a strong connection to groundwater; therefore, habitat alterations resulting from agricultural drainage maintenance activities increase the impact to flow regimes and aquatic communities, especially in times of infrequent precipitation and lower baseflow. In 2008, baseflow within the ditch had subsided to a trickle (Ohio EPA, 2011). Fish populations within Van Horn Creek were generally dominated by pollution tolerant species, including creek chub and bluntnose minnow.

Table 17: Critical Area #1 - Fish Community and Habitat Data

Indian Lake-Great Miami River HUC-12 (05080001 01 03)							
RM	Drainage Area (mi^2)	Total Species	QHEI	IBI	MIwb[a]	Predominant Species (Percent of Catch)	Narrative Evaluation
Van Horn Creek (WWH)							
0.97[H]	2.8	16	60.5	34*	N/A	Creek chub (24%), bluegill sunfish (16%), bluntnose minnow (14%)	Fair

(Source: Ohio EPA, 2011)

NOTES
IBI *Index of Biotic Integrity*
a *The Modified Index of Well Being (MIwb) is not applicable to headwater sites (drainage ≤20 mi2).*
QHEI *Qualitative Habitat Evaluation Index*
H *Headwaters site*
*** *Significant departure from applicable biocriteria (>4 IBI or ICI units, or >0.5 MIwb units). Underlined scores are in the poor to very poor range.*
N/A *Not applicable*
WWH *Warmwater Habitat*

Characteristics of the aquatic macroinvertebrate community for the **Indian Lake-Great Miami River HUC-12** are summarized below (Table 18). Analysis of the abundance, diversity, and pollution tolerance of existing aquatic macroinvertebrates found by Ohio EPA at these sampling locations, related to QHEI scores, can aid in the identification of causes and sources of impairment. Benthic communities within Van Horn Creek were of fair quality, scoring below the WWH criteria. Community diversity was low, yielding only five facultative EPT taxa and five pollution sensitive species, likely in relation to substrate embeddedness, heavy silt cover and lack of fast current. Residual pesticide contamination within the sediments of Van Horn Creek is also present, though impacts to the benthic community is thought to be negligible (Ohio EPA, 2011).

Table 18: Critical Area #1 - Macroinvertebrate Community Data

Indian Lake-Great Miami River HUC-12 (05080001 01 03)			
River Mile	**ICI Score-Narrative[a]**	**Notes (Density of Ql./Qt.)**	**Predominant Species**
Van Horn Creek (WWH)			
0.97[H]	N/A - Fair 5 sensitive taxa	Moderate qualitative density	Minnow mayflies, blackflies, flatworms (F)

(Source: Ohio EPA, 2011)

NOTES

H Headwaters site

a Narrative evaluation used in lieu of ICI (E=Exceptional; G=Good; MG=Marginally Good; H Fair =High Fair; F=Fair; L Fair=Low Fair; P=Poor; VP=Very Poor).

N/A Not applicable

3.2.3 Detailed Causes and Associated Sources

The single sampling location in Van Horn Creek in the **Indian Lake-Great Miami River HUC-12** is currently in *Non-Attainment* of the WWH designation due to habitat alterations caused by channelization. The data summarized previously in Table 12 (p.19) reveal a direct link between the presence of attributes in the watershed that have influence on the aquatic communities throughout the Van Horn Creek and other Indian Lake tributaries in *Critical Area #1*. These contributing attributes in *Critical Area #1* include:

- Channelization/No Recovery;
- Heavy/Moderate Silt Cover;
- Fair/Poor Development;
- Sparse/No Cover; and
- High/Moderate Embeddedness.

Many of the habitat attributes found during the QHEI sampling event (i.e., heavy silt cover, substrate embeddedness, etc.) are likely a result of land use activities, which includes impacts from agricultural operations within the watershed. From a far-field perspective, agricultural land use activities contribute to excessive nutrient loadings to the Ohio River, eventually reaching the Mississippi and then the Gulf of Mexico, contributing to its extensive hypoxic zone. The use of a variety of BMPs on private agricultural lands, at both in-field and edge-of-field locations can help reduce the amount and concentration of nutrient-laden surface runoff and tile drainage. Many BMPs can not only address reduction of nutrients in surface and drainage water, but they can also simultaneously address the loss of sediment from agricultural lands, which contributes to sediment-covered substrates in local waterways. In addition, a reduction of sediment loss to local waterways can also reduce nutrient loss to near-field and far-field waterbodies, as nutrients will also adsorb to sediment particles, potentially becoming dissolved at a later time. The implementation of BMPs on agricultural lands that are prone to sediment and nutrient loss serves as a benefit for both near-field and far-field waterbodies and aids in the protection of drinking sources for downstream communities, such as the City of Dayton.

3.2.4 Outline Goals and Objectives for the Critical Area

The overarching goal of any NPS-IS is to improve water quality scores in order to remove a waterbody's impairment status or protect quality areas to maintain attainment status. Agricultural land use activities in *Critical Area #1* contribute to not only near-field impairment and stressed aquatic communities in Van Horn Creek, but also far-field impairment through excessive nutrient loss to local waterways that flow to the Ohio River. Ohio EPA has estimated nutrient loadings associated with various land uses and sources within targeted HUC-12s in the ORB, and has set nitrogen and phosphorus reduction goals for agricultural and urban sources. To achieve the desired nutrient reductions from agricultural land use in the **Indian Lake-Great Miami River HUC-12**, the following interim goals have been established:

Goal 1. Reduce nitrogen loading contributions in the **Indian Lake-Great Miami River HUC-12** to a level at or below 88,000 lbs/year (20% reduction).
NOT ACHIEVED: Current estimated load contribution is 110,000 lbs/year.

Goal 2. Reduce phosphorus loading contributions in the **Indian Lake-Great Miami River HUC-12** to a level at or below 5,600 lbs/year (20% reduction).
NOT ACHIEVED: Current estimated load contribution is 7,000 lbs/year.

Simultaneous goals relate to the improvement of in-stream conditions within Van Horn Creek and other Indian Lake tributaries, in order to improve the health of aquatic communities. Implementation of BMP objectives geared towards nutrient reduction efforts will generally also help make incremental progress towards the following goals:

Goal 3. Achieve IBI score at or above 40 at State Route 366 in Van Horn Creek (RM 0.97).
NOT ACHIEVED: Site currently has a score of 34.

Goal 4. Achieve ICI score at or above 36 (Good) at State Route 366 in Van Horn Creek (RM 0.97).
NOT ACHIEVED: Site currently has a score of Fair (~22).

Goal 5. Maintain QHEI score at or above 55 at State Route 366 in Van Horn Creek (RM 0.97).
✓ ACHIEVED: Site currently has a score of 60.5.

Objectives

In order to make substantive progress toward the achievement of the annual nutrient load reduction goals of 22,000 lbs of total nitrogen and 1,400 lbs of total phosphorus for the **Indian Lake-Great Miami River HUC-12**, efforts must commence on more widespread implementation, according to the following objectives within *Critical Area #1.* Additionally, actions taken to address nutrient reduction will also help reduce stressors on aquatic communities within Van Horn Creek and other Indian Lake tributaries.

Objective 1: Implement nutrient management (planning and implementation through soil testing and Variable Rate Technology (VRT)) on at least at least 1,400 additional acres.

Objective 2: Plant cover crops on at least 1,200 additional acres annually.[3]

Objective 3: Implement conservation tillage (of at least 30% residue) on at least 1,700 additional acres[4].

Objective 4: Reduce nutrient loss from subsurface tile drainage through the installation of drainage water management structures that drain at least 50 acres.

Objective 5: Reduce nutrient loss from subsurface tile drainage through the installation of blind inlets that drain at least 45 acres.

