Environmental
Protection
Agency

Preliminary Modeling Results for the East Fork Little Miami River Watershed

Total Maximum Daily Load Development

Ohio EPA Technical Report AMS/2012-EFLMR-4

Division of Surface Water
Assessment and Modeling Section
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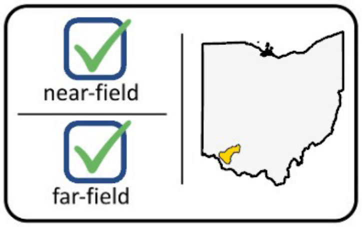

TMDL DEVELOPMENT | ●●●●○

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Executive summary

The Clean Water Act and U.S. Environmental Protection Agency (U.S. EPA) regulations require that states develop total maximum daily loads (TMDLs) for waters that the states list as impaired on their section 303(d) lists. A TMDL is a water quality restoration planning process that involves several steps, including target identification, source assessment, allocation of loads, and development of an implementation plan. The preliminary modeling results (PMR) document provides the analytical methods to develop a TMDL for the East Fork Little Miami River (LMR). This is the fourth step in the TMDL development process. This project outlines pollutant reductions needed to address most aquatic life use and public water supply use impairments in the watershed.

This report includes the methods and preliminary results for TMDLs that outline nutrient reductions for 17 small watershed assessment units. Nutrient TMDLs address 1) aquatic life use impairments of several stream due to organic enrichment and eutrophication and 2) the public drinking water supply use impairment of Harsha Lake due to harmful algae blooms. The same total phosphorus and total nitrogen targets are used for both the aquatic life use and public drinking water use impairments. Nutrient source assessment and calculations for nutrient reductions that meet TMDL targets are made using the Soil and Water Assessment Tool model. Nonpoint source nutrient allocations are proposed to address most of the needed pollution reduction. Modest nutrient reduction allocations for six small, permitted wastewater treatment plants are also outlined.

A TMDL for atrazine is also presented in this report. This TMDL address the City of Blanchester’s public drinking water supply use impairment due to atrazine. The report includes a source assessment of this pollutant. A statistical method is used to calculate this TMDL and a maximum daily concentration limit.

The preliminary implementation plan provides a framework for how Ohio EPA is proposing to implement wasteload allocations and achieve nonpoint source reductions. The implementation plan highlights the vast amount of work that has already been invested into the watershed and recommends areas to continue working. Recommendations including continually updating current NPS-ISs with new projects and the development of three new NPS-ISs. For developing and implementing this TMDL, an adaptive management approach will be used, allowing for new science to be incorporated as time progresses.

1. Background

In December 2013, U.S. EPA announced a vision for the Clean Water Act (CWA) Section 303(d) program to provide an updated framework for implementing responsibilities under the impaired waters program. U.S. EPA recognized that "...there is not a one-size-fits-all approach to restoring and protecting water resources." Under this vision, states can develop tailored strategies to implement the 303(d) program in the context of their water quality goals.

Ohio EPA selected the East Fork Little Miami River (LMR) watershed as a pilot project for implementing the new approach. This is due to the watershed's unique circumstances of overlapping aquatic life and public water supply use causes of impairment. These conditions provide the opportunity to integrate these uses into an alternative total maximum daily loads (TMDL) framework that offers improved remediation and protection outcomes to existing methods. This alternative approach also provides direct engagement with the priorities of the well-established East Fork Watershed Cooperative (EFWCoop) stakeholder group**.**

The preliminary modeling results (PMR) document provides the analytical methods to develop TMDLs for the East Fork LMR. This is the fourth step in the TMDL development process. This project addresses most aquatic life use and public water supply use impairments in the watershed. Figure 1 shows the impaired aquatic life use assessment units this TMDL project addresses. Public drinking water supply use impairments addressed in this watershed are at Harsha Lake due to algal toxin thresholds and at the three water sources for the city of Blanchester due to atrazine.

The report, 'Loading Analysis Plan and Supporting Data Acquisition Needed for the East Fork Little Miami River Basin'[1] (Ohio EPA, 2021), provides an overview of the information considered in proposing the strategy to address water quality impairments in this project. This loading analysis plan (LAP) also explains the water quality targets employed for this TMDL project. Since the water quality modeling for this project was previously developed by the U.S. EPA's Office of Research and Development (ORD), the LAP contains some modeling calibration and validation information. That modeling information is included in this PMR; however, the other components in the LAP noted above are not duplicated here. The next step of Ohio's TMDL process after this PMR is the draft TMDL report. That report will combine the needed elements for a complete TMDL from the LAP, this PMR, and additional information.

Due to non-attainment within the watershed, a study is being carried out to develop TMDLs as required by the CWA and the U.S. EPA's Water Quality Planning and Management Regulation. The complete TMDL report will define in-stream conditions, sources, pollutant targets, and needed reductions and recommend implementation strategies.

Table 1 lists the assessment units within the basin, showing causes of impairment and the actions taken to address those impairments by this TMDL project. Nutrient TMDLs for the total phosphorus (TP) and total nitrogen (TN) parameters apply to entire HUC-12s except where footnoted in Table 1.

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[1] epa.ohio.gov/static/Portals/35/tmdl/LAPs/Little%20Miami/EFLMR_LAP.pdf

The public drinking water supply use impairment due to algal toxin thresholds in Harsha Lake is only listed for one HUC-12 assessment (05090202 12 03) on Ohio's 303(d) list (Ohio EPA, 2022). However, the nutrients causing this impairment are delivered from a much larger watershed that contributes to this lake. Because of this, Table 1 lists 12 HUC-12s where TMDLs are developed to address this impairment. This approach can be considered analogous to the one Ohio EPA took with the "far-field" TMDL concept via the Maumee Watershed Nutrient TMDL in 2022.

The atrazine TMDLs only apply to the sub-watersheds draining to the city of Blanchester's drinking water sources within the HUC-12s noted in Table 1.

Figure 2 shows the HUC-12 assessment units with TMDLs developed for aquatic life use impairments in this project. Figure 3 shows the assessment units with TMDLs addressing the algal toxin threshold-based public drinking water use impairment at Harsha Lake. Note that most TMDLs are developed for complete HUC-12s, but some partial HUC-12s are also included in both figures. This is further explained in this project's LAP (Ohio EPA, 2021). A map detailing the atrazine TMDL watersheds is presented in section 2.2 of this report.

Some beneficial use impairments found in the 2012 assessment of the East Fork LMR are not addressed by this TMDL project. The project's LAP (Ohio EPA, 2021) explains that watershed assessment units (WAU) and recreation use impairments based on the *E. coli* indicator organism are included in Ohio EPA's Multi-Watershed Bacteria TMDL project. Habitat alterations that cause aquatic life use impairments are not addressed via a TMDL since the cause of impairment is not a pollutant. Instead, Ohio EPA is developing a multi-watershed statewide restoration plan to address this issue. More information about these statewide projects can be found on Ohio EPA's Multi-Watershed TMDL Projects webpage (see: ***epa.ohio.gov/divisions-and-offices/surface-water/reports-data/multi-watershed-tmdl-projects***).

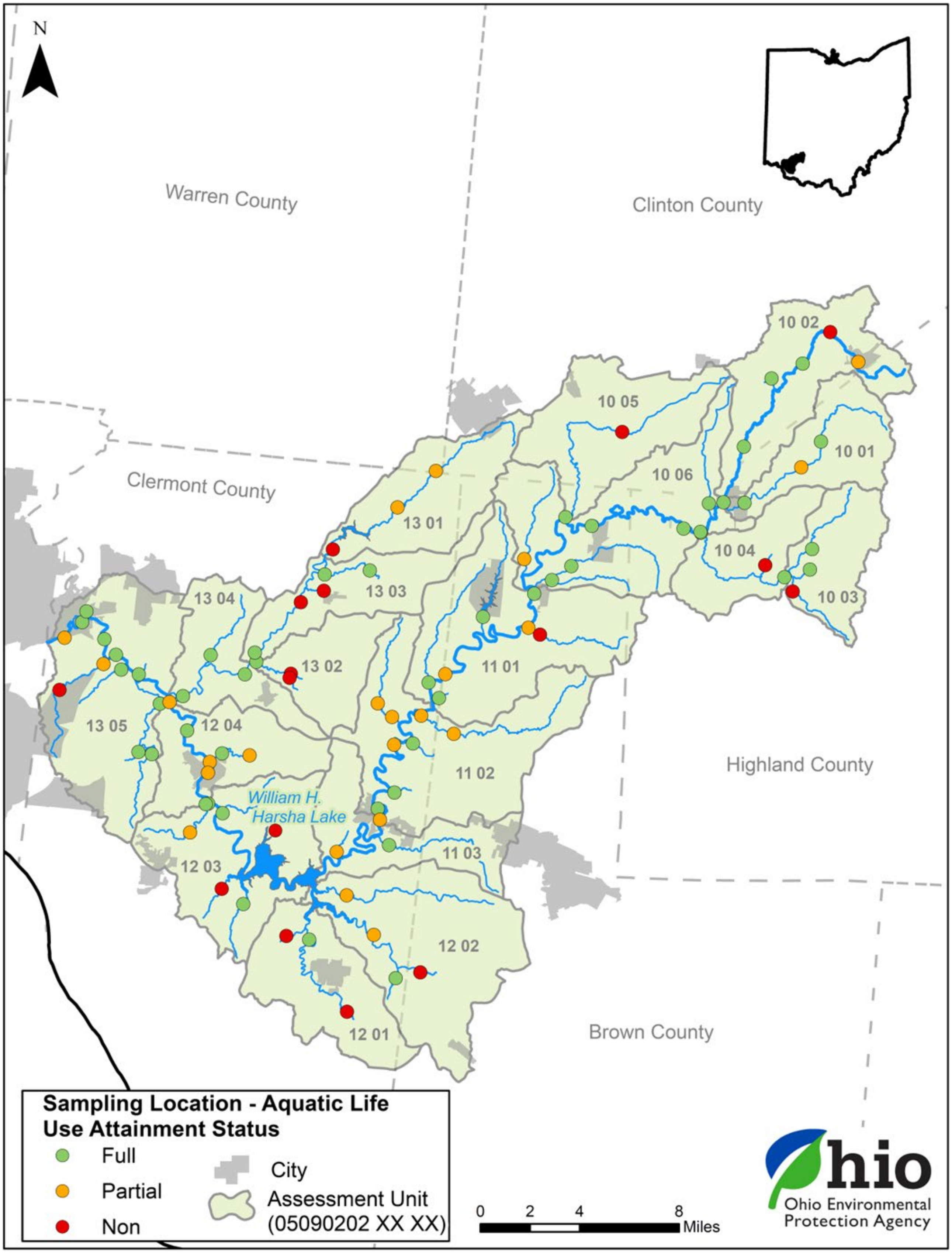

Figure 1. Map summarizing aquatic life use attainment status in the East Fork Little Miami River watershed in 2012.

Table 1. Summary of impairments in the East Fork Little Miami River watershed and the methods used to address impairments.

Assessment Unit (HUC8)	Narrative Description	Causes of Impairment (Beneficial use in parentheses[1])	Action Taken
Little Miami HUC 8 (05090202)			
07 02[2]	Second Creek	Atrazine (PDWSU)	Atrazine TMDL
10 01	Turtle Creek	Nutrient enrichment (ALU) Algae (PDWSU)	Total Phosphorus (TP) and Total Nitrogen (TN) TMDL
10 02	Headwaters East Fork Little Miami River	Organic enrichment (ALU) Algae (PDWSU)	TP and TN TMDL
10 03	Headwaters Dodson Creek	Organic enrichment (ALU) Algae (PDWSU)	TP and TN TMDL
10 04	Anthony Run-Dodson Creek	Organic enrichment (ALU) Algae (PDWSU)	TP and TN TMDL
10 05	West Fork East Fork Little Miami River	Algae (PDWSU)	TP and TN TMDL
		Atrazine (PDWSU)	Atrazine TMDL
10 06	Glady Creek-East Fork Little Miami River	Organic enrichment (ALU) Algae (PDWSU)	TP and TN TMDL
11 01	Solomon Run-East Fork Little Miami River	Low dissolved oxygen (ALU) Algae (PDWSU)	TP and TN TMDL
11 02	Fivemile Creek-East Fork Little Miami River	Organic enrichment (ALU) Algae (PDWSU)	TP and TN TMDL
11 03	Todd Run-East Fork LMR	Nutrient enrichment (ALU) Algae (PDWSU)	TP and TN TMDL
12 01	Poplar Creek	Low dissolved oxygen (ALU) Algae (PDWSU)	TP and TN TMDL
12 02	Cloverlick Creek	Low dissolved oxygen (ALU) Algae (PDWSU)	TP and TN TMDL
12 03[3]	Lucy Run-East Fork LMR	Algae (PDWSU)	TP and TN TMDL
12 04[4]	Backbone Creek-East Fork LMR	Low dissolved oxygen (ALU)	TP and TN TMDL
13 01	Headwaters Stonelick Creek	Organic enrichment (ALU)	TP and TN TMDL
		Atrazine (PDWSU)	Atrazine TMDL
13 02	Brushy Fork	Low dissolved oxygen (ALU)	TP and TN TMDL
13 03	Moores Fork-Stonelick Creek	Organic enrichment and low dissolved oxygen (ALU)	TP and TN TMDL
13 05[5]	Salt Run-East Fork LMR	Low dissolved oxygen (ALU)	TP and TN TMDL

[1] ALU = aquatic life use

[2] This HUC-12 is not in the East Fork Little Miami River watershed. Instead, it drains to the Little Miami River via Todd Fork. This project includes this assessment unit to address the three sources for the Village of Blanchester within the same effort.

[3] Only the portion of the HUC12 draining to Ulrey, Back, and Slabcamp runs for the nutrient TMDLs.

[4] Only the portion of the HUC12 draining to Backbone Creek.

[5] Only the portion of the HUC12 draining to Hull Run.

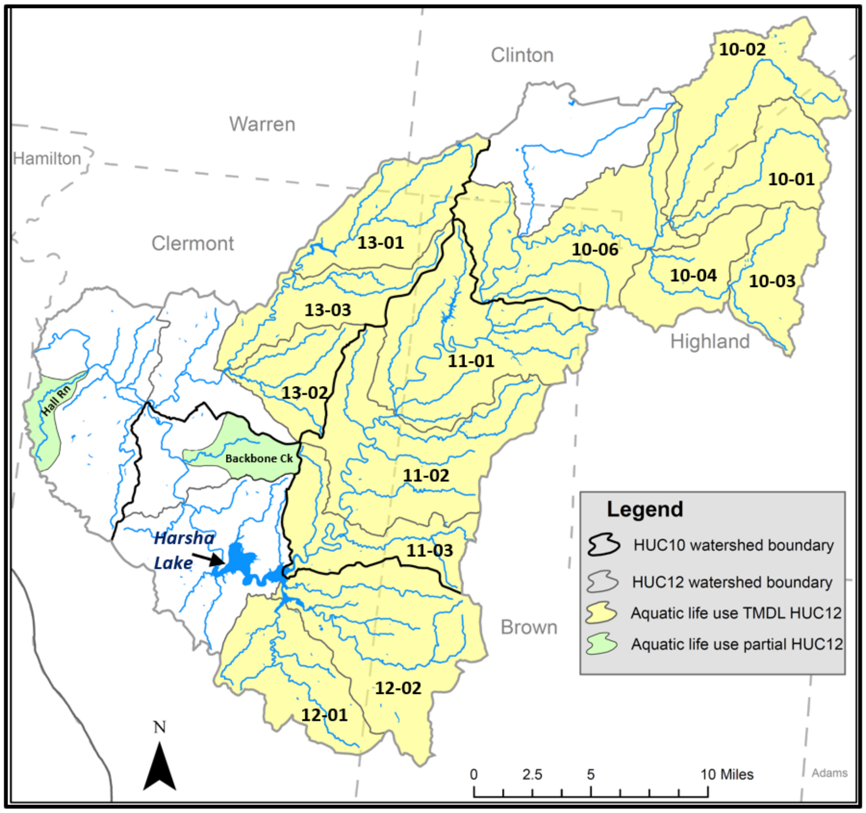

Figure 2. Map showing HUC-12 assessment units receiving TMDLs for aquatic life use impairments.

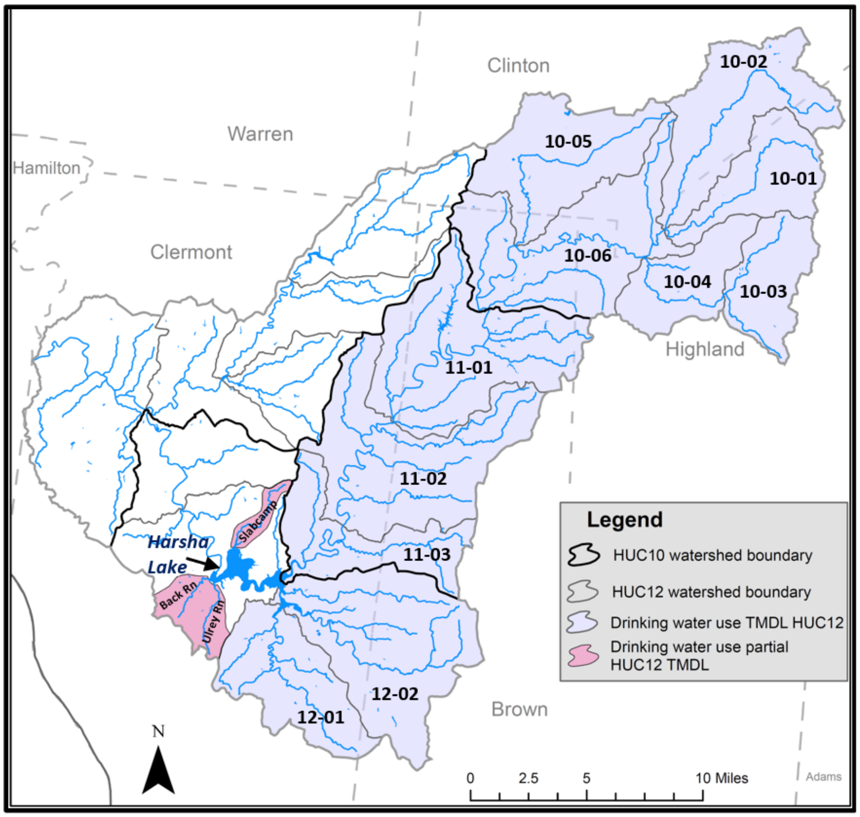

Figure 3. Map showing HUC-12 assessment units receiving TMDLs to address the impairment of Harsha Lake's public drinking water supply use due to algal toxin thresholds.

2. Pollutant discussion

Watershed characteristics relevant to the TMDLs being developed for the East Fork LMR watershed are documented in the 2014 biological and water quality report[2] (Ohio EPA, 2014). Linkages between water quality targets and pollutant sources used to develop these TMDLs are explained in the project's LAP (Ohio EPA, 2021). This section identifies the nature of the TMDL pollutant sources and their extent from point and nonpoint sources. This includes identifying the difference between the natural background of these pollutants and their anthropogenic-derived sources.

2.1. Total phosphorus and total nitrogen sources

The sources of total phosphorus (TP) and total nitrogen (TN) are primarily nonpoint sources in origin. However, in watersheds receiving nutrient TMDLs in this study area, a small amount of national pollutant discharge elimination system (NPDES) permitted sources of these nutrients exist. These are mainly municipal wastewater treatment plant discharges, but permitted stormwater and discharging household sewage treatment systems (HSTS) are also present.

2.1.1. Nonpoint sources of nutrients with no applicable permits

Unpermitted sources of nutrients entering streams result from various land management actions. The East Fork LMR watershed is dominated by row-crop agriculture, with soybean and corn as the primary crops. Other crops, such as alfalfa, hay, and vegetables, are present but less common. Low density development, small towns, villages, and country homes also exist throughout the watershed. Finally, some natural areas, predominantly forest stands, are present throughout the watershed. The following subsections discuss the various sources of unpermitted nonpoint sources of nutrients from these landscapes.

Agricultural fertilizer

Row crop agriculture requires specific concentrations of phosphorus and nitrogen in the soil to achieve expected crop yields. Phosphorus, nitrogen, and potassium fertilization is often needed to maintain adequate soil concentrations. Many agronomic factors are considered when determining fertilization farm management decisions, such as the type and amount of fertilizer used. Environmental factors come into play, dictating if nutrients used as fertilizer are exported off crop land to the stream network.

Two significant categories of row crop phosphorus fertilizer are commercial (sometimes called chemical or inorganic) and organic. Commercial phosphorus fertilizers are typically made by converting mineral rock phosphate to phosphoric acid and undergoing further chemical refinement. The resulting types of commercial fertilizers have varying concentrations of phosphate (the biologically available form of phosphorus) for crop uptake. Nitrogen is applied as a fertilizer in various forms. Several agronomic considerations go into what form and application style is used (Purdue, 1986). In the soil, nitrogen fertilizer is either applied in a nitrate form or undergoes biochemical reactions, becoming nitrate. While nitrate is the most available form of nitrogen for crop uptake, its chemical properties allow it to leach out of soils with water drainage readily. Soybeans are legumes that fix atmospheric nitrogen and, therefore, require very little

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[2] epa.ohio.gov/static/Portals/35/documents/East_Fork_LMR_TSD_2014.pdf

or no nitrogen fertilizer. Even so, most phosphorus fertilizer formulas for soybean contain some ammoniacal nitrogen.

Organic fertilizers consist of manure, composts, and biosolids. Concentrated livestock production is not present in this watershed, and therefore, organic fertilizers are minimally used.

The rate of fertilizer applied to fields in the East Fork LMR watershed is generally determined by the Tri-State Recommendations (Culman et al., 2020). Figure 4 shows the conceptual framework for phosphorus fertilizer recommendations. These recommendations were updated in 2020 and no longer call for any phosphorus applications above certain soil phosphorus concentrations; the “drawdown” application has been removed.

Determining nitrogen fertilizer application rates present many challenges. The recently updated Tri-State Fertilizer Recommendations (Culman et al., 2020) note that many crops require a large amount of nitrogen for successful yields; however, there are many pathways for nitrogen loss to the environment. Nitrogen fertilizer is also a significant cost for crop production. The fertilizer recommendations present varying nitrogen application rates based on the current cost of fertilizer compared to crop commodity prices.

