Yankee Run-St. Mary's River
Nonpoint Source Implementation Strategy

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ABBREVIATIONS AND ACRONYMS

Acronyms/Abbreviations	Definition
ACPF	Agricultural Conservation Planning Framework
ALU	aquatic life use
ARS	Agricultural Research Service (U.S. Department of Agriculture)
BMP	best management practice
CAFF	confined animal feeding facility
CAFO	concentrated animal feeding operation
DELT	deformity, [fin] erosion, lesion, or tumor
DEM	digital elevation model
EQIP	Environmental Quality Incentives Program
EPT	*Ephemeroptera*, *Plecoptera*, and *Trichoptera* (mayfly, stonefly, and caddisfly)
GIS	geographic information system
GLWQA	Great Lakes Water Quality Agreement
HAB	harmful algal bloom
HUC	hydrologic unit code
IBI	Index of Biotic Integrity
ICI	Invertebrate Community Index
LEAU	Lake Erie assessment unit
MIwb	Modified Index of well-being
NASS	National Agricultural Statistics Service (U.S. Department of Agriculture)
NPDES	National Pollutant Discharge Elimination System
NPS	nonpoint source
NPS-IS	Nonpoint Source Implementation Strategy
Ohio EPA	Ohio Environmental Protection Agency
PSS	project summary sheet
QHEI	Qualitative Habitat Evaluation Index
SRP	soluble reactive phosphorus
SWCD	soil and water conservation district
TBD	to be determined
TP	total phosphorus
TSD	technical support document
U.S. EPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey (U.S. Department of the Interior)
WASCOB	water and sediment control basin

Acronyms/Abbreviations	Definition
WAU	watershed assessment unit
WWH	warmwater habitat
WWTP	wastewater treatment plant

Unit of measure	Definition
lb/yr	pounds per year
mg/L	milligram per liter (part per million)
mg/m^2	milligram per square meter
µg/L	microgram per liter (part per billion)

ACKNOWLEDGEMENTS

Tetra Tech would like to thank the many partners who helped compile the information, maps and projects needed to create this document, especially the Mercer County Soil and Water Conservation District. This NPS-IS plan will help focus on projects to address the nonpoint source impairments in the *Yankee Run-St. Mary's River* subwatershed.

This NPS-IS plan was developed by Tetra Tech for the state of Ohio with support from U.S. EPA.

1 INTRODUCTION

The Saint Mary's River is a small river in Ohio that flows into Indiana and joins the St. Joseph River in Fort Wayne, Indiana to form the Maumee River. As such, the St. Mary's River ultimately drains to Lake Erie. This river along with several named and unnamed streams and ditches make up the *Yankee Run-St. Mary's River*[1] watershed assessment unit (WAU) with hydrologic unit code (HUC) 04100004 03 03. The *Yankee Run-St. Mary's River* WAU is in the *St. Marys* subbasin (HUC 04100004) and the Western Basin of Lake Erie. The *Yankee Run-St. Mary's River* WAU is 59 square miles and is southwest of the city of Van Wert and northeast of the city of Celina (Figure 1). The WAU lies in Van Wert and Mercer counties.

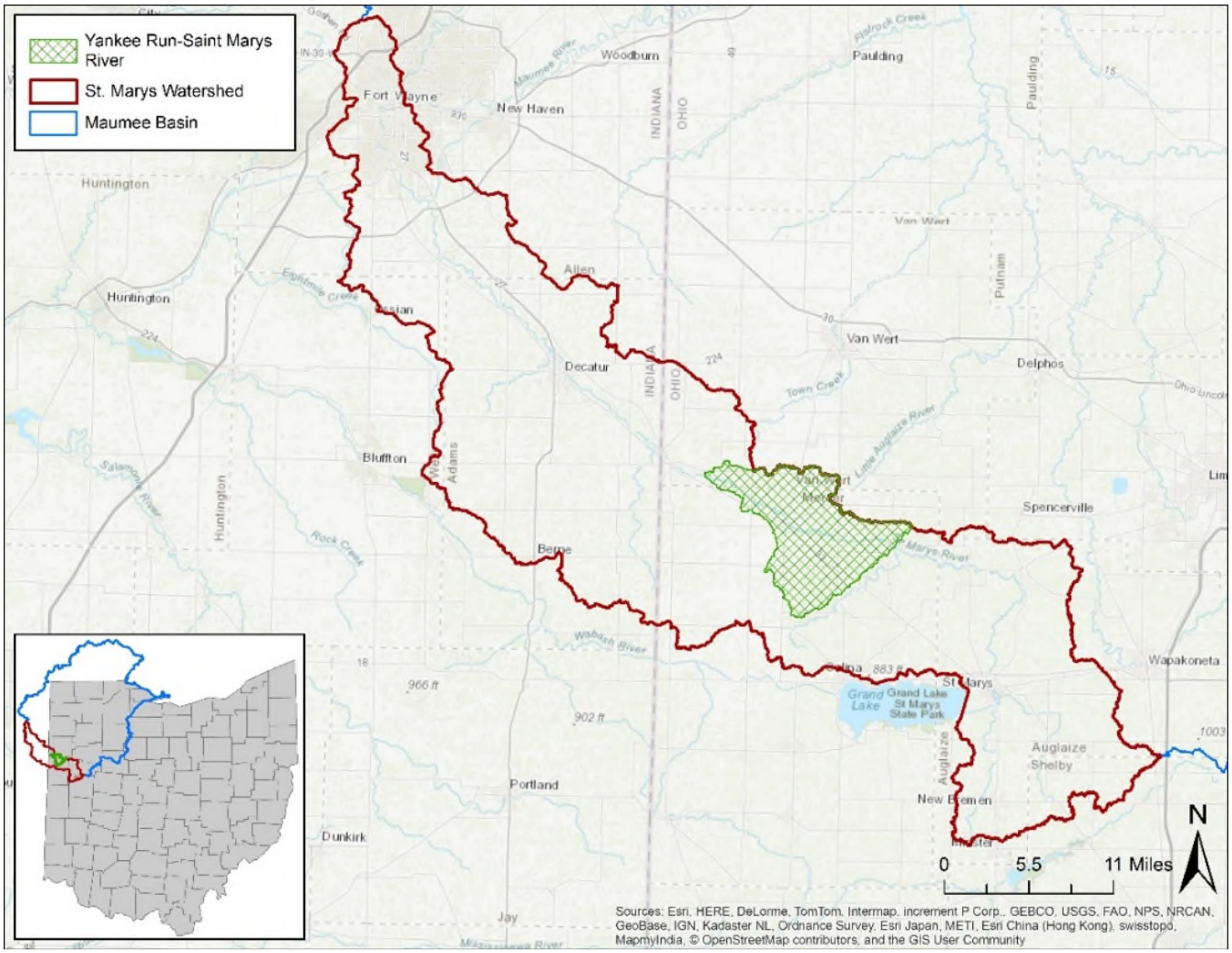


Figure 1. *Yankee Run-St. Mary's River* WAU in the *St. Marys* subbasin.

[1] The U.S. Geological Survey identifies this hydrologic unit as *Town of Willshire-Saint Marys River*. Throughout this plan, the WAU is referred to as the *Town of Willshire-St. Mary's River*. Generally, "St. Mary's" is used in this plan in lieu of "Saint Marys".

Many streams in the rural, agricultural *St. Marys* subbasin have been channelized and straightened to support tiled, row crop agriculture. In the *Yankee Run-St. Mary's River* WAU, the St. Mary's River is perennial. Its tributaries include both perennial and intermittent streams and drainage canals/ditches. The largest perennial tributaries are Dennison Ditch, Town Run, and Yankee Run.

State and federal nonpoint source (NPS) funding is now closely tied to strategic implementation-based planning that meets the U.S. Environmental Protection Agency's (U.S. EPA) nine minimum elements of a watershed plan for impaired waters. This nonpoint source implementation strategy (NPS-IS) plan was authored by Tetra Tech, under contract with U.S. EPA. Tetra Tech worked closely with the Ohio Environmental Protection Agency (Ohio EPA) and the Mercer County Soil and Water Conservation District (Mercer SWCD). The Yankee Run-St. Mary's River NPS-IS plan is one of seven NPS-IS plans being developed by Tetra Tech, under U.S. EPA contract, to address the far-field impacts of WAUs on Lake Erie. Other organizations are preparing NPS-IS plans for other WAUs in the Maumee River basin to address far-field impacts on Lake Erie; these plans are being funded through grants to support Ohio's Domestic Action Plan.

1.1 REPORT BACKGROUND

This document is the first of its kind to address both near-field impacts in this WAU and far-field impacts in Lake Erie. No watershed action plan was previously developed for this watershed. A technical support document (TSD) for the St. Mary's River watershed in Ohio, which include the *Yankee Run-St. Mary's River* WAU, was developed by Ohio EPA in 2018. This document builds upon and references information from that report and others.

This NPS-IS plan addresses near-field impacts on aquatic community health in the *Yankee Run-St. Mary's River* WAU and far-field impacts on Lake Erie. This plan does not address point source issues, including both permitted point sources and illicit discharges that are regulated by Ohio EPA. Other programs will create plans or lists to address other impairments in an effort to restore the area to fishable, swimmable and drinkable waters that meet water quality standards.

1.2 WATERSHED PROFILE AND HISTORY

The *Yankee Run-St. Mary's River* WAU is in western Ohio along the Van Wert and Mercer counties border that bisects the WAU. As shown in Figure 2, most of the WAU is within Dublin and Union townships (Mercer County) with smaller portions in Black Creek, Center, and Hopewell townships (Mercer County) and Liberty and Willshire townships (Van Wert County). In this WAU, the St. Mary's River flows northwesterly from the confluence of Twelvemile Creek in Mendon, through farmed areas and Rockford, and to the confluence of Black Creek.

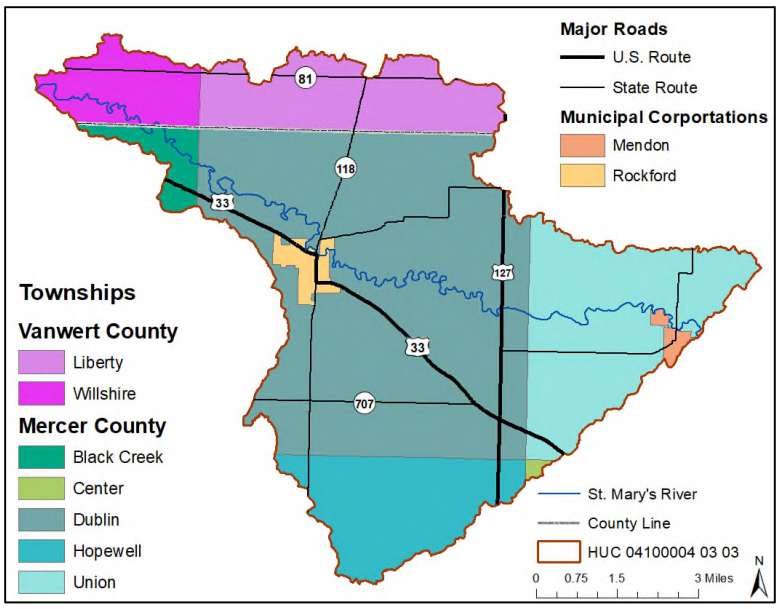


Figure 2. Political map of the *Yankee Run-St. Mary's River* WAU.

The WAU is primarily rural and agricultural. Two municipal corporations are in the WAU: the villages of Rockford and Mendon. The village of Rockford is just over three-quarters of a square mile and has a population of 1,120 (Census Bureau 2010). The village of Mendon is about one-half square mile and has a population of 662 (Census Bureau 2010).

1.3 PUBLIC PARTICIPATION AND INVOLVEMENT

When developing watershed planning and restoration plans such as this NPS-IS plan, it is important to have involvement and input from a diverse group of individuals and organizations. This group should include members of the public, private businesses and organizations, academia, governmental agencies, non-profits, and community organizations. Several partners have been working in the *Yankee Run-St. Mary's River* watershed to improve water quality and increase ecological restoration. These partners focus on a diverse set of interests, from access to green space to reducing nutrient loading in Lake Erie.

Some of the key partners working in the *Yankee Run-St. Mary's River* WAU include: Mercer SWCD, Van Wert SWCD, Mercer County Community and Economic Development, the Mercer County Health Department, the Mercer County Engineer's Office and Mercer County Farm Bureau. Meetings held to discuss the development of this NPS-IS plan included the following:

- Representatives of Tetra Tech and Ohio EPA met with Adams, Mercer, and Van Wert SWCDs on May 8, 2019 to kick-off the development of three NPS-IS plans (including this plan) and to tour the watershed.
- Mercer SWCD conducted a public stakeholder meeting on June 27, 2019 in Rockford, Ohio (Figure 3). The meeting covered four WAUs, including *Yankee Run-St. Mary's River*. Due to the wet spring, planting was delayed until June; thus, only a few farmers were able to attend. Mercer SWCD staff discussed NPS-IS plan development and agricultural BMP opportunities with the attendees.
- Mercer SWCD conducted four meetings with individual farmers to discuss specific project ideas]

Mercer SWCD operates cost-share programs for local-funding, for state-funding for pollution abatement and the Conservation Reserve Enhancement Program, and for federal-funding for the Conservation Reserve Program and Environmental Quality Incentives Program (EQIP). Mercer SWCD provides technical assistance for many types of projects that can reduce nutrient-loading in the *St. Mary's River* subbasin (e.g., comprehensive nutrient management planning, grassed waterways, wetland development/restoration). Finally, Mercer SWCD conducts adult and children educational programs (e.g., *Soils & Erosion* and *Enviroscape* for children and *Farm Tour* and *Pond Clinic* for adults). These program seek to educate children and adults about environmental issues (including water quality) and how to be better stewards of the land

This report was primarily authored by Tetra Tech. Chapters 1 and 2 were written using information from the TSD for the St. Mary's River watershed (Ohio EPA 2018). Critical areas, discussed in Chapter 3, were delineated by Tetra Tech with assistance from Mercer SWCD and with feedback from Ohio EPA. Project information in Chapter 4 was based upon project information provided by Mercer SWCD and Van Wert SWCD.

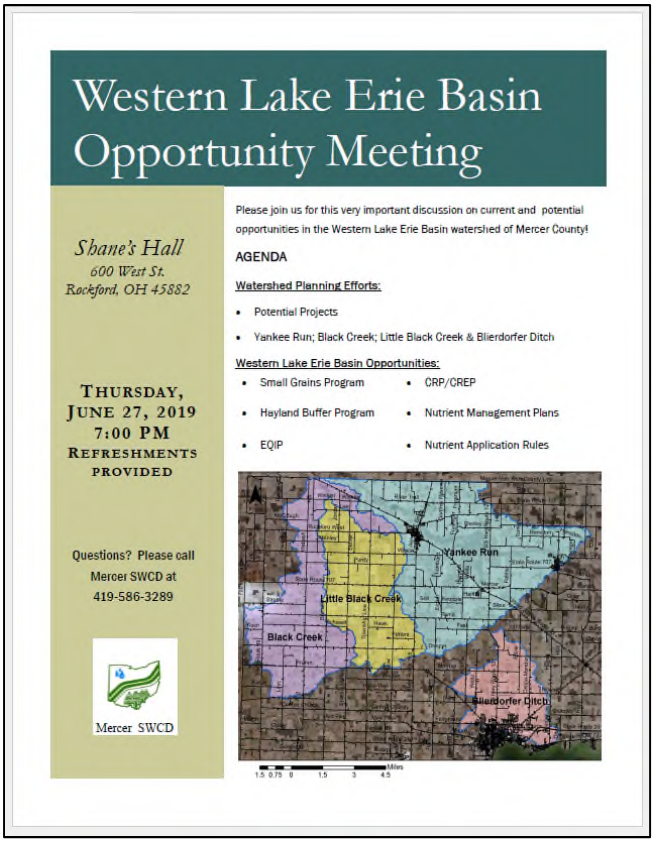


Figure 3. Flyer for June 27, 2019 meeting.

2 WATERSHED CHARACTERIZATION AND ASSESSMENT SUMMARY

The St. Mary's River is a small river that eventually joins with the St. Joseph River to form the Maumee River. Several unnamed and locally named ditches are tributary to St. Mary's River in this WAU. The *Yankee Run-St. Mary's River* WAU is rural with considerable row crop land throughout the watershed. Streams and ditches throughout the WAU have been straightened and channelized, typically to support agricultural operations. This section summarizes the watershed characterization and assessment of the *Yankee Run-St. Mary's River* WAU and is primarily based upon information presented in a TSD: *Biological and Water Quality Study of St. Marys River and Tributaries, 2015* (Ohio EPA 2018a).

2.1 SUMMARY OF WATERSHED CHARACTERIZATION

The *Yankee Run-St. Mary's River* WAU is predominated by row crop agriculture and contains two municipalities: the villages of Mendon and Rockford (Figure 4).

Agriculture in this WAU is typical of northwest Ohio. The vast majoring of crop land is in rotations of corn and soybean. Many agricultural property owners own several parcels, and they often use crop advisors for managing cultivated crop production. No regulated animal operations are in this WAU. However, many farms have small numbers of livestock.

Many agricultural parcels include residences. The villages of Mendon and Rockford are served by wastewater treatment plants. Rural residences use household sewage treatment systems. Potable water is derived from groundwater, either through public water systems or through private wells.

Source of spatial data: Farm Service Agency (2017).

Figure 4. Village of Rockford (Mercer County).

2.1.1 Physical and Natural Features

The *St. Mary's* subbasin is transitional between the *Eastern Corn Belt Plains* (#55) and *Huron-Erie Lake Plains* (#57) level III ecoregions (Ohio EPA 2018a). WAUs in the *St. Mary's* subbasin are also transitional and exhibit characteristics of both ecoregions. Also, the ecoregional boundaries have changed since their original delineations in 1977. Today, the *Yankee Run-St. Mary's River* WAU is in *Eastern Corn Belt Plains* (#55), but in the past this WAU was in the *Huron-Erie Lake Plain* (#57).

The *Eastern Corn Belt Plains* are composed of rolling till plains with extensive local end moraines and glacial deposits of Wisconsinian-age (U.S. EPA 2012). Historically, "beech forests were common on Wisconsinian soils while beech forests and elm-ash swamp forests dominated the wetter pre-Wisconsinian soils" (U.S. EPA 2012).

The *Huron/Erie Lake Plains* are composed of "broad, fertile, nearly flat plain punctuated by relict sand dunes, beach ridges, and end moraines" (U.S. EPA 2012). Historically, soil drainage was poor, and the ecoregion was predominated by elm ash swamp forests and beech forests (U.S. EPA 2012).

The largest waterbody in this WAU is the St. Mary's River (26.1 miles). The National Hydrography Dataset (U.S. Geological Survey [USGS] 2019b) includes over 30 tributaries to the St. Mary's River within this WAU. However, most are unnamed intermittent tributaries that range from 0.6 to 4.5 miles long.

Only three tributaries to the St. Mary's River are named in the National Hydrography Dataset (USGS 2019b):

- **Dennison Ditch** is 6.4 miles long and 2.9 miles are perennial
- **Town Run** is 8.8 miles long and 6.4 miles are perennial
- **Yankee Run** is 6.7 miles long and 2.0 miles are perennial)

Several tributaries to the St. Mary's River have their own tributaries, which are intermittent and range from 0.6 to 1.2 miles long. Town Run has the only named tributary: Ayre Ditch is 3.9 miles long and 0.3 miles are perennial.

2.1.2 Land Use and Protection

The *Yankee Run-St. Mary's River* WAU is predominantly cropland (84 percent; Table 1). Deciduous forest (5 percent) is contained within woodlots (Figure 5) and in the riparian corridor along the St. Mary's River. Several wooded wetland complexes are also in the St. Mary's Rive riparian corridor.

No public parks or protected lands are in the *Yankee Run-St. Mary's River* WAU.

Table 1. Land cover in the *Yankee Run-St. Mary's River* WAU

Land cover	Area (acres)	Relative area (percent)
Open water	115	<1%
Developed, open	1,688	4%
Developed, low intensity	494	1%
Developed, medium intensity	129	<1%
Developed, high intensity	46	<1%
Barren land	26	<1%
Deciduous forest	1,778	5%
Evergreen forest	8	<1%
Mixed forest	6	<1%
Shrub / scrub	4	<1%
Grassland / herbaceous	101	<1%
Pasture / hay	89	<1%
Cultivated crops	31,897	84%
Woody wetlands	1,218	3%
Emergent herbaceous wetlands	424	1%
Total	**38,024**	**100%**

Source of spatial data: National Land Cover Database 2016 (Yang et al. 2018).