Objective 6: Reduce erosion and nutrient loss through the installation or rehabilitation of grassed waterways (as a standalone practice or coupled with erosion control structures/other drainage management practices) that receive/treat surface water from at least 510 acres.

Objective 7: Reduce erosion and nutrient loss through the installation of filter strips/buffers (of at least a 50 ft setback) or saturated buffers that receive/treat surface water from at least 600 acres.

Objective 8: Reduce erosion and nutrient loss through the installation of forested riparian buffers (of at least a 100 ft setback) that receive/treat surface water from at least 5 acres.

Objective 9: Create, enhance and/or restore at least 40 acres of wetlands and/or water retention basins for treatment of agricultural runoff and/or nutrient reduction purposes from 1,000 total agricultural acres.

Objective 10: Reduce erosion from agricultural streambanks and drainage conveyances through natural channel design or two-stage ditch design stabilization techniques to at least 4,600 linear feet (~0.85 miles).

These objectives will be directed towards implementation on prioritized agricultural lands and are estimated to make progress towards the HTF's interim and final nutrient reduction goals (Table 19). Additional conservation activities within the **Indian Lake-Great Miami River HUC-12**, both on priority and secondary lands, may also make incremental progress towards nutrient reduction goals. The implementation of BMPs included in these objectives, as well as BMPs implemented through federal and state programs and other voluntary efforts may be tracked to monitor progress towards nutrient reduction goals within the watershed.

[3] Cover crop usage is estimated to occur on approximately 200 acres, based upon OpTIS data (Dagan, 2019). Cover crop plantings may be implemented in the absence of grant funding.

[4] Current estimates indicate reduced tillage occurs on approximately 3,700 acres, based upon OpTis data (Dagan, 2019).

Table 19: Estimated Annual Nutrient Load Reductions from Each Objective

Objective Number	Best Management Practice	Total Acreage Treated*	Estimated Annual Nitrogen Load Reduction (lbs)	Estimated Annual Phosphorus Load Reduction (lbs)
1	Nutrient Management (Planning and Implementation through Soil Testing and VRT)[a]	1,400	2,650	70
2	Cover Crops	1,200	3,140	100
3	Conservation Tillage (at least 30% residue)	1,700	4,540	600
4	Drainage Water Management Structures	50	240	-
5	Blind Inlets[b]	45	300	30
6	Grassed Waterways[c]	510	2,560	280
7	Filter Strips/Buffers (of at least 50 ft)[d]	600	3,150	280
8	Forested Buffers (of at least 100 ft)	5	35	10
9	Wetlands[e] and/or Water Retention Basins	1,000[f]	1,520	450
10	Streambank Stabilization/Two-stage Design	410[g]	3,870	240
TOTAL		**6,920**	**22,005**	**2,060**

(Source Model: Spreadsheet Tool for Estimating Pollutant Loads (STEPL), Version 4.4, (USEPA, 2018))

NOTES

a *Nutrient Management consists of "managing the amount (rate), source, placement (method of application) and timing of plant nutrients and soil amendments to budget, supply and conserve nutrients for plant production; to minimize agricultural nonpoint source pollution of surface and groundwater resources; to properly utilize manure or organic byproducts as a plant nutrient source; to protect air quality by reducing odors, nitrogen emissions (ammonia, oxides of nitrogen) and the formation of atmospheric particulates; and/or to maintain or improve the physical, chemical and biological condition of soil," as defined by the STEPL guidance documents (Tetra Tech, 2018).*

b *Blind inlet nitrogen reduction efficiency estimated from values listed in Gonzalez, Smith and Livingston, 2016.*

c *Grassed waterway nitrogen reduction efficiency estimated from urban grass swale efficiency in STEPL and phosphorus reduction efficiency from Ohio State University Extension, 2018.*

d *Concentrated flow must be distributed so the area can slow, filter, and/or soak in runoff. Design specifications will be Field Office Technical Guide (FOTG) 393 Filter strips/area, and/or CRP CP-11 or CP2 Filter recharge areas. Conservation Cover (FOTG 327 and CRP CP-21) would not be designed to treat contributing runoff.*

e *Nitrogen load reduction for wetlands was calculated using estimates of 14.35 lbs/acre nitrogen and 0.89 lbs/acres phosphorus for the Great Miami River watershed (Ohio EPA, 2021a).*

f *If drainage water is routed through restored/created wetlands, it is assumed a 50% reduction in nitrogen and phosphorus from total nutrient yield for the drainage area, with a 25:1 ratio of drainage area to receiving wetland (Hoffmann et al., 2012; Woltemade, 2000). For this objective of 40 wetland acres, total drainage area is 1,000 acres.*

g *One linear foot of stream is estimated to drain 0.09 acres in this sub-watershed.*

*** *More than one BMP may be implemented within fields.*

- *Nutrient reduction is negligible.*

Water quality monitoring is an integral part of the project implementation process. Both project-specific and routinely scheduled monitoring will be conducted to determine progress towards meeting the goals (i.e., water quality standards and nutrient reduction targets). Through an adaptive management process, the aforementioned objectives will be reevaluated and modified as necessary. Objectives may be added to make further progress towards attainment or reduction goals, or altered, as a systems approach of multiple BMPs can accelerate the improvement of water quality conditions. The *Nonpoint Source Management Plan Update* (Ohio EPA, 2020b) will be utilized as a reevaluation tool for its listing of all eligible NPS management strategies to consider including:

- Urban Sediment and Nutrient Reduction Strategies;
- Altered Stream and Habitat Restoration Strategies;
- Nonpoint Source Reduction Strategies; and,
- High Quality Waters Protection Strategies.