The application timing for both manure and commercial fertilizer depends on cropping system and field conditions. Precipitation or poor drainage can result in soil moisture levels that prevent the farmer from operating equipment in the field. Proper timing of fertilizer application is also important to minimize risk of loss due to runoff or erosion.

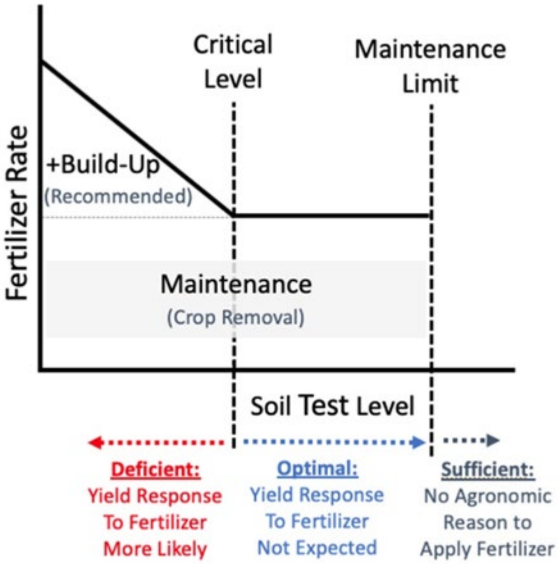

Figure 4. Figure shows the conceptual framework for fertilizer applications (Culman et al. 2020.)

Commercial and manure fertilizers enter stream networks and contribute to nutrient pollution. This is generally due to precipitation. These nutrient losses are typically consistent with the definition of agricultural stormwater and thus exempt from CWA regulation. A robust metanalysis of research studies with authors from United States Department of Agriculture Agricultural Research Service (USDA-ARS) found that generally less than 2% of applied phosphorus is lost from fields (Christianson et al., 2016). A similar study found nitrogen losses between 15% and 20% of what is applied each year (Christianson and Harmel, 2015). These environmental consequences impact agricultural producers economically. It is, therefore, beneficial for all interested parties to mitigate nutrient loss. Agricultural producers aim to minimize these costs while maintaining agronomic yield expectations. Many additional agricultural best management practices (BMPs) exist to address the risk of fertilizer pollution. These are outlined in the implementation framework of this report.

Like all nonpoint source pollutants, fertilizer nutrient loss from fields is driven by water movement. Large, infrequent precipitation has been shown to drive most of the phosphorus exports to streams. Baker et al. (2014) calculated 76% and 86% of the dissolved reactive phosphorus (DRP) and particulate phosphorus, respectively, is exported at high stream flows (i.e., during the 20% of the time with the highest flows) in northwestern Ohio's Maumee River. These high precipitation, high stream flow events can overwhelm measures taken to avoid fertilizer phosphorus loss, making them less effective. Nutrients from fertilizer are washed off fields and delivered to streams via runoff and subsurface tile drainage. Phosphorus can be attached to soil or other particles in the particulate form or in the dissolved form, most often monitored as DRP (Christianson et al., 2016). Phosphorus stored in naturally occurring soils and/or from prior crop fertilization is usually referred to as soil phosphorus or legacy phosphorus, respectively.

Most East Fork LMR watershed soils have high clay content, resulting in very low hydraulic connectivity and vertical soil permeability. Because of this, tile drainage is less effective and therefore tiling is much less common in this watershed than other Ohio agriculture regions. East Fork LMR soils are prone to fragipans and gully erosion, which exacerbate phosphorus runoff.

Soil sources

Various land uses, particularly cropland tillage and land clearing for development, accelerate soil erosion. It is undesirable for cropland to have excessive soil losses. There are also several environmental impacts when soil enters stream networks. Physically, some soil becomes sediment that smothers stream habitat and fills pool areas. Some of it becomes suspended solids in the water column, which makes the water murky-looking and more difficult for some organisms to function. Chemically, phosphorus is attached to the soil particles and can become suspended in the water column as particulate phosphorus or be separated in the stream in the dissolved form.

Over many decades, agricultural soil conservation tillage efforts and construction stormwater standards have significantly reduced soil erosion and sediment delivered to streams. Agricultural tillage is performed to control weeds, prepare a seedbed, manage crop residue, and increase fertility (by providing a short-term stimulus to soil microbial activity). Tillage can increase the risk of erosion by breaking apart soil structure and reducing crop residue. "Conventional tillage" is soil inversion, typically with a moldboard plow, in the fall, winter, or spring, followed by a disc, plow, or field cultivator. "Minimum tillage" replaces the moldboard plowing with chisel plowing, discing, or field cultivating. With "No-till," weed control is accomplished with herbicides, and the soil is not tilled. "Conservation tillage" is an umbrella term for both minimum and no-till.

While soil conservation has reduced the amount of nutrients, primarily phosphorus, being exported to waterways, there has been an increased realization of another source of phosphorus loss. Sharpley et al. (2013) describe legacy phosphorus as accumulated in soils because of prior nutrient applications and land management. This paper explains that water energy can mobilize particulate phosphorus in episodic events, delivering them to various accumulation points in a watershed. These points can occur on fields, at stream edges, in stream channels, and to the downstream collection point, such as Harsha Lake. Mobilization of dissolved phosphorus occurs due to biochemical processes from these accumulations.

Non-agricultural stormwater with no applicable permits

Non-agricultural stormwater sources of nutrients exported to the East Fork LMR watershed also contribute to nutrient loading. No matter the point of origin, non-agricultural stormwater pollution is spread out, and precipitation/runoff drives its delivery. While the mechanisms delivering nutrients from non-agricultural stormwater in permitted and non-permitted areas are the same, TMDLs require that non-agricultural stormwater be bifurcated based on whether the stormwater's source area is regulated under the CWA. The stormwater discharges from areas within regulated municipal separate storm sewer systems (MS4s) and from NPDES permitted stormwater facilities and construction sites are considered a point source and receive a wasteload allocation in TMDLs. The remaining stormwater loads are considered nonpoint sources and are included in the TMDL's load allocation.

Non-agricultural stormwater contributing to the nonpoint load is much more scattered than stormwater from permitted areas. Small communities, country homesteads, and roads dominate these areas.

Stormwater from regulated MS4s and other NPDES permitted facilities is regulated because of the impervious area, artificial drainage systems, total population, and/or density of developed areas. This results in permitted stormwater being more efficient at pollutant delivery to receiving waters than unpermitted stormwater. These factors also allow for more effectively implementing pollutant reduction activities with permitted non-agricultural stormwater.

Household sewage treatment systems with no applicable permits

Like non-agricultural stormwater, nutrients sourced from HSTS can be considered point or nonpoint in TMDL accounting. Systems designed to have a regular discharge, mainly those using aerators, are permitted by Ohio EPA and considered a point source. Conversely, onsite HSTSs are designed not to discharge treated waste. In these systems, the leachate from septic tanks is treated onsite via soil adsorption in leech fields. When these systems are underperforming or failing, nutrients can be discharged to waterways and are considered a nonpoint source.

Natural sources

Natural sources of nutrients are known to contribute some load in most river systems. Weathering of soil and parent rock is described as the primary natural source of phosphorus (Holtan et al., 1988). The decomposition of aquatic life and washed-off upland vegetation (such as leaf litter) can also be categorized as a natural source of nutrients (Wither and Jarvie, 2008). Forest land represent the largest portion of the area in the East Fork LMR watershed, contributing to natural sources of nutrients. About 29% of the total area receiving nutrient TMDLs is categorized as being forested.

Atmospheric deposition of nitrogen is considered a natural source in this document. However, fossil fuel combustion emissions and other human activities have significantly increased the amount of nitrogen deposition (Galloway et al., 2004). Nitrogen deposition compounds occur in various forms, such as inorganic reduced ammonia/ammonium, oxidized nitrate/nitrite, and organic (Paerl, 2022). Unlike carbon and nitrogen, there is no stable gaseous phase of phosphorus in the Earth's atmosphere. The dominant source of atmospheric deposition of phosphorus globally is mineral aerosols. In general, this is soil phosphorus mobilized by winds, often characterized as dust. In non-desert, industrialized areas, biogenic aerosols and combustion deposits are the primary sources (Mahowald et al., 2008).

Modeled sources of nutrients

The soil and water assessment tool (SWAT) modeling carried out for this TMDL is described in Section 3 of this report. This modeling is used to estimate the existing contribution of TP and TN to the watershed. Figure 5 shows the average proportion of source contributions for TP and TN for most of the watershed draining to Harsha Lake at the 11 03 HUC 12 outlet. The figure caption explains the various sources' abbreviations. These are based on calibrated modeling results from 2000 through the end of 2018. Monthly totals summarize loadings for each source, and the pie charts in this figure are based on a straight average of these totals.

The modeling work finds that over 95% of the TP and TN delivered to Harsha Lake are from land uses representing unregulated, nonpoint sources. Lands with row crops, soybean, and corn contribute most of each nutrient. Soybean production contributes 58% of the TP and TN exported to Harsha Lake. Corn production contributes around 18% of both nutrients. The dominance of soybean field contribution compared to corn reflects that much more land is planted in soybeans rather than corn.

The model shows hay pastures contribute 11% of the TP and 3% of the TN delivered to Harsha Lake. Nutrients from non-agricultural stormwater are presented in the Bermuda grasses model results. This land use is responsible for less than 6% of TP and 8% of the TN. Forest land contributes less than 2% of the TP and 3% of the TN. Wetlands are modeled to contribute a negligible amount of nutrients. Atmospheric deposition of TP is not generally included in watershed modeling. Model results show that atmospheric deposition is responsible for less than 3% of the TN delivered to Harsha Lake.

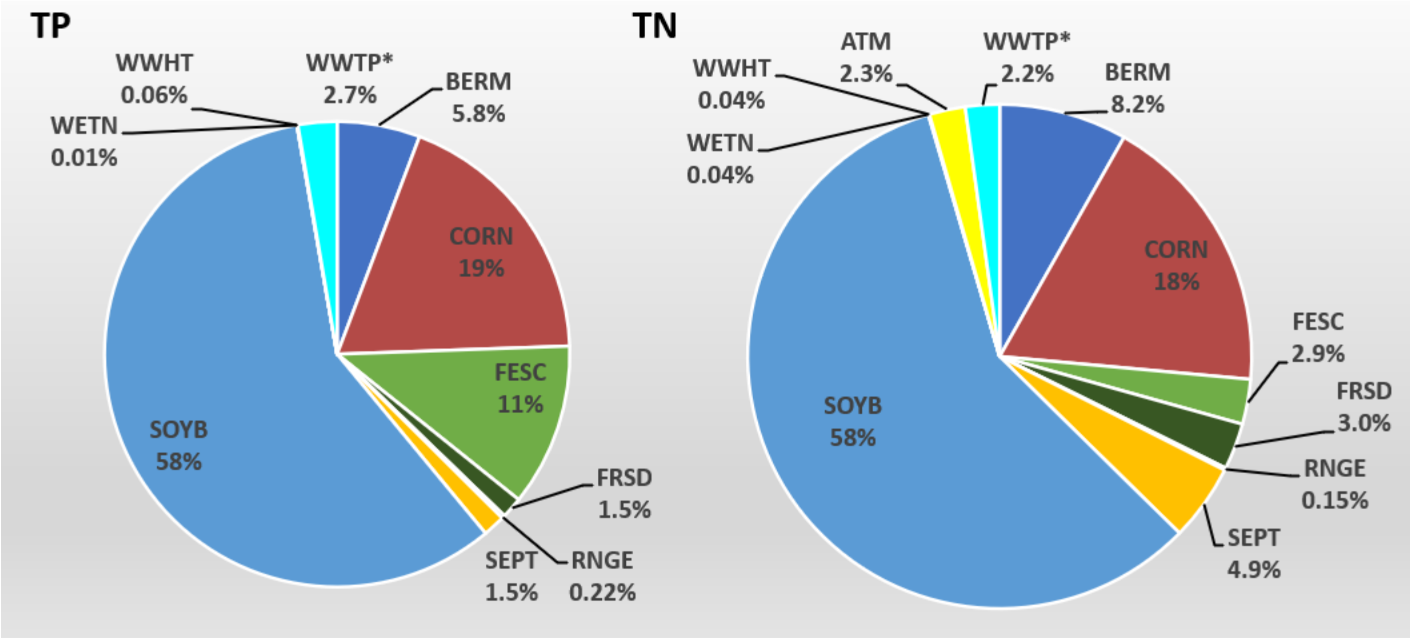

*Figure 5. Model results showing the average existing conditions relative sources of total phosphorus (left) and total nitrogen (right) of the portion of the East Fork Little Miami River watershed draining to Harsha Lake at the outlet the 11 03 HUC 12. BERM is Bermuda grasses, CORN is corn row crops, FESC is fescue grasses representing haying pasture, FRSD is forest land, RNGE is range land, SEPT is household sewage treatment plants, SOYB is soybean row crop, WATR is open water, WETN is wetlands, WWHT is winter wheat, and WWTP is wastewater treatment plants. * The WWTP loads in this simulation are set at the plants' design flow, which is greater than actual discharges.*

2.1.2. Permitted point sources

Ohio EPA regulates several permitted sources of nutrients via Ohio rules and by the NPDES framework. In TMDL budgeting, these sources fall within the wasteload allocations. Municipal NPDES wastewater treatment plants contribute the most significant proportion of phosphorus in this category. Permitted stormwater from urbanized areas and other permitted sources also discharge a very small amount of nutrients. Table 2 shows a breakdown of the various categories of permitted sources of phosphorus.

There are no permitted communities with combined sewer overflows, and there are no confined animal feeding operations in this watershed.

Ohio EPA issues several general permits that cover activities resulting in non-stormwater-related discharges of wastewater. Unlike individual NPDES permits, these permits cover a type of activity rather than a specific facility. Specific facilities that conduct certain activities apply for coverage under the general permit. Therefore, many facilities are covered under each general permit, some in the thousands. The treatment technologies for these sources are consistent, and eligibility criteria and/or appropriate limits within the general permit ensure individual evaluations are not needed to ensure water quality standards are met. Note that these facilities almost always contribute less pollutants than the minor public individual permits outlined above. General permits are divided into those considered to discharge wastes with nutrient concentrations greater than the background and those at or below background concentrations. The general permits that include nutrient-containing discharges cover discharging household sewage treatment systems and small sanitary discharges (i.e., small package plants, such as restaurants or mobile home parks). The non-nutrient discharging general permits are not included in the wasteload allocations of this TMDL.

Table 2. Summary of types of NPDES permitted sources. Detailed categories that are shaded in gray are not included in the nutrient TMDL wasteload allocations.

Program	Permit Type	Major Category	Detailed Category
Treatment facilities: Point source pipe(s) directly contributing waste to surface waters.	**Individual NPDES Permit**: Facility-specific permits issued for each facility.	**Public**: Treats a majority of municipal/human waste. Most often delivered from public sewer systems.	“Major”: Plants that treat about 1 million gallons a day or more.
			“Minor”: Plants that treat less than 1 million gallons a day.
		Industrial: Facilities that treat waste from industrial processes.	Nutrient discharging: Mostly commercial plants with nutrients at concentrations that require treatment. e.g., food processing facilities
			Non-nutrient discharging: Discharging plants that do not treat nutrients at concentrations greater than background. e.g., most drinking water treatment plants.
	General: Permits that cover facilities with similar operations and wastewater characteristics.	Nutrient discharging	Discharging general permits considered to contribute nutrients at concentrations greater than background. These include household sewage treatment systems and small sanitary discharges.
		Non-nutrient discharging	The several discharging general permits are not considered to contribute nutrients at concentrations greater than background.
Stormwater	**Individual**: Stormwater permits for individual entities.	Facility based	Stormwater controls measures and pollution prevention provisions, very often included within individual treatment facility permits.
		Municipal based	Phase I Individual MS4 permits.
	General: Permits that cover facilities or areas with similar operations.	Facility based	Construction and multi-sector industrial general stormwater permit (aka, MSGP).
		Municipal based	Phase II Small MS4 general permit.
Beneficial use	Beneficial use of materials – discharge of these materials is prohibited.	Biosolids	Field application of biosolids generated by publicly owned treatment works in Ohio.
		Land application	Wastewater treatment effluent irrigation.
			Industrial waste used for agronomic benefit.

Treatment plants

Facilities that discharge directly to streams or other waterways are considered first. These act as a traditional point source. Unlike permitted stormwater, which is primarily driven by precipitation, these sources are more directly driven by treatment plant influent flow rates associated with receiving municipal sewage or industrial wastewater flows. Municipal and some industrial wastes contain concentrations of nutrients that require additional management.

As seen in Table 2 above, treatment facility permits are first divided between individual and general permits. General permits are developed when the waste type and technology used to manage it are consistent, and permit conditions can cover many discharges.

Individually permitted treatment facilities that primarily process municipal waste are considered public permits by Ohio EPA. Municipal waste contains TP and TN due to nutrient inputs from human food consumption (Metson et al., 2012), detergents, and other activities.

Permitted wastewater treatment plants contribute about 1% of each nutrient for the existing conditions modeled in this watershed. There are no wastewater treatment plants with an average design flow at or greater than 1.0 million gallons a day (MGD) in the watersheds needing a TMDL in the EFLMR. One MGD is Ohio EPA's cutoff to designate significant wastewater treatment plants. There are major wastewater treatment plants that discharge to the East Fork LMR downstream of Harsha Lake, where no impairments in beneficial use due to nutrients have been documented. Therefore, those facilities are not included in this nutrient TMDL project.

Table 3 lists all individual permitted discharging facilities in assessment units receiving nutrient TMDLs in this project. Note that no individual permitted discharging facilities exist in the following HUC-12 assessment units: 10 04, 10 05, 11 03, 12 01, 13 05 (Hall Run only).

Table 3. Permitted wastewater treatment plants discharging to impaired HUC 12 assessment units

Permit	Facility Name	Assessment Unit (HUC12)	Design flow (MGD)	Continuous nutrient discharge?
1IJ00050	Martin Marietta Materials Lynchburg Plant	10 01	NA	Stormwater only
1PA00005	New Vienna WWTP	10 02	0.085	Yes
1PZ00029	Snow Hill Country Club	10 02	0.0125	Yes
1PG00100	Rolling Acres WWTP	10 03	0.01	Yes
1PX00122	HighCo Inc.	10 03	0.0007	Yes
1PB00105	Lynchburg WWTP	10 06	0.5	Yes
1PD00024	Fayetteville Perry Twp WWTP	11 01	Controlled discharge	Yes
1PB00034	Williamsburg WWTP	11 02	0.9	Yes
1PX00059	Locust Ridge Healthcare LLC	12 02	0.01	Yes
1PV00034	Forest Creek MHP	12 03	0.04	Yes
1PX00096	Woodland Christian Camp	12 03	0.006	Yes
1PV00002	Holly Towne Mobile Home Park	12 03	0.035	Yes
1IV00150	Clermont Co WRD BMW WTP	12 03	Lagoon	Yes
1IN00289	Arch Materials LLC	12 04	NA	Stormwater only
1PP00020	Stonelick State Park Campgrounds WWTP	13 01	0.03	Yes
1PT00077	Clermont NE Local Schools WWTP	13 02	0.04	Yes
1PA00106	Newtonsville Area WWTP	13 03	0.057	Yes

Permitted stormwater

Stormwater discharges are generated by runoff from land and impervious areas such as paved streets, parking lots, and building rooftops during rainfall and snow events. Stormwater often contains pollutants in quantities that could adversely affect water quality. The primary method to control stormwater discharges is through BMPs. Many of the watershed's stormwater discharges are regulated, considered point sources, and require coverage by an NPDES permit. Table 2 outlines the individual and general NPDES permits authorizing stormwater discharges.

Industrial facilities must apply to be covered by Ohio's Multi-Sector General Permit (MSGP) if they have the potential to discharge stormwater to a surface water of the state and participate in one or more of the 29 industrial sectors outlined in the permit. Facilities in these categories that do not have industrial materials or activities exposed to stormwater may file a No Exposure Certification form to Ohio EPA instead of obtaining NPDES permit coverage and submitting an NPDES permit application. Facilities covered by the general permit must implement stormwater controls and develop a stormwater pollution prevention plan. There are three facilities with MSGP coverage in the watersheds receiving nutrient TMDLs in this project.

Many facilities with individual public or industrial treatment facility permits meet the multi-sector general stormwater permit requirements. In most cases, stormwater control measures outlined in the general permit are incorporated into the facility's individual permit for their treatment facility's discharge(s). This allows the facility to not have to apply for the general permit. Ohio EPA also has the discretion to require a facility to apply for an individual NPDES permit for stormwater controls. This often happens for facilities with a history of known stormwater control issues. Stormwater controls outlined in an individual facility NPDES permit are like the multi-sector general permit; however, additional regulatory scrutiny occurs at individually permitted facilities. There are two individually permitted facilities with stormwater provisions draining to watersheds receiving nutrient TMDLs in this project. They are listed in Table 3 as contributing stormwater only. Neither of these permits, however, are considered to have a regular discharge of nutrients, i.e., they are not also "discharging" facilities.

Ohio EPA also maintains a general permit to limit stormwater impacts from construction sites. Projects that disturb one or more acres must apply for this general permit. Projects that disturb less than one acre but are part of a larger development plan or sale also need to be permitted to discharge stormwater. Conditions of the construction general permit require BMPs to control sediment export during soil disturbances and implement non-sediment pollutant controls for other construction-related activities (e.g., fuel storage, concrete rinse, fertilizer storage/application). Post construction practices that provide extended water detention and enhanced infiltration are intended to reduce and slow water, and pollutants movement out of the developed area. As of spring 2023, 33 active construction sites with general permit coverage in the watersheds received nutrient TMDLs in this project.

U.S. and Ohio EPA's stormwater programs address municipal-based stormwater runoff in two phases. Phase I of the stormwater regulations requires NPDES permits for discharges from MS4s serving large and medium municipalities. The size of the population the MS4 serves dictates whether it is considered a large or medium municipality. These Phase I MS4s are required to obtain an individual NPDES permit. There are no Phase I MS4 communities in this watershed.