Note: Areas were rounded to the nearest acre or percentage point. The *Totals* do not sum exactly due to rounding.

Source of spatial data: Farm Service Agency (2017).

Figure 5. Row crop land and woodlots in the *Yankee Run-St. Mary's River* WAU.

2.1.2.1 Cultivated Crop Land

Corn (29 to 39 percent) and soybean (52 to 61 percent) were the major crops in 2015 through 2018 based on the cropland data layers (National Agricultural Statistics Service [NASS] 2019; Table 2 and Figure 6).

Table 2. Cropland areas (acres) in the *Yankee Run-St. Mary's River* WAU

Crop	2015	2016	2017	2018
Corn	8,951	10,547	8,767	11,615
Soybean	18,046	15,543	18,276	15,941
Winter wheat	1,720	1,826	1,579	1,646
Double crop [a]	10	130	--	9
Hay [b]	343	431	728	564
Other crop [c]	692	1,247	874	260
Fallow/idle	100	27	1	4
Total	**29,860**	**29,747**	**30,195**	**30,039**

Source of spatial data: NASS 2019.

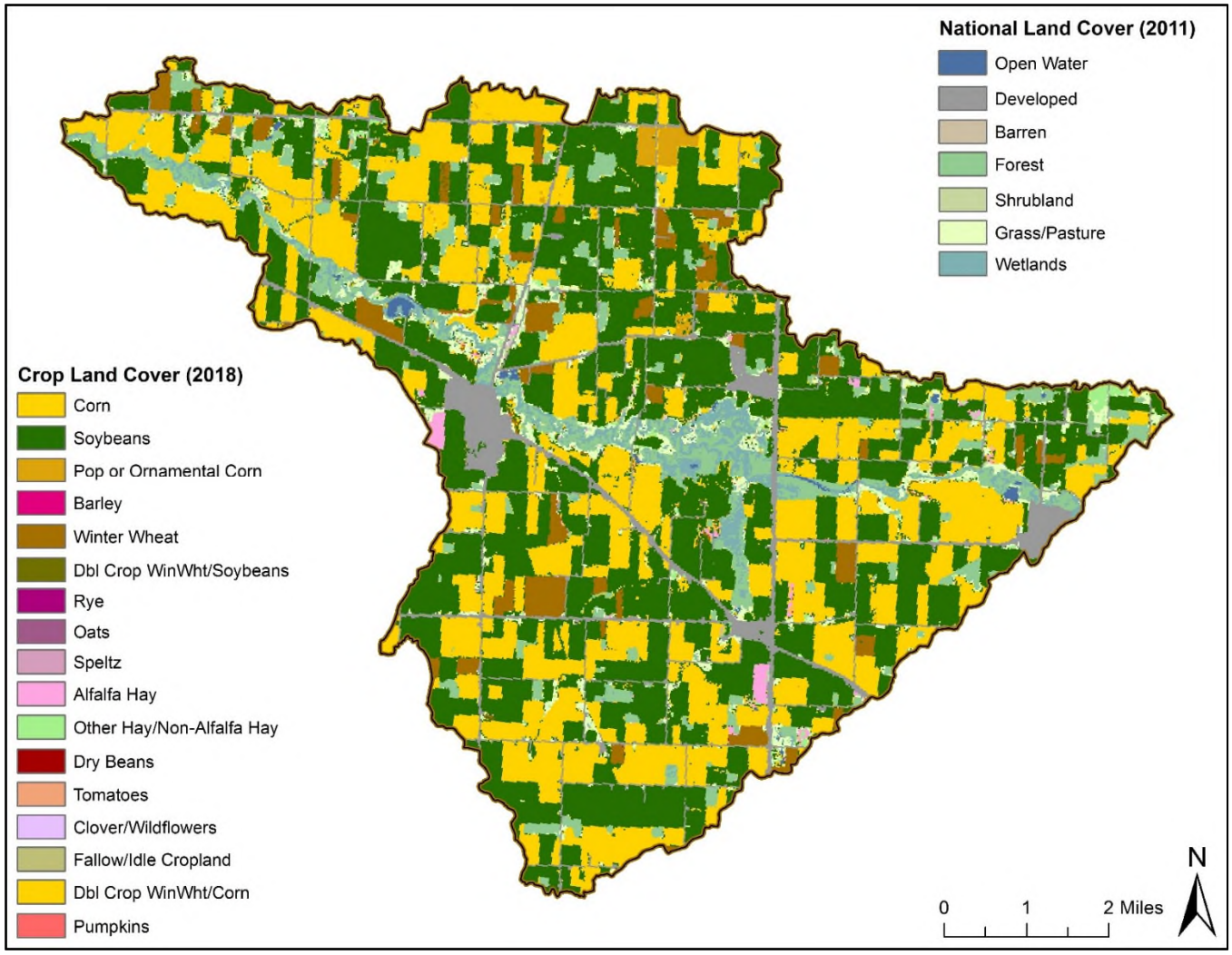
Notes

Areas were rounded to the nearest acre. The *Totals* do not sum exactly due to rounding.

a. Double crop of corn or soybeans with winter wheat.

b. Alfalfa hay and other hay/non-alfalfa hay.

c. Barley, clover/wildflower, dry beans, oats, pop- or ornamental corn, pumpkins, rye, sod/grass seed, speltz, and tomatoes.



Source: NASS 2019. The 2018 cropland data layer incorporates the 2011 National Land Cover Database.

Figure 6. Land cover in the *Yankee Run-St. Mary's River* WAU.

Crop rotations were evaluated in the Agricultural Conservation Planning Framework (ACPF) using common land units (2008)[2] and six-years of Cropland Data Layers (2013 through 2018); refer to Section 2.5 for a discussion of ACPF. Crops in most rotations were of either (1) corn and soybean (60 percent) or (2) corn, soybeans, and winter wheat (23 percent). Excluding common land units with non-agricultural land (e.g., urban, forest), 205 different six-year sequences of crops were identified. The most common crop rotations were alternating corn-soybean (30 percent), corn-soybean-soybean (5 percent), and corn-soybean-winter wheat (3 percent). Continuous corn (1 percent), soybean (6 percent), and pasture[3] (2 percent) were not frequent. Partially continuous soybean with one year of corn (7 percent) or winter wheat (2 percent) were more frequent than continuous soybean.

[2] The boundaries of the common land units were used with six years of Cropland Data Layers (2013 through 2018) to determine the majority crop for each common land unit for each year. Both agricultural and non-agricultural common land units were evaluated. However, only common land units without any forest or urban in the Cropland Data Layers were used to determine crop rotations.

[3] This analysis did not distinguish between pasture and grass crops (e.g., alfalfa hay).

Recent tillage practices (2016 through 2018) varied by spring and fall in the Mercer County watersheds that drain to Lake Erie (Mercer SWCD 2019c):

- **Spring**: Typically, corn, soybean, and winter wheat fields are tilled, while fields for hay and other crops are not. The majority of corn fields were tilled via a chisel plow (54 to 70 percent), while some fields had reduced tillage (9 to 15 percent) or no tillage (5 to 18 percent). Many soybean fields were not tilled (41 to 49 percent) or were mulch tilled (20 to 31 percent). A significant minority of soybean fields were chisel plowed (14 to 19 percent).
- **Fall**: Typically, corn, soybean, and winter wheat fields are tilled in the fall. No crop was conventionally tilled with a moldboard plow. The majority of corn fields were not typically tilled (44 to 77 percent), with significant minorities of mulch till (8 to 35 percent) or reduced till (12 to 46 percent). Soybean fields varied between no till (34 to 67 percent), reduced till (28 to 49 percent), or mulch till (3 to 20 percent). Tillage of winter wheat varied by year, including no till (9 to 80 percent), reduced till (20 to 83 percent), and mulch till (0 to 45 percent).

Fertilizer application in this WAU is typical of northwest Ohio. For corn, a phosphorus starter fertilizer is usually applied at spring planting, followed by nitrogen application 30-days after planting. Soybeans typically receive little to no fertilizer. Phosphorus fertilizer is applied in the fall when winter wheat is planted and nitrogen in the spring.

Grassed waterways are the most common structural BMPs in this WAU. Mercer SWCD (2019a) has assisted landowners with installing grassed waterways and nutrient removal wetlands (Table 3). Mercer SWCD also develops nutrient management plans and can assist landowners with incorporating variable rate technology with their chemical fertilizer application.

Table 3. Agricultural BMPs installed with the assistance of Mercer SWCD in 2009 through 2018

Agricultural BMP	Size	Treatment area
Grassed waterways [a]	24,639 feet (21.2 acres)	1,260 acres
Nutrient removal wetlands	*pool*: 28.3 acres *buffer*: 56.6 acres *wooded*: 6 acres	275 acres [b]

Source: Mercer SWCD (2019a).

Notes

a. An additional 1,927 feet (1.6 acres) of grassed waterways to treat 318 acres will be installed in 2019.

b. One wetland was installed in the floodplain of the St. Mary's River and its treatment area is not included in the 275 acres.

A review of EQIP records (U.S. Department of Agriculture 2018) did not identify any funded in projects in this WAU from 2014 through 2018.

2.1.2.2 Livestock Operations

One concentrated animal feeding facility (CAFF)[4] and no concentrated animal feeding operations (CAFOs)[5] are in the *Yankee Run-St. Mary's River* WAU. CAFF 17146 is in Van Wert County and has 207,360 chickens-layers (Ohio Department of Agriculture 2019). Smaller livestock operations and hobby farms are found throughout the WAU. A review of aerial imagery from the Farm Service Agency (2017) indicates several properties with fenced

[4] CAFFs are regulated by the Ohio Department of Agriculture's Livestock Environmental Permitting Program, which issues permits to install and permits to operate.

[5] CAFOs are regulated by Ohio EPA through the National Pollutant Discharge Elimination Program.

pastures and/or large buildings in both Mercer and Van Wert counties that may be smaller, unpermitted livestock operations.

In the Mercer County portion of the *Yankee Run-St. Mary's River* WAU, Mercer SWCD (2019b) identified the following nine livestock operations (Table 4). At the turkey and swine operations, the animals are always confined within buildings. Some turkey operations have additional manure storage beyond the barn floors. Turkey manure may be land-applied to cropland owned by other parties (i.e., not the owners of the turkey operations). The beef cattle operation is small with some access to open feedlots. Mercer SWCD (2019b) believes that all of these livestock operations have opportunities for comprehensive nutrient management planning.

Table 4. Livestock operations in the Mercer County portion of the *Yankee Run-St. Mary's River* WAU

Livestock species	No. of operations	No. of animal units
Beef cattle (heifer and calves)	3	150
Dairy cattle	1	(withheld)
Swine	1	(withheld)
Turkey	4	1,091

Source: Mercer SWCD (2019b).

2.1.2.3 Ditch Maintenance

Public and private ditches throughout Van Wert and Mercer counties are under various forms of maintenance. Maintenance can include mowing vegetation along the banks and channel side-slopes, removing logjams, and dipping (i.e., removing) accumulated sediment from the channel bottom. County maintenance is often performed to protect infrastructure and eliminate or reduce flooding. Ditches on private agricultural properties are maintained to ensure appropriate drainage from cultivated crop fields.

The St. Mary's River, Yankee Run, and Town Run are not under county maintenance (Mercer County Engineer's Office 2019). Tributary ditches to Yankee Run are under county maintenance (e.g., Hays Ditch No. 72-75).

If these waterbodies were under maintenance, then such maintenance would need to be considered when developing objectives to meet habitat restoration goals. In some cases, ditch maintenance can preclude habitat restoration and BMPs.

2.1.3 Permitted Point Sources

Five facilities and two household home sewage treatment systems (HSTS) in the WAU are covered by a National Pollutant Discharge Elimination System permit (NPDES; Ohio EPA 2019b; i.e., only these seven entities may discharge to surface waters)[6]. These facilities are beyond the scope of this NPS-IS plan; however, the facilities are briefly discussed herein:

- **DFGC Black LLC** (2PG00119) is a sanitary treatment facility that processes domestic sewage from the Deerfield Golf Course near the village of Rockford. The facility is permitted to discharge 14,000 gallons per day through one outfall to the St. Mary's River. The NPDES permit includes monitoring requirements

[6] The following permitted operations are not present in the WAU (https://epa.ohio.gov/gis; accessed May 2, 2019): composting facilities, concentrated animal feeding operations, construction site stormwater, industrial stormwater, and municipal separate sewer system stormwater. No small sanitary treatment facilities are in the WAU (Ohio EPA 2019b). No surface water protection areas are in the WAU. Five groundwater protection areas are in the WAU. Two groundwater protection areas are for community systems with two wells each: village of Mendon (OH5400612; wells are just outside of the WAU), village of Rockford (OH5401112). Three groundwater protection areas are for noncommunity systems with one well each: Deerfield Golf Course (OH5440912), Motor Inn Auto Truck Shop PWS (OH5433812), and St. Teresa Catholic Church (OH5434512).

(but not limits) for phosphorus and nitrogen effluent concentrations. The facility is authorized to transfer sewage sludge to another NPDES permittee.

- **Mendon Wastewater Treatment Plant** (WWTP; 2PA00058) is a controlled discharge lagoon that processes domestic sanitary sewage from the village of Mendon, which is partially within the *Yankee Run-St. Mary's River* WAU. The authorized discharge rate for this facility through its one outfall to the St. Mary's River is dependent upon the flow rate in the St. Mary's River. The NPDES permit includes monitoring requirements (but not limits) for phosphorus and nitrogen effluent concentrations. The permit has sanitary sewer overflow reporting requirements; however, no overflows were reported from May 2013 through December 2018.
- **Rockford Bulk Plant** (2IN00183) is an industrial facility owned by Belna Petroleum Inc. that is authorized to discharge industrial stormwater to the St. Mary's River. This facility is not anticipated to discharge appreciable amounts of nutrients or sediment.
- **Rockford Sewage Treatment Plant** (2PD00001) is a treatment facility that processes domestic sanitary sewage from the village of Rockford. The facility is permitted to discharge 450,000 gallons per day through one outfall to Little Muddy Creek. The NPDES permit includes monitoring requirements (but not limits) for phosphorus and nitrogen effluent concentrations. The permit has sanitary sewer overflow reporting requirements; however, no overflows were reported in 2008 through 2018.

  The facility is authorized to transfer sewage sludge to a solid waste landfill or another NPDES permittee. The facility is also authorized to dispose of sludge through land-application. However, Ohio EPA has no records of fields authorized for biosolids application in this WAU.
- **Shelly Materials** (2IJ00041) is a sand and gravel producer that is authorized to discharge to the St. Mary's River. The facility is permitted to discharge 4.8 million gallons per day through each of its two outfalls. Both outfalls discharge from sedimentation ponds along a settling channel.

Seven fields within this WAU are authorized for the application of biosolids. A 31-acre field in Mercer County (54-00017) is authorized to land-apply biosolids from the Willshire WWTP (2PA00013); however, this facility is currently only authorized to transfer sewage sludge to a solid waste landfill or another NPDES permittee (2PA00013*HD). Six fields[7] in Mercer County (115 acres total) are authorized to land apply biosolids from the Celina WWTP (2PD00033)[8], and this facility is currently authorized to dispose of sludge via land-application (2PD00033*QD) .

In addition to the Rockford and Mendon WWTPs, the WAU is served by HSTS. Off-site discharging HSTS are required to obtain general permit coverage; a cursory review of online data (Ohio EPA 2019a) indicates that two HSTS in the village of Rockford are covered by the general permit for HSTS (OHK000003).

As discussed in Section 2.1.2.2, one CAFF and no CAFOs with NPDES coverage are in the *Yankee Run-St. Mary's River* WAU.

[7] The six fields in Mercer County are: 54-00035, 54-00041, 54-00042, 54-00043, 54-00044, 54-00058.

[8] Several dozen fields in adjacent WAUs are also authorized to land-apply biosolids from the Celina WWTP.

2.2 SUMMARY OF BIOLOGICAL TRENDS

In 2015, biological and habitat data were collected at six assessment sites on the St. Mary's River, two sites on Town Run, and one site on Yankee Run. Six sites are in full attainment of their designated aquatic life use (ALU) of warmwater habitat (WWH)[9] in the *Huron-Erie Lake Plains* ecoregion[10] (Table 5); three sites are in partial attainment due to macroinvertebrate community health. No biological or habitat data were previously collected in this WAU.

In 2015, the Index of Biotic Integrity (IBI) and Modified Index of well-being (MIwb) scores attained the biological criteria at all sites. The Invertebrate Community Index (ICI)was evaluated quantitatively at sites on the St. Mary's River and qualitatively at tributary sites. ICI scores met biological criteria at five of six sites on the St. Mary's River (one of these five sites was in nonsignificant departure). Scores in nonsignificant departure from biological criteria are just below the criteria. Qualitative macroinvertebrate sampling at Yankee Run and Town Run did not meet biological criteria. Qualitative Habitat Evaluation Index (QHEI) scores met the targets at two sites on the St. Mary's River[11]. QHEI scores at several sites on the St. Mary's River are just below the target. However, QHEI scores on Yankee Run and Town Run are well below the target.

Table 5. Overall biological indices scores for the *Yankee Run-St. Mary's River* WAU

River	RM (DA)	ALU	IBI	MIwb	ICI	Status	QHEI	Site
St. Mary's River	70.40^{B} (251)	WWH	36	9.2	48	Full	56.5	302591
	65.70^{B} (261)	WWH	35	9.6	42	Full	49.0	P01K04
	61.50^{B} (279)	WWH	36	9.5	34	Full	54.8	P01K03
	57.82^{B} (295)	WWH	36	10.1	30^{ns}	Full	63.0	P01W08
	52.13^{B} (303)	WWH	31^{ns}	9.3	40	Full	58.5	P01K02
	47.48^{B} (309)	WWH	37	9.2	24	Partial	62.3	P01K01
Yankee Run	1.40^{H} (6.1)	WWH	42	--	Fair	Partial	26.8	303084
Town Run	1.87^{H} (5.6)	WWH	32	--	--	Full	38.0	303356
	1.25^{H} (7.1)	WWH	34	--	Fair	Partial	46.5	303085

Source: Ohio EPA 2018a (2015 data).

Notes

ALU = aquatic life use; B = boating; DA = drainage area in square miles; H = headwaters; IBI = Index of Biotic Integrity; ICI = Invertebrate Community Index; MIwb = Modified Index of well-being; ns = nonsignificant departure; QHEI = Qualitative Habitat Evaluation Index; RM = river mile; WWH = warmwater habitat.

Values in red do not meet their biological criteria or targets; values in green meet their biological criteria or targets.

[9] Biological criteria for WWH streams in the Huron-Erie Lake Plains ecoregion are: IBI scores of 28 (headwaters) and 34 (boating), MIwb score of 8.6 (boating), and ICI score of 34 (headwaters and boating).

[10] Biological data from the *Yankee Run-St. Mary's River* WAU are evaluated with biological criteria from the *Huron-Erie Lake Plain* ecoregion because Ohio EPA biologists determined that stream habitat in this WAU exhibits characteristic more similar to the *Huron-Erie Lake Plain* ecoregion than the *Eastern Corn Belt Plains* ecoregion. Refer to Section 2.1.1 for a discussion of the transitional nature of the *St. Mary's* subbasin.

[11] The QHEI targets for WWH streams are a score of 55 (headwaters) and 60 (boating).