3.3 Critical Area #2: Conditions, Goals & Objectives for Streambank and Riparian Restoration

3.3.1 Detailed Characterization

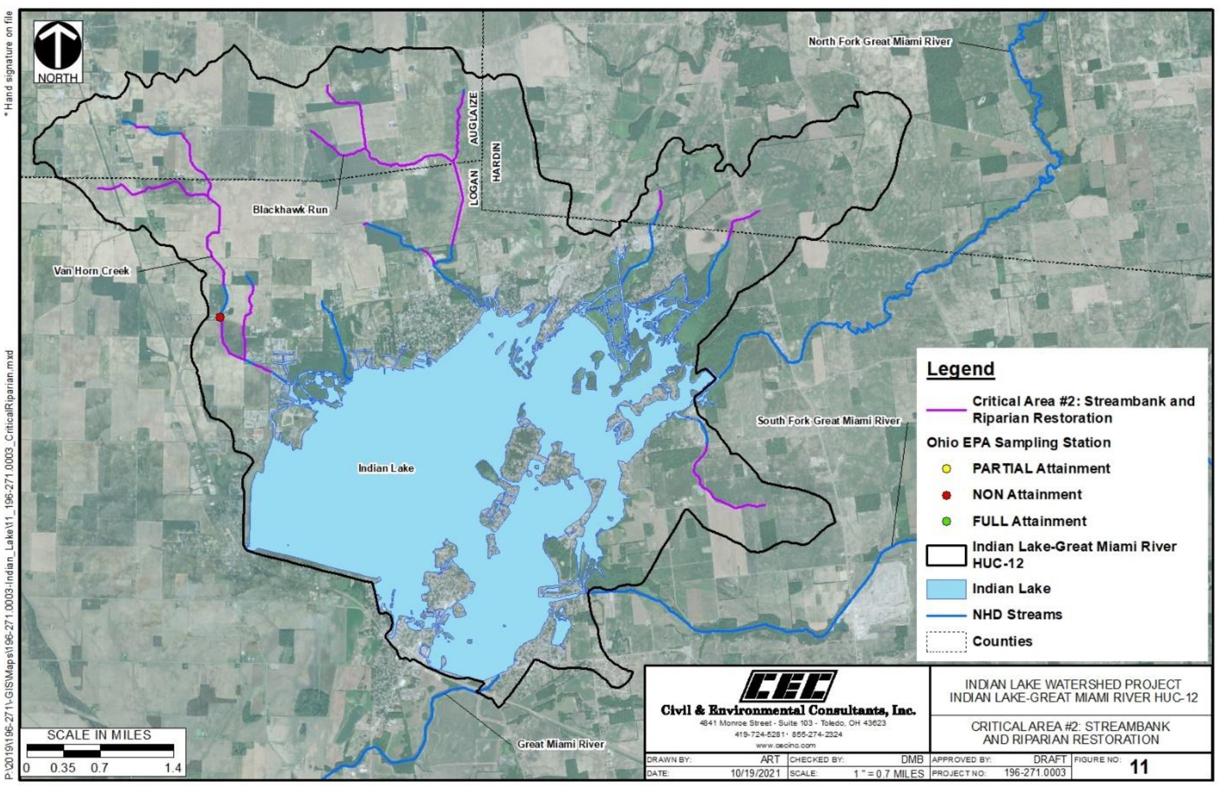

Figure 11: Indian Lake-Great Miami River HUC-12 Critical Area #2

The TMDL document for the upper Great Miami River identifies bank and riparian restoration and stream restoration as implementation strategies for addressing the habitat impairment within Van Horn Creek (Ohio EPA, 2012). The WAP identified at least 0.5 miles of unstable streambanks. Recent aerial imagery shows approximately 10 miles of stream length has little to no riparian buffer (Figure 11). While only Van Horn Creek was sampled within the **Indian Lake-Great Miami River HUC-12**, other direct tributaries to Indian Lake also exhibit similar habitat qualities (i.e., channelization, lack of riparian cover, etc.). Using the rationale described in the *Handbook for Developing Watershed Plans to Restore and Protect Our Waters* (USEPA, 2008) (Section 10.3.4): “In general, management practices are implemented immediately adjacent to the waterbody or upland to address the sources of pollutant loads", *Critical Area #2* includes approximately 55,968 linear feet (10.6 miles) of stream length and a 75-foot buffer width on each side. The potential for restoration of approximately 190 acres of riparian corridor exists in *Critical Area #2.*

3.3.2 Detailed Biological Conditions

Fish community data for the Van Horn Creek sampling site in **Indian Lake-Miami River HUC-12** is summarized below (Table 20). Analysis of the abundance, diversity and pollution tolerance of existing fish species found by Ohio EPA at each sampling location, in relation to the corresponding QHEI score, aids in the identification of causes and sources of impairment. Van Horn Creek is one stream within the Indian Lake watershed that does not have a strong connection to groundwater; therefore, habitat alterations resulting from agricultural drainage maintenance activities increase the impact to flow regimes and aquatic communities, especially in times of infrequent precipitation and lower baseflow. In 2008, baseflow within the ditch had subsided to a trickle (Ohio EPA, 2011). Fish populations within Van Horn Creek were generally dominated by pollution tolerant species, including creek chub and bluntnose minnow.

Table 20: Critical Area #2 - Fish Community and Habitat Data

Indian Lake-Great Miami River HUC-12 (05080001 01 03)							
RM	**Drainage Area (mi^2)**	**Total Species**	**QHEI**	**IBI**	**MIwb[a]**	**Predominant Species (Percent of Catch)**	**Narrative Evaluation**
Van Horn Creek (WWH)							
0.97[H]	2.8	16	60.5	34*	N/A	Creek chub (24%), bluegill sunfish (16%), bluntnose minnow (14%)	Fair

(Source: Ohio EPA, 2011)

NOTES
IBI *Index of Biotic Integrity*
a *The Modified Index of Well Being (MIwb) is not applicable to headwater sites (drainage ≤20 mi2).*
QHEI *Qualitative Habitat Evaluation Index*
H *Headwaters site*
* *Significant departure from applicable biocriteria (>4 IBI or ICI units, or >0.5 MIwb units). Underlined scores are in the poor to very poor range.*
N/A *Not applicable*
WWH *Warmwater Habitat*

Characteristics of the aquatic macroinvertebrate community for the **Indian Lake-Great Miami River HUC-12** are summarized below (Table 21). Analysis of the abundance, diversity, and pollution tolerance of existing aquatic macroinvertebrates found by Ohio EPA at these sampling locations, related to QHEI scores, can aid in the identification of causes and sources of impairment. Benthic communities within Van Horn Creek were of fair quality, scoring below the WWH criteria. Community diversity was low, yielding only five facultative EPT taxa and five pollution sensitive species, likely in relation to substrate embeddedness, heavy silt cover and lack of fast current. Residual pesticide contamination within the sediments of Van Horn Creek is also present, though impacts to the benthic community is thought to be negligible (Ohio EPA, 2011).

Table 21: Critical Area #2 - Macroinvertebrate Community Data

Indian Lake-Great Miami River HUC-12 (05080001 01 03)			
River Mile	**ICI Score-Narrative[a]**	**Notes (Density of Ql./Qt.)**	**Predominant Species**
Van Horn Creek (WWH)			
0.97[H]	N/A - Fair 5 sensitive taxa	Moderate qualitative density	Minnow mayflies, blackflies, flatworms (F)

(Source: Ohio EPA, 2011)

NOTES

H *Headwaters site*

a *Narrative evaluation used in lieu of ICI (E=Exceptional; G=Good; MG=Marginally Good; H Fair=High Fair; F=Fair; L Fair=Low Fair; P=Poor; VP=Very Poor).*

N/A *Not applicable*

3.3.3 Detailed Causes and Associated Sources

The single sampling location in Van Horn Creek in the **Indian Lake-Great Miami River HUC-12** is currently in *Non-Attainment* of the WWH designation due to habitat alterations caused by channelization. The data summarized previously in Table 12 (p.19) reveal a direct link between the presence of attributes in the watershed that have influence on the aquatic communities throughout the Van Horn Creek and other Indian Lake tributaries in *Critical Area #2*. These contributing attributes in *Critical Area #2* include:

- Channelization/No Recovery;
- No Sinuosity;
- Heavy/Moderate Silt Cover;
- Fair/Poor Development;
- Sparse/No Cover; and
- High/Moderate Embeddedness.

Habitat, as scored by the QHEI, is not a WQS; however, habitat is highly correlated with the performance of aquatic communities. In general, sites that score at least 60 (or 55 for headwaters streams) are successful at supporting WWH aquatic assemblages. Projects that address the above described habitat-related attributes (e.g., silt cover, pool/riffle development, etc.) through streambank stabilization and in-stream and riparian restoration will have a positive effect in the QHEI scoring index. As the habitat score (QHEI) becomes better, IBI, MIwb and ICI index scores are also expected to improve.

3.3.4 Outline Goals and Objectives for the Critical Area

The overarching goal of any NPS-IS is to improve water quality scores in order to remove a waterbody's impairment status or protect quality areas to maintain attainment status. For *Critical Area #2,* addressing streambank and riparian habitat conditions within Van Horn Creek and other Indian Lake tributaries will help ameliorate stresses from land use and boost index values for aquatic communities to maintain near-field attainment and reduce excessive sedimentation within Indian Lake.

The remaining goals for *Critical Area #2* of the **Indian Lake-Great Miami River HUC-12** are to reduce sedimentation and channelization effects to improve the aquatic scores through stabilizing streambanks and restoring banks, floodplains and riparian corridors. These goals are to specifically:

Goal 1. Achieve IBI score at or above 40 at State Route 366 in Van Horn Creek (RM 0.97).
NOT ACHIEVED: Site currently has a score of 34.

Goal 2. Achieve ICI score at or above 36 (Good) at State Route 366 in Van Horn Creek (RM 0.97).
NOT ACHIEVED: Site currently has a score of Fair (~22).