The Phase II MS4 regulations address stormwater runoff of areas serving populations less than 100,000, termed small MS4s. More particularly, small MS4s located partially or entirely within urbanized areas, as determined by the U.S. Bureau of the Census, and on a case-by-case basis outside of urbanized areas that Ohio EPA designates into the program. Small MS4s are permitted in Ohio via a general permit. All MS4 permits require the development of a stormwater management program. These permits encourage green infrastructure BMPs such as bioretention areas, vegetated swales, and permeable pavements. Several MS4s authorized under Ohio EPA's NPDES Small MS4 general permit are situated in watersheds designated to receive nutrient TMDLs as part of this project. Among them is Clermont County and Others (Ohio EPA Facility Permit No. 1GQ10002*DG). However, only specific co-permittees within this group have MS4 areas that drain into watersheds subject to nutrient TMDLs. They are: Clermont County; Batavia, Monroe, Ohio, Pierce, Stonelick, Tate, Union, and Williamsburg townships; along with the villages of Owensville and Williamsburg. Wasteload allocations and any additional permitting requirements resulting from this TMDL solely pertain to these co-permittees.

The Ohio Department of Transportation (Ohio EPA Facility Permit No. 4GQ00000*DG), also known as ODOT, is another permittee authorized under the Small MS4 general permit. Nutrient TMDL wasteload allocations apply only to those ODOT-controlled roads and associated facilities (ex: garages, maintenance facilities, and rest areas) that are located within both ODOT's regulated MS4 boundaries and the nutrient TMDL watersheds. This includes segments of State Routes 32 and 276 within the nutrient TMDL watersheds.

Stormwater behaves like nonpoint source pollution in that it is driven by precipitation. In Ohio EPA's nutrient mass balance reports, all stormwater is grouped within the coarse nonpoint source category (Ohio EPA, 2020). However, TMDLs require that permitted stormwater be included within the point source wasteload allocation. Therefore, the land area covered by stormwater permits has been estimated for this project. Section 3.2.3 below outlines the details of this accounting.

Nutrients from stormwater in residential communities come from a variety of sources. A study of various residential communities in Florida found that DRP dominated the phosphorus runoff in more than 90% of storm events monitored (Yang and Torr, 2018). This was attributed to the decomposition of plant material such as leaf litter, grass clippings, and eroded soils when conditions were wet. After prolonged dry periods, more soil-bound particulate phosphorus was found to runoff in that work. Trees, especially when streetside, contributed most of the phosphorus and nitrogen load from residential areas in a St. Paul, Minnesota study (Janke et al., 2017). The United States Geological Survey (USGS) examined the impact of leaf litter and the delivery of phosphorus via streets in a study of urban areas in Wisconsin (Selbig et al., 2020). This work found that frequent municipal street cleaning/sweeping can reduce total phosphorus and DRP load export by up to two-thirds compared to controls without street cleaning.

A study (Hobbie et al., 2017) examining nutrient budgets, also in St. Paul's urban areas, found pet waste dominated the phosphorus inputs to the system. While this brings up a different residential source, the study found greater overall phosphorus export due to high street density facilitating the stormwater runoff.

Older research, such as a detailed study of residential areas in Madison, WI, in the 1990s, found lawns and streets to contribute most of the total phosphorus and DRP (Waschbusch et al., 1999). The actual role of lawn fertilizer is often discussed as an urban stormwater source. In collaboration with the Ohio Lake Erie Phosphorus Task Force, the Scotts Miracle-Gro Company removed phosphorus as a component of residential lawn maintenance fertilizers in Ohio by 2012. This follows a similar trend of not including phosphorus in lawn fertilizers across the country. An expert panel convened to look at urban stormwater for the Chesapeake Bay Partnership (Aveni et al., 2013) documenting various studies examining lawn fertilizer phosphorus bans. These studies found phosphorus concentration reductions in both total phosphorus and DRP by about a quarter compared to pre-phosphorus lawn fertilizer bans. However, lawn fertilizers have been found to still dominate nitrogen urban stormwater runoff (Hobbie et al., 2017).

Suburban residential areas are generally considered to contribute less pollutants to stormwater overall than from more intensive urban land uses based on a meta-analysis of urban stormwater studies (Simpson et al, 2022). That study found land use types predict stormwater quality better than the density of impervious surfaces. It also determined that dissolved nutrients, such as DRP, nitrate, and ammonia, are less associated with solids and other pollutants most often examined from stormwater sources.

Permitted household sewage treatment systems

Residential homes not serviced by a municipal sewage treatment system maintain individual HSTS. HSTS fall into one of two main treatment types:

Onsite (non-discharging) or leach field systems percolate septic tank effluent through the soil. Soil microbes treat the effluent and there is no point source discharge from these systems.

Discharging systems provide enhanced treatment by creating an aerobic environment where microorganisms digest organic carbon and nitrogen, and oxidize it to non-toxic inorganic forms (i.e., nitrates). Effluent is then discharged to surface waters. The overall TP and TN removal is minimal in discharging HSTSs.

Ohio Department of Health (ODH) rules for sewage treatment systems require that all new and existing systems are issued an operation permit with an identified maintenance schedule, and for discharging systems, a sampling schedule to ensure the system is meeting discharge standards. As of January 1, 2015, all new and modified discharging systems are required to be covered by Ohio's general NPDES permit (OHK000004).

Both non-discharging and discharging HSTS systems can fail to treat waste as designed. Soils receiving septic tank effluent from non-discharging systems can become overloaded, which can cause effluent to surface or short circuit. This short circuit reduces treatment and results in discharges to surface water. A common failure of discharging systems occurs due to malfunctions of the mechanical components. In these cases, waste is minimally treated and exported pollutants are elevated.

Upon identification of a failing system, local health departments establish specific action plans and timeframes for correction of the nuisance conditions. These plans may include repair, alteration, or replacement of the sewage treatment system or connection to public sewers, where available.

In the TMDL accounting, nutrient loads from HSTS can be considered nonpoint or point sources depending on if each HSTS is permitted. Failing onsite HSTS discharges are not covered by Ohio EPA's general permit. The load is accounted for as a nonpoint source in the TMDL's load allocation.

Permitted beneficial use - biosolids

Ohio EPA's biosolids program regulates the beneficial use of biosolids generated by publicly owned treatment works in Ohio (OAC 3745-40[3]). The goals of the biosolids program are to protect public health and the environment, encourage the beneficial reuse of biosolids and minimize the creation of nuisance odors. Beneficial use requires that biosolids are used for an agronomic benefit displacing other agricultural fertilizers discussed above.

Discharges from the storage and beneficial use of biosolids are prohibited and will not receive a wasteload allocation in this TMDL. Runoff from agricultural fields, where appropriate management actions are followed, is agricultural stormwater and is part of the load allocation. Statewide, biosolids are a small source of agricultural nutrients. There are only a few fields approved for beneficial use of biosolids in the watersheds

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[3] epa.ohio.gov/static/Portals/35/rules/40_all_dec18.pdf

receiving nutrient TMDLs in the East Fork LMR and these fields have not received biosolid applications in the last five years through the end of 2022.

Permitted beneficial use - land application

Ohio EPA issues state permits that allow facilities to beneficially reuse liquid industrial wastes or land apply treated wastewater. These systems must be designed so discharges to waters of the state do not occur. Industrial liquid wastes must provide an agronomic benefit while protecting human health and the environment and treated wastewater must meet effluent limits in accordance with OAC 3745-42-13[4]. These facilities are issued individual permits containing different conditions specific to the treated wastewater or liquid industrial waste.

In this project's nutrient TMDL watersheds, there is one facility authorized to land apply treated effluent, Fayetteville Perry Township. The NPDES permit for Fayetteville Perry Township WWTP, 1PD00024, allows the facility to discharge effluent to surface water and does utilize land application. The permit does not limit volumes discharged through the land application system. However, during the period between February 1, 2018, and January 31, 2023, the WWTP did not utilize their land application system.

Modeled sources of permitted nutrients

Permitted sources contribute an extremely small portion of nutrients to this watershed. Figure 5 shows the load from individually permitting discharging facilities contributes about 3% of the phosphorus and 2% of the nitrogen discharged to Harsha Lake. The proportion of this source contributing to the other nutrient TMDL watersheds, downstream of Harsha Lake, is even smaller.

Very little of the stormwater in this watershed is regulated by Ohio EPA's NPDES program. Section 3.2.3 explains the methods used to calculate the extent of regulated stormwater.

Modeling found all sources of HSTS collectively discharge 2% of the TP and 4% of the TN entering Harsha Lake.

2.2. Atrazine sources

The atrazine TMDL developed for this project directly addresses the public drinking water supply use impairments due to atrazine for the village of Blanchester.

Atrazine is an herbicide used to selectively control annual grasses and broadleaf weeds before they emerge. In Ohio, atrazine is primarily applied to corn crops in the spring. Since it is applied prior to, or just after, corn emergence, much of its application occurs around between May and early June. Atrazine typically moves off fields with drainage water, most commonly after the first rainfall post-application. Thus, the movement of atrazine is more like nitrate export compared to phosphorus loss. As atrazine runs off fields, it can contaminate surface waters becoming a threat to public drinking water sources (ORSANCO, 1998).

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[4] epa.ohio.gov/static/Portals/35/rules/42-13_mar17.pdf

The only known source of atrazine pollution in the East Fork LMR watershed is from its pesticide use on row crops. Because of this, all atrazine present in surface waters is from agricultural nonpoint sources. This compound does not exist in nature and therefore no background load of atrazine exists.

Atrazine impacts to Blanchester's source water

This project's atrazine TMDL addresses the public drinking water supply use impairment for the village of Blanchester. This village's public drinking water supply draws from water sources in three different WAU HUC 12s. Figure 6 shows the location of these water sources and the Blanchester designated source protection areas.

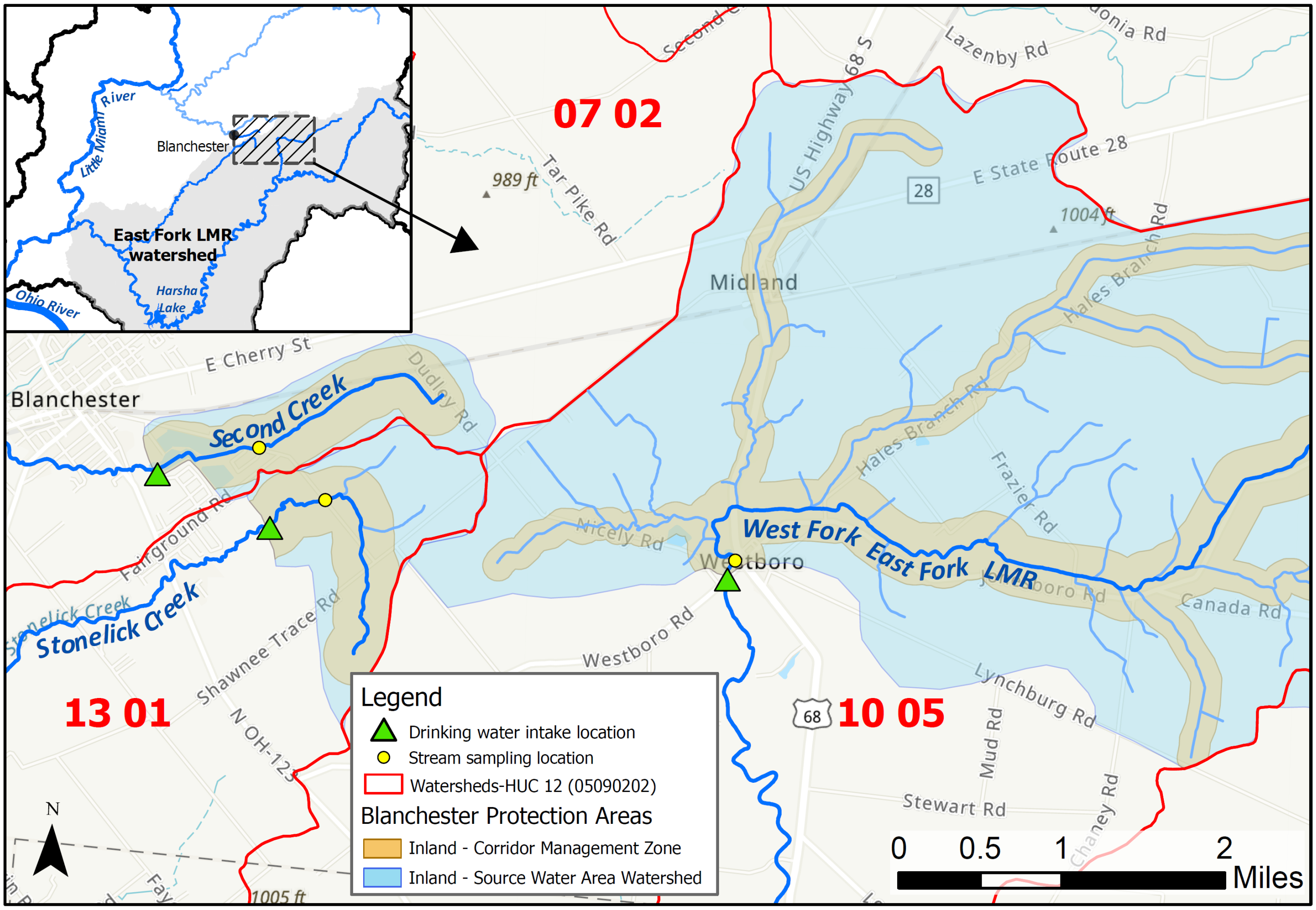

Figure 6. Map showing Blanchester drinking water sources and protection areas. HUC 12 watershed assessment units are delineated with red outlines and labels. This map does not show the reservoirs water that store water before treatment.

The village blends water from the three different sources to minimize the amount of atrazine in its raw intake water that it must treat. This blended raw intake water and finished water was regularly monitored for atrazine and its metabolites through the Atrazine Monitoring Program conducted by Syngenta and required by U.S. EPA from late 2003 through early 2020. Generally, a sample was collected every other week from

August through March. Weekly samples were mostly collected in the months of April through July. A total of 556 samples were collected during this time.

The results of the Syngenta Atrazine Monitoring Program's blended water samples are plotted on Figure 7. The water quality criteria for atrazine are 3 µg/L (based on a quarterly, 90-day average) and is included as a red horizontal line on Figure 7. This dataset's distribution is sharply right skewed with most values below the detection level, and highly leptokurtic due to occasional occurrences of high concentrations. The higher values are clustered together indicating that timing of excessive atrazine concentrations is important.

Given that elevated atrazine concentrations occur in temporal clusters and the fact that atrazine is assessed via a 90-day average, a 90-day critical condition analysis of the 16 years with complete sampling (2004-2019) was carried out. This assessment examined 10 fixed 90-day periods with the first one starting on February 1 and the last one starting on June 15. The number of years that exceed the community action level and the two largest 90-day average concentrations exceeding the 3.0 µg/L limit were determined. Table 4 presents the results of this analysis. This analysis determined that the 90-day period from April 15 to July 13 is the most important critical condition given this extensive dataset. This period is shaded for each year on Figure 7.

Note that all atrazine observations greater than 3.0 µg/L are included in the critical condition period starting on April 15 except for in 2008 and 2009. In those years elevated atrazine was observed starting in January. It seems likely that those observations were due to fall and/or winter application of the pesticide. Despite those several greater than 3.0 µg/L observations prior to the April 15 critical condition, additional elevated observations were made in those years' April 15-July 13 period that resulted in exceeding the 90-day community action level target. Winter elevated observations were not observed again after 2009. This will be further considered in the atrazine critical conditions, Section 3.3.4.

A notable aspect of the raw intake water dataset, evident in Figure 7, is that no elevated atrazine concentrations occurred after the spring of 2016 through the end of the monitoring period in January 2020. This observation may indicate that nonpoint source pollution reduction efforts have been successful in and/or the water systems has effectively avoided exceedances by blending and selective pumping from the three sources. The assessment units associated with Blanchester's drinking water sources are listed as impaired due to pesticides, as recently as the 2022 Integrated Report (Ohio EPA, 2022), and may need data from individual source intakes to demonstrate fully support of the use. This project's implementation efforts (Section 5.5.5) endeavors to better understand the reasons for these reductions. The final TMDL report will explain the process, including future monitoring and needed benchmarks, required to delist this impairment.

Limited atrazine monitoring in 2012 and 2013 occurred at the three separate water sources that serve Blanchester. The monitoring locations are shown with yellow symbols on Figure 6. Table 5 shows the results from this sampling. This monitoring confirms that elevated atrazine is present at all three water sources. Figure 8 plots these results in time and against a hydrograph of streamflow from the O'Bannon Creek near Loveland USGS gage (03244936). This gage is not in any of these watersheds but is the closest gage with continuous streamflow recorded. It is useful for understanding hydrologic conditions during the stream water sampling events.

The monitoring of the three stream sources was designed to occur when elevated atrazine concentrations may have been present in the streams. Sample collection targeted the spring season when atrazine farm application was most likely to occur. Sampling was also timed to occur during or just after precipitation events in the effort to capture atrazine runoff. Because of this, it is not unexpected that all the elevated observations coincided with the streamflow increases noted on Figure 8. However, several of the samples collected during these precipitation events did not find elevated atrazine results. This reinforces that the timing of atrazine field applications, in addition to precipitation events, is tightly linked to atrazine runoff as a pollutant in surface waters. This understanding should help with the TMDL's implementation recommendations.

Comparing the Syngenta Atrazine Monitoring Program's atrazine results against hydrologic events, such as streamflow, is less straightforward. This is because the Syngenta program sampled waters that were blended from these stream sources with the effort to minimize the amount of atrazine. Further, the water from all three of these sources is held in reservoirs of various sizes, and thus, for various amounts of time and dilution magnitudes. These factors disconnect the sample concentrations from the streamflow at the time of sampling.

These disconnecting factors can be observed by comparing the elevated stream samples during April 2012 and June 2013 (Table 5) to the Syngenta raw water samples in Figure 7. Note that two of the three stream sampling locations experienced large spikes in April 2012, but the Syngenta raw water samples did not see any spikes during this period. All three stream sources had very high spikes in June 2013 (values ranging from 37.3-71.2 µg/L at the one sampling event), yet the Syngenta raw water samples did not exceed 2.0 µg/L during this period. However, there was a slight increase in the June 2013 Syngenta samples.

The fact that an elevation of atrazine concentrations, however modest, in the Syngenta raw water samples did correspond to the June 2013 stream samples spike makes assessing the Syngenta raw water samples against hydrologic conditions a reasonable line of investigation. Figure 9 shows a concentration duration curve that plots the Syngenta raw water atrazine samples against the streamflow exceedance percentile on the day of the sampling. Again, streamflow from the O'Bannon Creek USGS gage is used to develop the hydrologic aspect of this analysis. Note that the O'Bannon Creek gage did not measure daily streamflow until October 2004; therefore, this flow duration curve analysis only uses atrazine data from October 2004 to January 2020. The diamonds filled in with orange indicate days when samples were collected, and the O'Bannon Creek gage streamflow contained 66% or greater runoff, according to the HYSEP baseflow separation algorithm (a hydrologic method for determining relative baseflow and runoff contributions). Concentrations in Figure 9 are plotted on a logarithmic scale due to the largely right skewed and censored nature of the dataset (i.e., a large majority of the results at, or near, the reporting limit). The community action level of 3.0 µg/L is shown as a red horizontal line on the figure.

Figure 9 does not show a noticeable trend of streamflow compared to concentration trends. Elevated atrazine results are evenly distributed across the various flow regimes. Additionally, raw water samples collected on days when the O'Bannon Creek gage was experiencing dominant runoff conditions, data represented by diamonds shaded in orange, are not more elevated than those collected on non-high runoff days. Figure 10 shows the same type of concentration duration curve analysis as Figure 9. However, it limits the atrazine observations to the 90-day critical condition window of April 15 through July 13 each year, 2005 through 2019. While the proportion of concentrations over three µg/L on Figure 10 is greater than the curve with all observations, the same lack of elevated values trending with streamflow is evident. These analyses confirm the factors discussed above regarding how blending of the water sources and dilution due to reservoir storage disconnects the timing of the raw drinking water from stream concentrations.

Notable in Figure 9 is the absence of values at the minimum reporting level (0.03 µg/L) during the lowest flows. In other words, atrazine was detected in all samples taken from the 81.1 exceedance percental and higher (to the right). All these low flow samples are from the period May 29 to November 22 (across all of the sampling years), with one exception. (The sample concentration from January 26, 2009, was very elevated at 8.83 µg/L and was from one of the two elevated concentration winters discussed above.) The timing of these results indicates that atrazine remains detectable for several months after higher spring stream flows have receded. Certainly, the storage and timing delay from the reservoirs contributes to this latent remaining detectable atrazine. This pattern of detectible atrazine present in all low flow samples reinforces the importance of the noted critical condition period of April 15 through July 13.

Overall, this source analysis confirms that critical conditions at this time of year and hydrologic events are important to atrazine pollution in Blanchester's sources of drinking water. Also, the nature of the blended source waters disconnects and dilutes the timing and magnitude of elevated atrazine concentrations. While the critical condition period is very important to target source reduction, atrazine concentrations year-round and throughout all flows must be included in this TMDL. This information is utilized for this TMDL development, as explained in Section 3.3.