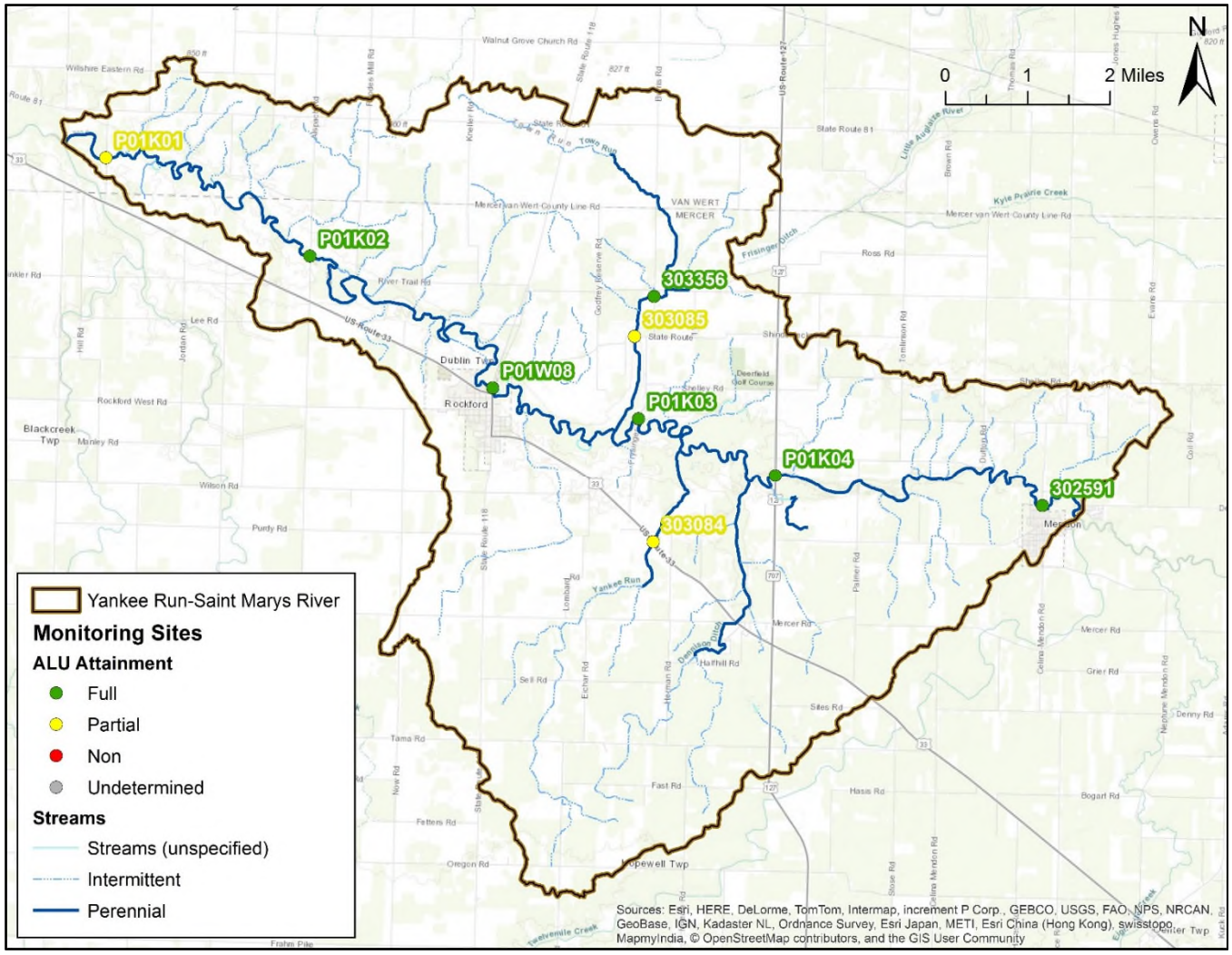


Figure 7. ALU attainment in the *Yankee Run-St. Mary's River* WAU.

2.2.1 Fish Community Health

Fish community health in the St. Mary's River within the HELP ecoregion and within the *Yankee Run-St. Mary's River* WAU ranged from *fair* to *exceptional*. Between 31 and 38 cumulative species were caught at the six sites in the WAU. The IBI at these sites typically scored well with the *total number of species*, *number of sunfish*, *percent of insectivores*, and *relative number minus tolerants*.

Fish community health in Yankee Run was *good*. The IBI at site 303084 scored well with the *total number of species*, *number of minnow species*, *percent of pioneering species*, *percent deformities, eroding fins, lesions, and tumor anomalies*, and *relative number minus tolerants.*

Fish community health at the two sites on Town Run was *fair*. The IBIs scored well with the *total number of species* and *number of minnow species*. No headwaters species were captured, while a high percent of omnivores were captured (lack of headwaters species and high percent of omnivores indicate poor fish community health).

2.2.2 Macroinvertebrate Community Health

The St. Mary's River generally had healthy macroinvertebrate communities. Many sites were dominated by mayflies, caddisflies, and midges. While several sites in the upper St. Mary's River did not attain biological criteria, most sites in the middle and lower St. Mary's River were in full attainment.

The modified Hester-Dendy substrate sampler was deployed to six sites on the St. Mary's River in the Yankee Run-St. Mary's River WAU. The predominant taxa were mayflies, caddisflies, and midges. At the most downstream site in the WAU (P01K01), the predominant taxa were midges only. Across the six sites, total taxa ranged from 44 to 65 taxa, with 26 to 45 quantitative taxa. During qualitative sampling, six to nine *Ephemeroptera*, *Plecoptera*, and *Trichoptera* (EPT) were captured and three to 11 sensitive taxa were captured. Higher percentages of EPT and sensitive taxa are indicative of healthy macroinvertebrate communities. No coldwater taxa were captured.

Only qualitative sampling was performed at Yankee Run (303084) and Town Run (303085). Yankee Run had 56 taxa, with six EPT taxa and one sensitive taxon. Town Run had 38 taxa, with four EPT taxa and one sensitive taxon. No coldwater taxa were captured in either stream, and tolerant taxa made up about half of the taxa captured in each stream. Both streams had *fair* macroinvertebrate community health.

2.2.3 Fish Habitat

In the HELP, the St. Mary's River (including within this WAU) had maximum depths greater than 40 centimeters, no channelization, moderate to heavy silt cover, fair to poor development, and moderate to high embeddedness. Most HELP sites also had no fast current and no riffles.

A review of aerial imagery indicates that most of the St. Mary's River flows through a wooded riparian corridor. Some segments flow through woodlots and along wetlands. However, some segments include wooded riparian buffers that are less than 50-feet wide with cultivated land just beyond the buffer. Anecdotal reports from residents indicate that the St. Mary's River overtops its banks following larger rainstorms and floods cropland in its floodplain.

Ohio EPA monitored six sites on the St. Mary's River in the *Yankee Run-St. Mary's River* WAU, and these sites had *fair* to *good* habitat. The sites typically had moderate to high sinuosity and moderate to extensive cover (both of which are indicative of good quality habitat). Sites that scored above or just below the QHEI target had boulder, cobble, or gravel substrates (i.e., good habitat), while those sites farther below the target had silt or muck substrates (i.e., poor habitat). Only two sites met the QHEI target (P01W08 and P01K01) and site P01K02 was just below the target. These three sites are in the downstream half of the WAU.

Yankee Run (303084) had *very poor* habitat, the upstream site on Town Run (303356) had *poor* habitat, and the downstream site on Town Run (303085) had *fair* habitat (Table 6). All three sites had maximum depths less than 40 centimeters, silt or muck substrates, moderate to heavy silt cover, fair to poor development, low sinuosity, no fast current, moderate to high embeddedness, and no riffles (all of these attributes are indicative of poor quality habitat).

Beyond the St. Mary's River corridor, Yankee Run flows through a grassed buffer (about 100-feet) that abuts cultivated crop fields. The stream is typically channelized, and some segments are straightened. A few segments in middle Yankee Run flow through wooded riparian buffers and through woodlots. Upper segments of Yankee Run and its intermittent tributaries are little more than agricultural waterways and ditches.

Town Run also flows through thin but wooded riparian buffers, along with grassed waterways and filter strips. Like Yankee Run, Town run flows through cultivated cropland and has many similar small tributaries.

Table 6. QHEI matrix with WWH and modified warmwater habitat attributes

Key QHEI component			WWH attributes											MWH attributes																			
														High influence						Moderate influence														
RM	QHEI score	Gradient (foot/mile)	Not channelized or Recovered	Boulder, Cobble, or Gravel substrates	Silt free substrates	Good/Excellent development	Moderate/High sinuosity	Extensive/Moderate cover	Fast current/Eddies	Low/Normal embeddedness	Maximum depth >40 centimeters	Low/Normal riffle embeddedness	**No. of WWH attributes**	Channelization or No recovery	Silt or Muck substrates	No sinuosity	Sparse/No cover	Maximum depth <40 centimeters	**No. of 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	**No. of moderate influence MWH attributes**
St. Mary's River																																	
70.4	56.4	0.90	●								●		4				●		1		●	●	●					●	●		●	6
65.7	49.0	0.50	●								●		2		●		●		2		●		●	●				●	●		●	6
61.5	54.7	0.50	●				●	●			●		4		●				1		●		●	●				●	●		●	6
57.8	63.0	1.00	●	●			●	●			●		5						0		●		●					●	●		●	5
52.1	58.5	0.90	●	●			●	●			●		5		●				1		●		●	●				●	●		●	6
47.5	62.3	0.60	●	●		●	●	●	●		●		7				●		1		●		●	●					●		●	5
Yankee Run																																	
1.4	26.8	3.25									●		1	●	●	●	●		4		●			●	●	●	●	●	●		●	8
Town Run																																	
2.1	38.0	4.50					●				●		2		●		●		2	●	●			●	●			●	●		●	7
1.3	46.5	4.50						●			●		2		●				1	●	●		●	●	●			●	●		●	8

Source: Ohio EPA 2018a. Data collected in 2015.

Notes

MWH = modified warmwater habitat; QHEI = Qualitative Habitat Evaluation Index; RM = river mile; WWH = warmwater habitat.

Value in green meets its target and values in red does not meet their target.

Ohio EPA collected sediment during one sampling event at each of two monitoring sites in this WAU. Particle size distribution data indicate that the stream's substrates were predominantly sand and larger (Figure 8): 45 percent at site P01K02 on the St. Mary's River and 60 percent at site 303356 on Town Run.

QHEI data indicate that Town Run had poor stream substrates (silt or muck; moderate to heavy silt cover) at both monitoring sites. QHEI data for all six monitoring sites on the St. Mary's River indicated moderate to heavy silt cover; however, three sites (including P01K02) had gravel, cobble, or boulder substrates, which are indicative of good quality habitat.

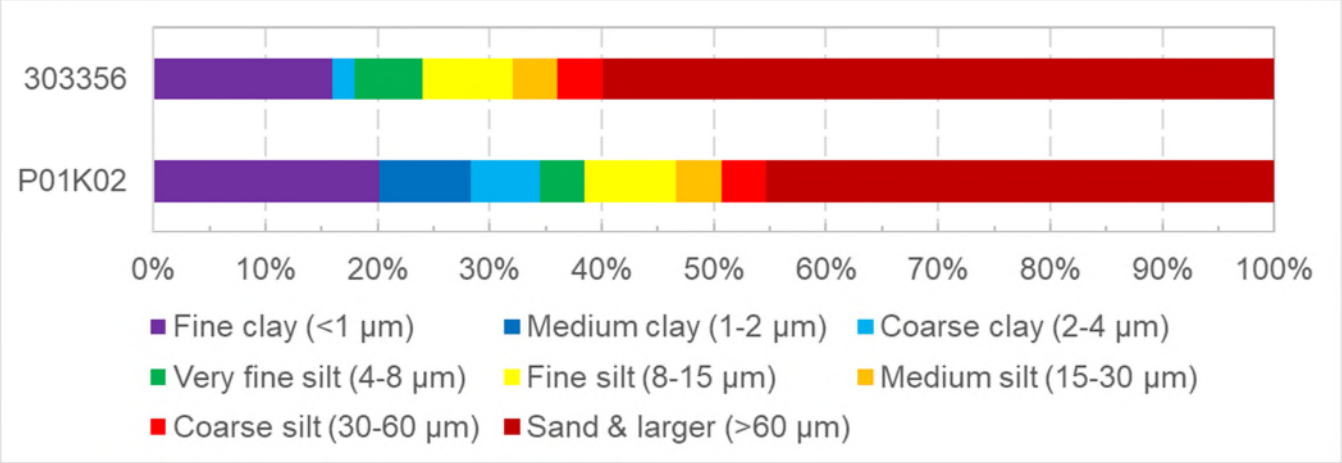


Figure 8. Substrate particle distribution at monitoring sites P01K02 on the St. Mary's River and 303356 on Town Run.

2.3 SUMMARY OF NUTRIENT WATER QUALITY

Nutrient-loading from the *Yankee Run-St. Mary's River* WAU contributes to the far-field impairment of Lake Erie. This section begins with a brief characterization of nutrient water quality in the *Yankee Run-St. Mary's River* WAU, then continues with an introduction of Annex 4, and ends with a discussion of nutrient target loads for the *Yankee Run-St. Mary's River* WAU based upon the goals of Annex 4.

2.3.1 Nutrients and Chlorophyll-*a*

The characterization of nutrient loading in the *Yankee Run-St. Mary's River* WAU begins with the evaluation of nutrient water quality sampling. Total phosphorus concentrations at headwaters sites on Yankee Run and Town Run were often greater than Ohio EPA's target of 0.08 mg/L for headwaters sites (Table 7). A limiting nutrient analysis using the Redfield Ratio (16:1) indicates that phosphorus is likely the limiting nutrient in Yankee Run and Town Run (Figure 9).

Ohio EPA (2018a) evaluated the August 18, 2015 water column samples from the St. Mary's River at monitoring sites P01K02, P01K03, and P01W08 for chlorophyll-*a* to evaluate sestonic algae: 127 micrograms per liter (µg/L) at site P01K02, 126 µg/L at site P01K03, and 127 µg/L at site P01W08. All three results exceed 100 µg/L that Ohio EPA (2018a) considers to be hypereutrophic based upon Dodds (2006). Samples with similar concentrations (127 µg/L and 134 µg/L) were collected on the same day from monitoring sites on the St. Mary's River in the *Town of Willshire-St. Mary's River* (HUC 04100004 03 03), which is the next downstream WAU.

Ohio EPA (2018a) also evaluated the September 16, 2015 water column sample from Town Run at monitoring site 303085 for chlorophyll-*a* (6.8 µg/L) to evaluate sestonic algae. In a small, headwaters stream like Town Run, benthic algal growth would be expected to dominate over sestonic algal growth; however, no benthic algae were sampled from stream substrates.

Table 7. Nutrient concentrations in Yankee Run and Town Run

Site	303084 (Yankee Run)		303356 (Town Run)		303085 (Town Run)	
Date	TP (mg/L)	TN [a] (mg/L)	TP (mg/L)	TN [a] (mg/L)	TP (mg/L)	TN [a] (mg/L)
June 24	**0.103**	12.77	--	--	**0.172**	4.02
July 8	**0.172**	9.53	--	--	**0.199**	8.46
July 22	0.073	8.23	--	--	**0.103**	4.36
August 5	**0.093**	1.91	--	--	0.069	2.97
August 19	**0.094**	0.98	--	--	0.07	0.95
August 26	--	--	--	--	**0.084**	0.66
September 2	0.043	0.98	0.028	1.20	0.05	0.75
September 16	--	--	--	--	0.056	0.75
September 23	--	--	0.032	0.33	--	--

Source: Ohio EPA (2018a).

Notes

mg/L = milligrams per liter; TN = total nitrogen; TP = total phosphorus.

Bolded blue values exceed the total phosphorus target of 0.08 mg/L for a headwaters stream.

a. Total nitrogen was calculated as the summation of *total Kjeldahl nitrogen* and *nitrate plus nitrite*, which were reported in the TSD (Ohio EPA 2018a).

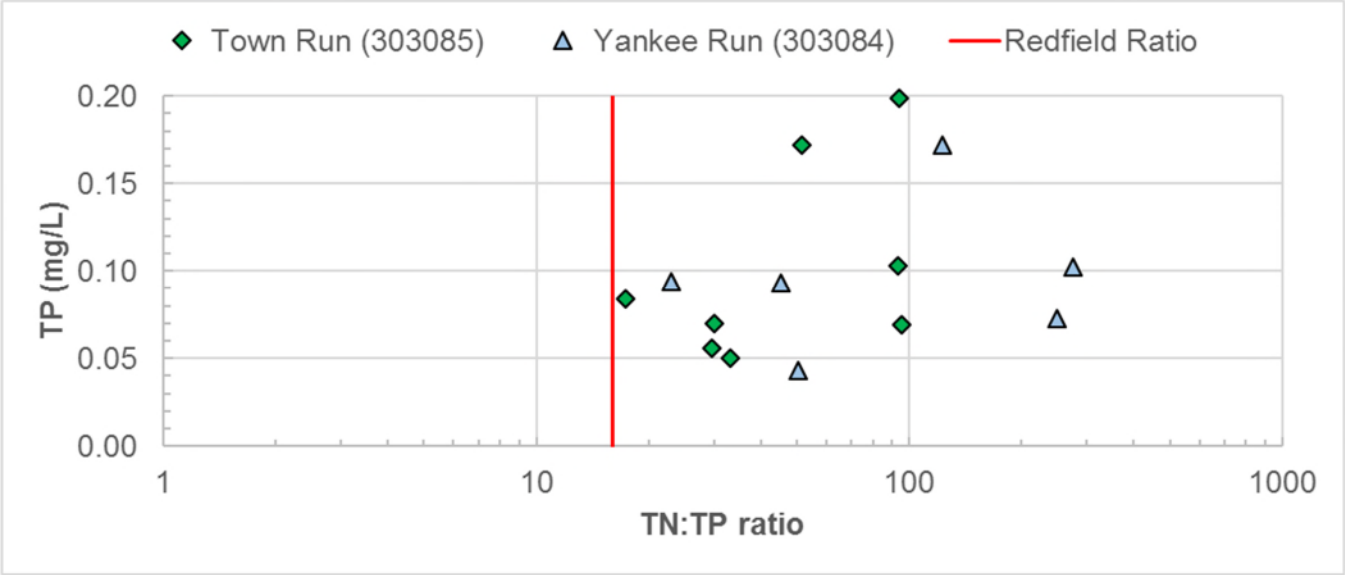


Figure 9. Limiting nutrient analysis at monitoring sites 303085 on Town Run and 303084 on Yankee Run.

Total phosphorus concentrations in the St. Mary's River were typically less than the target of 0.3 mg/L for large river sites[12]. A limiting nutrient analysis at sentinel site P01K02 on the St. Mary's River using the Redfield Ratio (16:1) indicates that phosphorus and nitrogen may be co-limiting (Figure 10).

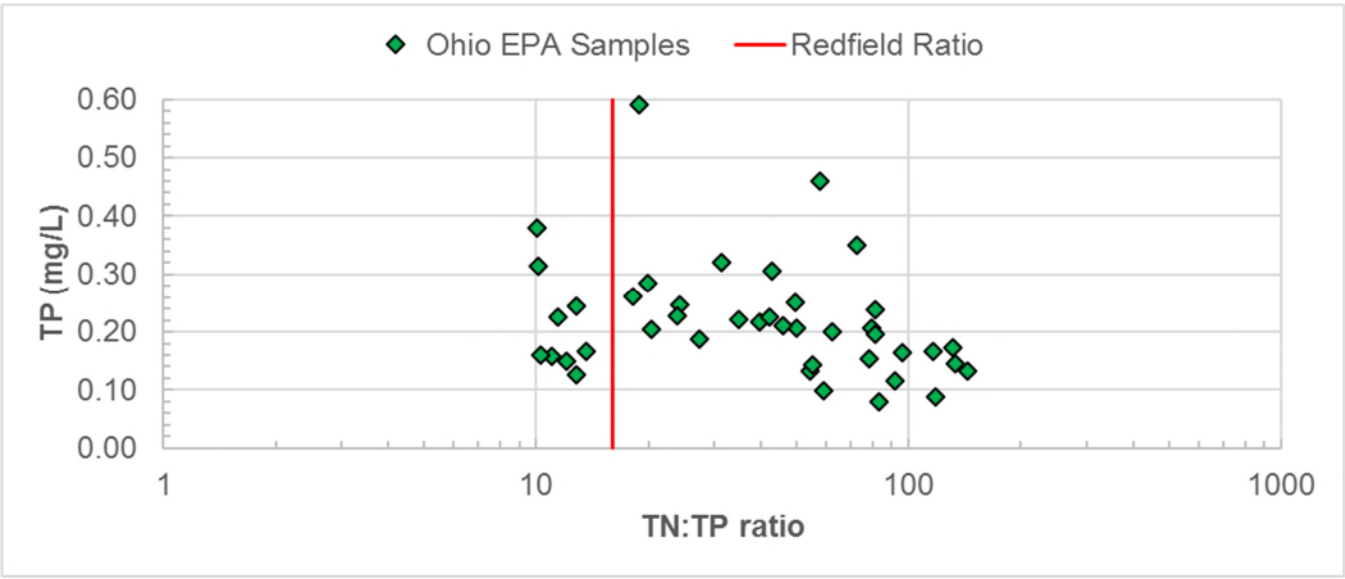


Figure 10. Limiting nutrient analysis at monitoring site P01K02 on the St. Mary's River.

[12] The following percentages of samples, collected in June through September 2015 (except as noted), exceeded 0.3 mg/L phosphorus: 302591 (0 percent; n=6), P01K04 (0 percent; n=6), P01K03 (29 percent; n=7), P01W08 (9 percent; n=11 ; September 2014 to September 2015), P01K02 (17 percent; n=42; April 2015 to March 2019), and P01K01 (0 percent; n=5).