Goal 3. Maintain QHEI score at or above 55 at State Route 366 in Van Horn Creek (RM 0.97).
✓ ACHIEVED: Site currently has a score of 60.5.

Objectives

The implementation of these objectives, partnered with implementation throughout other identified critical areas will help ameliorate negative impacts from current and former land use within the **Indian Lake-Great Miami River HUC-12**, and positive gains will be made towards maintaining near-field attainment and reducing far-field impairments. In order to achieve the overall NPS restoration goals of achieving *Full Attainment* within Van Horn Creek, the following objectives need to be achieved within *Critical Area #2:*

Objective 1: Stabilize at least one mile (5,280 linear feet) of degraded or downcut streambanks.

Objective 2: Restore at least one mile (5,280 linear feet) of stream channel through natural channel design methods and bioengineering, including, but not limited to, habitat rocks/boulders, root wads, mud sills and tree revetments.

Objective 3: Create, enhance or restore at least 8 acres of woody riparian corridor and/or riparian floodplain wetlands.

Water quality monitoring is an integral part of the project implementation process. Both project-specific and routinely scheduled monitoring will be conducted to determine progress towards meeting the goals (i.e., water quality standards and nutrient reduction targets). Through an adaptive management process, the aforementioned objectives will be reevaluated and modified as necessary. Objectives may be added to make further progress towards attainment or reduction goals, or altered, as a systems approach of multiple BMPs can accelerate the improvement of water quality conditions. The *Nonpoint Source Management Plan Update* (Ohio EPA, 2020c) will be utilized as a reevaluation tool for its listing of all eligible NPS management strategies to consider including:

- Urban Sediment and Nutrient Reduction Strategies;
- Altered Stream and Habitat Restoration Strategies;
- Nonpoint Source Reduction Strategies; and,
- High Quality Waters Protection Strategies.

3.4 Critical Area #3: Conditions, Goals & Objectives for Urban Nutrient Reduction

3.4.1 Detailed Characterization

In urban environments, NPS contributions to stormwater runoff can come from a variety of sources, including fertilizers, detergents, leaves and detritus, wild and domesticated animal excrement, lubricants, sediment erosion, and organic and inorganic decomposition processes (Carpenter *et al.*, 1998; Burton and Pitt, 2001). Urbanization and development often leads to increased pollutant availability, increased runoff, increased peak flows and stream "flashiness", stream instability, decreased stream function, decreased storage and retention capabilities and decreased pollutant assimilation in soils (ODNR, 2006). Many of these effects have a direct impact on aquatic life. In areas of low amounts of urbanization (5-10% imperviousness), stream ecosystems can rapidly decline (Schueler, 1994).

The *Indian Lake WAP* cites the **Indian Lake-Great Miami River HUC-12** as the sub-watershed with the largest potential for discharge of contaminants to Indian Lake due to its concentrated population of permanent residents and "weekenders" (ILWP, 2009). The majority of the urban land in this area is attributed to residential, with campgrounds and small businesses interspersed. Historical impairment within this sub-watershed was attributed to siltation from a variety of sources, including urban runoff and lack of storm sewers (ILWP, 2009). *Critical Area #3* contains the urban land surrounding Indian Lake, including the Villages of Lakeview and Russells Point and Indian Lake State Park (Figure 12).

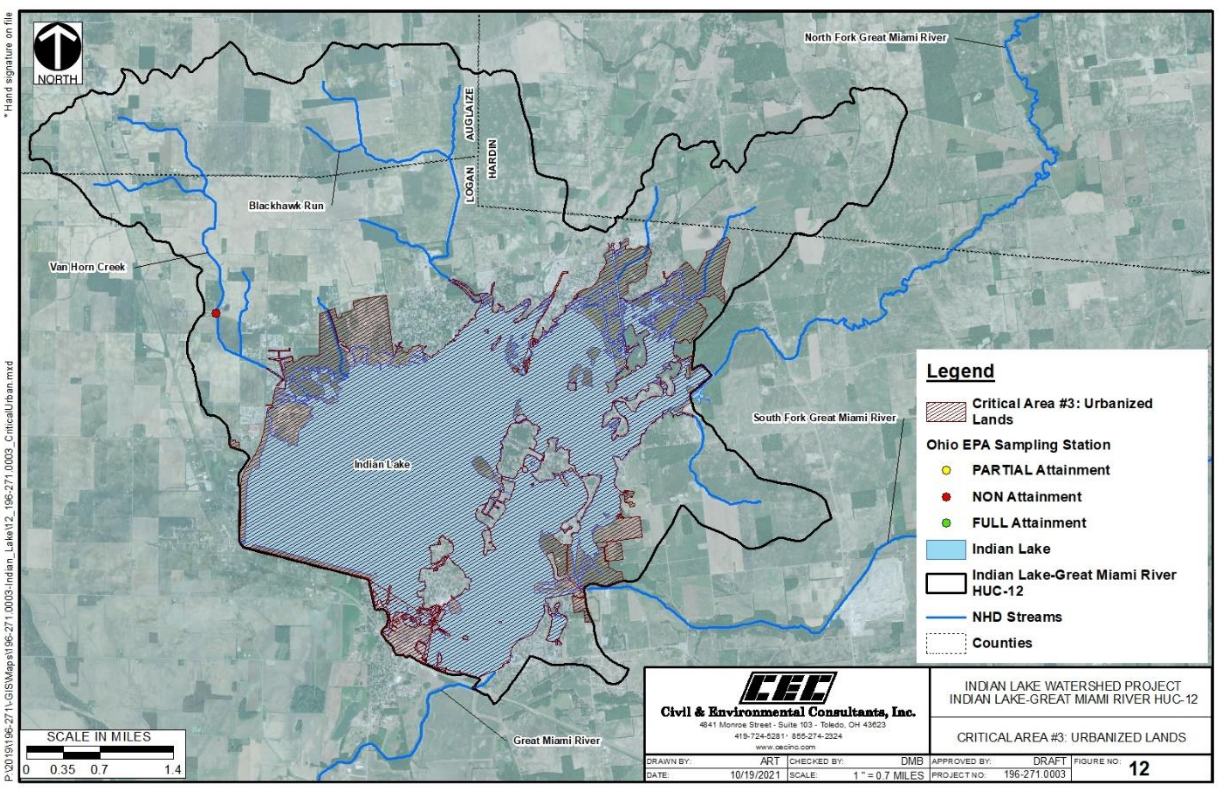

Figure 12: Indian Lake-Great Miami River HUC-12 Critical Area #3

3.4.2 Detailed Biological Conditions

No biological sampling points are contained within the geographic boundary of *Critical Area #3.*

3.4.3 Detailed Causes and Associated Sources

The presence and persistence of the hypoxic zone within the Gulf of Mexico has shown the need for reduced NPS pollution, particularly in regards to nitrogen and phosphorus, throughout the entire MARB, in which the **Indian Lake-Great Miami River HUC-12** is located. Ohio EPA has estimated nitrogen and phosphorus loadings from various land uses, including urban land use, within individual sub-watersheds in targeted areas of the ORB. Efforts to reduce nutrients from each of these contributing sources will focus on reaching the 20% reduction goal by 2025, as outlined by the HTF in 2014.

Reductions in nutrients in urban areas can help decrease overall NPS pollution and improve aquatic communities. Compared with natural land cover, shallow and deep infiltration and evapotranspiration decreases while surface runoff increases in urban lands (USEPA, 2003). When watersheds have as little as 10% impervious surface, studies have shown that not only does runoff increase substantially, but pollutant loads also increase (CWP, 1998).