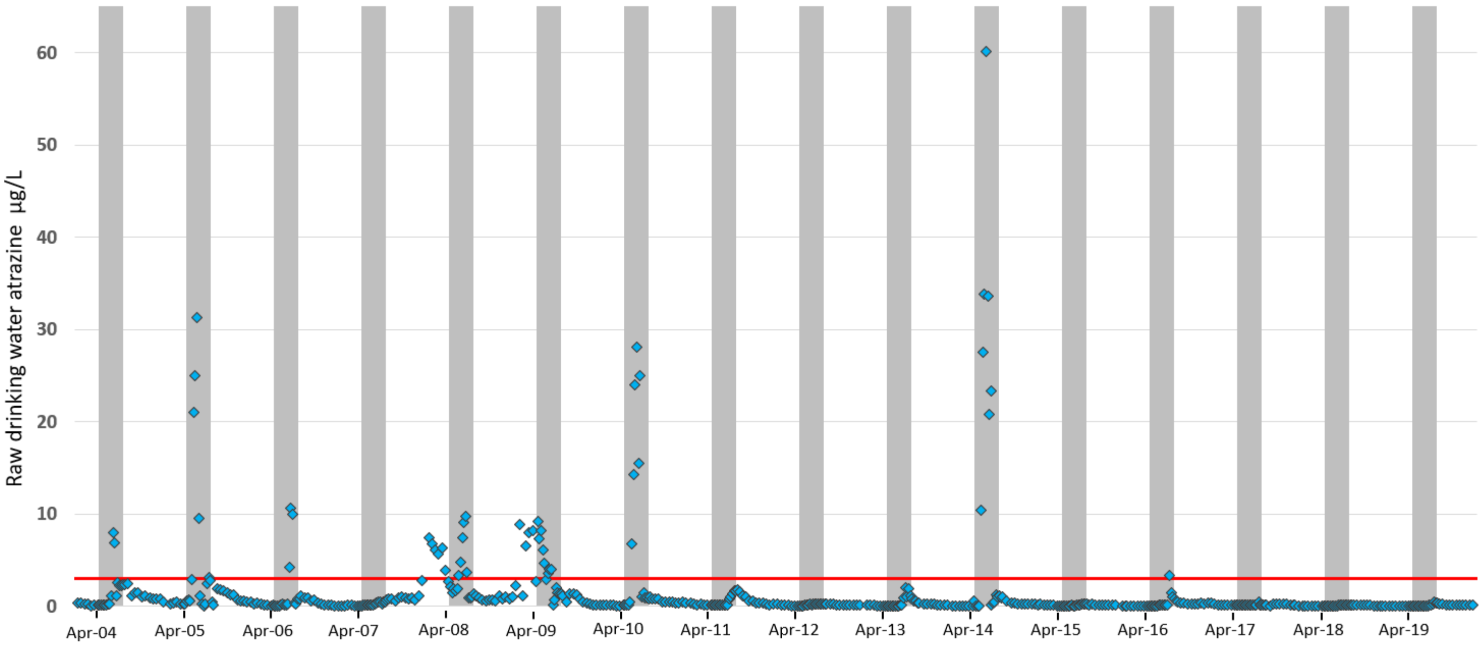

Figure 7. Blanchester raw drinking water intake atrazine concentration sample results from the Syngenta Atrazine Monitoring Program from late 2003 through early 2020. The red lines show the 90-day average community action level concentration of 3.0 µg/L. Vertical bars shade the 90-day period from April 15 through July 13.

Table 4. Critical condition assessment of Blanchester raw drinking water intake atrazine concentration sample results from the Syngenta Atrazine Monitoring Program.

90-day Assessment Window		Num. years with average >3.0 µg/L	Maximum 90-day average (µg/L)	2nd greatest 90-day average
Start	Stop			
1-Feb	1-May	2	6.37	3.74
15-Feb	15-May	3	6.73	3.87
1-Mar	29-May	4	12.05	8.26
15-Mar	12-Jun	5	15.58	8.13
1-Apr	29-Jun	5	17.55	8.99
15-Apr	**13-Jul**	**5**	**17.64**	**9.12**
1-May	29-Jul	4	16.52	9.24
15-May	12-Aug	4	14.82	9.47
1-Jun	29-Aug	3	7.68	6.93
15-Jun	12-Sep	1	3.03	NA

Table 5. Atrazine observations in µg/L from grab samples at the three separate water sources that serve Blanchester. Values greater than the 90-day average community action level of 3.0 µg/L are bolded.

Location	Whittacres Run @ Fancy St.	W. Fk. E. Fk. L. Miami R. UPST. Blanc. intake	Stonelick Creek @ Westboro Rd.
Ohio EPA station	**301781**	**301779**	**301780**
HUC 12 (05090202)	**07 02**	**10 05**	**13 01**
Drainage area (mi²)	**0.8**	**19.8**	**1.0**
3/14/2012	0.1	0.1	0.1
4/16/2012	0.4	**89.5**	0.6
4/17/2012	0.3	**84.4**	0.4
4/26/2012	0.5	**69.0**	**102.0**
5/8/2012	0.3	4.7	2.8
7/31/2012	0.1	0.5	Not sampled
4/24/2013	0.1	0.4	0.4
6/13/2013	**71.2**	**42.3**	**37.3**

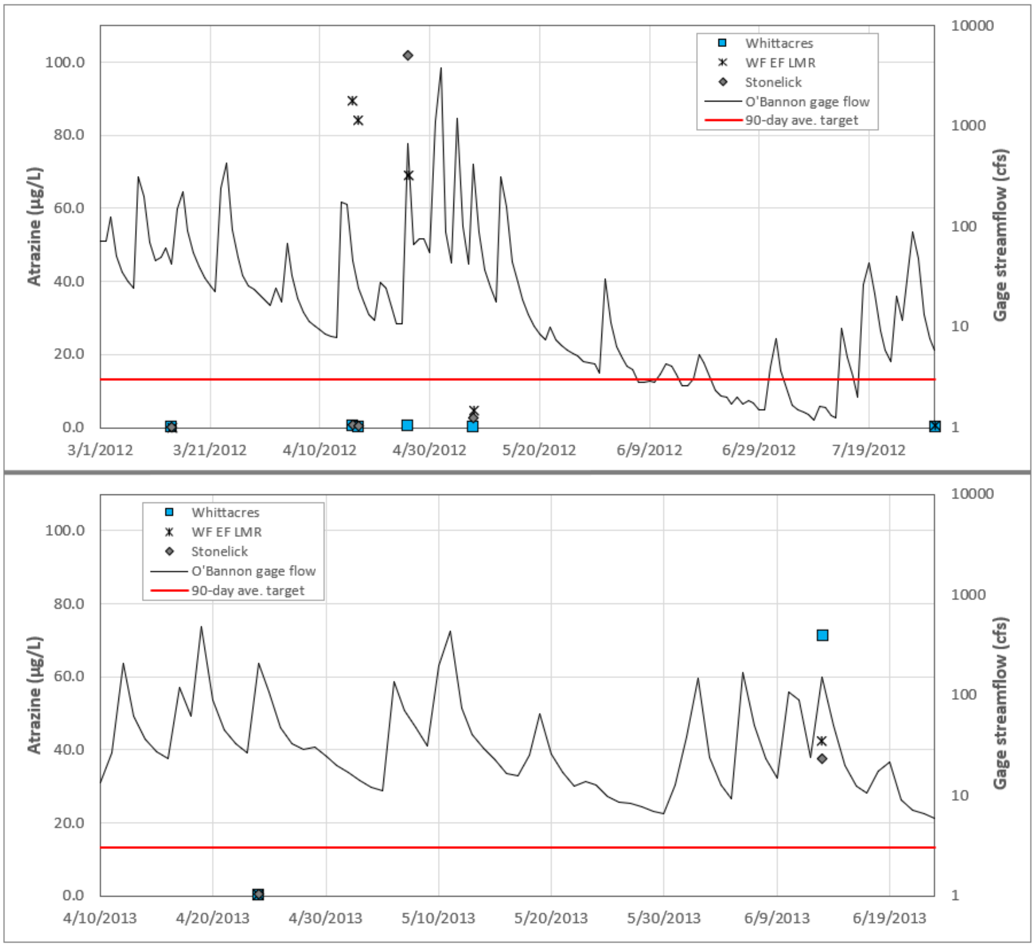

Figure 8. Atrazine observations from grab samples at the three separate water sources that serve Blanchester plotted against streamflow at the O'Bannon Creek USGS gage. The upper plot shows 2012; lower plot shows 2013.

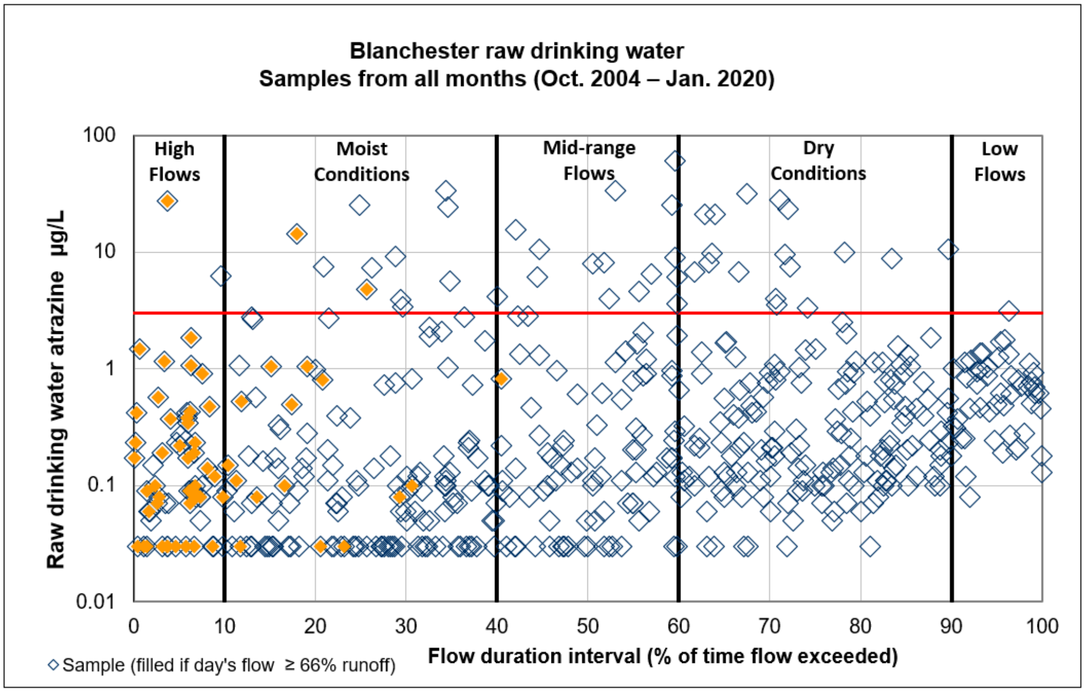

Figure 9. All Blanchester raw drinking water intake atrazine concentration sample results from the Syngenta Atrazine Monitoring Program from October 2004 through January 2020 plotted against the streamflow flow duration interval for the O'Bannon Creek near Loveland USGS gage. Symbols filled orange were collected on days the streamflow was greater than or equal to 66% runoff according to baseflow separation calculations.

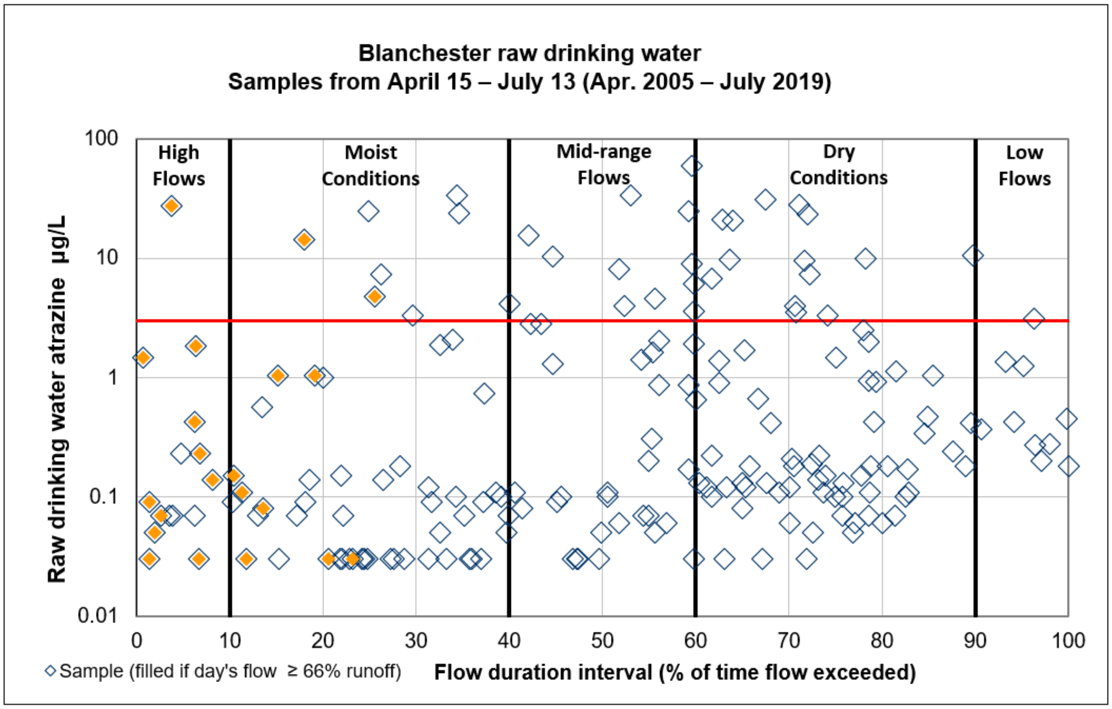

Figure 10. Blanchester raw drinking water intake atrazine concentration sample results from the Syngenta Atrazine Monitoring Program collected April 15 through July 12 in the years from October 2004 through January 2020 plotted against the streamflow flow duration interval for the O'Bannon Creek near Loveland USGS gage. Symbols filled orange were collected on days the streamflow was greater than or equal to 66% runoff according to baseflow separation calculations.

3. Analysis methods

As a part of the new Vision TMDL, this project addresses the assessment units contributing to the Harsha Lake public drinking water use impairments, as well as several causes of aquatic life use impairments, via a single nutrient TMDL modeling approach. Unlike many previous TMDLs developed by Ohio EPA, most aquatic life use TMDLs are developed for entire WAUs, which are mostly HUC-12s, rather than impaired assessment sites. The aquatic life use impaired assessment units that overlap with the Harsha Lake public drinking water supply TMDL are noted in Table 1.

This project's water quality targets used for the nutrient and atrazine TMDLs are presented in this project's LAP document (Ohio EPA, 2021). These are not reprinted in this report but are summarized below in section 3.2.1.

Watershed modeling is used to determine nutrient loadings and streamflow hydrology in this TMDL. Section 3.1 provides an overview of SWAT modeling, much of which is presented in this project's LAP (Ohio EPA, 2021). Section 3.1 further explains the model "tuning" that was carried out to most accurately establish TMDL allocations.

Section 3.2 focuses on the nutrient TMDLs. It explains how the SWAT modeling and other analyses are used to understand the existing condition nutrient loading sources. The section outlines the methods used to allocate loads for the nutrient TMDLs. This includes considerations for margin of safety, allowances for future growth, and critical conditions/seasonality.

Section 3.3 details how the atrazine TMDL in this effort is developed using empirical analyses of monitoring data.

3.1. Nutrient watershed modeling

This TMDL project utilizes water quality monitoring and modeling efforts carried out in the watershed by U.S. EPA, ORD. This work started with fulfilling U.S. EPA research objectives. The monitoring aspect of the project expanded to include several local partners, Clermont County Office of Environmental Quality and Clermont Soil and Water Conservation District key among them. This section documents how the monitoring efforts were used to develop a SWAT model for the East Fork LMR watershed. It also explains how the detailed water quality monitoring results are used to 'tune' the SWAT model outputs for this project's nutrient TMDLs.

3.1.1. Soil and Water Assessment Tool (SWAT)

Process models, like the soil and water assessment tool (SWAT), provide an effective means to simulate pollutant movement in a watershed. SWAT is designed to simulate agricultural watersheds, allowing the model developers to incorporate detailed agronomic and conservation practices. Nutrients applied as fertilizers and existing in soils are accounted for in detail. They are removed with crops, discharged to waterways, or remain on fields for the next season. All additional nutrient sources in a watershed, including from point sources and HSTS, are incorporated in SWAT modeling. Precipitation input data drives the movement of water and pollutants, which includes careful understanding of evapotranspiration, surface runoff, tile discharge, and groundwater storage.

SWAT is a river basin-scale model developed by U.S. Department of Agriculture - ARS at the Blackland (Texas) Research Center (TAMU, 2019). SWAT is a physically based model that operates on a daily time step (continuously) and effectively over several years. SWAT models nitrogen and phosphorus from diffuse, landscape sources and point sources. Landscape sources can be fine-tuned to conditions (i.e., soils, slopes, and hydrologic routings) and management practices (i.e., agricultural crop rotations, timing/types of fertilizers, and conservation practices). Once satisfactorily calibrated to existing conditions, SWAT can be used to examine various nutrient reduction scenarios. These scenarios can include the adoption of various types of agricultural and urban conservation practices and/or point source nutrient reductions. SWAT has been used extensively in the U.S. for TMDL applications, including Ohio (Ohio EPA, 2009 and Ohio EPA, 2012), and has been accepted by U.S. EPA as a modeling strategy for TMDL load development (U.S. EPA 1999). Throughout the East Fork LMR watershed, nutrient loading and stream flows have been modeled using SWAT by U.S. EPA, ORD.

SWAT was chosen by U.S. EPA ORD for this watershed because it can simulate the complexities involved in nutrient source trading. Sufficient daily flow information due to U.S. Geological Survey (USGS) gages were available for calibrating and validating the model. The streamflow data from the East Fork Little Miami River at Williamsburg, OH, gage, number 03246500, was used for model development upstream of Harsha Lake. The portion of the watershed downstream of Harsha Lake was developed with streamflow from the East Fork Little Miami River at Perintown, OH, number – 03247500, and Stonelick Creek near Perintown, OH, gage number 03247300. A robust stream nutrient dataset was available for model evaluation due to sampling activities carried out by U.S. EPA ORD and the Clermont County Office of Environmental Quality. Nutrient data collected and analyzed by Ohio EPA were also used in model evaluation.

Model set-up, calibration, and validation were carried out by U.S. EPA ORD for this effort. Nearly 16,000 hydrologic response units were developed for the upper East Fork LMR SWAT model with the intent to improve the spatial resolution for management scenario simulations (Karcher, et al., 2013). This allows for model output at the approximate spatial scale of individual land parcels, as seen in Figure 11.

Model development included a model sensitivity analysis, calibration, and validation efforts. The initial model setup was used to determine a number of sensitive parameters/rates. The SWAT calibration and uncertainty programs (SWAT CUP) tool was then used for an initial uncertainty analysis considering these sensitive parameters/rates. This involved running the model 1,000 times, altering those sensitive parameters/rates within reasonable ranges. The fit to observed data was assessed for each of these model runs. Based on these 1,000 runs, an updated, tighter range of better fit values for the sensitive model parameters/rates were determined by SWAT CUP. Model calibration involved running the model another 1,000 times with this new range of model parameters/rates. The single best fit of those runs was selected for making TMDL allocations, i.e., it became the calibrated TMDL model. That calibrated TMDL model was then used to test a different set of data observations that were not used in the calibration exercise. This became the model validation run.

The 1,000 modeled runs examined in the calibration step resulted in an updated range for the sensitive modeling parameters/rates. These are considered the calibrated model parameter/rate ranges. They can be used to assess modeling uncertainty. SWAT is a deterministic model in the sense that the same inputs will always result in the same outputs. Using ranges in the sensitive parameters to establish a distribution of model output for the variables of interest serves as a proxy for residual uncertainty.

An example of the utility of understanding model uncertainty in this way involves modeling scenarios for BMP effectiveness. The model has been set up with planned BMPs in place and run multiple times, varying the sensitive model parameters'/rates' within the calibrated ranges. Of those model runs, the parameters/rates from the run that resulted in the 5th percentile of BMP effectiveness were determined. Then, those model parameters/rates were used to model how many BMPs were required to meet water quality goals. Using the model parameters/rates at only the 5th percentile of effectiveness was a conservative measure to ensure water quality improvement will be met, given the realities of BMP pollutant reduction performance and modeling uncertainties.

Calibration and validation goodness of fit (GOF) statistics for the upper East Fork LMR calibrated TMDL SWAT model are given in Tables 6 and 7, respectively. These tables present a summary of comparing observed and simulated data from the "best" model run using a daily timestep. The p-factor quantifies the fraction of the measured data that is bracketed by the 95% probability prediction interval (denoted as 95PPU) of multiple models runs for analysis of model uncertainty. Values closer to one are considered optimal. The r-factor is the average width of the 95PPU band divided by the standard deviation of the measured variable. Values less than one are considered optimal. The Nash-Sutcliffe Efficiency (NSE) statistic test determines the relative magnitude of the model to observed variance. This essentially provides a rating of the noise compared to information on the fit. Values closer to one are optimal. The bR2 is the coefficient of determination (R^2) multiplied by the coefficient of the regression line between simulated and observed. The percent bias (PBIAS) test examines the average tendency of simulated data and provides a statistic for the overall over or underestimation of bias. Values greater than zero suggest an overall underestimate, and less than zero an overestimate; values close to zero are optimal.

Figure 12 shows a plot of observed versus simulated data for flow on both daily and monthly time series. The model performance statistics are based on the parameterization that optimized the model fit for all primary variables of interest, i.e., flow, sediment, and nitrogen and phosphorus species. It is important to note certain sensitive parameters affect more than one of the variables of interest. Therefore, maximizing the model fit for one variable may not result in the best fit for another. It is not practical to have multiple model parameterizations when running management scenarios, so the 'best' parameterization is somewhat subjective. For instance, the goodness of fit for flow was set as the highest priority, followed by TN and then TP.

The physiography of the lower EFLMR watershed dictated some adjustments to the model workflow developed for the upper watershed. Most adjustments were made to deal with contributing loads from Harsha Lake to the lower EF LMR mainstem. Since the mainstem river downstream of Harsha does not receive a nutrient TMDL, those adjustments need not be documented here. Similar model calibration was carried out for the Stonelick Creek watershed using a well-monitored point near Stonelick Creek's confluence with the EFLMR. Applicable to the Hall Run TMDL watershed, the lower watershed has a larger concentration of urban areas compared to the upper. Therefore, the results of the calibration were evaluated using urban stream monitoring sites.

The results of the lower watershed's model calibration exercise ended with a model not quite as well performing as the upper watershed (the values will be presented during the draft TMDL step of this project), but overall, the hydrologic and water quality model utilized for this TMDL is found to satisfactory, or better, meet the performance measures and evaluation criteria as outlined by Moriasi et al. (2015).