2.3.2 Annex 4 of the Great Lakes Water Quality Agreement

Recent work under the U.S.-Canada Great Lakes Water Quality Agreement (GLWQA) – Annex 4 led to the establishment of binational phosphorus load reduction targets for the Western and Central basins of Lake Erie, with an emphasis on reducing phosphorus contributions that are the key driver of summer harmful algal blooms (HABs). The Annex 4 phosphorus reduction targets for Lake Erie are as follows (GLWQA 2015; U.S. EPA 2018):

- **To minimize the extent of hypoxic zones in the waters of the Central Basin of Lake Erie:** A 40 percent reduction in annual total phosphorus entering the western and central basins of Lake Erie—from the United States and from Canada—to achieve an annual load of 6,000 metric tons to the Central Basin. This amounts to a reduction from the United States and Canada of 3,316 metric tons and 212 metric tons respectively.
- **To maintain algal species consistent with healthy aquatic ecosystems in the nearshore waters of the Western and Central basins of Lake Erie:** A 40 percent reduction in spring (March 1 through July 31) total and soluble reactive phosphorus loads from the following watersheds where algae is a localized problem: in Canada, Thames River and Leamington tributaries; and in the United States, Maumee River, River Raisin, Portage River, Toussaint Creek, Sandusky River and Huron River.
- **To maintain cyanobacteria biomass at levels that do not produce concentrations of toxins that pose a threat to human or ecosystem health in the waters of the Western Basin of Lake Erie:** A 40 percent reduction in spring (March 1 through July 31) total and soluble reactive phosphorus loads from the Maumee River in the United States.

These targets were formally adopted by the United States and Canada in February 2016. The affected States (Indiana, Ohio, and Michigan) have developed domestic action plans that describe how the 40 percent reduction goals will be met.

Load reduction goals presented in this NPS-IS plan are based upon the achievement of the Annex 4 goal of 40 percent reductions in total phosphorus (TP) and soluble reactive phosphorus (SRP) loading. Load goals were set for the Maumee River at Waterville[13] (6,330 square miles) based upon 40 percent reductions from the 2008 baseline year (Table 8). These goals were developed to reduce HABs in the Western Basin and hypoxia in the Central Basin of Lake Erie.

Table 8. Annex 4 loads for the Maumee River at Waterville

Phosphorus	Baseline load (metric tons of phosphorus)	Goal load (metric tons of phosphorus)
Annual TP	3,812	2,287
Spring TP	1,414	860
Spring SRP	302	186

Sources: Great Lakes Water Quality Agreement 2015, Ohio Lake Erie Commission 2018, U.S. EPA 2018.

Note: Spring is defined as March 1st through July 31st.

[13] The U.S. Geological Survey operates a continuously recording flow gage on the Maumee River at Waterville (04193500). The National Center for Water Quality Research at Heidelberg University regularly collects water chemistry samples from this location (1975-present).

2.3.3 Baseline Load Estimates

Ohio EPA (in development) estimated spring TP loads for the 2008 baseline year for all WAUs in the Maumee River watershed. The loads were estimated for five sources (Ohio EPA in development, Appendix A):

- **Wastewater Treatment**: Loads were estimated using facility design flows and discharge monitoring reports or using data from similar facilities.
- **HSTS**: Loads were estimated using the literature per capita yields, the estimated population served by HSTS, and phosphorus reduction ratios based upon one of three general system types.
- **Agriculture**, **Developed**, and **Natural**: Loads were estimated by distributing the quantity of the total load less the wastewater treatment and HSTS loads. This quantity was distributed between the three land cover classes using the relative area of each land cover class and the ratio of yields. The ratio of yields is 10:5:1 for agriculture to developed to natural.

Estimated baseline 2008 loads and goal loads are presented in Table 9 for Ohio.

- **Spring TP**: Published by Ohio EPA (in development).
- **Spring SRP**: Estimated as 21 percent of the spring TP loads published by Ohio EPA (in development). The 21 percent factor is derived from the ratio of spring SRP to spring TP for the Maumee River at Waterville for both the 2008 baseline load and the goal load. Refer back to Section 2.3.1 for the Maumee River at Waterville loads.
- **Annual TP**: Estimated as 2.7 times the spring TP loads published by Ohio EPA (in development). The 2.7 factor is derived from the ratio of annual TP to spring TP for the Maumee River at Waterville for both the 2008 baseline load and the goal load. Refer back to Section 2.3.1 for the Maumee River at Waterville loads.

As discussed in Section 2.3.1, the load reduction goals are 40 percent of 2008 baseline loads for spring TP, spring SRP, and annual TP. The goal loads presented in Table 9 are therefore 60 percent of the total estimated 2008 baseline loads.

Table 9. Estimated loads for the *Yankee Run-St. Mary's River* WAU

Source	Spring TP	Spring SRP	Annual TP
Estimated 2008 baseline loads			
Agriculture	30,000	6,300	81,000
Developed	1,500	320	4,100
Natural	340	<100	920
HSTS	590	120	1,600
Total	**32,000**	**6,800**	**88,000**
Goal loads			
Total	**20,000**	**4,100**	**53,000**

Source: Ohio EPA (in development).

Notes

HSTS = household sewage treatment system; SRP = soluble reactive phosphorus; TP = total phosphorus.

Spring is defined as March 1st through July 31st.

Loads greater than 100 pounds are rounded to two significant digits. Loads less than 100 pounds are reported as "<100".

2.4 SUMMARY OF POLLUTION CAUSES AND ASSOCIATED SOURCES

This NPS-IS plans addresses causes and sources of both near-field (i.e., the *Yankee Run-St. Mary's River* WAU) and far-field (i.e., Lake Erie) impairments. Row crop agriculture (and associated activities) are sources of both near-field and far-field impairments.

2.4.1 Near-Field

Ohio EPA (2018a) identified causes and sources of near-field impairment to three assessment sites.

- The St. Mary's River at Harner Road (P01K01) is in partial attainment due to macroinvertebrate community health. The site is impaired by natural causes from natural sources. As the QHEI score meets its target, this impairment will not be addressed by this NPS-IS plan.
- Yankee Run at U.S. Route 33 (303084) and Town Run at State Route 117 (303085) are in partial attainment due to *fair* macroinvertebrate community health. Both sites are impaired by (1) sedimentation and siltation and (2) alteration in streamside covers. The source of impairment is channelization.

Runoff from crop fields, via tiles, is the likely source of the moderate to heavy silt cover and the moderate to high embeddedness observed in Yankee Run and Town Run. Such runoff also likely contributes to elevated nutrient concentrations detected in water column samples collected at Ohio EPA's monitoring sites.

Ohio EPA (2018a) did not identify causes or sources of near-field impairment at the six monitoring sites that were in full attainment of their ALU. However, some sites may be threatened.

- The St. Mary's River at Mendon-Celina Road (302591), at U.S. Route 127 (P01K04), and at Frysinger Road (P01K03) each meet biological criteria but their QHEI scores are just below targets (in the *fair* range). These three sites on the St. Mary's River are distinguished from the other sites on the St. Mary's River by the lack of boulder, cobble, and gravel substrates and the presence of silt and muck substrates.
- The St. Mary's River at State Route 118 (P01W08) meets biological criteria and its QHEI score meets its target but the ICI score is in nonsignificant departure.
- The St. Mary's River at Townline Road (P01K02) meets biological criteria but its QHEI score is just below the target and the IBI score is in nonsignificant departure.

In unnamed streams and ditches across the WAU, stream channel habitat is degraded by row crop agriculture. Segments of intermittent streams and ditches throughout the WAU are straightened and channelized. Many segments of intermittent streams are farmed almost up to the streambanks.

2.4.2 Far-Field

The *Western Basin Shoreline* (041202000201) and *Western Basin Open Waters* (041202000301) Lake Erie Assessment Units (LEAUs) are impaired for their recreation use and public drinking water use (Ohio 2018c):

- **Recreation Use**: Harmful algal blooms (HABs) impair recreation use in the *Western Basin Shoreline* and *Western Basin Open Waters.* Dermal contact, ingestion, and inhalation (of water droplets) of waters experiencing HABs can make humans or animals sick because some species of algae in HABs produce cyanotoxins.
- **Public Drinking Water Use**: HABs also impair the public drinking water use in the *Western Basin Shoreline* and the *Western Basin Open Waters* LEAUs. Elevated microcystin concentrations were detected in the raw water for the public water supplies serving Carroll Township, Ottawa County, the cities of Oregon and Toledo, and the villages of Kelleys Island and Marblehead. *Microcystins* (liver toxins) are produced by certain species of algae during HABs.

HABs in the Western Basin and hypoxia in Central Basin of Lake Erie are caused by nutrient-loading from watershed-runoff in the *Maumee* basin. These impairments are considered far-field because the runoff migrates from WAUs that can be hundreds of river-miles upstream of the impaired LEAUs.

Agricultural NPS are the predominant sources of nutrient loading to the Western Basin of Lake Erie (Ohio EPA 2018b). Nutrients are ultimately derived from chemical fertilizers, pesticides, and manure. After application of chemical fertilizers, pesticides, or manure, runoff (via tiles) from precipitation events can transport nutrients from crop fields to surface waterways. Runoff from livestock operations (including manure storage) can also transport nutrients to streams. Additionally, livestock with unrestricted access to streams can directly deposit manure in waterways. Finally, HSTS, point sources, and illicit discharges (including spills) can also contribute nutrient loads to streams. However, these sources are relatively insignificant compared with the NPS loads from agricultural operations.

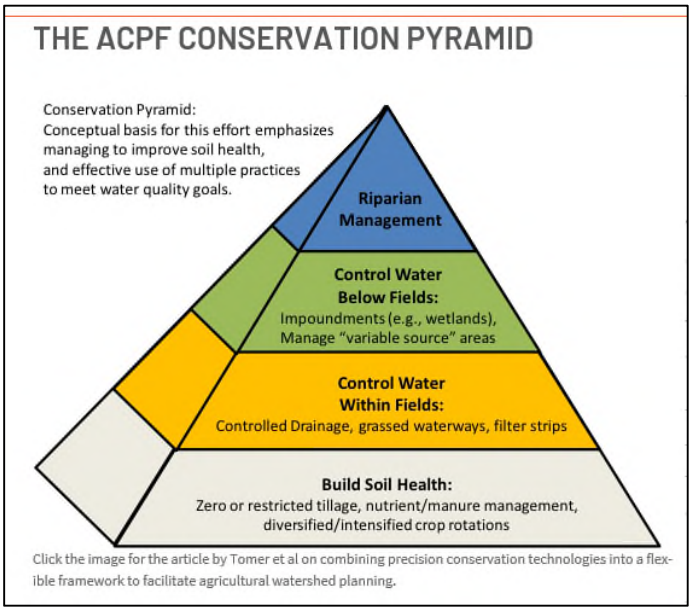
Additional information about nutrient-loading to Lake Erie from the Maumee River watershed is presented in the following publications:

- *Informing Lake Erie Agriculture Nutrient Management via Scenario Evaluation* (Scavia et al. 2016)
- *Nutrient Mass Balance Study for Ohio's Major Rivers* (Ohio EPA 2018b)
- *Recommended Phosphorus Loading Targets for Lake Erie* (Great Lakes Water Quality Agreement 2015)
- *State of Ohio's Domestic Action Plan 1.1* (Ohio Lake Erie Commission 2018)
- *U.S. Action Plan for Lake Erie. Commitments and strategy for phosphorus reduction* (U.S. EPA 2018)

2.5 ADDITIONAL INFORMATION: ACPF

The Agricultural Conservation Planning Framework (ACPF) "supports agricultural watershed management by using high-resolution elevation data and an ArcGIS toolbox to identify site-specific opportunities for installing conservation practices across small watersheds" (Agricultural Research Service [ARS] 2019a). ACPF is based upon a framework that is "informed by landowner and community preferences, is compatible with voluntary implementation policies, and could be used to achieve the potential broad-based benefits of precision-conservation in a flexible way (Tomer et al. 2013, p. 113A).

ACPF sites agricultural BMPs that control or reduce the movement of water and nutrients within agricultural fields and at and below field edges (Tomer et al. 2013); this is presented conceptually in the ACPF Conservation Pyramid (Figure 11). ACPF sites the following seven agricultural BMPs:



Source: Tomer et al. (2013).

Figure 11. ACPF Conservation Pyramid.

- Controlled drainage (drainage water management)
- Edge-of-field bioreactors
- Grassed waterways
- Contour buffer strips
- Water and sediment control basins (WASCOB)
- Saturated riparian buffers
- Nutrient removal wetlands

Additional useful spatial data (e.g., runoff risk from agricultural fields to waterbodies) are generated, and ACPF can also site stream channel riparian management opportunities.

ACPF is one of many tools that can be used by watershed managers to develop implementation strategies. As with any tool, certain limitations must be considered when evaluating results (see text box below).

Important Considerations When Reviewing ACPF Results

- ACPF evaluates landscape factors (e.g., topography, hydrography, land cover) and soil properties, at the field-scale, with BMP siting and design requirements to identify candidate locations for BMP installation. Candidate BMP sites must be field-verified while evaluating their potential for implementation, and engineering design will need to consider site-specific factors and limitations.
- ACPF evaluates BMPs separately and can identify multiple candidate BMPs for the same field even though BMPs can be mutually exclusive.
- ACPF is not a BMP-optimization tool (i.e., it does not rank the best locations for the various BMPs based on effectiveness, cost, or other factors).
- ACPF identifies candidate locations where BMPs could be installed; ACPF does not identify locations where BMPs should be installed.

2.5.1 Geographic Information System Approach for ACPF

ACPF is a set of geographic information system (GIS) based "software tools to identify candidate locations for different types of conservation practices that can be placed within and below fields in order to reduce, trap and treat hydrologic flows, and thereby improve water quality in agricultural watersheds" (Porter et al. 2018, p. 1).

ACPF uses a file geodatabase structure with a separate file geodatabase for each watershed defined by a 12-digit HUC. ARS published file geodatabases for over 8,700 such watersheds online. Digital elevation models (DEMs) are not provided in the published file geodatabases and must be obtained by users. The DEMs need significant pre-processing before ACPF can be run.

For additional information about ACPF, refer to the ACPF website (https://acpf4watersheds.org/) and user's manual (Porter et al. 2018).

2.5.2 ACPF for the Yankee Run-St. Mary's River WAU

ACPF was run for the *Yankee Run-St. Mary's River* WAU using a 3-meter resolution DEM from the National Elevation Dataset (USGS 2019a) and a file geodatabase provided by ARS (2019b). The tool was run using cropland data layers representing the years 2013 through 2018. Default input values were selected for all potential BMPs, with the exception of nutrient removal wetlands and WASCOBs. Minimum values were used for impoundment height and buffer height for nutrient removal wetlands and embankment height for WASCOBs to site the largest number of potential BMPs across the watershed. Output from the ACPF tool was provided to the local SWCDs to inform their discussions with landowners about potential conservation practices.

At the WAU-scale, grassed waterways and controlled drainage are the most frequently identified candidate BMPs (Table 10). Candidate contour buffer strips may not have been identified very frequently due to a lack of significant topographic change (i.e., the WAU is too flat), while the minimum size criterion (150-acres, contiguous) may have limited the identification of candidate nutrient removal wetlands.

Table 10. ACPF results for the *Yankee Run-St. Mary's River* WAU

Agricultural BMP	No. of BMPs	Total size	Treated area (acres)
Length-Based BMPs			
Contour buffer strip	31	7 miles	--
Grassed waterway	789	74 miles	--
Saturated buffer	343 [a]	111 miles	10,068
Area-Based BMPs			
Controlled drainage	639	10,809 acres	10,809
Edge of field bioreactor	217	52 acres	10,378
Nutrient removal wetland	13	37 (107) [b] acres	3,088
WASCOB	60	54 acres	581

Notes

BMP = best management practice; WAU = watershed assessment unit.

Length in miles and area in acres are rounded to the nearest mile or acre.

a. Carbon enhancement (for nitrate removal) is necessary for 53 of the 343 potential saturated buffers.

b. The wetland pooled area is 37 acres and the vegetated buffer area is 107 acres.

A quality assurance evaluation indicated that several fields that appear to be agricultural in orthoimagery (Farm Service Agency 2017) are not identified as agricultural in the common land units dataset. ACPF excluded any fields from analysis if they were not identified as agricultural in the common land units dataset. Additionally, ACPF identified several candidate saturated buffers along the St. Mary's River that may be in error because the wetted perimeter of the St. Mary's River was not burnt into the DEM (i.e., ACPF may be considering some of the open water and shoreline to actually be outside of the bankfull width).

3 CONDITIONS & RESTORATION STRATEGIES FOR CRITICAL AREAS

3.1 OVERVIEW OF CRITICAL AREAS

As summarized in Section 2.4.1, sampling locations along the St. Mary's River, Yankee Run, and Town Run are not in full attainment of the designated ALUs:

- **Full attainment:** Six sites are in full attainment: five sites on the St. Mary's River (sites 302591, P01K04, P01K03, P01W08, and P01K02) attain WWH biological criteria and site 303356 on Town Run meets the IBI headwaters criterion (macroinvertebrates were not evaluated at site 303356).
- **Partial attainment:** Three sites are in partial attainment. One site each on Yankee Run (303084) and Town Run (303085) is in partial-attainment of headwaters WWH biological criteria for the *Huron-Erie Lake Plain* ecoregion. Site P01K01 on the St. Mary's River in partial attainment of boating WWH biological criteria due to natural conditions.
- **Non-attainment:** No sites are in non-attainment of WWH biological criteria.

The *Yankee Run-St. Mary's River* WAU also contributes nutrient loads to the St. Mary's River and ultimately Lake Erie. Nutrient loading throughout the Maumee River watershed is causing HABs in the Western Basin of Lake Erie and hypoxia in the Central Basin.

Three critical areas have been identified to address the NPS that are believed to be causing the impairments (Figure 12):

- *Lower Yankee Run* (Critical Area #1) addresses near-field impairments (within the WAU) to macroinvertebrate community health and degraded stream habitat. The critical area is a riparian corridor along the lower segments of the stream.
- *Lower Town Run* (Critical Area #2) addresses near-field impairments (within the WAU) to macroinvertebrate community health and degraded stream habitat. The critical area is a riparian corridor along the lower segments of the stream.
- *Agricultural Lands* (Critical Area #3) addresses far-field impairments (to Lake Erie) derived from agricultural nutrient-loading. The critical area is composed of agricultural parcels throughout the WAU, less any woodlots within such parcels.

While QHEIs at monitoring locations on the St. Mary's River throughout the WAU are not meeting targets and a few IBI and ICI scores for sites on the St. Mary's River are in non-significant departure, no near-field critical areas were developed to address the threatened waters of the St. Mary's River. The implementation of projects to address *Agricultural Lands* (Critical Area #3), especially those in the high priority areas within 100-feet of the St. Mary's River, may also improve near-field fish and macroinvertebrate community health. If such projects do not improve communities' health, then additional critical areas and projects to address near-field threats may need to be identified in the future.