3.4.4 Outline Goals and Objectives for the Critical Area

The overarching goal of any NPS-IS is to improve water quality scores in order to remove a waterbody's impairment status or protect quality areas to maintain attainment status. Urban land use activities in *Critical Area #3* contribute to not only stressed aquatic communities in Indian Lake, but also far-field impairment through excessive nutrient loss to local waterways that flow to the Ohio River. Ohio EPA has estimated nutrient loadings associated with various land uses and sources within targeted HUC-12s in the ORB, and has set nitrogen and phosphorus reduction goals for agricultural and urban sources. To achieve the desired nitrogen and phosphorus reduction from urban land use in the **Indian Lake-Great Miami River HUC-12**, the following goal has been established:

Goal 1. Reduce nitrogen loading contributions in the **Indian Lake-Great Miami River HUC-12** to a level at or below 10,400 lbs/year (20% reduction).
NOT ACHIEVED: Current estimated load contribution is 13,000 lbs/year.

Goal 2. Reduce phosphorus loading contributions in the **Indian Lake-Great Miami River HUC-12** to a level at or below 630 lbs/year (20% reduction).
NOT ACHIEVED: Current estimated load contribution is 790 lbs/year.

Objectives

In order to make substantive progress toward the achievement of the urban nitrogen load reduction goal of 2,600 lbs and phosphorus load reduction goal of 160 lbs for the **Indian Lake-Great Miami River HUC-12**, efforts must commence on more widespread implementation, according to the following objectives within *Critical Area #3.*

Objective 1: Reduce stormwater inputs and impacts in the sub-watershed by implementing green infrastructure projects within *Critical Area #3* that retain, detain, and/or treat runoff from at least 800 acres of urbanized impermeable surfaces (i.e., parking lots, roads, etc.).

Objective 2: Reduce stormwater inputs and impacts in the sub-watershed by restoring and/or creating floodplain and wetland detention/storage basins to retain, detain and/or treat urban drainage from at least one acre of tributaries draining to Indian Lake.

Water quality monitoring is an integral part of the project implementation process. Both project-specific and routinely scheduled monitoring will be conducted to determine progress towards meeting the goals (i.e., water quality standards and nutrient reduction targets). Through an adaptive management process, the aforementioned objectives will be reevaluated and modified as necessary. Objectives may be added to make further progress towards attainment or reduction goals, or altered, as a systems approach of multiple BMPs can accelerate the improvement of water quality conditions. The *Nonpoint Source Management Plan Update* (Ohio EPA, 2020b) will be utilized as a reevaluation tool for its listing of all eligible NPS management strategies to consider including:

- Urban Sediment and Nutrient Reduction Strategies;
- Altered Stream and Habitat Restoration Strategies;
- Nonpoint Source Reduction Strategies; and,
- High Quality Waters Protection Strategies.

CHAPTER 4: PROJECTS AND IMPLEMENTATION STRATEGY

Projects and evaluation needs identified for the **Indian Lake-Great Miami River HUC-12** are based upon identified causes and associated sources of NPS pollution. Over time, these critical areas will need to be reevaluated to determine progress towards meeting restoration, attainment and nutrient reduction goals. Time is an important variable in measuring project success and overall status when using biological indices as a measurement tool. Some biological systems may show fairly quick response (i.e., one season), while others may take several seasons or years to show progress towards recovery. In addition, reasons for the impairment other than those associated with NPS sources may arise. Those issues will need to be addressed under different initiatives, authorities or programs that may or may not be accomplished by the same implementers addressing the NPS issues.

Implementation of practices described in this NPS-IS may also contribute to nutrient load reduction (specifically the interim 20% reduction in nitrogen and phosphorus loading in the MARB). Nutrient load reduction efforts are consistent with the HTF Action Plan and New Goal Framework (HTF, 2014).

For the **Indian Lake-Great Miami River HUC-12** there are three *Project and Implementation Strategy Overview Tables* (subsection 4.1, 4.2 and 4.3). Future versions of this NPS-IS may include subsequent sections as more critical areas are refined and more projects become developed to meet the requisite objectives within a critical area. The projects described in the *Overview Table* have been prioritized using the following three-step prioritization method:

Priority 1 Projects that specifically address one or more of the listed Objectives for the Critical Area.

Priority 2 Projects where there is land-owner willingness to engage in projects that are designed to address the cause(s) and source(s) of impairment or where there is an expectation that such potential projects will improve water quality in the **Indian Lake-Great Miami River HUC-12**.

Priority 3 In an effort to generate interest in projects, an information and education campaign will be developed and delivered. Such outreach will engage citizens to spark interest by stakeholders to participate and implement projects like those mentioned in Priority 1 and 2.

Project Summary Sheets (PSS) follow the *Overview Tables*, if projects were identified; these provide the essential nine elements for short-term and/or next step projects that are in development and/or in need of funding. As projects are implemented and new projects developed, these sheets will be updated. Any new PSS created will be submitted to the state of Ohio for funding eligibility verification (i.e., all nine elements are included).

4.1 Critical Area #1 Project and Implementation Strategy Overview Table

Table 22: Indian Lake-Great Miami River HUC-12 (05080001 01 03) — Critical Area #1							
Goal	Objective	Project #	Project Title (EPA Criteria g)	Lead Organization (EPA criteria d)	Time Frame (EPA Criteria f)	Estimated Cost (EPA Criteria d)	Potential/Actual Funding Source (EPA Criteria d)
Urban Sediment and Nutrient Reduction Strategies							
Altered Stream and Habitat Restoration Strategies							
Agricultural Nonpoint Source Reduction Strategies							
High Quality Waters Protection Strategies							
Other NPS Causes and Associated Sources of Impairment							

At this time, no short-term projects have been identified for *Critical Area #1*; therefore, no Project Summary Sheets are included.

4.2 Critical Area #2 Project and Implementation Strategy Overview Table

Table 23: Indian Lake-Great Miami River HUC-12 (05080001 01 03) — Critical Area #2							
Goal	Objective	Project #	Project Title (EPA Criteria g)	Lead Organization (EPA criteria d)	Time Frame (EPA Criteria f)	Estimated Cost (EPA Criteria d)	Potential/Actual Funding Source (EPA Criteria d)
Urban Sediment and Nutrient Reduction Strategies							
Altered Stream and Habitat Restoration Strategies							
Agricultural Nonpoint Source Reduction Strategies							
High Quality Waters Protection Strategies							
Other NPS Causes and Associated Sources of Impairment							

At this time, no short-term projects have been identified for *Critical Area #2*; therefore, no Project Summary Sheets are included.

4.3 Critical Area #3 Project and Implementation Strategy Overview Table

Table 24: Indian Lake-Great Miami River HUC-12 (05080001 01 03) — Critical Area #3							
Goal	**Objective**	**Project #**	**Project Title (EPA Criteria g)**	**Lead Organization (EPA criteria d)**	**Time Frame (EPA Criteria f)**	**Estimated Cost (EPA Criteria d)**	**Potential/Actual Funding Source (EPA Criteria d)**
Urban Sediment and Nutrient Reduction Strategies							
1, 2	1	1	Urban Runoff Linear Treatment Wetlands in Indian State Park	ILWP, with ODNR	Short (1-3 years)	$401,275	Ohio EPA §319, H2Ohio
1, 2	1	2	Treatment Wetland in Indian State Park	ILWP, with ODNR	Short (1-3 years)	$237,800	Ohio EPA §319, H2Ohio
Altered Stream and Habitat Restoration Strategies							
Agricultural Nonpoint Source Reduction Strategies							
High Quality Waters Protection Strategies							
Other NPS Causes and Associated Sources of Impairment							

4.3.1 Project Summary Sheet(s)

The Project Summary Sheets provided below were developed based on the actions or activities needed to achieve nutrient reduction targets in the **Indian Lake-Great Miami River HUC-12**. These projects are considered next step or priority/short term projects and are considerably ready to implement. Medium and longer-term projects will not have a Project Summary Sheet, as these projects are not ready for implementation or need more thorough planning.