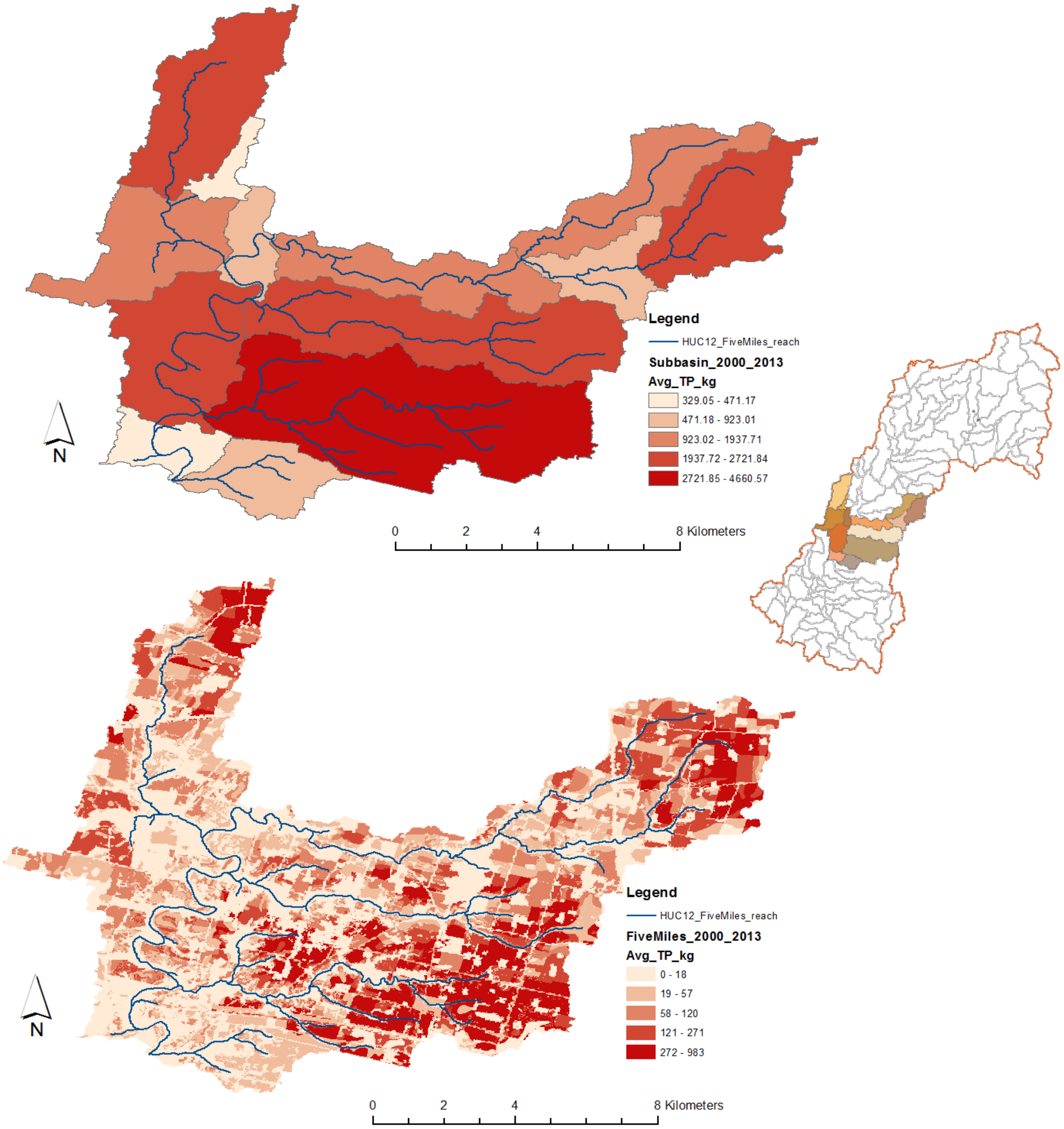

Figure 11. Example spatial resolution of total phosphorus loading model output for one HUC 12 (05090202 11 02). Top: the modeled subwatershed scale. Bottom: the hydrologic response unit scale TP loading model output. (Adapted from Nietch et al. in revision).

Table 6. Upper East Fork LMR SWAT model GOF statistics for model calibration.

Statistics for daily observed and simulated data.

Variable	Timeframe	Units	p-factor	r-factor	NSE	bR2	PBIAS
Flow	1/1/2000 - 07/31/2011	m^3/sec	0.57	0.70	0.52	0.23	2.90
Sediment		ton/day	0.20	14.64	0.28	0.09	4.30
ORGP	4/10/2008 - 07/31/2011	kg/day	0.54	1.54	0.23	0.06	-48.90
MINP		kg/day	0.16	0.62	0.18	0.09	1.10
TP		kg/day	0.22	1.03	0.26	0.08	-25.00
ORGN		kg/day	0.28	0.16	0.28	0.26	-17.80
NO3		kg/day	0.16	0.59	0.05	0.21	6.70
NH4		kg/day	0.30	0.41	0.27	0.40	-4.30
TN		kg/day	0.17	0.31	0.38	0.38	-6.60

Statistics for daily observed and simulated data aggregated into a monthly time step.

Variable	Timeframe	Units	p-factor	r-factor	NSE	bR2	PBIAS
Flow	1/1/2000 - 07/31/2011	m^3/sec	0.57	0.70	0.73	0.62	2.60
Sediment		ton/day	0.20	14.64	0.51	0.31	4.20
ORGP	4/10/2008 - 07/31/2011	kg/day	0.54	1.54	0.40	0.23	-49.20
MINP		kg/day	0.16	0.62	0.21	0.26	0.40
TP		kg/day	0.22	1.03	0.41	0.23	-25.50
ORGN		kg/day	0.28	0.16	0.54	0.29	-18.20
NO3		kg/day	0.16	0.59	0.38	0.39	7.40
NH4		kg/day	0.30	0.41	0.60	0.42	-4.50
TN		kg/day	0.17	0.31	0.65	0.45	-6.60

Table 7. Upper East Fork LMR SWAT model GOF statistics for model validation.

Statistics for daily observed and simulated data.							
Variable	**Timeframe**	**Units**	**p-factor**	**r-factor**	**NSE**	**bR2**	**PBIAS**
Flow	08/01/2011 - 02/28/2014	m^3/sec	0.24	0.59	0.43	0.23	-51.50
Sediment		ton/day	0.34	5.12	0.33	0.11	-42.50
ORGP		kg/day	0.48	1.86	0.17	0.05	42.70
MINP		kg/day	0.17	0.47	0.29	0.10	18.20
TP		kg/day	0.25	1.14	0.30	0.10	29.70
ORGN		kg/day	0.22	0.41	0.25	0.16	31.70
NO3		kg/day	0.17	1.06	-0.03	0.00	-23.00
NH4		kg/day	0.19	0.27	0.31	0.09	23.70
TN		kg/day	0.18	0.80	0.35	0.11	1.50
Statistics for daily observed and simulated data aggregated into a monthly time step.							
Variable	**Timeframe**	**Units**	**p-factor**	**r-factor**	**NSE**	**bR2**	**PBIAS**
Flow	08/01/2011 - 02/28/2014	m^3/sec	0.24	0.59	0.33	0.56	51.20
Sediment		ton/month	0.34	5.12	0.66	0.73	41.50
ORGP		m^3/month	0.48	1.86	0.14	0.10	-42.70
MINP		kg/month	0.17	0.47	0.22	0.22	-18.30
TP		kg/month	0.25	1.14	0.27	0.22	-29.70
ORGN		kg/month	0.22	0.41	0.14	0.40	3.00
NO3		kg/month	0.17	1.06	0.24	0.44	47.60
NH4		kg/month	0.19	0.27	0.72	0.55	9.50
TN		kg/month	0.18	0.80	0.69	0.72	27.90

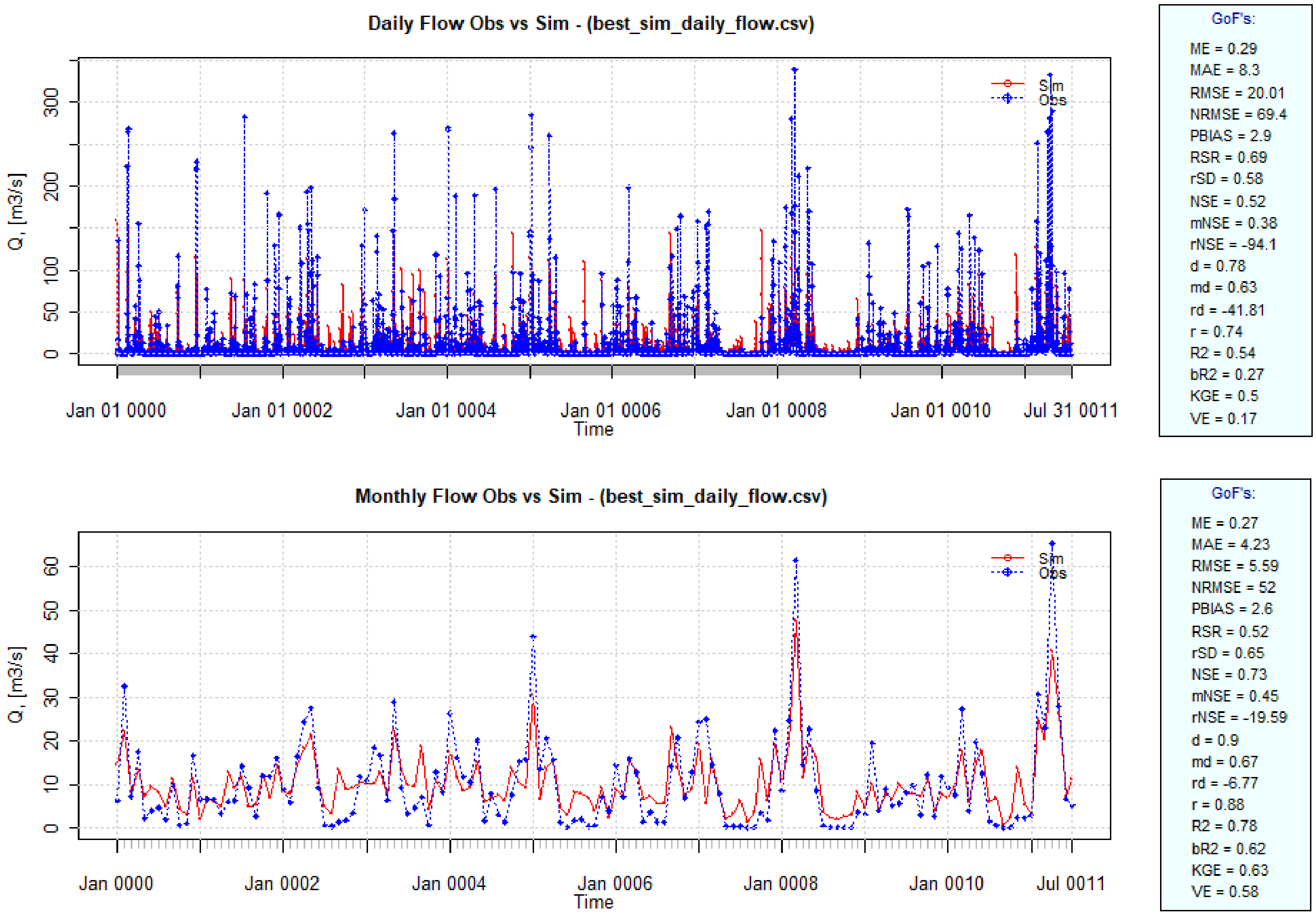

Figure 12. Upper East Fork LMR SWAT simulated and observed flow time series after calibration. Daily (top) and monthly (bottom) plots based on daily data along with GOF statistics adjacent to each ME= Mean Error, MAE= Mean Absolute Error, RMSE=Root Means Square Error, NRMSE%=Normalized Root Means Square Error, PBIAS%=Percent Bias, RSR=Ratio of RMSE to the standard deviation of the observations, rSD=Ratio of Standard Deviations, NSE=Nash-Sutcliffe Efficiency, mNSE=modified Nash-Sutcliffe Efficiency, rNSE=relative Nash-Sutcliffe Efficiency, d=Index of Agreement, md=Modified Index of Agreement, rd=Relative Index of Agreement, r=Pearson Correlation Coefficient, R2=Coefficient of Determination, bR2=R2 multiplied by the coefficient of the regression line between simulated and observed, KGE=Kling-Gupta Efficiency, VE=Volumetric Efficiency. The time scale for this modeling run includes 2000 through 2011.

3.1.2. Tuning existing condition modeled loads

It is standard practice to calibrate and validate SWAT models primarily focused on a downstream calibration station. The upper East Fork LMR SWAT model is calibrated to the streamflow and water quality monitoring station at the East Fork LMR River at Williamsburg (USGS station 03246500). The model for the watershed downstream of Harsha Lake uses the East Fork Little Miami River at Perintown, OH (USGS station 03247500) and Stonelick Creek near Perintown, OH (USGS station 03247300) as its calibration stations. As described above, the SWAT models used in this TMDL have been calibrated to a satisfactory level of quality.

Best practices for modeling warn model developers not to "over-fit" a model. This occurs when model calibration attempts to predict relatively subtle changes in observed data. By over-fitting a model calibration, model outputs, and observation match better than standard calibration. However, this match goes beyond the expectations of the model's predictive ability to a degree. Such changes to a model can result in it predicting erroneous results when the model is used to simulate future scenarios or other non-observed situations (Borsuk et al., 2002).

The U.S. EPA ORD modelers involved in this project made efforts not to over-fit the SWAT modeling calibration to avoid these issues. This is demonstrated above with the acceptable goodness of fit statistics for the model validation (Table 7). The validation exercise compared model output to streamflow and water quality observations that were not used in model calibration. However, there exists an opportunity to improve existing condition model results at a smaller geographic scale than what was used to calibrate the SWAT model. This is due to a long-term water quality monitoring network throughout the watershed. This includes 30 monitoring stations that have been regularly monitored since 2008. More details about this monitoring program are provided in this project's LAP (Ohio EPA, 2021). Because of the robust nature of this monitoring program, these data can be used to adjust the existing condition of SWAT-modeled outputs outside of the model.

This existing condition "tuning" is carried out on SWAT model outputs for every HUC-12, or sub-HUC-12, receiving a nutrient TMDL. This is done by comparing the modeled existing condition distribution of concentrations for a given HUC-12 to the most applicable monitoring station's distribution of observed concentrations. An adjustment factor is derived that shifts the median of the modeled concentration distribution to equal the median of the observed concentrations for each nutrient within each TMDL watershed. This adjustment factor, for example, a reduction of 20%, is then applied to every modeled concentration for that nutrient in that HUC 12 watershed.

Figure 13 illustrates this concept with the 05090202 11 02 subwatershed HUC-12 used as an example. This figure shows concentration distributions for TP and TN for the modeled/pre-adjusted condition, the tuned existing condition, and the observation station used for the tuning. Note that outliers in this figure follow the Tukey method, which considers values outliers only if they lie 1.5 times the interquartile range from the 75th percentile value. Some outlying values are not shown as they are greater than the scale of the y-axis in the figure.

The now tuned distribution of existing conditions concentrations are converted back to nutrient load using the same modeled streamflow. This results in a "tuned existing condition" load to which TMDLs are applied.

The robust dataset of stream nutrient observations could have alternatively been used more directly for TMDL development without employing a SWAT model. The observed concentrations could be utilized as a TMDL via a load duration curve method. However, were this to occur, the more detailed stream hydrology modeled by SWAT would not be available. A less robust method to determine streamflow would then be employed. The understanding of source contributions that SWAT supplies would also be missing. This would result in less precise allocations and severely limit the ability to model pollutant reduction practice scenarios that could be used to meet the TMDL.

By using this hybrid approach, the tuned SWAT loadings for this TMDL maximize the benefits of water quality modeling while closely aligning the loading allocations to the distributions of observed nutrient concentrations for each of the HUC12s in this exercise. The tuning exercise effectively makes the modeled distributions more directly reflect observed concentrations while avoiding overfitting of model parameters. The approach allows for using the model's hydrologic simulation (the best fit among the variables of interest) to derive the frequency of various loading probabilities, as well as systematically allocating loads among sources because each source is assigned a unique loading rate in the model's output. Therefore, the relative proportions among sources can be calculated in a more directly integrated manner, and subsequent restoration scenario modeling can be conducted and tied directly to specific sources (Nietch et al., forthcoming).

The monitoring sites used to tune the unadjusted model results are provided in Table 8. Monitoring sites listed in the table with six characters are Ohio EPA stations. The remaining stations, noted with three characters, are part of the local monitoring program. Information about these sites can be found in the LAP document for this project (Ohio EPA, 2021; see the LAP's Figure 4). Note that there are no monitoring sites used to tune the three partial HUC12 TMDL watersheds within the 05090202 12 03 HUC 12. This is part of the larger watershed that is not included in the long-term monitoring program, resulting in only limited information about existing concentrations. The TMDLs developed for these three partial HUC 12 watersheds are based on the SWAT modeling results without applying the tuning described in this section.

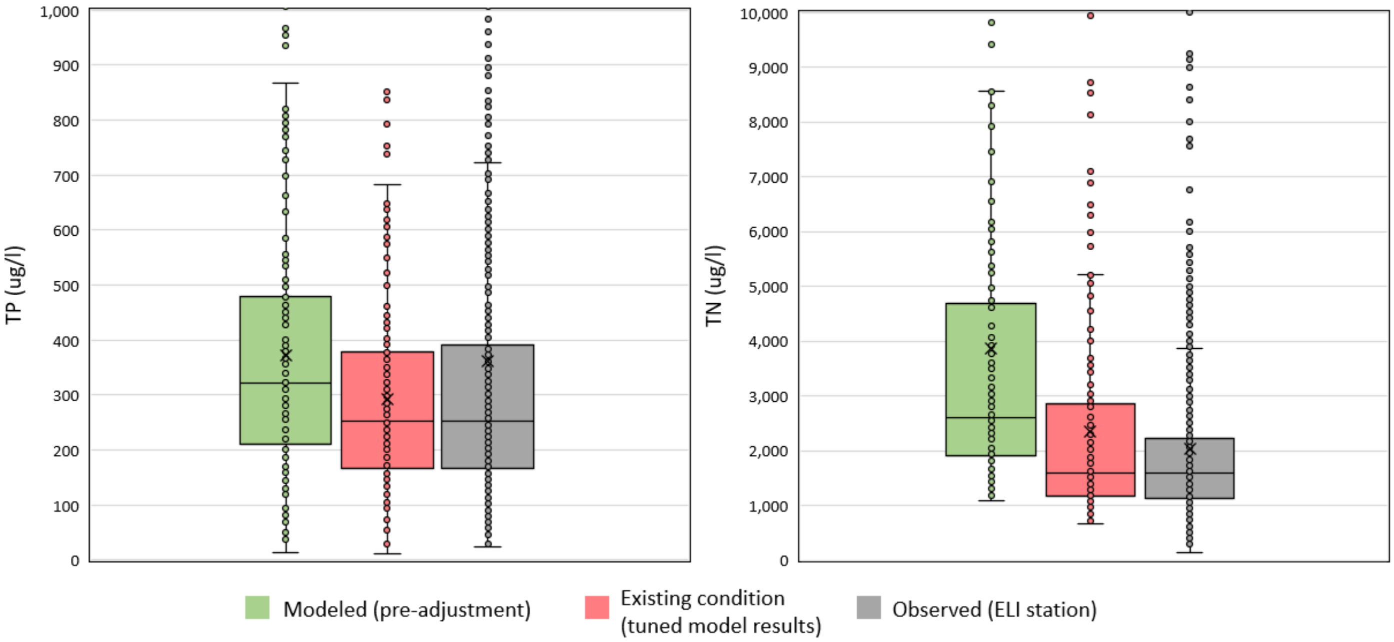

Figure 13. Total phosphorus (left) and total nitrogen (right) concentration distributions for modeled (pre-adjustment), modeled existing conditions (tuned) and observed (at the ELI station) for the 05090202 11 02 subwatershed HUC 12.

Table 8. Monitoring sites are used to tune existing model condition modeling results.

Assessment Unit (HUC8)	Narrative Description	Monitoring Site Used for Model Tuning
Little Miami HUC 8 (05090202*)*		
10 01	Turtle Creek	M04S52
10 02	Headwaters East Fork Little Miami River	506/S15
10 03	Headwaters Dodson Creek	890
10 04	Anthony Run-Dodson Creek	S51
10 05	West Fork East Fork Little Miami River	S50
10 06	Glady Creek-East Fork Little Miami River	EFY/EFG
11 01	Solomon Run-East Fork Little Miami River	EFB
11 02	Fivemile Creek-East Fork Little Miami River	EFI
11 03	Todd Run-East Fork LMR	ELI
12 01	Poplar Creek	CLC
12 02	Cloverlick Creek	CLC
12 03[1]	Lucy Run-East Fork LMR	Not tuned
12 04[2]	Backbone Creek-East Fork LMR	301903/301904/BBC
13 01	Headwaters Stonelick Creek	301905/M04S42/200492/MOF
13 02	Brushy Fork	OWT/301911/301912/301913/BRF
13 03	Moores Fork-Stonelick Creek	STC/M99Q14/301906/M04S41
13 05[3]	Salt Run-East Fork LMR	HLR/200481/M04P13

[1] Only the portion of the HUC12 draining to Ulrey, Back, and Slabcamp runs for the nutrient TMDLs.

[2] Only the portion of the HUC12 draining to Backbone Creek.

[3] Only the portion of the HUC12 draining to Hull Run.

3.2. Nutrient TMDL allocation methods

3.2.1. Determining the amount of nutrient load available for allocations

The LAP report for this project explains that the natural background nutrient concentrations observed at minimally disturbed assessment sites in the watershed were used to determine reference conditions. Additionally, target concentrations were determined based on various analyses of the impaired uses. The reference/background concentrations for TP and TN are 0.055 and 0.433 mg/L, respectively. The target TP and TN concentrations are 0.077 and 0.707 mg/L, respectively.

The tuned modeling results of the existing concentration distributions are compared to the reference condition and target expectations to determine the amount of nutrient reduction required. Both the reference concentration and target concentrations were developed based on the central tendency (i.e., median) of the concentration distribution of various observations (for more detail, see this project’s LAP; Ohio EPA, 2021). Therefore, the following calculations focus on the median of modeled distributions.

Calculating the difference between the reference load and the existing loading conditions is an important step in this TMDL development. It is carried out by first determining the nutrient reduction required so that half of the existing conditions modeled meet the reference condition concentrations. This exercise is done using the modeled average monthly loading output. The nitrogen or phosphorus reduction required to meet the reference concentrations that have been translated to a modeled loading distribution and scaled to an annual amount (i.e., kg/yr). The reduction needed to reach the reference condition varies for each HUC12 requiring a TMDL. It ranges from 3% to 78% for TP and 18% to 78% for TN. Of the 19 nutrient TMDL watersheds, the median load reduction required to reach the reference condition is 69% and 53% for TP and TN, respectively. This exercise results in a reference TN and TP load for each TMDL watershed.