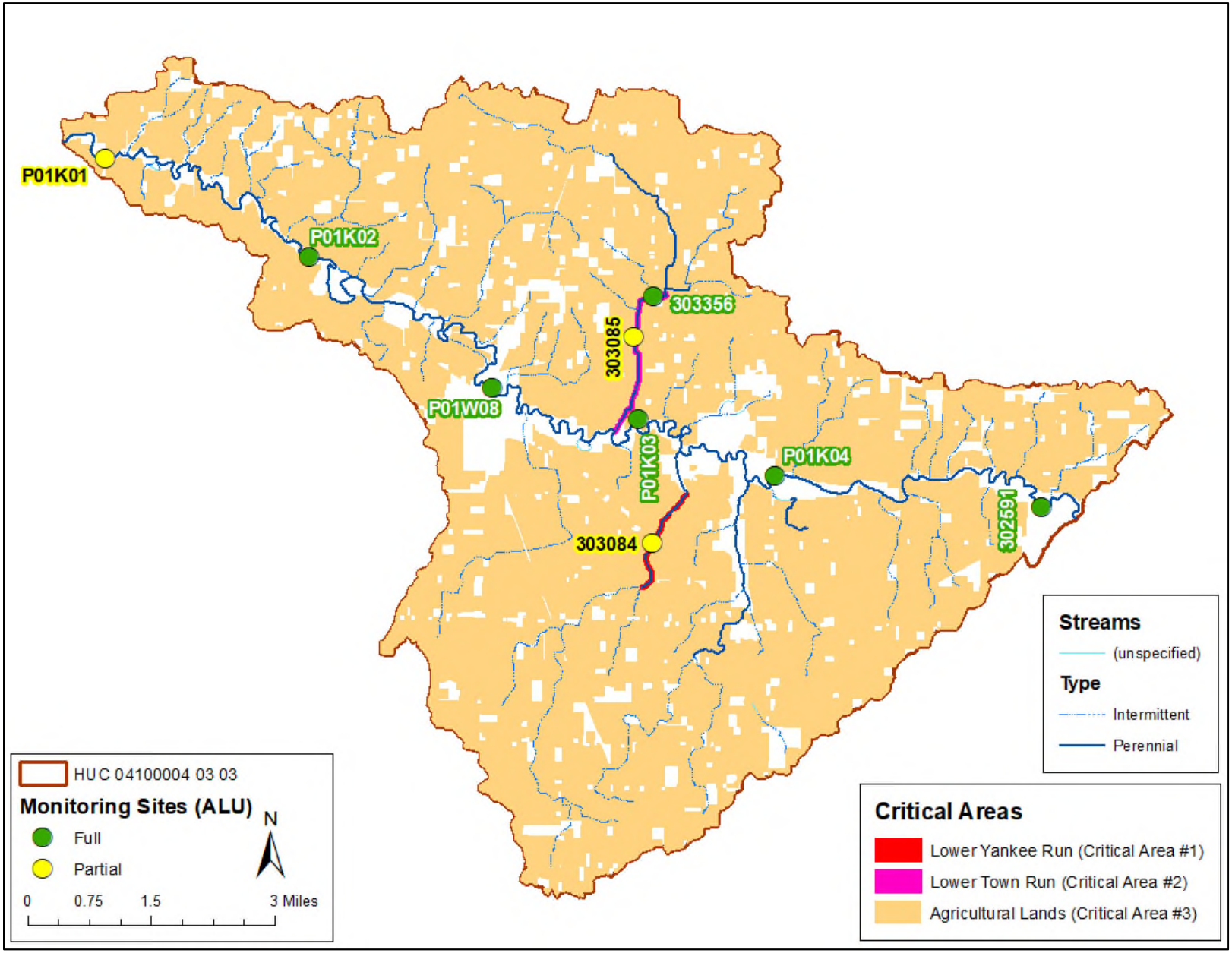


Figure 12. Critical Areas in the *Yankee Run-St. Mary's River* WAU.

3.2 CRITICAL AREA #1: CONDITIONS, GOALS, & OBJECTIVES

3.2.1 Detailed Characterization

The *Lower Yankee Run* (Critical Area #1) is a 300-foot buffer (150-feet on each side) along 1.4 river miles of Yankee Run from upstream of U.S. Route 33 to the wetland and forest complex along the St. Mary's River (Figure 13). The 47.5-acre critical area excludes a farm pond, the U.S Route 33 right-of-way, and a parking lot. These areas were excluded because the infrastructure precludes the installation of restoration projects.

Yankee Run in this critical area is a perennial stream that receives flow from tile drainage and upstream intermittent streams and ditches. The stream channel has a trapezoidal cross-section, is deeply incised, and its form is monotonous[14]. Much of the land that drains directly to Yankee Run is cultivated crop fields (Table 11). Upstream of the forest and wetland complex along the St. Mary's River, Yankee Run has a thin riparian buffer (less than 50-feet wide). Riparian buffers along several segments are conservation cover[15] enrolled in the Conservation Reserve Enhancement Program. Other segments have thinly wooded riparian buffers, often with a single line of trees.

Ditch (No. 72-75) is just upstream of U.S. Route 33 on the right bank of Yankee Run; this ditch is maintained by Mercer County.

Table 11. Land cover in the *Lower Yankee Run* critical area

Land cover	Area (acres)	Relative area (percent)
Developed, open	<0.1	<1%
Developed, low intensity	<0.1	<1%
Cultivated crops	47.3	>99%
Emergent herbaceous wetlands	<0.1	<1%
Total	**47.5**	**100%**

Source of spatial data: National Land Cover Database 2016 (Yang et al. 2018).

Notes

Areas were rounded to the nearest one-tenth acre or percentage point. The *Totals* do not sum exactly due to rounding.

Open water, developed (medium intensity), developed (high intensity), barren land, deciduous forest, evergreen forest, mixed forest, shrub/scrub, grassland/herbaceous, pasture/hay, and woody wetlands are not present.

[14] Charles Boucher, field biologist, Ohio EPA, electronic communication, July 31, 2019.

[15] Conservation cover is practice 327 (Natural Resources Conservation Service 2017).

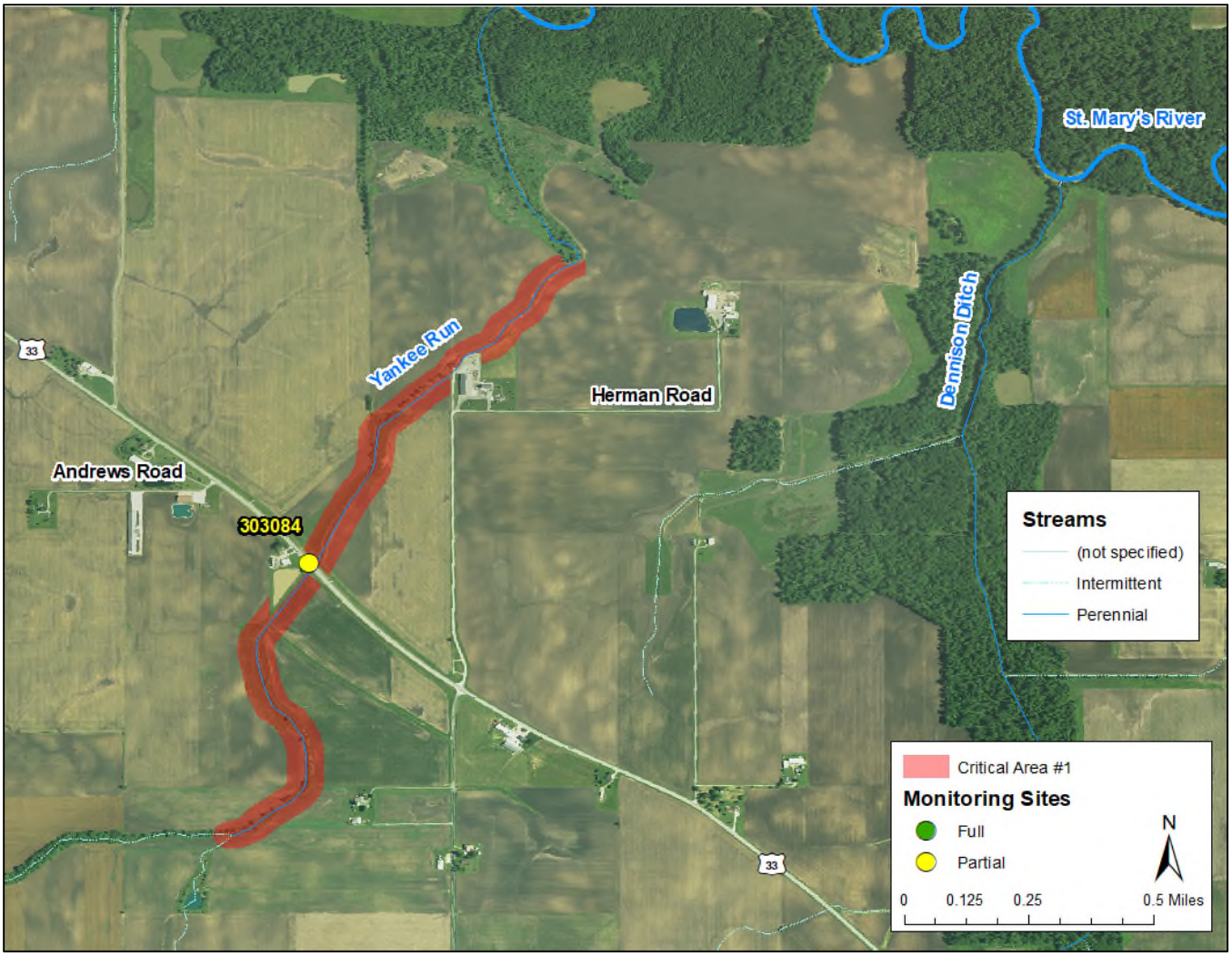


Figure 13. *Lower Yankee Run* (Critical Area #1).

3.2.2 Detailed Biological Condition

Ohio EPA (2018a) evaluated fish and macroinvertebrate community health in 2015 at site 303084 (Figure 14) within the critical area. Fish community health was *good* (Table 12) and macroinvertebrate community health was *fair* (Table 13).

Fish community health was *good* despite *very poor* fish habitat. The IBI score was *good* because of the influence of certain larger river species (e.g., gizzard shad) that migrated from the St. Mary's River[16]. Thus, it appears that improvements to the fish community health in the St. Mary's River in recent years are also impacting small tributaries to the St. Mary's River.

[16] Charles Boucher, field biologist, Ohio EPA, electronic communication, July 31, 2019.

Macroinvertebrate community health was *fair* and more reflective of degraded habitat. The total number of taxa (56) and number of EPT taxa (6) were more indicative of better macroinvertebrate community health. However, half of the taxa were tolerant and only one taxon of sensitive species were captured, which are indicative of worse macroinvertebrate community health. With a few more sensitive species, macroinvertebrate community health may improve into nonsignificant departure of biological criteria[17].

Fish habitat was *very poor* for a headwaters stream. Yankee Run is a straightened, channelized stream with little to no sinuosity. Dominant substrates were fine, and coarse material was heavily embedded. The stream flows through row crop fields, and much of the riparian corridor has limited vegetation with no trees. Yankee Run has no fast current and Ohio EPA observed no riffles.

Source: Ohio EPA 2015. August 20, 2015.

Figure 14. Yankee Run at monitoring site 303084 (RM 1.40), looking downstream (northeast).

Table 12. Fish community health and habitat data –*Critical Area #1*

RM	DA	QHEI	Total species	MIwb	IBI	Predominant species (percent of catch in each pass)	Narrative evaluation
1.40	6.1	26.5	24	--	42	Common carp (34%), gizzard shad (15%), green sunfish (10%), black bullhead (8%)	Good

Source: Ohio EPA 2018a. Data collected in 2015.

Notes

DA = drainage area, in square miles; IBI = Index of Biotic Integrity; MIwb = Modified Index of well-being; QHEI = Qualitative Habitat Evaluation Index; RM = river mile.

Green scores meet the IBI biological criteria or QHEI target. Red scores do not meet the IBI biological criteria or QHEI target.

Table 13. Macroinvertebrate community health data –*Critical Area #1*

RM	ICI	No. of taxa			Predominant species
		Total	EPT	Cold	
1.40	Fair	56	6	0	Corixids (water boatmen)

Source: Ohio EPA 2018a. Data collected in 2015. Qualitative data are presented.

Notes

Cold = coldwater species; ICI = Invertebrate Community Index; EPT = qualitative *Ephemeroptera*, *Plecoptera*, and *Trichoptera*; RM = river mile.

Green scores meet the ICI biological criteria. Red scores do not meet the ICI biological criteria.

[17] Charles Boucher, field biologist, Ohio EPA, electronic communication, July 31, 2019.

3.2.3 Detailed Causes and Associated Sources

Ohio EPA (2018a) identified the causes of impairment to Yankee Run at site 303084 (RM 1.40) to be (1) sedimentation and siltation and (2) alteration in streamside covers; the agency identified the source of impairment to be channelization. Field observations by Ohio EPA and a review of 2017 aerial imagery confirms that several segments of lower Yankee Run are straightened and have only thin riparian buffers. Many segments' buffers appear to be herbaceous and do not include trees.

The in-stream habitat throughout the critical area is degraded by several symptoms of its agricultural setting including direct habitat alteration (from channelization and bridge culverts), flow alteration (flashiness from tile drainage), and loss of riparian cover (i.e., much of the *Lower Yankee Run* has sparse to no trees in the riparian area).

3.2.4 Goals and Objectives for Critical Area #1

As explained in detail above and by Ohio EPA (2018a), *Critical Area #1* is primarily impaired by sedimentation/siltation and alteration in streamside covers from channelization due to agricultural development. Yankee Run has been modified to accommodate cultivated crop land, including the installation of drain tiles and removal of riparian trees and wetlands. Restoration of stream channel morphology, the riparian corridor, and in-stream habitat will be needed to improve aquatic community health in *Critical Area #1.*

Challenges to Achieving Goals and Objectives

- Cultivated crop land is within 40-feet of Yankee Run and landowners may not be willing to remove crop land from production.
- Yankee Run is culverted under several road bridges and farm equipment bridges. These culverts can be barriers to biotic migration, which may hinder colonization from nearby fish and macroinvertebrate populations.

3.2.4.1 Goals

The overall NPS restoration goals of any NPS-IS plan are to improve IBI, ICI, and QHEI scores such that a waterbody is brought into full attainment of the designated ALU. Partial attainment in this critical area is due to a *fair* macroinvertebrate community health score. Additionally, the QHEI score is well below the headwaters target (*very poor*). Therefore, the goals for *Lower Yankee Run* (Critical Area #1) of the *Yankee Run-St. Mary's River* WAU are to improve IBI, ICI, and QHEI scores at site 303084 (RM 1.40) so that the site will improve from partial attainment to full attainment of the designated ALU. These goals are specifically to:

Goal 1. Achieve an IBI score of 28 at site 303084 (RM 1.40) on Yankee Run.

- Achieved: Site 303084 has a score of 32 .

Goal 2. Achieve ICI score of 34 (or narrative score of *good*) at site 303084 (RM 1.40) on Yankee Run.

- Not achieved: Site 303084 has a score of *fair*.

Goal 3. Achieve a QHEI score of 55 at 303084 (RM 1.40) on Yankee Run.

- Not achieved: Site 303084 has a score of 26.5.

3.2.4.2 Objectives

Achievement of the overall NPS restoration goal of full attainment will be challenging (see text box above) and socio-economic factors will likely preclude full stream channel restoration and reconnection of incised channels to the floodplain. Instead, this NPS-IS plan will focus on reducing sedimentation that impairs benthic macroinvertebrate community health. The following objectives need to be achieved within the *Lower Yankee Run* (Critical Area #1):

Objective 1 Establish riparian buffers and implement riparian management strategies along 1,450 lineal feet[18] of Yankee Run to reduce sediment-loading from overland flow into Yankee Run.

- *Restore and protect riparian habitat* (Ohio EPA 2013; Goal 2.03.01)
- *Increase native shrub and tree plantings in riparian areas* (Ohio EPA 2013; Goal 2.03.04)
- *Encourage riparian setback and development standards and codes* (Ohio EPA 2013; Goal 2.05.01)
- *Establish voluntary no plow zones in riparian areas* (Ohio EPA 2013; Goal 3.04.03)

Objective 2 Install two-stage ditches, over-wide ditches, or similar practices along 1,450 lineal feet[19] of Yankee Run to reduce sediment-loading in Yankee Run.

- *Restore and protect natural flow conditions* (Ohio EPA 2013; Goal 2.04.01)
- *Establish voluntary no-mow zones* (Ohio EPA 2013; Goal 2.05.02)

To reduce sedimentation in *Lower Yankee Run* (Critical Area #1), sediment-loading to Yankee Run from upland sources will also need to be reduced. Agricultural BMPs that can reduce nutrient- and sediment-loading are recommended for *Agricultural Lands* (Critical Area #3). The *Agricultural Lands* critical area is presented in Section 3.4 and its objectives are presented in Section 3.4.4.2.

As these objectives are implemented, water quality monitoring (both project-related and regularly scheduled monitoring) will be conducted to determine progress toward meeting the identified goals (i.e., water quality standards). These objectives will be reevaluated and modified, as necessary. When reevaluating, Ohio's *Nonpoint Source Management Plan Update* (Ohio EPA 2013) will be referenced, which has a complete listing of all eligible NPS management strategies.

[18] The critical area is 7,256-feet long. Assuming a 20 percent implementation rate and rounding to the nearest 50-feet yields a length of 1,450-feet.

[19] The critical area is 7,256-feet long. Assuming a 20 percent implementation rate and rounding to the nearest 50-feet yields a length of 1,450-feet.

3.3 CRITICAL AREA #2: CONDITIONS, GOALS, & OBJECTIVES

3.3.1 Detailed Characterization

The *Lower Town Run* (Critical Area #2) is a 300-foot buffer (150-feet on each side) along 2.1 river miles of Town Run from Old Town Run Road (confluence of Ayre Ditch) downstream to the mouth on the St. Mary's River (Figure 15 and Figure 16). The 75.5-acre critical area excludes the rights-of-way for State Route 117, Frysinger Road, and Old Town Run Road. These areas were excluded because the infrastructure precludes the installation of restoration projects.

Source: Ohio EPA 2015. August 20, 2015.

Figure 15. Town Run at monitoring site 303085.

Town Run in this critical area is a perennial stream that receives flow from tile drainage, upstream perennial segments of Town Run, and intermittent streams and ditches. The stream channel has a trapezoidal cross-section, it is deeply incised, and its form is monotonous[20]. Much of the land that drains directly to Town Run is cultivated crop fields (Table 14). Upstream of the forest and wetland complex along the St. Mary's River, Town Run has a thin riparian buffer (less than 50-feet wide). Riparian buffers along several segments are conservation cover[21] enrolled in the Conservation Reserve Enhancement Program. Other segments have thinly wooded riparian buffers.

Table 14. Land cover in the *Lower Town Run* critical area

Land cover	Area (acres)	Relative area (percent)
Developed, open	0.5	1%
Barren land	0.4	1%
Cultivated crops	67.2	89%
Woody wetlands	6.6	9%
Emergent herbaceous wetlands	0.7	1%
Total	**75.5**	**100%**

Source of spatial data: National Land Cover Database 2016 (Yang et al. 2018).

Notes

Areas were rounded to the nearest acre or percentage point. The *Totals* do not sum exactly due to rounding.

Open water, developed (low intensity), developed (medium intensity), developed (high intensity), deciduous forest, evergreen forest, mixed forest, shrub/scrub, grassland/herbaceous, and pasture/hay are not present.

[20] Charles Boucher, field biologist, Ohio EPA, electronic communication, July 31, 2019.

[21] Conservation cover is practice 327 (Natural Resources Conservation Service 2017).

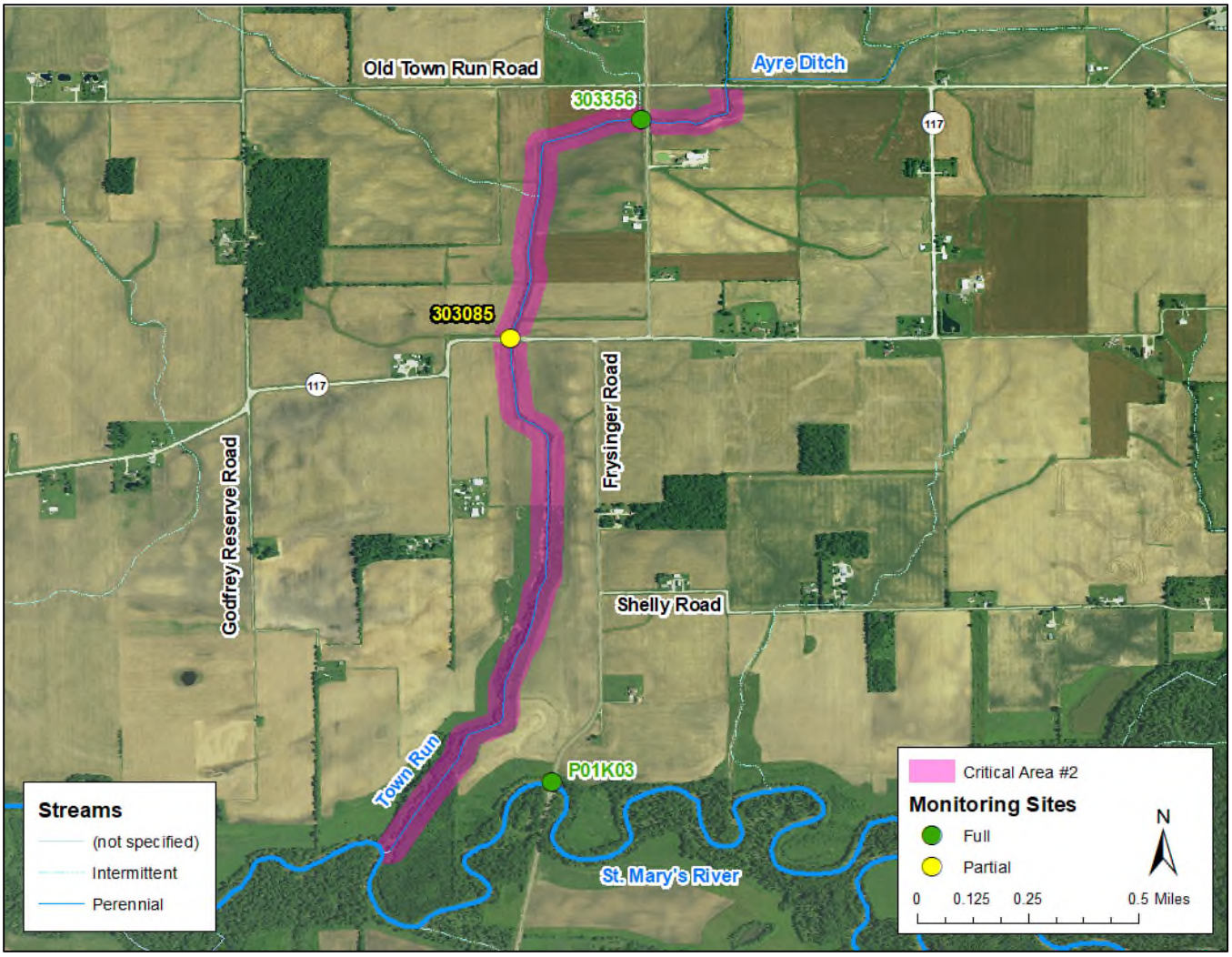


Figure 16. *Lower Town Run* (Critical Area #2).