Table 25: Critical Area #3 – Project #1

Nine Element Criteria	Information needed	Explanation
n/a	**Title**	Urban Runoff Linear Treatment Wetlands in Indian State Park
criteria d	**Project Lead Organization & Partners**	ILWP, in cooperation with ODNR
criteria c	**HUC-12 and Critical Area**	Indian Lake-Great Miami River HUC-12 (05080001 01 03) – *Critical Area #3*
criteria c	**Location of Project**	Indian Lake State Park Campground; 40.513851, -83.899631
n/a	**Which strategy is being addressed by this project?**	Urban Sediment and Nutrient Reduction Strategies
criteria f	**Time Frame**	Short (1-3 years)
criteria g	**Short Description**	Expansion of stormwater ditches for wetland treatment
criteria g	**Project Narrative**	The proposed project incorporates two areas that expand current stormwater ditches into treatment wetlands or linear wetlands. Western Wetland An approximate 1.4 acre area is proposed for restoration in-line with an existing rock-lined channel located between internal campground roadways and camping pad sites to treat stormwater flow from other areas (both impervious and natural surfaces) within the Indian Lake Campground facility. The restoration area would include an approximate 0.75-acre wetland (up to 2,000 CY of grading) with mixed habitat elevations from 0.2 to 1.0 feet deep to disperse and retain stormwater and facilitate groundwater recharge. The remaining area would be planted with native vegetation as a protective buffer from campers and roadway traffic. It is anticipated that 450 woody shrub stems per acre across the 1.4 acre area would be planted in combination with native seed. The wetland would contain a reinforced spillway that would convey surface water back to the receiving drainage ditch. Ditch Wetland An approximate 2.0 acre area is proposed for restoration in-line with an existing drainage ditch located between a main access road and a number of camping pad sites to treat stormwater flow

Table 25: Critical Area #3 – Project #1		
Nine Element Criteria	**Information needed**	**Explanation**
		from other areas (both impervious and natural surfaces) within the Indian Lake Campground facility. The current ditch is lined with grass and experiences rill erosion in areas. The restoration area would include a long, linear wetland ranging from 30 to 50 feet wide and approximately 900 feet long (up to 1,650 CY of grading) with mixed habitat elevations from 0.2 to 0.5 feet deep to disperse and retain stormwater and facilitate groundwater recharge. The remaining area would be planted with native vegetation as a protective buffer from campers and roadway traffic. It is anticipated that 450 woody shrub and tree stems per acre across the 2.0 acre area would be planted in combination with native seed. The wetland would contain a reinforced spillway that would convey surface water back to the receiving drainage ditch which conveys to a canal at the Indian Lake State Park boat ramp a short distance away. This project could occur in conjunction with the Treatment Wetland in Indian State Park Project to recognize efficiencies in construction cost.
criteria d	**Estimated Total cost**	$401,275
criteria d	**Possible Funding Source**	Ohio EPA §319, H2Ohio
criteria a	**Identified Causes and Sources**	Cause: Nutrient loadings, leading to far-field impacts Source: Agricultural land use activities
criteria b & h	**Part 1: How much improvement is needed to remove the NPS impairment for the whole Critical Area?**	The overall goal in *Critical Area #1* is to reduce estimated annual total nitrogen and total phosphorus loads. Current estimates indicate the urban contribution to the annual load is 13,000 lbs. of nitrogen and 790 lbs. of phosphorus. In order to meet the HTF nutrient reduction goals, annual loads must be reduced by 20%, or 2,600 lbs. of nitrogen and 130 lbs. of phosphorus.
	Part 2: How much of the needed improvement for the whole Critical Area is estimated to be accomplished by this project?	It is expected that this project will cause a decrease in annual nitrogen loadings by 6 lbs. (0.2% progress) and annual phosphorus loadings by 2 lbs. (1.5% progress).
	Part 3: Load Reduced?	Estimated annual reduction: 6 #N/year; 2 #P/year; 0.9 tons sediment/year
criteria i	**How will the effectiveness of this project in addressing the NPS impairment be measured?**	It is generally unrealistic to monitor load reduction from individual urban practices; however, ambient monitoring is conducted throughout the ORB by organizations such as Ohio EPA and Heidelberg University. These entities will continue long term monitoring on various tributaries in the ORB to track load reduction trends.
criteria e	**Information and Education**	The ILWP, along with ODNR and park staff, will promote the project through several media outlets with press releases, news articles, ILWP newsletter blurbs, website and social media postings. The ILWP will conduct tours of the project site, and appropriate project signage will be placed at the site.

Table 1: Critical Area #3 – Project #2		
Nine Element Criteria	**Information needed**	**Explanation**
n/a	**Title**	Treatment Wetland in Indian State Park
criteria d	**Project Lead Organization & Partners**	ILWP, in cooperation with ODNR
criteria c	**HUC-12 and Critical Area**	Indian Lake-Great Miami River HUC-12 (05080001 01 03) – *Critical Area #3*
criteria c	**Location of Project**	Indian Lake State Park Campground; 40.510241, -83.897213
n/a	**Which strategy is being addressed by this project?**	Urban Sediment and Nutrient Reduction Strategies
criteria f	**Time Frame**	Short (1-3 years)
criteria g	**Short Description**	Treatment wetland for urban runoff prior to release to Indian Lake
criteria g	**Project Narrative**	An approximate 1.4-acre area is proposed for restoration in-line with a grass lined ditch and sand volleyball court located near the public use beach and boat launch to treat stormwater flow from other areas (both impervious and natural surfaces) within the Indian Lake Campground facility. The restoration area would include an approximate 0.75-acre wetland (up to 2,000 CY of grading) with mixed habitat elevations from 0.2 to 1.0 feet deep to disperse and retain stormwater and facilitate groundwater recharge. The remaining area would be planted with native vegetation as a protective buffer from campers and roadway traffic. It is anticipated that 450 woody shrub stems per acre across the 1.4 acre area would be planted in combination with native seed. The wetland would contain a reinforced spillway that would convey treated surface water back to Indian Lake. This project could occur in conjunction with the Urban Runoff Linear Treatment Wetlands in Indian State Park Project to recognize efficiencies in construction cost.
criteria d	**Estimated Total cost**	$237,800
criteria d	**Possible Funding Source**	Ohio EPA §319, H2Ohio
criteria a	**Identified Causes and Sources**	Cause: Nutrient loadings, leading to far-field impacts Source: Agricultural land use activities
criteria b & h	**Part 1: How much improvement is needed to remove the NPS impairment for the whole Critical Area?**	The overall goal in *Critical Area #1* is to reduce estimated annual total nitrogen and total phosphorus loads. Current estimates indicate the urban contribution to the annual load is 13,000 lbs. of nitrogen and 790 lbs. of phosphorus. In order to meet the HTF nutrient reduction goals, annual loads must be reduced by 20%, or 2,600 lbs. of nitrogen and 130 lbs. of phosphorus.
	Part 2: How much of the needed improvement for the whole Critical Area is estimated to be accomplished by this project?	It is expected that this project will cause a decrease in annual nitrogen loadings by 29 lbs. (1.1% progress) and annual phosphorus loadings by 10 lbs. (7.7% progress).
	Part 3: Load Reduced?	Estimated annual reduction: 29 #N/year; 10 #P/year; 4.4 tons sediment/year

Table 1: Critical Area #3 – Project #2		
Nine Element Criteria	**Information needed**	**Explanation**
criteria i	**How will the effectiveness of this project in addressing the NPS impairment be measured?**	It is generally unrealistic to monitor load reduction from individual urban practices; however, ambient monitoring is conducted throughout the ORB by organizations such as Ohio EPA and Heidelberg University. These entities will continue long term monitoring on various tributaries in the ORB to track load reduction trends.
criteria e	**Information and Education**	The ILWP, along with ODNR and park staff, will promote the project through several media outlets with press releases, news articles, ILWP newsletter blurbs, website and social media postings. The ILWP will conduct tours of the project site, and appropriate project signage will be placed at the site.