Next, the TMDL loading capacity is determined for each watershed. A similar method used to determine the reference condition load is carried out for this aspect. A fixed reduction value is applied to the monthly model output for the existing condition in each watershed. The reduction amount that results in 50% of the monthly loads meeting the target concentration (back-calculated from the load) is determined. Again, these reduction amounts vary for each watershed. They range from -37% to 70% for TP and -34% to 64% for TN. Of the 19 nutrient TMDL watersheds, the median load reduction required to reach the target concentration is 56% and 23% for TP and TN, respectively. The load that results from this reduction becomes the TMDL loading capacity for a given watershed. The watersheds that have a negative required reduction for TP or TN indicate that they are already meeting the TMDL target for that nutrient.

Since the reference condition load is considered the natural background, its load is not allocated to anthropogenic sources. Therefore, the amount of load available to be allocated is calculated as the difference between the loading capacity and the reference condition. It is this load that is allocated to various sources in the manner that is proposed in the remainder of this section.

This concept is illustrated in Figure 14.

Figure 15 shows an example of the loading results of this exercise for the 11 02 HUC-12 subwatershed. This figure plots the TP and TN monthly loads of this watershed's existing conditions, TMDL loading capacity, and reference condition. These are plotted against load exceedance probability, which essentially sorts loads by magnitude. In this example, the TP reduction applied to the existing conditions to meet the TMDL loading capacity at the 50th percentile of the loading distribution is 70%. To meet the reference condition, the existing TP conditions would need to be reduced by 78%. The reductions applied to the existing TN conditions were 56% and 73% to meet the loading capacity and reference conditions, respectively.

Implementation of this TMDL endeavors to reduce pollutants from managed lands. No reductions from the background loads are expected. This means that 70% and 56% reductions from the existing TP and TN anthropogenic sources, respectively, are required to meet the TMDL for the watershed exemplified in Figure 15. Note that the load to be allocated to these sources is represented in Figure 15 as the area between the yellow and blue lines.

Figure 15 illustrates that this TMDL method essentially shifts the distribution of loads to meet pollutant reduction needs. The method acknowledges that a distribution of loading occurs. This is largely due to increasing loads with greater streamflow. Figure 16 demonstrates this by plotting TP and TN daily loads for the three conditions against streamflow exceedance probability.

Such loading distributions will continue to occur even with the nutrient pollutant controls maximized. Setting the TMDL loading capacity to meet the target concentrations 50% of the time (i.e., the 50th percentile of the distribution of targeted concentrations) allows for practical pollutant reduction goals. Reserving background loads and limiting TMDL allocations to just anthropogenic sources provides reasonable assurances that enough pollutant reductions will achieve water quality goals.

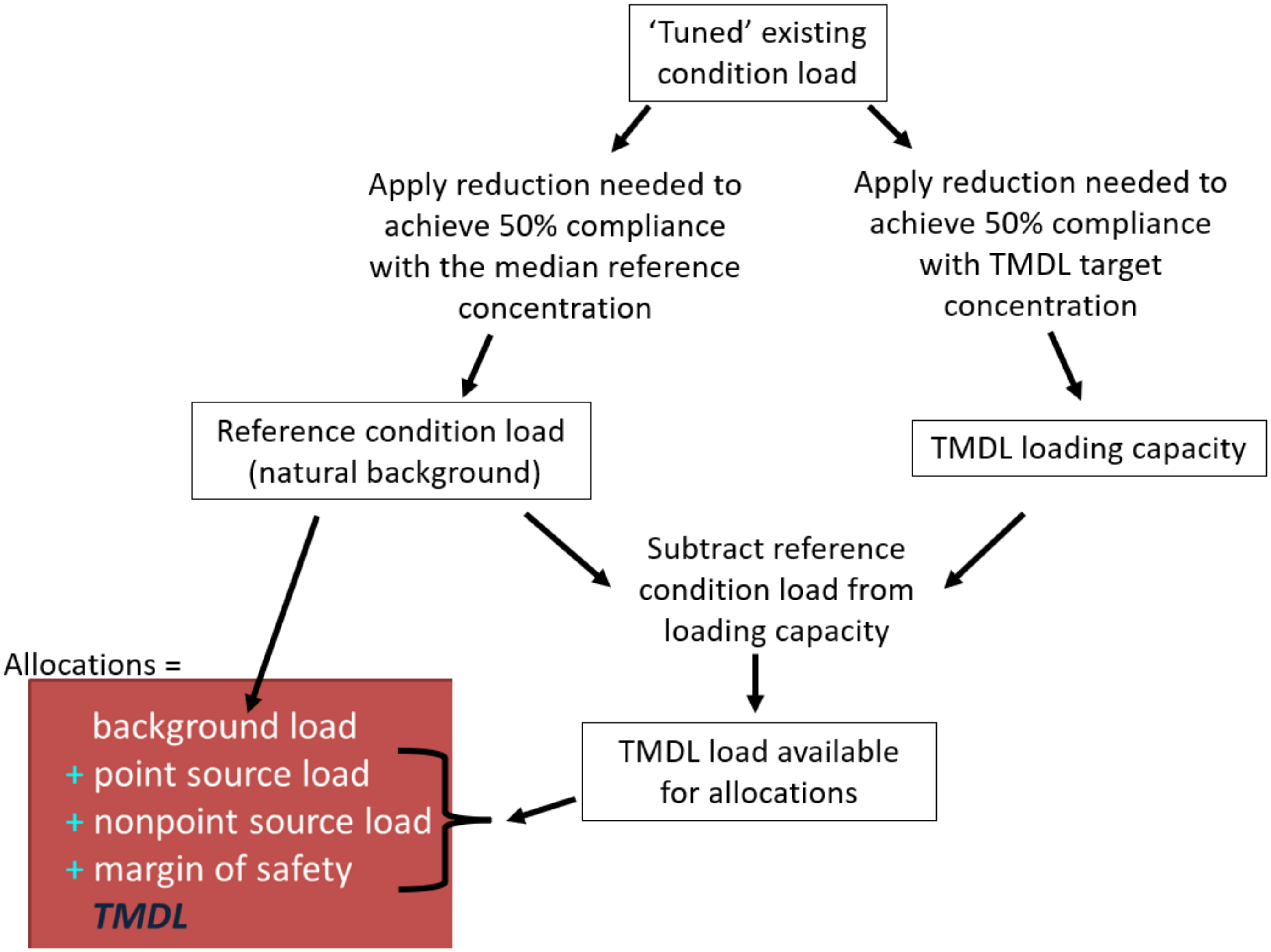

Figure 14. Nutrient TMDL available allocation loading modeling concept.

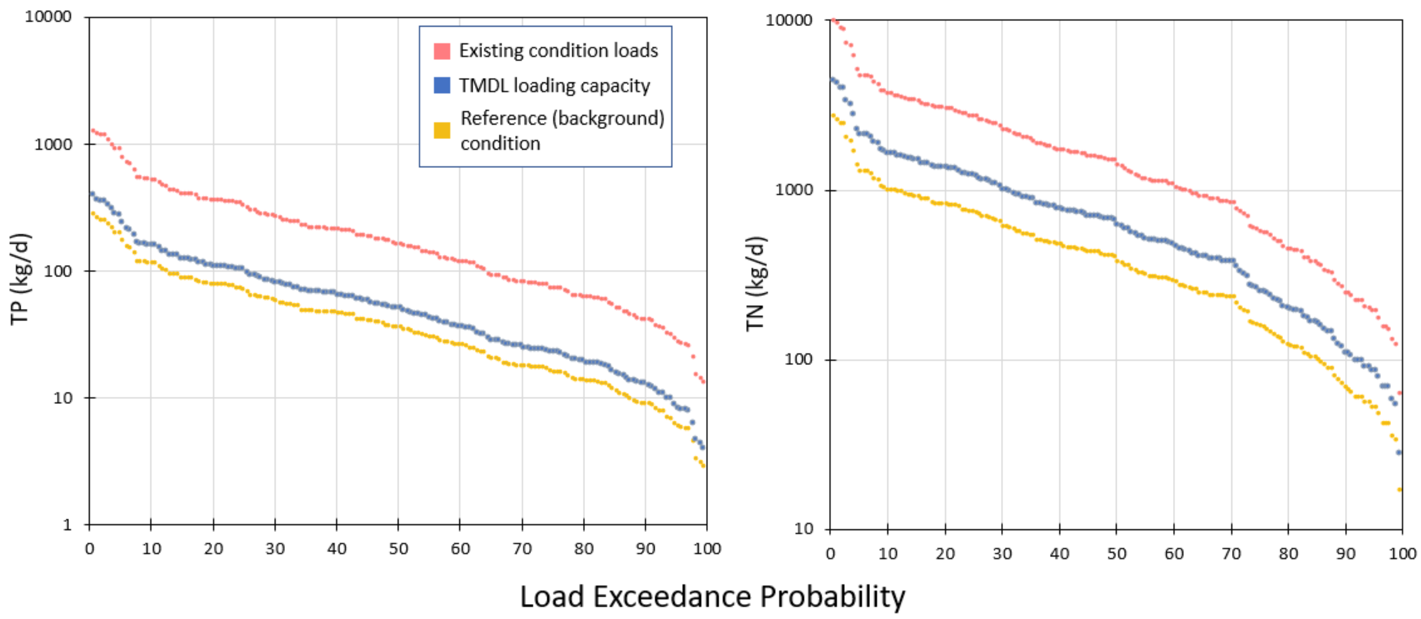

Figure 15. Example load exceedance curves showing modeled existing conditions, TMDL loading capacity, and reference (background) total phosphorus (left) and total nitrogen (right) for the 05090202 11 02 subwatershed HUC 12.

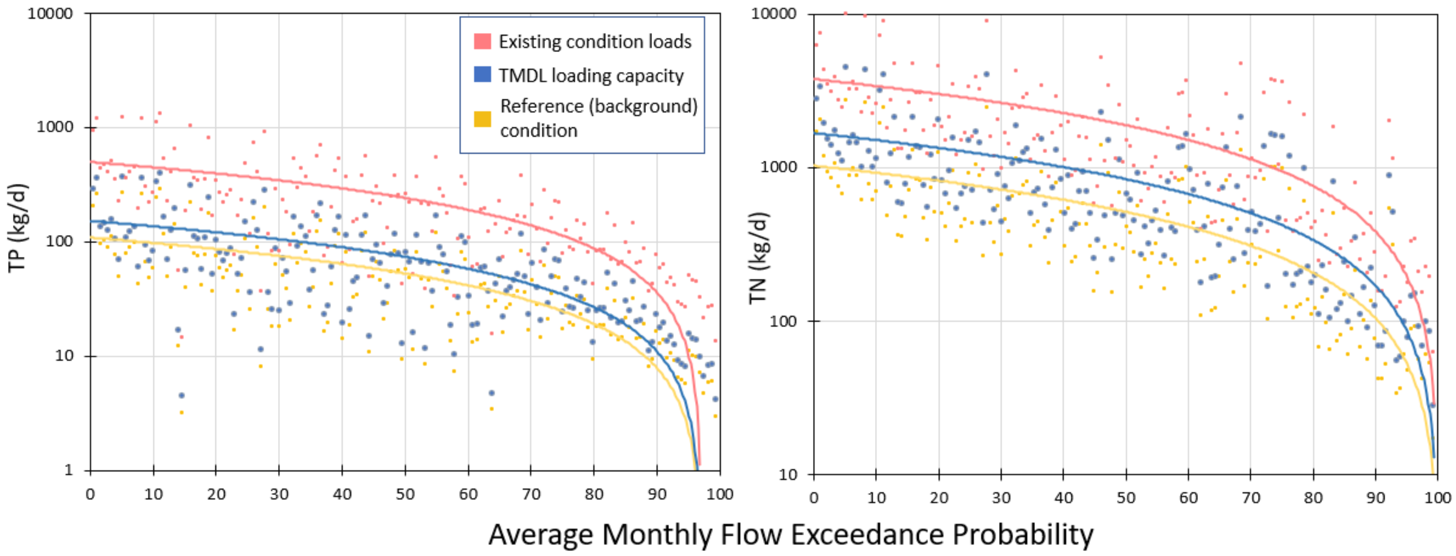

Figure 16. Example flow exceedance curves showing modeled existing conditions, TMDL loading capacity, and reference (background) total phosphorus (left) and total nitrogen (right) for the 05090202 11 02 subwatershed HUC 12.

3.2.2 Overall nutrient allocations approach

When considering allocating pollutants to various sources, U.S. EPA (1999) provides guidance that TMDL administering agency's "must find an acceptable combination of allocations that adequately protects water quality standards." There are several factors of equitability to consider when proposing TMDL allocations. These factors are considered here and result in a proposed allocation methodology.

Since the CWA does not have the authority to regulate non-permitted stormwater sources of pollutants, the breakdown of permitted and non-permitted allocations can be very important. The nutrients delivered to this watershed are primarily from agricultural nonpoint sources. Outside of direct discharges of agricultural nutrients to streams, which are unacceptable according to federal and state regulations (see Ohio Revised Code Section 6111.04 and OAC 901:13-1, OAC 901:5, OAC 901:10-1-10), the vast majority of the nutrient sources in this watershed are unregulated. TMDL allocations for unregulated sources serve as guidance for voluntary actions. However, TMDL allocations for CWA permitted sources (such as wastewater treatment plants) result in regulatory actions that are consistent with the allocations.

Because of these realities, upon the final publication of the LAP for this project (Ohio EPA, 2021), methods to allocate available load to the permitted sources were considered. Ohio EPA first identified which discharging wastewater treatment plants where nutrient reductions are feasible or are needed to address near-field impairments. Of the 15 plants noted as discharging nutrients listed in Table 3, six were considered reasonable to target for nutrient reductions. These six were determined based on plant size, treatment technology, geography of impairments in relation to the plant, and various other considerations. In short, the plants considered for reductions were big enough and/or had the technological ability to, within reason, reduce the amount of nutrients discharged. Table 9 lists the plants considered for reductions and provides a short explanation of these considerations.

Table 9. Permitted wastewater treatment plants that are considered for nutrient reductions in this TMDL.

Permit	Facility Name	Design flow (MGD)	Considerations for identifying facilities where nutrient reductions are feasible or needed to address near-field impairments
1PA00005	New Vienna	0.085	Already limited to not discharge between June and September to address near-field issues. Controlled discharge lagoon offers potential opportunities for land application. Nutrient load limits to address far-field impairment (Harsha) are appropriate.
1PB00105	Lynchburg	0.5	Discharging to the mainstem East Fork LMR, this plant is big enough so additional nutrient removal technology is feasible.
1PD00024	Fayetteville	Controlled discharge	Nutrient reductions will help address near-field impairments. Have the technology for effluent land application.
1PB00034	Williamsburg	0.9	Facility utilizes biological nutrient removal technology to comply with existing phosphorus limits. Additional reductions for nitrogen should be possible through facility optimization.
1PA00106	Newtonsville Area	0.057	A new plant was installed since watershed assessment with nutrient reduction technology.
1PZ00029	Snow Hill	0.0125	Nutrient limits, or reduced discharges through land application, will help address near-field impairments.

The next step was to determine the mix of permitted versus unpermitted allocations and to examine various magnitudes of reductions. This step included stakeholder outreach via the attendance of an East Fork Cooperative meeting in early 2021. The overall TMDL concept was presented at this meeting, including the wastewater treatment plants considered eligible for nutrient allocations. Then, four potential allocation approaches were proposed. These approaches adjusted the mix of wastewater treatment reduction between two extreme conditions. The first extreme reduction condition is equal reductions required of these wastewater treatment plants as the nonpoint source reduction required to meet the TMDL. The other extreme is with no wastewater treatment reductions. The pros and cons of each of these approaches were also presented to the stakeholder group and are shown in Table 10.

The reduction required values on Table 10 uses draft allocation values for the 05090202 11 02 subwatershed HUC-12. This HUC-12 includes all the mainstem East Fork LMR's watershed that drains to Harsha Lake. While there are other nutrient TMDLs in this project that include other parts of the watershed, this HUC-12 captures most of the load and was determined as acceptable for these considerations to apply for the whole project.

The nonpoint source reductions required for the various approaches shown in Table 10 cover a small range from 55.5% to 56.5%. This reflects the fact that nonpoint sources of nutrients dominate the existing conditions. No matter how deeply the wastewater treatment plant loads are cut, the nonpoint sources still require a great deal of reduction. The first two allocation approaches would result in regulatory actions requiring costly treatment technology at the wastewater treatment plants. Considering these costs, these allocation approaches were dismissed as inequitable.

The fourth allocation approach explicitly requires no reductions from the wastewater treatment plants. Most wastewater treatment plants discharge continuously, and their effluent concentrations can dominate during low streamflow conditions. It is important to consider that these TMDLs are developed to be protective of both far- and near-field impairments (addressing public drinking water supply and aquatic life use, respectively). Requiring no reductions from wastewater treatment plants would not be protective of the near-field TMDLs for impaired streams' aquatic life use. Therefore, the fourth allocation approach is not reasonable.

Presented last intentionally, the third allocation approach outlines moderate concentration limits for the wastewater treatment plants. Most of the wastewater treatment plants discharging to watersheds receiving nutrient TMDLs in this project do not currently have total phosphorus or total nitrogen limits. Therefore, this approach does reflect reduction efforts from these sources.

Based on the considerations explained above, the third approach is used to set the proposed allocations for the six permitted facilities shown in Table 9.

Other permitted sources of nutrients, such as permitted stormwater and discharging HSTSs, also receive TMDL allocations. These represent a very small portion of the existing load, however, and were not as important for consideration of the overall allocation approach described in this section.

Table 10. Proposed nutrient allocation approaches using the 05090202 11 02 subwatershed HUC 12.

Allocation approach	Reduction required		Pros	Cons
	Nonpoint source	WWTP point sources		
1) All sources reduce an equal amount of reduction.	55.5%	55.5%	All sources are treated equally.	Extremely costly for point sources.
2) Point sources have strict concentration limits (0.5 mg/L TP & 5 mg/L TN). Nonpoint sources are required to make up the difference.	56.1%	20.6%	Second closest to all sources treated equally.	Very costly for point sources.
3) Point sources have moderate concentration limits (1 mg/L TP & 10 mg/L TN). Nonpoint sources are required to make up the difference.	**56.3%**	**10.3%**	**All sources are still making an effort. More do-able for point sources.**	**Point sources do not reduce as much % as nonpoint sources.**
4) No point source reductions. A nonpoint source is required to make all reductions.	56.5%	0%	No regulatory requirements.	Point sources are not required to make any reductions.

3.2.3 Nutrient wasteload allocations

As explained in subsection 3.2.1 and illustrated in Figure 14, allocations are apportioned based on the available loading capacity, which does not include the reference/background load.

Discharging treatment plants

Based on the third allocation approach outlined in the preceding section, wasteload allocations are calculated for the six individual permitted wastewater treatment plants, listed above in Table 9. This uses the permitted average design flow for each facility, listed above in Table 3, and 1 mg/L total phosphorus and ten mg/L total nitrogen concentrations.

The Williamsburg wastewater treatment is the only exception to the above. This facility's total phosphorus wasteload allocation is calculated using 0.7 mg/L. Williamsburg's permit already has a monthly total phosphorus concentration limit of 1.0 mg/L.

As noted above, the Fayetteville Perry Township WWTP facility, 1PD00024, is permitted to discharge effluent to surface waters and via land application. No wasteload allocation is provided for land application as this practice is not expected to result in effluent discharge to waters of the state. However, a wasteload application for the facility's effluent discharge is calculated. Since this facility's discharges are controlled, i.e., not continuous, it does not have an average design flow listed in its permit. The flow used for this allocation is based on the treatment plant's design from their permit application submitted to Ohio EPA, 0.18 MGD. Ohio EPA's NPDES permitting management will propose how these allocations are implemented within this facility's permit once this TMDL report is approved by U.S. EPA.

There is one facility covered by Ohio's small sanitary general permit (OHS000005) in the East Fork LMR watershed. It drains to Cloverlick Creek in the 12-digit HUC ending 12 02. Facilities covered by this permit must have an average design flow less than 25,000 gallons per day; however, Ohio EPA is aware that most discharge significantly less than this amount. To allocate an adequate load for facilities covered by this general permit, a daily discharge flow rate of 12,500 gallons per day is used to calculate the wasteload allocation. A total phosphorus effluent concentration of 2.5 mg/L is assumed for these plants for this calculation. The total nitrogen wasteload allocation is calculated based on 20.0 mg/L.

All permitted point source discharges of a TMDL pollutant must receive a wasteload allocation. Therefore, wasteload allocations are calculated for the treatment plants that discharge nutrients but are not considered eligible for nutrient reductions. These are the discharging facilities listed in Table 3, but not Table 9. Wasteload allocations for these facilities are calculated using each facility's average design flow times 2.5 mg/L total phosphorus concentration and 20.0 total nitrogen concentration. These concentrations are used to reflect that no new nutrient reduction is required from these plants due to this TMDL.

Permitted stormwater

There are several groups of permitted stormwater that must be broken out for TMDL wasteload allocations. The area covered by MS4 permitting is based on existing U.S. Census geospatial data. The MS4 coverage area within nutrient TMDL watersheds was delineated via a GIS analysis. Facility based stormwater is permitted by individual NPDES permits and by the multi-sector general permit (OHR000007). The areas for all facilities permitted in both categories have been delineated in GIS by Ohio EPA staff. This includes the areas for two individual NPDES permits, stormwater controls, and three facilities covered by the multi-sector general permit. None of the facility-based permitted stormwater areas are within the MS4 areas.

When filing for coverage of Ohio EPA's general permit (OHC000005) for construction activities, permittees must state the construction site location and number of acres impacted. The area of this permitted stormwater is accounted for by summing the number of acres impacted within each of the watersheds receiving a nutrient TMDL. The sum of acres covered by this general permit at the time modeling calculations were carried out, spring 2023, are used to develop this wasteload allocation. While the number of acres for this general permit is much more transient in nature than other types of permits, using the acres present in spring 2023 provides an adequate allocation placeholder. If a much larger construction project were proposed for a nutrient TMDL WAU that would result in exceeding the wasteload allocation, the allowance for future growth allocation could be used to make up the difference.