3.3.2 Detailed Biological Condition

Ohio EPA (2018a) evaluated fish and macroinvertebrate community health in 2015 at sites 303085 and 303356 within the critical area. Fish community health (Table 15) and macroinvertebrate community health (Table 16) were *fair*.

Fish community health was *good* despite *very poor* fish habitat. The influence of groundwater augmentation of streamflow likely mitigated some of the negative influences of *very poor* fish habitat[22].

The fish captured at site 303085 (RM 1.25) had 24 percent deformities, fin erosion, lesion, and tumor (DELT) anomalies, which is the highest percentage DELT anomalies of any site reported in the St. Mary's River TSD (Ohio EPA 2018a). Ohio EPA sampled 303356 (RM 1.87) to further investigate the DELT anomalies; site 303356

[22] Charles Boucher, field biologist, Ohio EPA, electronic communication, July 31, 2019.

had 2 percent DELT anomalies. In the St. Mary's TSD, the only two sample sites on headwaters streams with a DELT greater than 0.1 percent were the two sites on Town Run.

Macroinvertebrate community health was *fair* and more reflective of degraded habitat. The total number of taxa (38) and number of EPT taxa (4) were more indicative of better macroinvertebrate community health. However, like Yankee Run, half of the taxa were tolerant and only one taxon of sensitive species were captured, which are indicative of worse macroinvertebrate community health. With a few more sensitive species, macroinvertebrate community health may improve into nonsignificant departure of biological criteria[23].

Table 15. Fish community health and habitat data –*Critical Area #2*

RM	DA	QHEI	Total species	MIwb	IBI	Predominant species (percent of catch in each pass)	Narrative evaluation
1.87	5.6	38.0	22	--	32	Central stoneroller (32%), common carp (16%), bluntnose minnow (14%), creek chub (12%).	Fair
1.25	7.1	46.5	21	--	34	Green sunfish (25%), bluegill sunfish (13%), white sucker (11%), yellow bullhead (9%).	Fair

Source: Ohio EPA 2018a. Data collected in 2015.

Notes

DA = drainage area, in square miles; IBI = Index of Biotic Integrity; MIwb = Modified Index of well-being; QHEI = Qualitative Habitat Evaluation Index; RM = river mile.

Green scores meet the IBI biological criteria or QHEI target. Red scores do not meet the IBI biological criteria or QHEI target.

Table 16. Macroinvertebrate community health data –*Critical Area #2*

RM	ICI	No. of taxa			Predominant species
		Total	EPT	Cold	
1.25	Fair	38	4	0	Corixids (water boatmen), midges

Source: Ohio EPA 2018a. Data collected in 2015. Qualitative data are presented.

Notes

Cold = coldwater species; ICI = Invertebrate Community Index; EPT = qualitative *Ephemeroptera*, *Plecoptera*, and *Trichoptera*; RM = river mile.

Green scores meet the ICI biological criteria. Red scores do not meet the ICI biological criteria.

3.3.3 Detailed Causes and Associated Sources

Ohio EPA (2018a) identified the causes of impairment to Town Run at site 303085 (RM 1.25) to be (1) sedimentation and siltation and (2) alteration in streamside covers; the agency identified the source of impairment to be channelization. A review of 2017 aerial imagery confirms that several segments of lower Town Run are straightened and have thin riparian buffers. Many segments' buffers appear to be herbaceous and do not include trees.

Ohio EPA (2018a) did not identify causes and sources of impairment at site 303356. This site attains its IBI criterion, but the site was not evaluated for macroinvertebrate community health. A QHEI score of 38 is indicative of *poor* quality habitat. For the purposes of this NPS-IS plan, the causes and sources that impair

[23] Charles Boucher, field biologist, Ohio EPA, electronic communication, July 31, 2019.

macroinvertebrate community health at site 303085 are assumed to also impair macroinvertebrates at site 303356.

The in-stream habitat throughout the critical area is degraded by several symptoms of its agricultural setting including direct habitat alteration (from channelization and bridge culverts), flow alteration (flashiness from tile drainage), and loss of riparian cover (i.e., much of the *Lower Town Run* has sparse to no trees in the riparian area).

3.3.4 Goals and Objectives for Critical Area #2

As explained in detail above and by Ohio EPA (2018), *Critical Area #2* is primarily impaired by sedimentation/siltation and alteration in streamside covers from channelization due to agricultural development. Town Run has been modified to accommodate cultivated crop land, including the installation of drain tiles and removal for riparian trees and wetlands. Restoration of stream channel morphology, the riparian corridor, and in-stream habitat will be needed to improve aquatic community health in *Critical Area #2*

Challenges to Achieving Goals and Objectives

- Cultivated crop land is within 40-feet of Town Run and landowners may not be willing to remove crop land from production.
- Town Run is culverted under several road bridges. These culverts can be barriers to biotic migration, which may hinder colonization from nearby fish and macroinvertebrate populations.

3.3.4.1 Goals

The overall NPS restoration goals of any NPS-IS plan are to improve IBI, ICI, and QHEI scores such that a waterbody is brought into full attainment of the designated ALU. Partial attainment in this critical area is due to a *fair* macroinvertebrate community health score. Additionally, the QHEI scores are below the headwaters target (*poor* and *fair*). Therefore, the goals for *Lower Town Run* (Critical Area #2) of the *Yankee Run-St. Mary's River* WAU are to improve IBI, ICI, and QHEI scores at site 303085 (RM 1.25) so that the site will improve from partial attainment to full attainment of the designated ALU. These goals are specifically to:

Goal 1. Achieve an IBI score of 28 at site 303085 (RM 1.25) on Town Run.

- Achieved: Site 303085 has a score of 34 .

Goal 2. Achieve ICI score of 34 (or narrative score of *good*) at site 303085 (RM 1.25) on Town Run.

- Not achieved: Site 303085 has a score of *fair*.

Goal 3. Achieve a QHEI score of 55 at 303085 (RM 1.25) on Town Run.

- Not achieved: Site 303085 has a score of 46.5.

3.3.4.2 Objectives

Achievement of the overall NPS restoration goal of full attainment will be challenging (see text box above) and socio-economic factors will likely preclude full stream channel restoration and reconnection of incised channels to the floodplain. Instead, this NPS-IS plan will focus on reducing sedimentation that impairs benthic

macroinvertebrate community health. The following objectives needs to be achieved within the *Lower Town Run* (Critical Area #2):

Objective 1 Establish riparian buffers and implement riparian management strategies along 2,250 lineal feet[24] of Yankee Run to reduce sediment-loading from overland flow into Town Run.

- *Restore and protect riparian habitat* (Ohio EPA 2013; Goal 2.03.01)
- *Increase native shrub and tree plantings in riparian areas* (Ohio EPA 2013; Goal 2.03.04)
- *Encourage riparian setback and development standards and codes* (Ohio EPA 2013; Goal 2.05.01)
- *Establish voluntary no plow zones in riparian areas* (Ohio EPA 2013; Goal 3.04.03)

Objective 2 Install two-stage ditches, over-wide ditches, or similar practices along 2,250 lineal feet[25] of Town Run to reduce sediment-loading in Yankee Run.

- *Restore and protect natural flow conditions* (Ohio EPA 2013; Goal 2.04.01)
- *Establish voluntary no-mow zones* (Ohio EPA 2013; Goal 2.05.02)

To reduce sedimentation in *Lower Town Run* (Critical Area #2), sediment-loading to Town Run from upland sources will also need to be reduced. Agricultural BMPs that can reduce nutrient- and sediment-loading are recommended for *Agricultural Lands* (Critical Area #3). The *Agricultural Lands* critical area is presented in Section 3.4 and its objectives are presented in Section 3.4.4.2.

As these objectives are implemented, water quality monitoring (both project-related and regularly scheduled monitoring) will be conducted to determine progress toward meeting the identified goals (i.e., water quality standards). These objectives will be reevaluated and modified, as necessary. When reevaluating, Ohio's *Nonpoint Source Management Plan Update* (Ohio EPA 2013) will be referenced, which has a complete listing of all eligible NPS management strategies.

[24] The critical area is 11,168-feet long. Assuming a 20 percent implementation rate and rounding to the nearest 50-feet yields a length of 2,250-feet.

[25] The critical area is 11,168-feet long. Assuming a 20 percent implementation rate and rounding to the nearest 50-feet yields a length of 2,250-feet.

3.4 CRITICAL AREA #3: CONDITIONS, GOALS, & OBJECTIVES

3.4.1 Detailed Characterization

The *Agricultural Parcels* (Critical Area #3) is composed of all parcels with agricultural land in the *Yankee Run-St. Mary's River* WAU. Agricultural parcels were visually identified in GIS using parcel data obtained from the Mercer County Auditor's Office (2019) and Van Wert County Engineer's Office (2018) and using orthoimagery from the Farm Service Agency (2017). In GIS, after the agricultural parcels were identified and exported, woodlots were excised from the parcels. Agricultural parcels less the woodlots (Figure 17) span the entire WAU and are a total of 32,034-acres (50-square miles). This critical area is predominantly cultivated crop lands (94 percent; Table 17). Many agricultural parcels include structures (e.g., homes, barns) and infrastructure (e.g., roads); while they are included in the critical area, they are a very small portion.

Two high priority areas for future BMP implementation were identified in the *Agricultural Parcels* critical area:

- **Priority Area 'A': Agricultural parcels (less woodlots) within 100-feet of the St. Mary's River**. Using GIS, this priority area was delineated by identifying all agricultural parcels within 100-feet of a polygon representing the area of the St. Mary's River in the high-resolution National Hydrography Dataset (USGS 2019b). The 3,981-acre priority area is 93 percent cultivated crop land (Table 17).
- **Priority Area 'B': Agricultural parcels (less woodlots) within 100-feet of streams and ditches**. This priority area was delineated by identifying all agricultural parcels within 100-feet of a stream or ditch that was represented in the high-resolution National Hydrography Dataset (USGS 2019b), excluding those parcels in Priority Area 'A'. The 16,618-acre priority area is 95 percent cultivated crop land (Table 17).

Table 17. Land cover in the *Agricultural Lands* critical area

Land cover	*Agricultural Lands* (Critical Area #3)		Priority Area 'A'		Priority Area 'B'	
	Area (acres)	Relative area (percent)	Area (acres)	Relative area (percent)	Area (acres)	Relative area (percent)
Open water	6	<1%	2	<1%	5	<1%
Developed, open	1,247	4%	108	3%	638	4%
Developed, low intensity	127	<1%	7	<1%	56	<1%
Developed, medium intensity	19	<1%	<1	<1%	11	<1%
Developed, high intensity	7	<1%	<1	<1%	4	<1%
Barren land	16	<1%	10	<1%	2	<1%
Deciduous forest	134	<1%	10	<1%	78	<1%
Evergreen forest	<1	<1%	--	--	<1	<1%
Mixed forest	<1	<1%	--	--	<1	<1%
Shrub / scrub	1	<1%	--	--	<1	<1%
Grassland / herbaceous	29	<1%	8	<1%	16	<1%
Pasture / hay	53	<1%	19	<1%	22	<1%
Cultivated crops	30,250	94%	3,712	93%	15,760	95%
Woody wetlands	83	<1%	60	2%	19	<1%
Emergent herbaceous wetlands	59	<1%	44	1%	9	<1%
Total	**32,034**	**100%**	**3,981**	**100%**	**16,618**	**100%**

Source of spatial data: National Land Cover Database 2016 (Yang et al. 2018).

Note: Areas were rounded to the nearest acre or percentage point. The *Totals* do not sum exactly due to rounding.

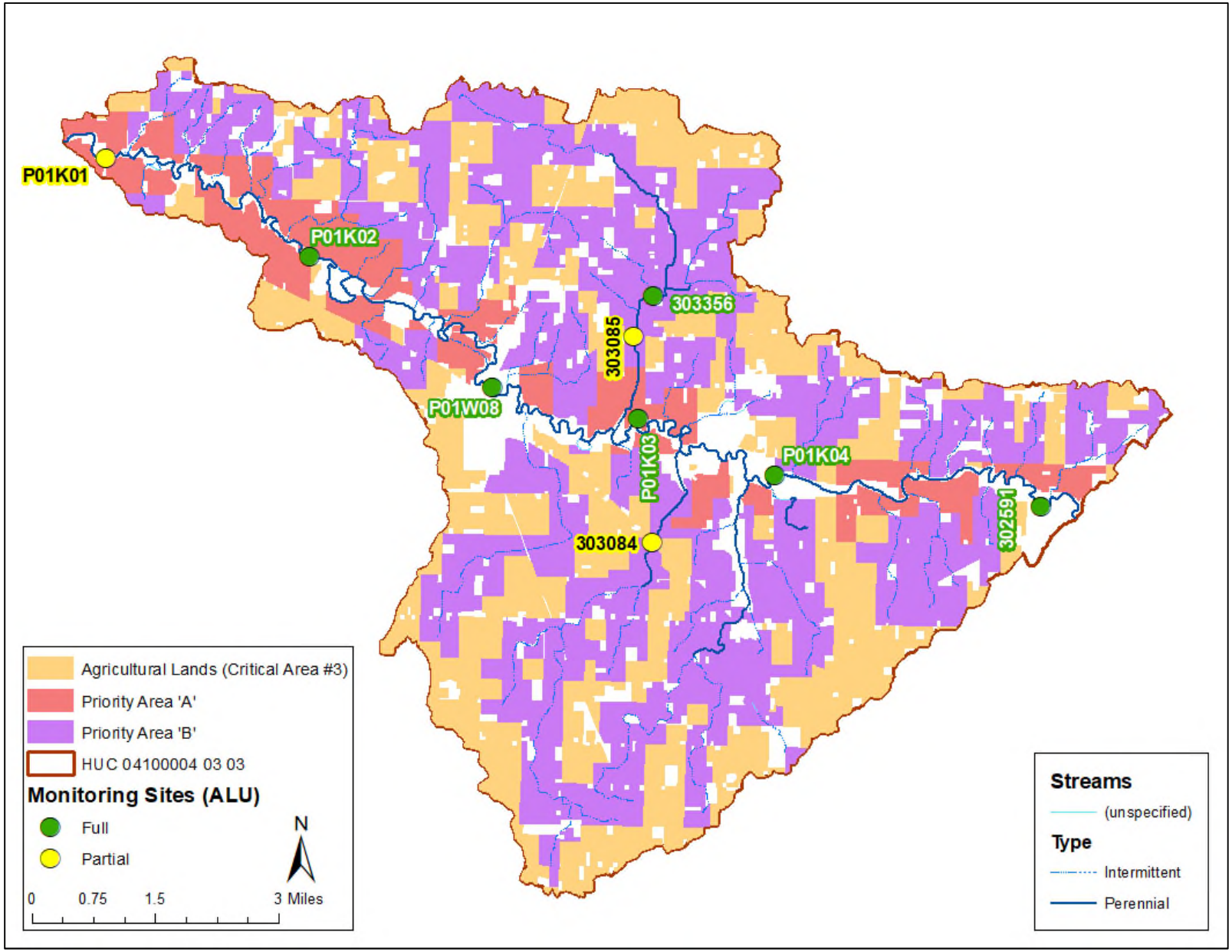


Figure 17. *Agricultural Lands* (Critical Area #3).

3.4.2 Detailed Biological Condition

The *Agricultural Lands* critical area addresses far-field nutrient loading to Lake Erie. WAU-scale biological condition is not relevant to this critical area. Refer to the TSD (Ohio EPA 2018a) for detailed discussion of biological and habitat condition at the eight monitoring sites in this WAU.

3.4.3 Detailed Causes and Associated Sources

Lake Erie is impaired by nutrient-loading from predominantly agricultural NPS throughout the Western Basin of Lake Erie. In the *Yankee Run-St. Mary's River* WAU both cultivated crop and livestock operations generate nutrient loads that migrate to surface waters and eventually reach Lake Erie.

3.4.4 Goals and Objectives for Critical Area #3

As explained in detail above and by Ohio EPA (2018), *Critical Area #3* contributes nutrient-loading to the St. Mary's River and eventually Lake Erie that results in HABs and hypoxia in Lake Erie. Waterbodies throughout the WAU have been modified to accommodate cultivated crop land, including the installation of drain tiles and removal of wetlands. Implementation of BMPs that reduce or retain water and nutrients and BMPs that control erosion or retain sediment will be needed to improve the water quality of the St. Mary's River and Lake Erie.

Challenges to Achieving Goals and Objectives

The critical area is composed of cultivated crop land and landowners may not be willing to remove crop land from production.

3.4.4.1 Goals

The overall NPS restoration goals of any NPS-IS plan are to improve a waterbody such that is brought into full attainment of the impaired designated use. This critical area addresses far-field nutrient loading from the *Yankee Run-St. Mary's River* WAU to the St. Mary's River and ultimately to Lake Erie that is impaired by HABs and hypoxia. Therefore, the goals for *Agricultural Lands* (Critical Area #3) of the *Yankee Run-St. Mary's River* WAU are to reduce nutrient loading to far-field locations.

These goals are specifically to:

Goal 1. Reduce the agricultural spring (Mary through July) TP load by 12,000 pounds (40 percent reduction of 2008 baseline load of 30,000 pounds)

- Not achieved: The spring TP load has only been reduced by an estimated 610 pounds.

Goal 2. Reduce the agricultural spring (Mary through July) SRP load by 2,500 pounds (40 percent reduction of 2008 baseline load of 6,300 pounds)

- Not achieved: The spring SRP load has only been reduced by an estimated 130 pounds.

Goal 3. Reduce the agricultural annual TP load by 32,000 pounds (40 percent reduction of 2008 baseline load of 49,000 pounds)

- Not achieved: The spring TP load has only been reduced by an estimated 1,700 pounds.

The estimation of loads reduced by BMPs installed since the 2008 baseline year is presented in Appendix A.

3.4.4.2 Objectives

To achieve the overall NPS restoration goal of full attainment (which will be challenging, see text box above). Two types of strategies are recommended: sediment- and nutrient reduction strategies and drainage water management strategies.

Sediment- and nutrient-reduction strategies reduce sediment and nutrient migration from agricultural properties to streams and shallow groundwater. These strategies include implementing 4R fertilizer practices[26], nutrient management planning, planting cover crops, and using minimally invasive tillage practices. Such practices reduce the amount of sediments and nutrients that can be mobilized and transported off property.

Drainage water management strategies are practices for managing the timing, volume, and rate of surface and subsurface flow that is discharged from agricultural operations to streams and shallow groundwater. These strategies include the installation of retention devices and drainage tile controls, the creation of saturated buffers, and the creation of basins or wetlands. Such practices retain or detain water.

Drainage water management

Perhaps the single most important action that can be taken to reduce nutrient loadings and impacts on Ohio streams is to reduce the rate and amount of runoff from agricultural production areas.

(Ohio EPA 2013a, p. 38, Goal 3.03.01)

Mercer SWCD estimated the maximum feasible BMP implementation over the next 10 to 15 years to develop the following five objectives for the *Agricultural Lands* (Critical Area #3). BMP implementation should focus on the priority areas.