CHAPTER 5: WORKS CITED

Auglaize County Health Department. 2021. *Household Sewage Treatment Systems.* https://www.auglaizehealth.org/environmental-health-division/household-sewage-treatment-systems. Accessed May 20, 2021.

Burton, G.A. Jr., and R. Pitt. 2001. *Stormwater Effects Handbook: A Tool Box for Watershed Managers, Scientists, and Engineer*s. CRC Press, Inc., Boca Raton, FL.

Carpenter, S.R., N.F. Caraco, D.L. Correll, R.W. Howarth, A.N. Sharpley and V.N. Smith. 1998. Nonpoint Pollution of Surface Waters with Phosphorus and Nitrogen. *Ecology Applications*, vol. 8, p.559.

Center for Watershed Protection (CWP). 1998. *Rapid Watershed Planning Handbook*. Ellicott City, Md.

Dagan. 2019. *Operational Tillage Information System*. https://ctic.org/optis_tabular_query. Accessed February 19, 2021.

Gonzalez, J.M., D.R. Smith and S.J. Livingston. 2016. Blind Inlets as Conservation Practices to Improve Water Quality. https://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=1071&context=agroenviron. Accessed October 28, 2019.

Hoffmann, C.C., L. Heiberg, J. Audet, B. Schønfeldt, A. Fuglsang, B. Kronvang, N.B. Ovesen, C. Kjaergaard, H.C.B. Hansen and H.S. Jensen. 2012. Low phosphorus release but high nitrogen removal in two restored riparian wetlands inundated with agricultural drainage water. *Ecological Engineering*. 46, p.75-87.

Homer, C.G., J.A. Dewitz, S. Jin, G. Xian, C. Costello, P. Danielson, L. Gass, M. Funk, J. Wickham, S. Stehman, R.F. Auch and K.H. Ritters. 2020. Conterminous United States land cover change patterns 2001-2016 from the 2016 National Land Cover Database. *ISPRS Journal of Photogrammetry and Remote Sensing*. v. 162, June 2, 2020, p.184-199. https://doi.org/10.1016/j.isprsjprs.2020.02.019.

Hypoxia Task Force (HTF). 2014. *Mississippi River Gulf of Mexico Watershed Nutrient Task Force New Goal Framework.* https://www.epa.gov/sites/production/files/2015-07/documents/htf-goals-framework-2015.pdf. Accessed April 15, 2020.

Indian Lake Watershed Project (ILWP). 2009. *Indian Lake Watershed Project Watershed Action Plan.* https://epa.ohio.gov/dsw/nps/endorsedwap. Accessed November 21, 2019.

Logan County. *Logan County History.* http://co.logan.oh.us/630/Historical-Information. Accessed May 20, 2021.

Logan County Health District. 2021. *Household Sewage Treatment Systems.* https://loganhealth.org/household-sewage-treatment-systems/. Accessed May 26, 2021.

Ohio Department of Health (ODH). 2013. *Household Sewage Treatment System Failures in Ohio: A Report on Local Health Department Survey Responses for the 2012 Clean Watersheds Needs Survey.* https://odh.ohio.gov/wps/portal/gov/odh/know-our-programs/sewage-treatment-systems/resources-and-education/2012hstsfailureratesinohio. Accessed October 21, 2020.

Ohio Department of Health. 2021. *BeachGuard.* https://publicapps.odh.ohio.gov/beachguardpublic/. Accessed May 26, 2021.

Ohio Department of Natural Resources (ODNR). 2001. *Gazetteer of Ohio Streams*. 2nd Edition. https://minerals.ohiodnr.gov/Portals/minerals/pdf/industrial%20minerals/gazetteer_ohio_streams.pdf. Accessed June 8, 2020.

Ohio Department of Natural Resources (ODNR). 2001a. *Indian Lake Experiencing Significant Aquatic Vegetation Growth.* https://ohiodnr.gov/wps/portal/gov/odnr/discover-and-learn/safety-conservation/about-ODNR/news/Indian-Lake-Vegetation-Growth. Accessed December 6, 2021.

Ohio Department of Natural Resources (ODNR). 2001b. *Indian Lake State Park.* https://ohiodnr.gov/wps/portal/gov/odnr/go-and-do/plan-a-visit/find-a-property/indian-lake-state-park. Accessed March 2, 2021.

Ohio Department of Natural Resources (ODNR). 2001c. *Interactive Geology Map.* https://gis.ohiodnr.gov/website/dgs/geologyviewer/#. Accessed January 21, 2021.

Ohio Department of Natural Resources (ODNR). 2020. *Ohio Mussel Survey Protocol, updated April, 2020*. https://ohiodnr.gov/static/documents/wildlife/permits/dow-protocol-ohio-mussel-survey.pdf. Accessed February 2, 2021.

Ohio Environmental Protection Agency (Ohio EPA). 1999. *Association between Nutrients, Habitat and the Aquatic Biota of Ohio's Rivers and Streams*. https://www.epa.ohio.gov/portals/35/lakeerie/ptaskforce/AssocLoad.pdf. Accessed September 13, 2019.

Ohio Environmental Protection Agency (Ohio EPA). 2011. *Biological and Water Quality Study of the Upper Great Miami River and Selected Tributaries 2008, Technical Report EAS/2011-1-1.* https://epa.ohio.gov/static/Portals/35/documents/Upper_GMR_TSD_2008.pdf. Accessed January 21, 2021.

Ohio Environmental Protection Agency (Ohio EPA). 2012. *Total Maximum Daily Loads for the Great Miami River (upper) Watershed.* https://www.epa.ohio.gov/static/Portals/35/tmdl/GMRupperReport_Final.pdf. Accessed January 21, 2021.

Ohio Environmental Protection Agency (Ohio EPA). 2013. *Total Maximum Daily Loads for the Ottawa River (Lima Area) Watershed*. https://epa.ohio.gov/Portals/35/tmdl/OttawaLima_Report_Final.pdf. Accessed August 27, 2019.

Ohio Environmental Protection Agency (Ohio EPA). 2016a. *Indian Lake Water Pollution Control Facility NPDES Permit.* http://wwwapp.epa.ohio.gov/dsw/permits/doc/1PK00002.fs.pdf. Accessed May 20, 2021.

Ohio Environmental Protection Agency (Ohio EPA). 2016b. *Guide to Developing Nine-Element Nonpoint Source Implementation Strategic Plans in Ohio.* https://epa.ohio.gov/Portals/35/nps/319docs/NPS-ISPlanDevelopmentGuidance816.pdf. Accessed June 4, 2020.

Ohio Environmental Protection Agency (Ohio EPA). 2018a. *Nineteen Northwest Ohio Counties, City of Shelby Receive Funding from Ohio EPA to Help Homeowners with Failing Home Septic Systems.* https://epa.ohio.gov/News/Online-News-Room/News-Releases/nineteen-northwest-ohio-counties-city-of-shelby-receive-funding-from-ohio-epa-to-help-homeowners-with-failing-home-septic-systems. Accessed March 1, 2021.

Ohio Environmental Protection Agency (Ohio EPA). 2018b. *Twelve Southwest Ohio Counties Receive Funding from Ohio EPA to Help Homeowners With Failing Home Septic Systems.* https://www.epa.state.oh.us/News/Online-News-Room/News-Releases/twelve-southwest-ohio-counties-receive-funding-from-ohio-epa-to-help-homeowners-with-failing-home-septic-systems. Accessed May 26, 2021.