Figure 17 shows example results for part of the East Fork LMR watershed delineating various types of permitted stormwater. Table 11 shows the calculated stormwater areas.

To calculate nutrient wasteload allocations for the MS4, facility based, and construction permitted stormwater areas, the percent of area that falls into each category is calculated out of its watershed's allocatable load available after the discharging wasteload allocations, margin of safety and allowance for future growth have been set aside. This reflects that permitted stormwater allocation is essentially removed from the nonpoint source load allocation. This is determined for each HUC12 and sub-HUC12 nutrient TMDL watershed. The same allocation that would have been given to that amount of area under the nonpoint load allocation is itemized to the appropriate permitted stormwater source(s) as wasteload allocations. The calculation is based on a proportion of area within each permitted stormwater category compared to the total watershed area. The nonpoint load allocation methods are explained in section 3.2.4 below.

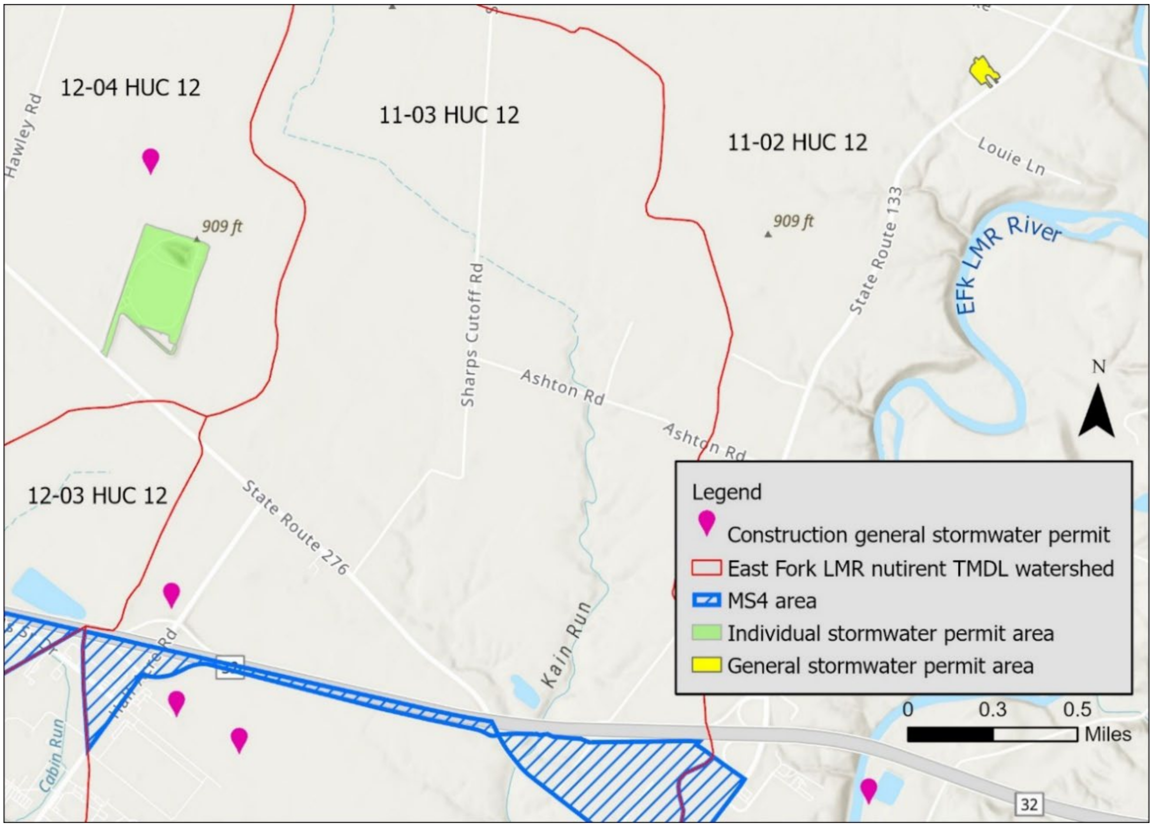

Figure 17. Map showing example of permitted stormwater areas delineated in East Fork LMR nutrient TMDL watersheds in eastern Clermont County area.

Table 11. Permitted stormwater areas broken out by nutrient TMDL watersheds

Permit Number	Permit Name	Assessment Unit	Area (acres)
Municipal Separate Storm Sewer System (MS4) area			
OHQ000004	Small municipal MS4	11 02	302
		11 03	539
		12 03 (Back Run)	2,004
		12 03 (Ulrey Run)	431
		12 04 (Backbone Ck)	819
		13 05 (Hall Run)	3,290
Individual stormwater permitted area.			
1IJ00050	Martin Marietta	10 01	187
1IN00289	Arch Materials	12 04 (Backbone Ck)	39
General stormwater permitted area.			
OHR000007	Industrial stormwater	10 03	134
		11 03	3

Permit Number	Permit Name	Assessment Unit	Area (acres
Construction stormwater permitted area.			
OHC000005	Small and large construction activities	10 02	9
		11 01	9
		11 02	12
		11 03	251
		12 01	198
		12 03 (Back Run)	3
		12 04 (Backbone Ck)	62
		13 02	4
		13 03	2
		13 05 (Hall Run)	99
		-	-

Permitted household sewage treatment plants

The SWAT watershed modeling determined the amount of TP and TN load delivered from all HSTS sources in each nutrient TMDL watershed. The model does not separate this HSTS load by system type. However, the systems designed to discharge are permitted by Ohio EPA general permit OHK000004 (see Section 2.1.2 for more detail). Post-SWAT-model calculations are required to determine the WLA for discharging HSTSs.

In 2013, Ohio Department of Health published the results of a survey, conducted by county health departments in 2012, as an inventory of existing HSTS in the state by Ohio EPA district. Table 12 outlines the results of this survey that characterizes the HSTS type. The East Fork LMR watershed is within the Ohio EPA's Southwest District. The HSTS study indicates that 22% of the HSTSs in this zone of the state are discharging and, therefore, are, or eventually should be, permitted by the Ohio EPA general permit.

Calculating the nutrient wasteload allocations for discharging HSTS starts with determining the allocatable load available after the discharging facility wasteload allocations, margin of safety and allowance for future growth have been set aside. Then, the proportion of HSTS of the existing conditions modeled load is applied to that available/allocatable load. This results in the total TMDL-allocated HSTS load. This results in the same pollutant reduction required for all nonpoint sources. Finally, 22% of that allocated HSTS is calculated to determine the discharging HSTS WLA. This occurs for both TP and TN.

Table 12. Proportions of total HSTS systems grouped into categories for Ohio's Nutrient Mass Balance Study. From the 2012 ODH statewide inventory (ODH, 2013).

Ohio EPA District	Working Soil Adsorption (%)	Failing Soil Adsorption (%)	Discharging (%)
Northwest	41.5	26.5	32
Northeast	44	27	29
Central	42.8	25.2	32
Southwest	**64**	**14**	**22**
Southeast	61.2	10.8	28

3.2.4 Nutrient load allocations

The nutrient loading capacity available for allocations is explained above in Section 3.2.1. That section describes that the modeled existing load attributed to natural sources are not subject to allocation reductions. Instead, they are incorporated into the existing, unreduced natural background load.

The existing condition loading attributed from anthropogenic sources are subject to reduction. The reduced load from anthropogenic nonpoint sources of land use and the unpermitted portion of nutrients from HSTS therefore makes up the load allocation. This load is calculated as the remainder of loading capacity after reserving the background load, all permitted wasteload allocations (Section 3.2.3), the margin of safety (Section 3.2.6), and the allowance for future growth (Section 3.2.7).

Only one load allocation is provided for TP and TN in each nutrient TMDL watershed. These load allocations are not subdivided out by land uses and unpermitted HSTS. Presenting a single load allocation per TMDL watershed allows for implementation flexibility. For instance, if more nonpoint source nutrient reduction can be achieved from one land use, it may allow other land uses to not have to be reduced as much. Also, downstream implementation actions, such as side-channel nutrient reduction wetlands – which are already being implemented in this watershed – reduce nutrients that are already combined from many sources. While the source proportions of the nutrients being reduced in such practices can be calculated, it is not nearly as clear as single source reduction implementation actions (i.e., increasing the use of the 4R agricultural fertilization program).

Another important reason for not subdividing the load allocation is that it would increase the computational complexity of what is used to calculate TMDL allocations. The greater the use of modeling details in allocation settings, the greater the uncertainty in the results. As explained in the margin of safety discussion (section 3.2.6), efforts are made to minimize uncertainties throughout this project.

Overall, were the load allocations sub-divided out by modeled sources, the resulting allocations would be more prescriptive than is required by TMDLs and could reduce the success of the TMDL project. The single load allocation gives room for adaptive management of the implementation of nutrient reduction practices.

3.2.5 Allocating nutrient loads from upstream "nested" watersheds in downstream "receiving" watersheds

Six nutrient TMDL watersheds in this project are downstream of other nutrient TMDL watersheds. The downstream watersheds are "receiving" watersheds because they receive water from outside of their own geographic drainage area. The upstream watersheds that drain to receiving watersheds are considered "nested" watersheds. The water quality modeling results used for this TMDL calculate all the pollutants and water that flow through each TMDL watershed to its downstream outlet. This includes pollutants from any nested watersheds. Because of this, allocations are essentially carried down from nested watersheds to their receiving watersheds. The SWAT model accounts for some instream processing of nutrients moving downstream, which slightly impacts nonpoint sources of pollutants. As can be seen in the TMDL results section, however, the wasteload allocation results from nested watersheds are carried downstream in whole to receiving watersheds.

Table 13 shows which nested watersheds flow into the receiving nutrient TMDL watersheds. This table shows that several watersheds are both nested and receiving watersheds. This occurs in the HUC 12 watersheds that start with the number codes 10 and 11 when shorted to just the last four digits (i.e., the 10-digit HUC codes that end in 10 and 11). The nested TMDL watersheds accumulate in this part of the greater East Fork LMR watershed. By the end of this accumulation, the HUC 12 with the number code 11 03 had eight nested watersheds draining into it.

Table 13. Receiving and nested nutrient TMDL watersheds.

Receiving/downstream nutrient TMDL watersheds		Nested/upstream nutrient TMDL watershed(s) draining to the receiving watershed listed to the left.	
HUC 12	**Narrative Description**	***HUC 12***	**Narrative Description**
10 04	Anthony Run-Dodson Creek	10 03	Headwaters Dodson Creek
10 06	Glady Creek-East Fork LMR	10 01	Turtle Creek
		10 02	Headwaters East Fork LMR
		10 04 (& nested ‘shed)	Anthony Run-Dodson Creek
		10 05	West Fork East Fork LMR
11 01	Solomon Run-East Fork LMR	10 06 (& nested ‘sheds)	Glady Creek-East Fork LMR
11 02	Fivemile Creek-East Fork LMR	11 01 (& nested ‘sheds)	Solomon Run-East Fork LMR
11 03	Todd Run-East Fork LMR	11 02 (& nested ‘sheds)	Fivemile Creek-East Fork LMR
13 03	Moores Fork-Stonelick Creek	13 01	Headwaters Stonelick Creek

3.2.6 Nutrient margin of safety

The Clean Water Act requires that a TMDL include a margin of safety (MOS) to account for any lack of knowledge concerning the relationship between load allocations, wasteload allocations, and water quality. U.S. EPA guidance (U.S. EPA, 1999) explains that the MOS may be implicit (i.e., incorporated into the TMDL through conservative assumptions in the analysis) or explicit (i.e., expressed in the TMDL as loadings set aside for the MOS). For this TMDL, both implicit and explicit MOSs are used.

Implicit MOS

The implicit margin of safety is often described as making conservative assumptions and decisions throughout the TMDL development process. The following outlines actions taken in the development of this TMDL that should be considered part of the implicit margin of safety:

- The targets developed for this provide a high degree of confidence that they will lead to the desired ecosystem response. The same numeric targets are used to address the impairments of HABs-caused public drinking water supply use and nutrient-caused aquatic life use impairments. However, two independent analyses were used to determine these values.

- As documented in the loading analysis plan (Ohio EPA, 2021), the targets directly addressing HABs were developed based on relationships of HAB occurrences and a large dataset of nutrient observations. These datasets included the U.S. Army Corps of Engineers' regular monitoring of Harsha Lake, which started in 1987, and U.S. EPA’s ORD expansive stream sampling throughout this watershed, which began in 2013. These data were used to determine stream natural background nutrient concentrations based on a reference site approach. Data preceding HABs in Harsha Lake were used to determine nutrient concentrations that will limit the production of HABs. These concentrations were then used to develop targets and the modeling approach for this TMDL.

- The other analysis that supports this project's nutrient targets considered the results of DNA metabarcoding of diatoms in the watershed's stream network. This involved DNA extraction and statistical analysis of the algae community. Community change points were identified based on the nutrient concentration from the streams where the algae were collected. This work corroborated the HAB/nutrient relationship nutrient targets and is explained in this project's Loading Analysis Plan (Ohio EPA, 2021) as sufficient justification for using those same set of targets to address the stream aquatic life use impairments. The research that went into this target setting has also been published in a peer-reviewed journal (Smucker et al., 2020) and is currently being considered by U.S. EPA as a method to develop stream nutrient concentration benchmarks elsewhere in the country.

- The watershed modeling in this project was developed and calibrated using the same robust set of observations that went into developing the targets. Section 3.1 and cited works within that section document how these observations go well beyond the minimum requirements to develop a SWAT model. The section further documents the probabilistic style of sensitivity and calibration analysis utilized in model development. An independent set of observations were then used to verify the model was calibrated and acceptable.

- This SWAT watershed modeling has been developed by federal researchers working at an academic level. Section 3.1 explains the Karcher et al. (2013) publication and forthcoming Nietch et al. (in revision), which are peer-reviewed efforts written specifically about the East Fork LMR SWAT modeling. This illustrates that the scientific rigor for this modeling goes well beyond what is typically employed for TMDLs.

- Section 3.1 describes the part of the long-term water quality monitoring throughout the watershed that is used for this TMDL development, though not for the SWAT model development. These data are used to tune the watershed model outputs for this TMDL project. This is done by adjusting the model output's distribution to fit the median of the observed distribution. Typical SWAT model development calibrates to larger watersheds (such as an 8-digit HUC or a collection of 10-digit HUCs) rather than to the single 12-digit HUC management units. However, the TMDLs for this project are developed for 12-digit HUCs or smaller watersheds. This model output tuning allows for more accurate existing conditions to be used for setting TMDL allocations.

- Section 3.2 outlines the method for setting the TMDL loading capacity. This method is developed using a practical approach to shifting the distributions of water quality pollutants. Compared to other TMDL loading capacity methods that focus on just a central tendency of model results, such as the average or median load, this method provides for a more real-world approach. It encompasses the reality that periods of greater and lesser loads exist while still being protective of the water quality targets.

- Also unique to this project, as described in Section 3.2, is that the natural background loads are reserved independently. This TMDL can separate these background loads from the anthropogenic nonpoint sources due to the water quality monitoring throughout the watershed. This also provides a margin of safety by significantly limiting the nonpoint source allocations to pollutants due to human land uses. Whether this should be considered an implicit or explicit margin of safety is discussed below.

- A single nonpoint source load allocation is set for each watershed's nutrient TMDL. The modeling results could be used to break down nonpoint sources of nutrients (i.e., from row crop agriculture, non-regulated developed land, etc.). However, Section 3.2.4 outlines that that detail is not used to prescribe source-specific load allocations. Part of the reason for this is to minimize the amount of modeling computational uncertainty that would be passed along to the TMDL allocations.

- Section 3.1 contains an example of how the calibrated SWAT model uncertainty has, and can, be used above to develop implementation scenarios. The example describes a conservative application of the model to ensure success at meeting water quality goals. While this practice does not impact the modeling used to determine TMDL allocations, it should be considered another aspect of implicit MOS employed for this project.

Explicit MOS

The information above shows that this project employs a great deal of scientific rigor and conservative assumptions that should be considered part of the implicit MOS. However, quantifying these measures presents a real problem. Dilks and Freedman (2004) note that if a TMDL only uses implicit MOS, there exists no guidance as to what is appropriately conservative. This renders the magnitude of MOS unknown.

For instance, separating the natural background load from the anthropogenic nonpoint source allocation was noted above. While this seems like a reasonable measure to consider as an MOS, there is always a natural background of nutrients in surface waters. Therefore, reserving such a natural background can be considered something that should always be done. Given that point of view, the amount of load reserved for the natural background should certainly not be described as an explicit MOS. Even considering this as an implicit MOS could be called into question. Picking a proportion of the amount of this load that could be stated as MOS would be, at best, a guess. Extending this argument, quantifying how much MOS results from the extensive scientific rigor used for target settings and modeling would be even more opaque.

The concrete aspect of an explicit MOS, with a finite amount of load reserved, is therefore considered for this project. The often-stated goal for setting explicit TMDL MOS is to somehow base it on quantified uncertainties in estimating pollutant loadings and water quality responses (U.S. EPA, 1999). However, a scholarly review of over 100 TMDL projects with explicit MOSs found all but one of them selected safety factors arbitrarily (as reported in Dilks and Freedman, 2004). Due to this, a National Research Council report on TMDLs made a renewed call for uncertainty analyses be used as the basis for MOS setting (NRC, 2001).

Turning a model's uncertainty analysis into an explicit TMDL MOS however, is not a straightforward task. Zhang and Yu (2004) point out that no uniform guidance has been distributed by U.S. EPA or others to TMDL developers for MOS calculations. That paper also notes that model uncertainty alone does not account for all unknowns that could warrant load being reserved. For instance, hydrology, specifically the metrological events that drive hydrology, greatly dictates the magnitude and timing of nonpoint sources of pollutant loads. Accounting for the natural randomness in precipitation is suggested as a consideration for MOS calculations that lies outside of traditional watershed model uncertainty analysis.

The Dilks and Freedman (2004) paper outlines four attributes for a proper TMDL MOS: "1) account for uncertainty in TMDL calculation; 2) consider the degree of protection; 3) address data limitation/implementation concerns; and 4) be feasible to conduct on a widespread basis." The following considers the MOS for these nutrient TMDLs in light of these four attributes.

1) Account for uncertainty in the TMDL calculation:

    Section 3.1 explains how the modeling uncertainty analysis is developed for this watershed's SWAT model. A practical application of using this model uncertainty is presented for making implementation scenarios. Directly relating this model uncertainty to an explicit TMLD MOS is not proposed for this TMDL project.

    Zhang and Yu (2004) discuss various considerations in calculating explicit MOSs for TMDLs. As noted above, these authors note that factors driving pollutant sources, such as precipitation in nonpoint source dominated systems, should be considered in addition to traditional modeling variation. They also suggest that MOS allocation scenarios be considered when setting MOS.

    Nonpoint sources deliver most nutrients to the East Fork LMR watersheds, which receive nutrient TMDLs. Zhang and Yu (2004) present a case study of an MOS calculation method that shifts to applying more explicit MOS, as more allocations lean towards nonpoint sources. This suggests the obvious reality that nonpoint sources are, by nature, more variable than point sources, which are largely from highly controlled wastewater treatment plants.

    Based on these factors, for the East Fork LMR TMDL, the nonpoint source dominance of loads explains that having some explicit MOS is certainly needed.

2) Consider degree of protection:

    The Dilks and Freeman (2004) paper notes that scientific credibility in setting a MOS is important; however, the degree of protection that the TMDL will result in water quality goals is, "ultimately a policy decision." Several aspects of this project noted above in the considerations of the implicit MOS are applicable here. This project has two high quality target setting methods, academic-level watershed modeling, and specific allocations of the natural background load – all of which are based on comprehensive water quality monitoring datasets. This list demonstrates broad scientific rigor leveraged to develop the TMDL. And it justifies moderating an explicit MOS.

3) Address data limitation/implementation concerns:

The smaller the dataset used to make a prediction, the lower the certainty of the results of that prediction. Therefore, it is practical to consider that the amount of explicit MOS should, at least partially, be based on the wealth of information used to make the TMDL decisions. The water quality data used to develop the East Fork LMR TMDL is continuous since 2008. Thirty monitoring points are sampled regularly, most every other week. Synthesis of these data was carried out by federal researchers and their collaborators.

The initial implementation plan for this TMDL, Section 6 of this report, and the Reasonable Assurances to be written for this project's forthcoming draft TMDL explain the existing water quality implementation efforts in the East Fork LMR watershed. In short, there is a very active, results-focused network of natural resource protection practitioners. The U.S. EPA federal research interest continues to provide support to these efforts facilitated via the East Fork Watershed Cooperative. As explained in Section 3.1, the watershed model used to develop this TMDL has already been applied to predict the effectiveness of best management practices. That example explains how the calibrated model's uncertainty analysis was used to set practice goals in a conservative manner.

Overall, this is a data-rich watershed already active in pollutant reduction implementation actions. Concerns about data and/or implementation weaknesses are minimal. No additional explicit MOS is required due to consideration of these factors.

4) Be feasible to conduct on a widespread basis:

The Dilks and Freedman (2004) paper explains this component to mean that a MOS approach is straightforward enough that TMDL developers can practice the method and that stakeholders can understand. The federal research partners to this project certainly can calculate an explicit MOS mathematically tied to model and/or other quantifiable uncertainties. However, it is the intent of this TMDL, being one of Ohio's Vision TMDL projects, to present new concepts in TMDL development. This consideration of attributes that weigh into determining an MOS is an approach that Ohio-developed TMDLs can adhere to in a feasible fashion henceforth. It also provides for a weight-of-evidence approach that allows for less quantifiable aspects to be part of an explicit MOS setting. And therefore, is overall more feasible than a straight statistically calculated explicit MOS.

As noted above, Feedman et al. (2002) reviewed over 100 TMDLs with explicit MOS and found all but one were selected "arbitrarily." More recent research, however, considered the meaning of arbitrary in the sense that no definitive guidance is provided to jurisdictions for developing MOS. Nunoo et al. (2020) used language processing software to analyze 150 MOS explanations randomly selected from 38,000 approved TMDLs. The study reported that 84% of these TMDLs did not outline mathematical calculation methods that went into setting MOS. However, all these TMDLs did provide justifications. It is important to stress that all the TMDLs examined were approved by U.S. EPA. The authors of that study, therefore, suggest that the secondary dictionary definition of the word arbitrary, "depending on individual discretion and not fixed by law," should strongly be considered. With no formal guidance on how to calculate MOS, this definition seems to fit and justifies such qualitative approaches to determining explicit MOSs as reasonable. In summary, arbitrary MOS selection in the sense that it is randomly picked out of the air is not reasonable but arbitrary in that it is determined in a case-by-case manner does have merit.