Objective 1 Write and implement nutrient management plans for 20,000 acres of crop land**.** This objective includes comprehensive nutrient management planning for small (non-permitted) livestock operations.

- *Encourage whole farm conservation planning* (Ohio EPA 2013a, Goal 3.01.01)

Objective 2 Install grassed waterways (or improve existing waterways) to treat drainage from 1,000 acres of crop land.

- *Reduce erosion and nutrient- and sediment-loss to surface waters* (Ohio EPA 2013a, Goal 3.01.02)

Objective 3 Install nutrient removal wetlands to treat drainage from 1,000 acres of crop land.

- *Reduce the rate and amount of runoff* (Ohio EPA 2013a, Goal 3.03.01)
- *Increase treatment of field runoff* (Ohio EPA 2013a, Goal 3.03.02)

[26] Right source, Right rate, Right time, and Right place.

Objective 4 Install saturated buffers at 5 to 10 properties to treat about 200 acres of crop land.

- *Reduce erosion and nutrient- and sediment-loss to surface waters* (Ohio EPA 2013a, Goal 3.01.02)
- *Reduce the rate and amount of runoff* (Ohio EPA 2013a, Goal 3.03.01)
- *Increase treatment of field runoff* (Ohio EPA 2013a, Goal 3.03.02)

Objective 5 Along the St. Mary's River, remove 500 acres of marginal and flood-prone crop land from production**.** Restore these areas to natural land covers (e.g., forest, wetland).

- *Restore and protect riparian habitat* (Ohio EPA 2013; Goal 2.03.01)
- *Increase native shrub and tree plantings in riparian areas* (Ohio EPA 2013; Goal 2.03.04)
- *Reduce erosion and nutrient- and sediment-loss to surface waters* (Ohio EPA 2013a, Goal 3.01.02)

The estimation of loads that could be reduced by implementing these objectives are presented in Appendix B.

Candidate locations that are suitable for certain structural agricultural BMPs were identified using ACPF, including structural BMPs that could achieve Objectives #2, #3, and #4. The full set of results (including spatial data and mapping) are available from the Mercer SWCD. These results are summarized in Table 18.

Based upon the estimated load reductions presented in Appendix B, full implementation of these objectives will not likely be sufficient to achieve the Annex 4 goals of 40 percent TP and SRP reduction. Ohio EPA and Mercer SWCD hope that achievement of these objectives will sway additional unwilling landowners to begin considering agricultural BMPs to reduce nutrient- and sediment-loading. If more landowners become willing to implement such BMPs, the objectives will need to be revised.

As these objectives are implemented, water quality monitoring (both project-related and regularly scheduled monitoring) will be conducted to determine progress toward meeting the identified goals (i.e., Annex 4 goal of 40 percent reduction). These objectives will be reevaluated and modified, as necessary. When reevaluating, Ohio's *Nonpoint Source Management Plan Update* (Ohio EPA 2013) will be referenced, which has a complete listing of all eligible NPS management strategies.

Table 18. ACPF results for *Agricultural Lands* (Critical Area #3)

Agricultural BMP	*Agricultural Lands* (Critical Area #3)			Priority Area 'A'			Priority Area 'B'		
	No. of Candidate BMPs	Total size [a]	Treated area [b]	No. of Candidate BMPs	Total size [a]	Treated area [b]	No. of Candidate BMPs	Total size [a]	Treated area [b]
Length-Based BMPs									
Contour buffer strip	31	7	--	0	--	--	23	5	--
Grassed waterway	779	74	--	70	7	--	452	49	--
Saturated buffer	283[c]	92	7,521	93[d]	31	3,290	202[e]	65	4,706
Area-Based BMPs									
Controlled drainage	634	10,766	10,766	75	1,124	1,124	418	7,029	7,029
Edge of field bioreactor	215	51	10,315	26	6	1,160	106	26	5,256
Nutrient removal wetland	12	35 (105) [f]	2,930	2	3 (6) [g]	319	10	32 (99) [h]	2,610
WASCOB	60	54	581	9	7	51	36	35	418

Notes

BMP = best management practice.

a. Total size is in miles for length-based BMPs and is in acres for area-based BMPs. Miles and acres are rounded to the nearest mile or acre.

b. Treated area is in acres and is rounded to the nearest acre.

c. Carbon enhancement is necessary for 42 of the 283 potential saturated buffers.

d. Carbon enhancement is necessary for 19 of the 93 potential saturated buffers.

e. Carbon enhancement is necessary for 27 of the 202 potential saturated buffers.

f. The wetland pooled area is 35 acres and the vegetated buffer area is 105 acres.

g. The wetland pooled area is 3 acres and the vegetated buffer area is 6 acres.

h. The wetland pooled area is 32 acres and the vegetated buffer area is 99 acres.

4 PROJECTS AND IMPLEMENTATION STRATEGY

Projects and evaluations believed to be necessary to address the causes and sources of impairments to the *Yankee Run-St. Mary's River* WAU are presented by critical area in this section. As Ohio EPA assesses attainment using numeric biological criteria, periodic re-evaluation of biological condition will be necessary to determine if the implemented projects restore the critical areas. Similarly, Ohio EPA will re-evaluate far-field conditions as projects to reduce nutrient-loading are implemented.

Time is a key factor to consider when measuring project success and overall status. Biological systems in some cases can show response quickly (e.g., one season); others system may take longer (e.g., several seasons, years) to show recovery (Meals, Dressing, & Davenport 2010). There may also be reasons other than nonpoint source pollution for the impairment. Those issues will need to be addressed under different initiatives, authorities or programs which may or may not be accomplished by the same implementers addressing the nonpoint source pollution issues.

The *Yankee Run-St. Mary's River WAU* was delineated into three critical areas to address causes and sources of impairment. An overview table is presented for each critical area in the following subsections (4.1.1, 4.2.1, and 4.3.1). Projects in each of the three critical areas were prioritized using the following process:

Highest priority	Directly addresses one or more of the critical area's objectives
	Indirectly or directly affect one or more objectives of another critical areas
	Landowner support
	Within priority areas 'A' or 'B' (for the *Agricultural Lands* critical area)
Higher priority	Directly address one or more of the critical area's objectives
	Landowner support
Lower priority	Indirectly address one or more of the critical area's objectives
	Landowner support
Lowest priority	Indirectly address one or more of the critical area's objectives

If additional NPS impairments are identified for an existing critical area, the critical area's overview table will be updated. If a new impairment is determined that is not within an existing critical area, then a new critical area will be delineated, and a new summary table will be created.

Project Summary Sheets (PSS) are in Sections 4.1.2, 4.2.2, and 4.3.2. These PSS 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 PPS 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: OVERVIEW TABLE AND PROJECT SHEETS

In the future, information will be included in a table that is a condensed overview of all identified projects needed for NPS restoration of the *Lower Yankee Run* critical area. PSSs will be included for short-term projects or any project that is considering seeking funding in the near future. Only those projects with complete PSS will be considered for state and federal nonpoint source program funding.

4.1.1 Critical Area #1: Project Implementation Strategy Overview Table

During the development of this NPS-IS plan, Mercer SWCD was unable to find a landowner within the *Lower Yankee Run* critical area that was willing to consider implementing a stream or riparian restoration project.

4.1.2 Critical Area #1: Project Summary Sheets

In the future, the PSSs provided below will be developed based on the actions or activities needed to restore Yankee Run sampling site 303084 (RM 1.40) to attainment of the ALU designation. These projects will be considered next step or priority/short term projects. Medium and long-term projects are not presented in PSSs since they are not yet ready for implementation.

Critical Area 1: Project 1		
Nine Element Criteria	**Information Needed**	**Explanation**
n/a	Title	
criterion d	Project Lead Organization and Partners	
criterion c	HUC-12 & Critical Area	
criterion c	Project Location	
n/a	Which strategy is being addressed by this project?	
criterion f	Time Frame	
criterion g	Short Description	
criterion g	Project Narrative	
criterion d	Estimated Total Cost	
criterion d	Possible Funding Source	
criterion a	Identified Causes and Sources	
criteria b & h	Part 1: How much improvement is needed to remove the NPS impairment associated with this Critical Area?	
	Part 2: How much of the needed improvement for the whole Critical Area is estimated to be accomplished by this project?	
	Part 3: Load reduced?	
criterion i	How will the effectiveness of this project in addressing the NPS impairment be measured?	
criterion e	Information and Education	

4.2 CRITICAL AREA #2: OVERVIEW TABLE AND PROJECT SHEETS

In the future, information will be included in a table that is a condensed overview of all identified projects needed for NPS restoration of the *Lower Town Run* critical area. PSSs will be included for short-term projects or any project that is considering seeking funding in the near future. Only those projects with complete PSS will be considered for state and federal nonpoint source program funding.

4.2.1 Critical Area #2: Project Implementation Strategy Overview Table

During the development of this NPS-IS plan, Mercer SWCD was unable to find a landowner within the *Lower Yankee Run* critical area that was willing to consider implementing a stream or riparian restoration project.

4.2.2 Critical Area #2: Project Summary Sheets

In the future, the PSSs provided below will be developed based on the actions or activities needed to restore Town Run sampling site 303085 (RM 1.25) to attainment of the ALU designation. These projects will be considered next step or priority/short term projects. Medium and long-term projects are not presented in PSSs since they are not yet ready for implementation.

Critical Area 2: Project 1		
Nine Element Criteria	**Information Needed**	**Explanation**
n/a	Title	
criterion d	Project Lead Organization and Partners	
criterion c	HUC-12 & Critical Area	
criterion c	Project Location	
n/a	Which strategy is being addressed by this project?	
criterion f	Time Frame	
criterion g	Short Description	
criterion g	Project Narrative	
criterion d	Estimated Total Cost	
criterion d	Possible Funding Source	
criterion a	Identified Causes and Sources	
criteria b & h	Part 1: How much improvement is needed to remove the NPS impairment associated with this Critical Area?	
	Part 2: How much of the needed improvement for the whole Critical Area is estimated to be accomplished by this project?	
	Part 3: Load reduced?	
criterion i	How will the effectiveness of this project in addressing the NPS impairment be measured?	
criterion e	Information and Education	

4.3 CRITICAL AREA #3: OVERVIEW TABLE AND PROJECT SHEETS

The information included in the Table 19 is a condensed overview of all identified projects needed for NPS restoration of the *Agricultural Lands* critical area. PSSs are included for short-term projects or any project that is considering seeking funding in the near future. Only those projects with complete PSS will be considered for state and federal nonpoint source program funding.

4.3.1 Critical Area #3: Project Implementation Strategy Overview Table

The *Agricultural Lands* critical area is based upon far-field NPS pollution of Lake Erie. The overview table (Table 19) provides a quick summary of what needs to be done where and what problem (cause/source) will be addressed. The table includes projects at all levels of development (e.g., concept, in progress), and the table is intended to show a prioritized path toward restoration of the *Agricultural Lands* critical area in the *Yankee Run-St. Mary's River* WAU. Many agricultural BMPs, like the example in Figure 18, will need to be installed to reduce nutrient- and sediment-loading to the St. Mary's River and Lake Erie.

Note: The Great Lakes Nutrient and Sediment Reduction Program (2017) awarded $25,083 to Mercer SWCD. A series of in-line BMPs were installed in a grassed waterway that drains 230-acres to reduce gully erosion and sediment-loading to the St. Mary's River. The series of BMPs are a blind inlet, followed by stone-bedded wetlands, and then wetland pool areas.

Figure 18. Improvements to a grassed waterway in the *Yankee Run-St. Mary's River* WAU.

Table 19. Critical Area #3: Overview table for *Agricultural Land*

Goal	Objective	Project	Project title	Lead organization (criteria d)	Timeframe (criteria f)	Estimated cost (criteria d)	Potential/actual funding sources (criteria d)
Urban sediment and nutrient reduction strategies							
not applicable							
Altered stream and habitat restoration strategies							
not applicable							
Agricultural nonpoint source reduction strategies							
1,2,3	1	1	Nutrient Management Planning for 2,500-Acres of Crop Land	Mercer SWCD	Short	$60K-$80K	EQIP, local
1,2,3	2	2	Install Two Grassed Waterways	Mercer SWCD	Short	$50K	CRP
1,2,3	2	3	Install Three Grassed Waterways	Mercer SWCD	Short	$55K	CRP, Ohio EPA §319, H2Ohio
1,2,3	3	4	Treatment Wetland Installation	Mercer SWCD	Short	$60K	CRP, CREP
1,2,3	2	5	Install One Grassed Waterway	Van Wert SWCD	Short	$50K	CRP, CREP, SB 299
High quality waters protection strategies							
not applicable							
Other NPS causes and associates sources of impairment							
none identified (yet)							

Note: CREP = Conservation Reserve Enhancement Program; CRP = Conservation Reserve Program; EQIP = Environmental Quality Incentives Program; SB = Senate Bill.

4.3.2 Critical Area #3: Project Summary Sheets

The PSSs provided below were developed based on the actions or activities needed to reduce nutrient- and sediment-loading to the St. Mary's River and ultimately Lake Erie. These projects are considered next step or priority/short term projects. Medium and long-term projects are not presented in PSSs since they are not yet ready for implementation.

Critical Area 3: Project 1		
Nine Element Criteria	**Information Needed**	**Explanation**
n/a	Title	Nutrient Management Planning for 2,500 Acres of Crop Land
criterion d	Project Lead Organization and Partners	Mercer SWCD
criterion c	HUC-12 & Critical Area	*Yankee Run-St. Mary's River* (04100004 03 03) *Agricultural Lands* (Critical Area #3)
criterion c	Project Location	Small livestock farms in the WAU
n/a	Which strategy is being addressed by this project?	Agricultural NPS
criterion f	Time Frame	Short
criterion g	Short Description	Comprehensive nutrient management planning for small livestock farms
criterion g	Project Narrative	The livestock farms located in this WAU utilize manure to fertilize crops (typically corn, soybeans and wheat) grown on fields they own or neighboring fields. Mercer SWCD will assist these farms with developing a comprehensive nutrient management plan utilizing soil testing and manure testing to develop recommendations for manure application timing, placement and methods. These plans will also identify issues at the livestock headquarters to prepare those farms for future EQIP funding.
criterion d	Estimated Total Cost	$60,000 - $80,000
criterion d	Possible Funding Source	EQIP, Ohio EPA §319, H2Ohio
criterion a	Identified Causes and Sources	*Causes*: Far-field nutrient-loading *Sources*: Cultivated crops with subsurface drainage, small livestock operations
criteria b & h	Part 1: How much improvement is needed to remove the NPS impairment associated with this Critical Area?	Spring TP: must be reduced more than 11,000 pounds Spring SRP: must be reduced more than 2,300 pounds Annual TP: must be reduced more than 30,000 pounds
	Part 2: How much of the needed improvement for the whole Critical Area is estimated to be accomplished by this project?	7% of Goal #1 (830 pounds / 12,000 pounds) 7 % of Goal #2 (180 pounds / 2,500 pounds) 7% of Goal #3 (2,200 pounds / 32,000 pounds) 25% of Objective #1 (2,500 acres / 10,000 acres)
	Part 3: Load reduced?	Spring TP: 830 pounds Spring SRP:180 pounds Annual TP: 2,200 pounds
criterion i	How will the effectiveness of this project in addressing the NPS impairment be measured?	Ohio EPA will evaluate the effects of BMP implementation for Ohio's portion of the *St. Mary's River* subbasin using daily phosphorus data collected at USGS gage 04181049. Directly linking this specific project's impacts to the impairment in Lake Erie is not possible.

criterion e	Information and Education	Most of the time, in the agricultural community, the best way to promote a best management practice is through other farmers that have already implemented said practice. Mercer SWCD will reach out to farmers to begin this work and then over time, expand efforts beyond livestock farms to those that farm cropland only.

Notes

EQIP = Environmental Quality Incentives Program ; NPS = nonpoint source; SRP = soluble reactive phosphorus; TP = total phosphorus.

Load reductions for nutrient management plans were calculated assuming a phosphorus reduction efficiency of 35 percent (Appendix C).

Critical Area 3: Project 2		
Nine Element Criteria	**Information Needed**	**Explanation**
n/a	Title	Install Two Grassed Waterways
criterion d	Project Lead Organization and Partners	Mercer SWCD
criterion c	HUC-12 & Critical Area	*Yankee Run-St. Mary's River* (04100004 03 03) *Agricultural Lands* (Critical Area #3)
criterion c	Project Location	Private properties (exact location withheld) Sections 6 and 12, Dublin Township, Mercer County
n/a	Which strategy is being addressed by this project?	Agricultural NPS
criterion f	Time Frame	Short
criterion g	Short Description	Install two previously designed grassed
criterion g	Project Narrative	Install grassed waterway 'A' (2,000-feet long; treats 296-acres; in Priority Area 'B') and 'B' (800-feet long; treats 22 acres). Grassed waterways to be planted with Kentucky bluegrass, Kentucky 31 tall fescue, and perennial ryegrass. Install blind inlets, rip-rap, erosion control blankets, and rock-pads. Follow Natural Resources Conservation Service (2019) standard 412.
criterion d	Estimated Total Cost	$50,000
criterion d	Possible Funding Source	Conservation Reserve Program
criterion a	Identified Causes and Sources	*Causes*: Far-field nutrient-loading *Sources*: Cultivated crops with subsurface drainage, small livestock operations
criteria b & h	Part 1: How much improvement is needed to remove the NPS impairment associated with this Critical Area?	Spring TP: must be reduced more than 11,000 pounds Spring SRP: must be reduced more than 2,300 pounds Annual TP: must be reduced more than 30,000 pounds
	Part 2: How much of the needed improvement for the whole Critical Area is estimated to be accomplished by this project?	1% of Goal #1 (90 pounds / 12,000 pounds) 1% of Goal #2 (19 pounds / 2,500 pounds) 1% of Goal #3 (240 pounds / 32,000 pounds) 32% of Objective #2 (318 acres / 1,000 acres)
	Part 3: Load reduced?	Spring TP: 90 pounds Spring SRP:19 pounds Annual TP: 240 pounds
criterion i	How will the effectiveness of this project in addressing the NPS impairment be measured?	Ohio EPA will evaluate the effects of BMP implementation for Ohio's portion of the *St. Mary's River* subbasin using daily phosphorus data collected at USGS gage 04181049. Directly linking this specific project's impacts to the impairment in Lake Erie is not possible.
criterion e	Information and Education	Pictures from projects can be shared on social media and Mercer SWCD's website. Highlights from each year's installed projects are shared at the Mercer SWCD annual meeting as well. These projects really sell themselves.

Notes

NPS = nonpoint source; SRP = soluble reactive phosphorus; TP = total phosphorus.

Load reductions for grassed waterways were calculated assuming a phosphorus reduction efficiency of 30 percent (Appendix C).

Critical Area 3: Project 3		
Nine Element Criteria	**Information Needed**	**Explanation**
n/a	Title	Install Three Grassed Waterways
criterion d	Project Lead Organization and Partners	Mercer SWCD
criterion c	HUC-12 & Critical Area	*Yankee Run-St. Mary's River* (04100004 03 03) *Agricultural Lands* (Critical Area #3)
criterion c	Project Location	Private properties (exact location withheld) Sections 11 and 13, Dublin Township, Mercer County
n/a	Which strategy is being addressed by this project?	Agricultural NPS
criterion f	Time Frame	Short
criterion g	Short Description	Install two previously designed grassed waterways and design and install a third grassed waterway
criterion g	Project Narrative	Install grassed waterway 'A' (800-feet long; treats 91-acres) and 'B' (1,700-feet long; treats 146 acres). Design and install grassed waterway 'C' (to treat about 54 acres). Grassed waterways to be planted with Kentucky bluegrass, Kentucky 31 tall fescue, and perennial ryegrass. Install blind inlets, rip-rap, erosion control blankets, and rock-pads. Follow Natural Resources Conservation Service (2019) standard 412.
criterion d	Estimated Total Cost	$55,000
criterion d	Possible Funding Source	Conservation Reserve Program, Ohio EPA §319, H2Ohio
criterion a	Identified Causes and Sources	*Causes*: Far-field nutrient-loading *Sources*: Cultivated crops with subsurface drainage, small livestock operations
criteria b & h	Part 1: How much improvement is needed to remove the NPS impairment associated with this Critical Area?	Spring TP: must be reduced more than 11,000 pounds Spring SRP: must be reduced more than 2,300 pounds Annual TP: must be reduced more than 30,000 pounds
	Part 2: How much of the needed improvement for the whole Critical Area is estimated to be accomplished by this project?	1% of Goal #1 (82 pounds / 12,000 pounds) 1% of Goal #2 (17 pounds / 2,500 pounds) 1% of Goal #3 (220 pounds / 32,000 pounds) 29% of Objective #2 (290 acres / 1,000 acres)
	Part 3: Load reduced?	Spring TP: 82 pounds Spring SRP:17 pounds Annual TP: 220 pounds
criterion i	How will the effectiveness of this project in addressing the NPS impairment be measured?	Ohio EPA will evaluate the effects of BMP implementation for Ohio's portion of the *St. Mary's River* subbasin using daily phosphorus data collected at USGS gage 04181049. Directly linking this specific project's impacts to the impairment in Lake Erie is not possible.
criterion e	Information and Education	Pictures from projects can be shared on social media and Mercer SWCD's website. Highlights from each year's installed projects are shared at the Mercer SWCD annual meeting as well. These projects really sell themselves.