Ohio Environmental Protection Agency (Ohio EPA). 2020a. *2020 Ohio Integrated Report.* https://www.epa.ohio.gov/dsw/tmdl/OhioIntegratedReport#123145148-2018. Accessed June 4, 2020.

Ohio Environmental Protection Agency (Ohio EPA). 2020b. *Nonpoint Source Management Plan Update (FY2019-2024)*. https://epa.ohio.gov/Portals/35/nps/2019-NPS-Mgmt-Plan.pdf. Accessed September 22, 2020.

Ohio Environmental Protection Agency (Ohio EPA). 2020c. *Nutrient Mass Balance Study for Ohio's Major Rivers 2020*. https://www.epa.ohio.gov/Portals/35/documents/Nutrient-Mass-Balance-Study-2020.pdf. Accessed December 30, 2020.

Ohio Environmental Protection Agency (Ohio EPA). 2021a. *Basic_NMB_plus_equations worksheet (draft, unpublished)*. Provided by Ohio EPA-Division of Surface Water, Nonpoint Source Program.

Ohio Environmental Protection Agency (Ohio EPA). 2021b. *Individual NPDES Permits Interactive Map.* https://oepa.maps.arcgis.com/apps/webappviewer/index.html?id=b680bd65d1874023ae6ec2f911acb841. Accessed January 3, 2021.

Ohio Environmental Protection Agency (Ohio EPA). 2021c. *River Miles Index Interactive Map*. https://www.arcgis.com/apps/webappviewer/index.html?id=4f93b8e37d4640a6ab3ac43d2914d25e. Accessed January 29, 2021.

Ohio Environmental Protection Agency (Ohio EPA). 2021d. *Southwest Ohio Communities Receive $2.6 Million in Financing from Ohio EPA for Wastewater, Drinking Water Infrastructure Improvements.* https://epa.ohio.gov/wps/portal/gov/epa/about/media-center/news/southwest-ohio-communities-receive-26-million-in-financing-from-ohio-epa-for-wastewater-drinking-water-infrastructure-improvements. Accessed December 29, 2021.

Ohio Lake Erie Commission (OLEC). 2020. *Promoting Clean and Safe Water in Lake Erie: Ohio's Domestic Action Plan 2020 to Address Nutrients.* https://lakeerie.ohio.gov/Portals/0/Ohio%20DAP/Ohio%20DAP%202020%20DRAFT%202020-01-28.pdf?ver=2020-01-28-123210-883. Accessed December 8, 2020.

Ohio State University (OSU) Extension. 2018. *A Field Guide to Identifying Critical Resource Concerns and Best Management Practices for Implementation*. Bulletin 969. College of Food, Agricultural, and Environmental Sciences.

Schueler, T. 1994. The Importance of Imperviousness. *Watershed Protection Techniques.* 1(3):100-111.

Smith, A. 2021. ODNR Tackling Weed Problem at Indian Lake. *Limaohio.com.* https://www.limaohio.com/sports/470317/odnr-tackling-weed-problem-at-indian-lake. Accessed December 6, 2021.

Tetra Tech, Inc. 2017. *Spreadsheet Tool for Estimating Pollutant Load (STEPL) Input Data Server.* https://ofmpub.epa.gov/apex/grts/f?p=109:333. Accessed January 21, 2021.

Tetra Tech, Inc. 2018. *BMP Descriptions for STEPL and Region 5 Models.* http://it.tetratech-ffx.com/steplweb/models$docs.htm. Accessed November 22, 2019.

United States Army Corps of Engineers (USACE). 2020. *Plan for the Ohio River Basin: 2020-2025.* https://www.lrh.usace.army.mil/Portals/38/docs/orba/Plan%20for%20the%20Ohio%20River%20Basin_FINAL.PDF?ver=s5zhd_NfTAZ7ao0bWhBLpA%3d%3d. Accessed December 8, 2020.

United States Census Bureau (US Census Bureau). 2010. *Quick Facts.* https://www.census.gov/quickfacts. Accessed January 30, 2021.

United States Department of Agriculture (USDA). 2012. *Census of Agriculture.* https://www.nass.usda.gov/Publications/AgCensus/2012/. Accessed February 2, 2021.

United States Department of Agriculture (USDA). 2019. *Census of Agriculture, 2017*. https://www.nass.usda.gov/Publications/AgCensus/2017/Online_Resources/Ag_Atlas_Maps/index.php. Accessed January 5, 2021.

United States Department of Agriculture (USDA) - Natural Resources Conservation Service (NRCS). 2018. *ProTracts Data Spreadsheet, as of October 2014.* Received in personal communication from Rick Wilson Ohio EPA-DSW, §319 program.

United States Environmental Protection Agency (USEPA). 2003. *Protecting Water Quality from Urban Runoff.* https://www3.epa.gov/npdes/pubs/nps_urban-facts_final.pdf. Accessed January 9, 2020.

United States Environmental Protection Agency (USEPA). 2007. *Hypoxia in the Northern Gulf of Mexico: An Update by the EPA Science Advisory Board*. https://yosemite.epa.gov/sab/sabproduct.nsf/C3D2F27094E03F90852573B800601D93/$File/EPA-SAB-08-003complete.unsigned.pdf. Accessed July 20, 2021.

United States Environmental Protection Agency (USEPA). 2008. *Handbook for Developing Watershed Plans to Restore and Protect Our Waters.* https://www.epa.gov/sites/production/files/2015-09/documents/2008_04_18_nps_watershed_handbook_handbook-2.pdf. Accessed on October 28, 2019.

United States Environmental Protection Agency (USEPA). 2013. *Primary Distinguishing Characteristics of Level III Ecoregions of the Continental United States.* https://www.epa.gov/eco-research/ecoregion-download-files-state-region-5#pane-33. Accessed April 20, 2020.

United States Environmental Protection Agency (USEPA). 2017. *Mississippi River/Gulf of Mexico Watershed Nutrient Task Force Report to Congress, August 2017, Second Biennial Report.* https://www.epa.gov/sites/default/files/2017-11/documents/hypoxia_task_force_report_to_congress_2017_final.pdf. Accessed July 20, 2021.

United States Environmental Protection Agency (USEPA). 2018. *Spreadsheet Tool for Estimating Pollutant Load (STEPL), Version 4.4.* https://www.epa.gov/nps/spreadsheet-tool-estimating-pollutant-loads-stepl. Accessed September 22, 2020.

United States Environmental Protection Agency (USEPA). 2020. *History of the Hypoxia Task Force*. https://www.epa.gov/ms-htf/history-hypoxia-task-force. Accessed December 8, 2020.

United States Fish and Wildlife Service (USFWS). 2018. *Ohio – County Distribution of Federally-Listed Endangered, Threatened and Proposed Species, updated January 29.* https://www.fws.gov/midwest/endangered/lists/ohio-cty.html. Accessed March 2, 2021.

United States Fish and Wildlife Service (USFWS). 2020. *National Wetlands Inventory.* https://www.fws.gov/wetlands/data/Mapper.html. Accessed February 22, 2021.

United States Geological Survey (USGS). 2019. *Protected Areas Database of the United States (PAD-US).* https://maps.usgs.gov/padus/. Accessed June 2, 2020.

United States Geological Survey (USGS). 2021. *StreamStats: Streamflow Statistics and Spatial Analysis Tools for Water-Resources Applications.* https://www.usgs.gov/mission-areas/water-resources/science/streamstats-streamflow-statistics-and-spatial-analysis-tools?qt-science_center_objects=0#qt-science_center_objects. Accessed January 3, 2021.

Woltemade, C.J. 2000. *Ability of Restored Wetlands to Reduce Nitrogen and Phosphorus Concentrations in Agricultural Drainage Water.* Journal of Soil and Water Conservation. 55(3): 303-309.