Notes

NPS = nonpoint source; SRP = soluble reactive phosphorus; TP = total phosphorus.

Load reductions for grassed waterways were calculated assuming a phosphorus reduction efficiency of 30 percent (Appendix C).

Critical Area 3: Project 4		
Nine Element Criteria	**Information Needed**	**Explanation**
n/a	Title	Treatment Wetland Installation
criterion d	Project Lead Organization and Partners	Mercer SWCD
criterion c	HUC-12 & Critical Area	*Yankee Run-St. Mary's River* (04100004 03 03) *Agricultural Lands* (Critical Area #3)
criterion c	Project Location	Section 15, Dublin Township, Mercer County
n/a	Which strategy is being addressed by this project?	Agricultural NPS
criterion f	Time Frame	Short
criterion g	Short Description	A treatment wetland to treat runoff from 296 acres of cropland, houses, and roads.
criterion g	Project Narrative	This project will include approximately three acres of water pool area with up to seven acres of surrounding grass buffer. Just under 300 acres of land drains through the area. Warm-season grasses, such as big bluestem, sideoats grama, switchgrass, various forbs and more will be planted in the buffer area.
criterion d	Estimated Total Cost	$60,000
criterion d	Possible Funding Source	CRP/CREP
criterion a	Identified Causes and Sources	*Causes*: Far-field nutrient-loading *Sources*: Cultivated crops with subsurface drainage, small livestock operations
criteria b & h	Part 1: How much improvement is needed to remove the NPS impairment associated with this Critical Area?	Spring TP: must be reduced more than 11,000 pounds Spring SRP: must be reduced more than 2,300 pounds Annual TP: must be reduced more than 30,000 pounds
	Part 2: How much of the needed improvement for the whole Critical Area is estimated to be accomplished by this project?	1% of Goal #1 (140 pounds / 12,000 pounds) 1% of Goal #2 (30 pounds / 2,500 pounds) 1% of Goal #3 (370 pounds / 32,000 pounds) 30% of Objective #3 (300 acres / 1,000 acres)
	Part 3: Load reduced?	Spring TP: 140 pounds Spring SRP:30 pounds Annual TP: 370 pounds
criterion i	How will the effectiveness of this project in addressing the NPS impairment be measured?	Ohio EPA will evaluate the effects of BMP implementation for Ohio's portion of the *St. Mary's River* subbasin using daily phosphorus data collected at USGS gage 04181049. Directly linking this specific project's impacts to the impairment in Lake Erie is not possible.
criterion e	Information and Education	Pictures from projects can be shared on social media and Mercer SWCD's website. Highlights from each year's installed projects are shared at the Mercer SWCD annual meeting as well.

Notes

NPS = nonpoint source; SRP = soluble reactive phosphorus; TP = total phosphorus.
Load reductions for treatment wetlands were calculated assuming a phosphorus reduction efficiency of 50 percent (Appendix C).

Critical Area 3: Project 5		
Nine Element Criteria	**Information Needed**	**Explanation**
n/a	Title	Install 1 Grassed Waterway
criterion d	Project Lead Organization and Partners	Van Wert SWCD
criterion c	HUC-12 & Critical Area	*Yankee Run-St. Mary's River* (04100004 03 03) *Agricultural Lands* (Critical Area #3)
criterion c	Project Location	Private Property Section 33, Liberty Township, Van Wert County
n/a	Which strategy is being addressed by this project?	Agricultural NPS
criterion f	Time Frame	Short
criterion g	Short Description	Install 1 previously designed grassed waterway
criterion g	Project Narrative	Install Grassed Waterway, 2,762 feet long, treating 210 acres. Grassed waterway to be planted following NRCS standard 412. Install blind inlets, rip-rap, erosion control blankets, and rock-pads
criterion d	Estimated Total Cost	$50,000
criterion d	Possible Funding Source	CRP, CREP, SB 299
criterion a	Identified Causes and Sources	*Causes*: Far-field nutrient-loading *Sources*: Cultivated crops with subsurface drainage, small livestock operations
criteria b & h	Part 1: How much improvement is needed to remove the NPS impairment associated with this Critical Area?	Spring TP: must be reduced more than 11,000 pounds Spring SRP: must be reduced more than 2,300 pounds Annual TP: must be reduced more than 30,000 pounds
	Part 2: How much of the needed improvement for the whole Critical Area is estimated to be accomplished by this project?	<1% of Goal #1 (59 pounds / 12,000 pounds) <1% of Goal #2 (12 pounds / 2,500 pounds) <1% of Goal #3 (160 pounds / 32,000 pounds) 21% of Objective #2 (210 acres / 1,000 acres)
	Part 3: Load reduced?	Spring TP: 59 pounds Spring SRP:12 pounds Annual TP: 160 pounds
criterion i	How will the effectiveness of this project in addressing the NPS impairment be measured?	Ohio EPA will evaluate the effects of BMP implementation for Ohio's portion of the *St. Mary's River* subbasin using daily phosphorus data collected at USGS gage 04181049. Directly linking this specific project's impacts to the impairment in Lake Erie is not possible.
criterion e	Information and Education	Project success stories and photographs of completed projects will be displayed on Van Wert SWCD's Facebook page and website. These are very popular projects and customers are very familiar with them.

Notes

CREP = Conservation Reserve Enhancement Program; CRP = Conservation Reserve Program; NPS = nonpoint source; SB = Senate Bill; SRP = soluble reactive phosphorus; TP = total phosphorus.

Load reductions for grassed waterways were calculated assuming a phosphorus reduction efficiency of 30 percent (Appendix C).

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APPENDIX A. ESTIMATED LOAD REDUCTIONS FROM EXISTING BMPS

Phosphorus load reductions from existing BMPs were estimated by calculating

1. The crop land phosphorus loading rate
2. The existing phosphorus load before BMP treatment
3. The phosphorus load reduction due to BMP treatment

Loads and reductions were estimated for the Annex 4 goals of springtime TP, springtime SRP, and annual TP.

CROP LAND PHOSPHORUS LOADING RATES

The crop land phosphorus loading rates were calculated by dividing the 2008 baseline agricultural loads (spring TP, spring SRP, and annual TP) by the area of cultivated crop land in the *Yankee Run-St. Mary's River* WAU. The WAU is comprised of 31,987 acres of cultivated crop; refer to Section 2.1.2 for a discussion of land cover in this WAU.

30,000 pounds spring TP per 31,891 acres crop land = 0.94 pounds spring TP per acre

6,300 pounds spring SRP per 31,891 acres crop land = 0.20 pounds spring SRP per acre

81,000 pounds annual TP per 31,891 acres crop land = 2.5 pounds annual TP per acre

GRASSED WATERWAYS

The load reductions for grassed waterways were calculated by applying the phosphorus removal efficiency to the estimated phosphorus load that was treated by grassed waterways.

- Mercer SWCD (2019a) reports 24,639 feet of grassed waterway that treat drainage from 1,260 acres of crop land (i.e., about 4 percent of all the crop land in the WAU) have been installed since 2008 (Section 2.1.2.1)
- Grassed waterways were assumed to reduce phosphorus loads by 30 percent (Appendix C).

The 1,260 treated acres were multiplied by the crop land phosphorus loading rates to estimate the 2008 baseline loads for the 1,260 acres. The three 2008 baseline loads were multiplied by 30 percent to estimate the BMP load reduction.

Example 2008 baseline load calculation: 1,260 acres * 0.94 pounds spring TP per acre

1,185 pounds

1,200 pounds (two significant digits for reporting)

Example BMP load reduction calculation: 1,185 pounds * 30 percent reduction

356 pounds

360 pounds (two significant digits for reporting)

Table A - 1. Grassed waterway load reduction

Pollutant	2008 baseline load	BMP load reduction
Spring TP	1,200	360
Spring SRP	250	76
Annual TP	3,200	950

Note: Loads are in pounds and are rounded to two significant digits.

NUTRIENT REMOVAL WETLANDS

The load reductions for nutrient removal wetlands were calculated by applying the phosphorus removal efficiency to the estimated phosphorus load that was treated by the nutrient removal wetlands.

- Mercer SWCD (2019a) reports 28.3 acres of pool, 56.6 acres of buffer, and 6.0 acres of woods in nutrient removal wetlands that treat drainage from 275 acres of crop land have been installed since 2008 (Section 2.1.2.1)
- Nutrient removal wetlands were assumed to reduce phosphorus loads by 50 percent (Appendix C).

The 1,260 treated acres were multiplied by the crop land phosphorus loading rates to estimate the 2008 baseline loads for the 1,260 acres. The three 2008 baseline loads were multiplied by 50 percent to estimate the BMP load reduction.

Table A - 2. Nutrient removal wetlands load reduction

Pollutant	2008 baseline load	BMP load reduction
Spring TP	260	130
Spring SRP	55	28
Annual TP	690	350

Note: Loads are in pounds and are rounded to two significant digits.

EXISTING BMP LOAD REDUCTIONS

The existing BMP load reductions in the *Agricultural Lands* critical area were estimated by summing the individual estimates for each BMP. Thus, the results in Table A - 3 are the summations of the results from Table A - 1 and Table A - 2.

The existing grassed waterways and nutrient removal wetlands in the *Yankee Run-St. Mary's River* WAU reduce phosphorus levels about 4 percent of the goal (i.e., 4 percent of the Annex 4 goal of 40 percent), which is about a 2 percent overall reduction.

Table A - 3. Existing BMP load reductions

Pollutant	WAU load reduction goal	Existing BMP load reduction
Spring TP	12,000	490
Spring SRP	2,500	100
Annual TP	32,000	1,300

Note: Loads are in pounds and are rounded to two significant digits.

APPENDIX B. ESTIMATED LOAD REDUCTIONS FOR FUTURE BMPS

Phosphorus load reductions for future BMPs were estimated by calculating

1. The crop land phosphorus loading rate (and in one case, the natural land loading rate)
2. The existing phosphorus load before BMP treatment
3. The phosphorus load reduction due to BMP treatment

Loads and reductions were estimated for the Annex 4 goals of springtime TP, springtime SRP, and annual TP.

CROP AND NATURAL LAND PHOSPHORUS LOADING RATES

The crop land phosphorus loading rates were calculated by dividing the 2008 baseline agricultural loads (spring TP, spring SRP, and annual TP) by the area of cultivated crop land in the *Yankee Run-St. Mary's River* WAU. The WAU is comprised of 31,987 acres are cultivated crop; refer to Section 2.1.2 for a discussion of land cover in this WAU.

30,000 pounds spring TP per 31,891 acres crop land = 0.94 pounds spring TP per acre

6,300 pounds spring SRP per 31,891 acres crop land = 0.20 pounds spring SRP per acre

81,000 pounds annual TP per 31,891 acres crop land = 2.5 pounds annual TP per acre

The natural land phosphorus loading rates were calculated by dividing the 2008 baseline natural land loads (spring TP, spring SRP, and annual TP) by the area of natural land[27] in the *Yankee Run-St. Mary's River* WAU. The WAU is comprised of 3,438 acres are natural; refer to Section 2.1.2 for a discussion of land cover in this WAU.

340 pounds spring TP per 3,438 acres natural land = 0.099 pounds spring TP per acre

71 pounds spring SRP per 3,438 acres natural land = 0.021 pounds spring SRP per acre

820 pounds annual TP per 3,438 acres natural land = 0.24 pounds annual TP per acre

NUTRIENT MANAGEMENT PLANNING (OBJECTIVE #1)

Objective #1 is to develop and implement nutrient management plans for 20,000 acres of crop land (Section 3.4.4.2). This objective includes comprehensive nutrient management planning for small (non-permitted) livestock operations. Implementation of nutrient management plans are assumed to remove 35 percent of phosphorus loads (Appendix C).

The 20,000 acres were multiplied by the crop land phosphorus loading rates to estimate the 2008 baseline loads for the 20,000 acres. The three 2008 baseline loads were multiplied by 35 percent to estimate the BMP load reduction.

[27] Natural is composed of deciduous forest (1,778 acres), evergreen forest (8 acres), mixed forest (6 acres), shrub/scrub (4 acres), woody wetlands (1,218 acres), and emergent herbaceous wetland (424 acres).

Example 2008 baseline load calculation: 20,000 acres * 0.94 pounds spring TP per acre

18,800 pounds

19,000 pounds (two significant digits for reporting)

Example BMP load reduction calculation: 18,800 pounds * 35 percent reduction

6,580 pounds

6,600 pounds (two significant digits for reporting)

Table B - 1. Nutrient management plan load reduction

Pollutant	2008 baseline load	BMP load reduction
Spring TP	19,000	6,600
Spring SRP	4,000	1,400
Annual TP	50,000	18,000

Note: Loads are in pounds and are rounded to two significant digits.

GRASSED WATERWAYS (OBJECTIVE #2)

Objective #2 is to install or improve grassed waterways to treat 1,000 acres of crop land (Section 3.4.4.2). Grassed waterways are assumed to remove 30 percent of phosphorus loads (Appendix C).

The 1,000 acres were multiplied by the crop land phosphorus loading rates to estimate the 2008 baseline loads for the 1,000 acres. The three 2008 baseline loads were multiplied by 30 percent to estimate the BMP load reduction.

Table B - 2. Grassed waterway load reduction

Pollutant	2008 baseline load	BMP load reduction
Spring TP	940	280
Spring SRP	200	60
Annual TP	2,500	750

Note: Loads are in pounds and are rounded to two significant digits.

NUTRIENT REMOVAL WETLANDS (OBJECTIVE #3)

Objective #3 is to install nutrient removal wetlands to treat 1,000 acres of crop land (Section 3.4.4.2). Nutrient removal wetlands are assumed to remove 50 percent of phosphorus loads (Appendix C).

The 1,000 acres were multiplied by the crop land phosphorus loading rates to estimate the 2008 baseline loads for the 1,000 acres. The three 2008 baseline loads were multiplied by 50 percent to estimate the BMP load reduction.

Table B - 3. Nutrient removal wetland load reduction

Pollutant	2008 baseline load	BMP load reduction
Spring TP	940	470
Spring SRP	200	100
Annual TP	2,500	1,300

Note: Loads are in pounds and are rounded to two significant digits.

REMOVE MARGINAL CROP LAND FROM PRODUCTION (OBJECTIVE #5)

Objective #5 is to remove 500 acres of marginal and flood-prone crop land along the St. Mary's River from production, and to then restore these areas to natural land cover (Section 3.4.4.2).

To estimate the 2008 baseline load for these 500 acres, the 500 acres were multiplied by the crop land phosphorus loading rates. To estimate the load once the land is restored to natural land covers, the 500 acres were multiplied by the natural land phosphorous loading rates. The reduction was calculated as the difference between the 2008 baseline load as crop land and the load as natural land.

Converting the marginal crop land to certain types of natural land covers (e.g., wetlands) could also result in additional load reductions if it drains runoff from active crop lands. However, insufficient information is available to estimate the extent that this might occur.

Table B - 4. Removal of marginal and flood-prone crop land load reduction

Pollutant	2008 baseline load	BMP load reduction	Load after BMP implementation
Spring TP	470	420	50
Spring SRP	100	98	2.1
Annual TP	1,300	1,000	310

Note: Loads are in pounds and are rounded to two significant digits.

FUTURE BMP LOAD REDUCTIONS

The future BMP load reductions in the *Yankee Run-St. Mary's River* WAU were estimated by summing the individual estimates for each BMP. Thus, the results in Table B - 5 are the summations of the results from Table B - 1, Table B - 2, Table B - 3, and Table B - 4.

The future nutrient management planning, grassed waterways, nutrient removal wetlands, and removal of marginal and flood-prone cropland in the *Agricultural Lands* will reduce phosphorus levels about 26 percent, which is 65 percent of the Annex 4 goal (i.e., 26 percent divided by 40 percent is 65 percent).

Table B - 5. Future BMP load reductions

Pollutant	*Agricultural Lands* load reduction goal	Future BMP load reduction if all the objectives were fully implemented
Spring TP	12,000	7,800
Spring SRP	2,500	1,700
Annual TP	32,000	21,000

Note: Loads are in pounds and are rounded to two significant digits.

APPENDIX C. AGRICULTURAL PHOSPHORUS LOAD REDUCTION

For this NPS-IS plan, agricultural BMP phosphorus load reduction effectiveness was estimated using information provided by Mercer SWCD, studies identified by the Ohio State University Extension's *AgBMP* system (https://agbmps.osu.edu/home), and pertinent literature.

GRASSED WATERWAYS

Grassed waterways were assumed to reduce phosphorus loads by 30 percent. Limited research is published for the phosphorus removal efficiencies with grassed waterways in the Midwest.

- In a review of published studies of residential and highway grassed swales, Schueler et al. (1992) found that the expected TP removal efficiency of well-designed and well-maintained grassed swales 30 percent.
- In a review of published studies, Dosskey (2001) identified several studies that showed grassed waterways reduce gully erosion, runoff, and sediment loads. Pollutants attached to sediment were also reduced because sediment-loading was reduced.
- In a five-year study of paired agricultural watersheds with and without grassed waterways[28], Fiener and Auerswald (2009) found that grassed waterways do not appreciable reduce dissolved reactive phosphorus levels. Dissolved pollutant loads only decreased due to the reduction of runoff.

NUTRIENT MANAGEMENT PLANNING

Nutrient management planning was assumed to reduce phosphorus loading by 35 percent. There is a wide range in the reported effectiveness of nutrient management planning to remove phosphorus. Effectiveness depends on the specific practices recommended in the nutrient management planning (Heartland Regional Water Coordination Initiative 2013):

- *Soil sampling and testing*: 0% to 25% reduction in SRP and TP.
- *Test livestock waste for nutrient value*: 0% to 30% reduction in SRP and TP (when manure is land-applied)
- *Optimization of crop rotation*: 25% reduction in SRP and TP.
- *Subsurface application of fertilizer*: 60% to 70% reduction in SRP and 20% to 50% reduction in TP.
- *Pre-plant incorporation of phosphorus fertilizer in the top 2-inches of soil before the first runoff event*: 60% to 70% reduction in SRP and 20% reduction in TP.

NUTRIENT REMOVAL WETLANDS

Nutrient removal wetlands were assumed to reduce phosphorus loads by 50 percent based upon Mercer SWCD monitoring results from nutrient removal wetlands installed in Mercer County. Phosphorus load reduction ranged from 40 to 80 percent, depending upon the time of the year, in Mercer County wetlands.

The 50 percent reduction is consistent with several studies.

[28] The paired watersheds are part of the Scheyern Experimental Farm north of Munich Germany. The crop rotations were of potatoes, winter wheat, and maize; mustard was planted as a cover crop. No mineral phosphorus fertilizer was applied.

- Kovaic et al. (2000) report that TP removal from constructed wetlands was 2% and SRP was 22% over a three year period.
- Case studies in Maryland, Illinois, and Iowa indicate wetlands can remove 68% of nitrate-nitrogen and 43% of phosphorus can be retained from drainage water (Woltermade 2000).
- Wetlands plants are removing 61 percent of the TP and 32 percent of the SRP in mesocosms established near Defiance, Ohio (*Toledo Blade*; Henry 2019).
- A wetland was designed and installed in southeast Minnesota to treat subsurface drainage from farmland. Over a three year period, the wetland reduced nitrate-nitrogen loads by 68% and SRP loads by 76% (Lenhart et al. 2016).

SATURATED BUFFERS

Saturated buffers were assumed to not reduce phosphorus loads by appreciable amounts. In a study of total dissolved phosphorus removal in saturated buffers treating tile drainage from 10 fields in Illinois, Indiana, Iowa, and Minnesota, researchers found no consistent trend with total dissolved phosphorus removal and that nine of the ten saturated buffers were not effective sinks of phosphorus (Utt, Jaynes, and Albertsen 2015).

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