Continuing with the concept of feasibility, the exact nature of an explicit MOS should be considered. Explicit MOSs are most often applied by reserving a proportion of the loading capacity. This reduces the loading capacity available for allocations. Unless an approved TMDL is officially reevaluated, this reserved load remains untouched in perpetuity. Because of this permanence, assessing the feasibility of an explicit MOS should consider more than just if it can be easily calculated or understood.

The NRC (2001) report noted above that called on the MOS in TMDLs to be based more often on uncertainty analyses, observing that explicit MOS can be so large that it is inefficient and costly. Dilks and Freedman (2004) state that explicit MOS tied directly to model uncertainty can result in so much MOS that implementation is impractical. With TMDL pollutant reduction needs compounded by excessive MOS, stakeholder reluctance to implement reduction practices can peak (Nunoo et al., 2020). This means extensive, costly, and most likely unattainable pollutant reductions would be required. Inflicting such costs, especially with the good chance of unsuccessfully meeting water quality goals, is altogether untenable. In short, explicit MOSs can be set too high.

Zhang and Yu (2004) suggest one way to address this is to calculate a maximum MOS and adjust down from there based on local specifics. As noted throughout this discussion, that paper considered determining the most variable quantitative component in the TMDL development and applying to it a first-order error analysis. The example those authors provide considered regional precipitation variability resulting in a maximum explicit MOS of 10%. The same analysis was carried out for each local TMDL watershed, yielding a 10% or lower explicit MOS for each waterbody.

While the first-order error analysis presented by Zhang and Yu (2004) is an elegant solution to solving the MOS problem, it does not take into consideration less quantifiable implicit safety measures. Organizing those measures via the four attributes outlined above allows for a more weight-of-evidence approach to setting an explicit MOS. The idea of a standard explicit MOS to be used as an anchoring point, however, is worth a closer look. The value of 10% is repeated again and again in the literature cited in this discussion. Nunoo et al. (2020) suggest that the myriad existing TMDLs having used 10%, based on extremely variable justifications, may have established an "unconscious standard." Those authors state that this could be compared to the overwhelming scientific consensus to use 0.05 as the bar for statistical significance in hypothesis testing.

Given this discussion, Ohio EPA proposes to anchor explicit MOSs at 10% of the TMDL loading capacity. Various project particularities, both quantitative and qualitative, will be used to adjust from this anchor for each project. Adjustments may increase or decrease the explicit MOS based on project details as described above using the four attributes proposed by Dilks and Freedman (2004).

The first attribute of a proper MOS, discussed above, for the East Fork LMR's nutrient TMDLs notes that an explicit MOS should certainly be considered. The remaining three attributes provide justifications for moderating this MOS. For this moderation, it is reasonable that the 10% explicit MOS anchor can be significantly adjusted downwards. However, many of these justifications are unquantifiable and related to aspects discussed in the implicit MOS considerations above. Therefore, bifurcating the 10% MOS can not be mathematically solved. The most non-arbitrary, fair manner of this division is, therefore, to halve the anchor point. Taking half of a value for calculations has been used extensively in environmental calculations as an equitable measure when quantifying factors are limited. For instance, when the upstream water quality of a parameter needed to calculate a permit wasteload allocation is below analytical reporting level, Ohio EPA uses half of that parameter's reporting level for the calculation.

The result of this discussion is the use of an explicit MOS of 5% for this project's allocatable nutrient TMDL loads. The allocatable load is the loading capacity minus the background load; see Section 3.2.1 for details.

3.2.7 Nutrient allowance for future growth

An allowance for future growth (AFG) in a TMDL can be used to "account for reasonably foreseeable increases in pollutant loads" (U.S. EPA, 1999). Some TMDL projects provide an explicit amount of load, often calculated as a proportion of the target. The AFG used in a TMDL is often tied to observed and expected human population growth and shifts in industrial activities that may impact the production and delivery of pollutants. Having AFG set aside in a TMDL can be useful for permitted point sources, especially when new facilities are proposed after a TMDL is developed and endorsed by U.S. EPA.

Human population projections do not predict a large influx of people in the part of the East Fork LMR watershed receiving nutrient TMDLs. Brown, Clinton, and Highland counties are all expected to see population declines from 2020-2030 (Mehri et al., 2020). Clermont County is projected to experience a small population increase. However, it is reasonable to expect most of that increase to occur in the western portion of the county that is geographically connected to the Cincinnati metro area; the nutrient TMDLs predominantly cover the eastern portion.

While only a small amount of population growth is expected for the nutrient TMDL watersheds, Ohio EPA prioritizes the regionalization of municipal wastewater treatment whenever feasible. Because of this, it is recognized that some load reserved for future growth is prudent. This would allow for new or expanding wastewater treatment plants to be allocated some of this additional load, providing adequate nutrient reduction efforts are made. An allowance for future growth load of 2% is reserved for both TP and TN from allocatable nutrient TMDL loads.

3.2.8 Allocation adjustments

This subsection describes slight adjustments that were made to the final TMDL allocations. These adjustments were required because the allocation methods described up to this point in this report were not adequate in two small, partial HUC-12 watersheds. In the initial TMDL allocations for the partial HUC-12s of Back and Ulrey runs (both in the 12 03 HUC 12) the wasteload allocations calculated for the discharging wastewater treatment plants exceeded the initial available allocatable load. This situation applies to TP in both watersheds and only the TN for Back Run.

To address the lack of available loading capacity, small reductions in the load allocations of the other nutrient TMDL watersheds upstream of Harsha Lake are made. This results in increased available load to accommodate the wasteload allocations for Back and Ulrey runs' TMDLs. These small watersheds are only impaired due to the impairment of public drinking water supply use in Harsha Lake; see Table 1. Because these nutrient TMDLs do not also address aquatic life use impairment, this method of increasing the loading capacity while making up for it by reducing other watersheds upstream of Harsha Lake is appropriate.

Only enough load was transferred from the other watersheds to accommodate Back and Ulrey run' WLAs. This means that the nonpoint source load allocations and stormwater-based wasteload allocations for Ulrey and Back runs are zero. These are very small watersheds with the majority of landcover in natural uses (i.e., forests and wetlands). Expecting nutrient loads to be at or near background levels with minimal implementation efforts is reasonable.

The calculations to determine how much load allocation to reduce from the other watersheds upstream of Harsha Lake nutrient is based on each watershed's allocatable load available after the discharging wastewater treatment plants wasteload allocations, the MOS, and AFG were reserved. The next step determined the proportion of this remaining load allocation from each TMDL watershed compared to the total load allocations for all these upstream of Harsha watersheds. Then, that proportion determined for each watershed was multiplied by the total amount of needed load for Back and Ulrey run. Note that only the load allocation contributed from a watershed is used for these calculations. The load downstream watersheds receive from nested watersheds is not included.

The following provides an example of this calculation. This example shows how the load removed from the upstream Harsha Lake HUC-12 10 05 was determined. The combined needed amount of TP load for Back and Ulrey run is 107 kg/year. The initial TP allocatable load, after reserving the allocations noted in the above paragraph, for the HUC-12 10 05 is 684 kg/year, and the sum of this available load for all the upstream Harsha Lake watersheds (excluding Back and Ulrey) is 7,384 kg/year. Since 684 divided by 7,384 is 9.26%, that percentage is multiplied by the needed 107 kg/year. This results in 9.9 kg/year of TP load allocation that is reduced from HUC-12 10 05 and given to Back and Ulrey runs. This reduces HUC-12 10 05's load allocation to 674 kg/year. (Note that the results section shows a load allocation for this HUC 12 as 673 kg/year. This is because the discharging HSTS reduces the load allocation by 0.8 kg/year.)

3.2.9 Nutrient seasonality and critical conditions

Federal regulations (40 CFR 130.7(c)(1)) require that TMDLs take into consideration seasonal variation in watershed conditions and pollutant loading. Seasonal variation was accounted for in the nutrient TMDLs by the continuous monitoring and modeling of nearly 20 years of pollutant loads.

The critical condition can be thought of as the "worst case" scenario (low flow, high temperature, etc.) of environmental conditions in the water body for which the loading expressed in the TMDL will continue to meet water quality standards. This project's nutrient TMDLs address both near- and far-field beneficial use impairments. This document and this project's LAP (Ohio EPA, 2021) explain that it is acceptable to use the same TMDL targets and methods to address both impairments. However, seasonality and critical conditions considerations drastically vary for each impairment.

For the near-field, aquatic life use impairments in this watershed, eutrophic or nutrient enrichment conditions exert biological stress due to rapidly shifting dissolved oxygen. In addition, many assessment sites in this watershed are impaired due to organic enrichment. This type of enrichment impacts aquatic life use by persistent low dissolved oxygen. This project's LAP (Ohio EPA, 2021) linked excessive nutrients to driving the impact of organic enrichment as well. Dodds, 2006 outlined that a stream system can be pushed to such a net heterotrophic state when excessive instream organic growth accumulates (referred to as autochthonous sources).

Instream enrichment issues are typically exacerbated when streamflow is low, temperatures are high, and daylight hours are long—all conditions associated with summer months. These conditions are the times that algae are least likely to be limited by anything other than nutrient availability (i.e., there is abundant solar energy and optimal growth temperatures). While this condition is most prevalent in summer months' low flow conditions, nutrients deposited in streams at the end of higher flow events also contribute to near-field concerns (Dodds, 2006 refers to this material as allochthonous sources). Due to these factors of pollutant delivery, the spring and even winter months must also be considered when addressing near-field impairments.

Pollutant seasonality considerations for the far-field drinking water HABs impairment differ. While the HABs of concern for this impairment grow in the summer months in Harsha Lake, their growth is in response to longer-term nutrient loadings. The lake's average water residence time is 737 days (calculated by U.S. EPA using 1997 through 2017 data following the methods outlined in Francy et al., 2015). This partially reflects the elongated dimensions of this run-of-the-river reservoir. Distribution forces moving nutrients, especially in the dissolved form, through the lake are expected to take time that could be as long as the stated residence time. Further, nutrients, especially in the particulate form, are present in the lake's bed. Biogeochemical reactions can make these bed-bound nutrients available for HAB growth through the process known as internal loading. Due to these factors, nutrients delivered throughout the year are important to addressing the HAB impairment.

Addressing the HAB impairment shifts the seasonality concerns from *when* to *how* much nutrients are exported. Large storm events in the spring result in most of the phosphorus export. Nitrogen export after storm events is well documented. Given that this TMDL takes on both near- and far-field impairments at the same time, a resulting single critical condition is not specified.

This seasonality discussion has geographic implications. Nutrient reduction anywhere in the watershed upstream of Harsha Lake helps address the far-field impairment. Were this the only protected use this TMDL applies to, it would be acceptable if one TMDL watershed reduced more nutrients than its target by the same margin that another watershed did not meet its target. However, each aquatic life uses impaired nutrient watershed must meet its target to restore that beneficial user's expectations. When considering nutrient reduction implementation, if all other factors are equal, actions should be prioritized in the TMDL watersheds identified to address both impairments.

3.3. Atrazine TMDL allocation methods

This section describes an empirical TMDL calculation method to address the impairment of public drinking water supply use for the village of Blanchester for the atrazine pesticide. This is an appropriate approach given the sole-source nature of atrazine and the robust dataset available to describe the existing conditions.

3.3.1 Modeling and allocation methods

There is only one source of atrazine. It is the nonpoint source runoff from row crop agricultural pesticide use. Because of this, there are no point sources of atrazine and no wasteload allocations in this atrazine TMDL. Additionally, there is no natural background for atrazine. This simplifies the allocation of the TMDL's loading capacity. All loads, minus what is reserved for explicit MOS, are allocated to the nonpoint source load allocation.

Ohio's 303(d) impairment assessment of the village of Blanchester's public drinking water supply use attainment is due to atrazine pesticide levels in source water and treated water. The source water is blended from three stream sources (those sources are further discussed in Section 2.2 of this report). Because the water quality standard is determined at the blended point of multiple water sources, the TMDL calculations are developed for this combined, blended water source.

The assessment of Blanchester's atrazine in Section 2.2 presents evidence of atrazine pollution being driven by hydrologic events. A U.S. EPA (2007) guidance document outlined various methods for expressing TMDLs, given different considerations. Based on this guidance, a flow variable expression is appropriate for this TMDL. A flow variable TMDL expression results in a greater TMDL load capacity as stream flows increase. To develop this flow variable expression, a load duration curve (LDC) will be utilized for this TMDL.

To determine long-term flows for the LDC, the drainage area yield method is used with the closest, most appropriate USGS gage with a long-term streamflow record. The USGS gage O'Bannon Creek near Loveland, OH (03244936) is used to develop the flow records for the blended source waters that contribute to Blanchester's drinking water. The sum of the three stream water sources' drainage areas is used for the blended drinking water's drainage area in the flow calculation. The O'Bannon Creek gage's drainage area is 54.5 mi^2, and the combined three drinking water sources drainage area is 22.1 mi^2. The LDC's flow record is set as the same period analyzed with a concentration duration curve in Section 2.2 (Figure 9). This is October 2004 through January 2020, and pairs with the existing dataset of atrazine observation data from the Syngenta Atrazine Monitoring Program.

A load duration curve is generated by plotting the product of a target pollutant concentration and the values of a flow duration curve (FDC). An FDC is the cumulative frequency of the daily mean flows that are ordered based on flow magnitude without consideration of the date or the time of year at which the flow occurred. The cumulative frequency is arranged from the highest magnitude flows to the lowest. From this, the percent of time (i.e., measured in the number of days) that a given flow is exceeded is expressed along the x-axis of the curve. The highest flows are exceeded at the lowest frequency, and the lowest flows are exceeded at the highest frequencies.

The TMDL target for this impaired beneficial use is based on a 90-day average community action standard of 3.0 µg/L. This concentration value is used to develop the TMDL via the LDC method. However, since the standard is based on a 90-day average, a further step is taken. The 2007 U.S. EPA guidance explains various methods for expressing TMDLs as a daily value when developed for standards that have non-daily durations. This guidance specifies a method to calculate a maximum daily limit (MDL) for maintaining non-daily standards when data are lognormally distributed as the following equation:

$$MDL = LTA \cdot \exp(Z_p \sigma_y - 0.5\, \sigma_y^2)$$

where

LTA = long term average of water quality standard

Z_p = the z-score associated with the target recurrence interval

$\sigma_y = \sqrt{\ln(CV^2 + 1)}$

CV = coefficient of variation of the untransformed data

The LTA is 3.0 µg/L, which is based on the water quality standard. The z-score of 2.291 was derived from an averaging period of 90 days, which yields a recurrence interval of 98.9%. The coefficient of variation was calculated using the complete blended raw Blanchester intake water dataset (discussed in Section 2.2). This value was calculated as the division of the mean (1.47 µg/L) of the 556 samples by the standard deviation (3.28 µg/L).

This results in an MDL for the Blanchester's blended raw drinking water of 31.9 µg/L.

In this application, the MDL calculation is applied to the atrazine concentration standard, which results in a concentration. The U.S. EPA 2007 guidance presents this method for calculating the actual TMDL load for static (i.e., non-flow variable) pollutants with non-daily standards. The application of this method here is more similar to how it is presented in Appendix B of the U.S. EPA guidance. That appendix calculates such an MDL to develop a concentration-based TMDL. However, this is not a concentration-based atrazine TMDL. Rather, the MDL concentration is applied to the flows throughout this TMDL's LDC. Therefore, the MDL in this effort is more in line with determining a value analogous to a single day maximum concentration of atrazine that, over the course of 90 days, would indicate the likelihood of exceeding the 90-day average. Including this MDL along with the TMDL LDC is intended to aid in monitoring and implementation of pollutant reduction efforts.

3.3.2 Atrazine margin of safety

The nutrient TMDL MOS (Section 3.2.6) explains the MOS procedure which Ohio EPA intends to employ moving forward from this Vision TMDL project. More briefly, the same process is examined here for this atrazine TMDL. This starts with outlining the factors that contribute to an implicit MOS. Based on these factors and other elements of this TMDL, four attributes that have been suggested as required for a proper MOS are examined. These considerations are then used to determine the amount of explicit MOS required for this TMDL, if any.

Implicit MOS

The following outlines actions and considerations taken in the development of this TMDL that should be considered part of the implicit margin of safety:

- The targets are based on a water quality standard codified in OAC 3745-1-33(A) Table 33-1, which follows recommendations from U.S. EPA. Rather than targets developed expecting to result in a certain ecological response that would restore waters to full attainment of beneficial use, like the nutrient TMDLs in this project, meeting the atrazine targets inherently meets the public drinking water supply use. This reduces a great deal of uncertainty because once pollutant reductions meet the target, for a reasonable amount of time, the water quality standard will automatically be met. This is considered a significant implicit MOS.

- The monitoring used to develop this TMDL, presented in Section 2.2, features a great deal of continuous samples over a very long period. This reduces uncertainty in the understanding of the nature of atrazine pollution in this setting.

- Atrazine has only one source in this watershed. This greatly reduces many uncertainties. There is no uncertainty about what the source of the pollutant is. This allows more attention to be placed on the where, when, and how of atrazine applications in this watershed that result in runoff to the drinking water source waters. The fact that the three drinking water sources combined watershed drainage area is so small, 22.1 mi^2, further reduces the uncertainty that this TMDL will result in recovery of the beneficial use. In short, the smaller area and sole source nature of this TMDL significantly add to the reasonable assurances that improvements to this impairment can be achieved.

Explicit MOS

Dilks and Freedman (2004) outline four attributes for a proper TMDL MOS: “1) account for uncertainty in TMDL calculation; 2) consider degree of protection; 3) address data limitation/implementation concerns; and 4) be feasible to conduct on a widespread basis.” The following considers the MOS for this project in light of these four attributes. These factors are considered to help determine if and how much explicit MOS is required for this TMDL.

1) Account for uncertainty in the TMDL calculation:

An empirical, data-driven approach is used to calculate this atrazine TMDL. The method determines the loading capacity based on the target concentration multiplied by whatever water volume is present in Blanchester’s drinking water source. While very straightforward, this method is acceptable because there is a single pollutant source, and meeting the concentration target over a certain duration automatically results in recovery of the impaired water quality use. This also results in very low loading capacity calculation uncertainty.

Source delivery is more complicated. Zhang and Yu (2004) suggest that more explicit MOS is required, the more allocations lean towards nonpoint sources. The delivery of atrazine is exclusively a nonpoint source. It is driven by hydrologic events that coincide with the pollutant’s application as a row-crop pesticide. Application best practices recommend avoiding times when weather events are forecasted, but weather forecasting, like all modeling, is not foolproof. This uncertainty justifies some degree of explicit MOS.

2) Consider degree of protection:

As explained above, meeting target concentrations, given a certain duration, will result in the delisting of this impaired use. This is a less complicated linkage compared to most aquatic life use and algal impairments. Because of this, the degree of protection from reducing atrazine runoff from drinking water sources is robust. Therefore, no additional explicit MOS is called for due to this attribute.

3) Address data limitation/implementation concerns:

As stated in the nutrient MOS, the smaller the dataset used to make a prediction, the lower the certainty in the results of that prediction. Because of the Syngenta Atrazine Monitoring Program, a very robust dataset of existing atrazine concentrations is available. This allows for a detailed examination of conditions, such as the determination of a critical condition explained in Section 2.2. This monitoring program ended in January 2020. Future monitoring will be based on Blanchester's drinking water permit compliance requirements, which monitor at a lower frequency than the Syngenta program. However, since these data are directly used to determine use attainment, these cannot be considered a limitation. Because of this, no additional uncertainty occurs due to data paucity requiring additional explicit MOS.

4) Be feasible to conduct on a widespread basis:

Ohio EPA's new approach to MOS calculations, being initially presented in this TMDL project, follows a practical weight-of-evidence approach. Instead of picking a finite single or set of analytical methods/equations, uncertainty from all expectations is considered. These factors are used to determine if an explicit MOS is justified. If one is justified, then the amount greater than or less an anchor of 10% is determined. This approach is considered more feasible than other strictly analytical alternatives and less arbitrary (see Section 3.2.6 for more detail).

The above considerations explain that an explicit MOS is deemed necessary. Given the empirical calculation and target concentrations directly tied to impairment standards increasing the 10% MOS anchor is not justified. Considering the exclusively nonpoint source and weather driven nature of atrazine pollution, there is no reasonable cause for reducing the 10% anchor.

The result of this discussion is that 10% of the atrazine loading capacity will be reserved as an explicit MOS.

3.3.3 Allowance for Future Growth

Given that atrazine in waters is only from nonpoint source runoff due to its row-crop pesticide use, there is no reasonably foreseeable increase in its pollutant load. Rather a reduction of this pollutant from this sole source is required to occur, or be documented, to achieve desired beneficial use expectations. Because of these factors, no allowance for future is allocated in this atrazine TMDL.

3.3.4 Seasonality and Critical Conditions

The source atrazine discussion for the Village of Blanchester's drinking water sources, Section 2.2, explores the seasonality of atrazine pollution. Most elevated atrazine concentrations coincide with the springtime conditions when the pesticide is applied to row crops. Hydrologic events drive the runoff of this atrazine.

Existing best management recommendations for the application of atrazine consider its runoff potential. Applications should avoid periods when storm events are forecasted.

Section 2.2 also examined data from the Syngenta Atrazine Monitoring Program to determine a critical condition. This analysis found that the 90-day period from April 15 to July 13 captures the most elevated atrazine concentrations in these source waters. Though it was noted that detectable atrazine remains in the village's water systems for several months after that period. Still, the elevated atrazine concentrations during the April 15 to July 13 period, and general understanding of when atrazine is applied, indicates that pollution reduction implementation resources should focus on this critical condition.

Two consecutive years did experience elevated concentrations outside of the identified critical condition. These occurred in the late winters of 2008 and 2009. It is suspected that fall atrazine application was responsible for those periods.

Even though a critical condition period has been delineated, this TMDL is applicable year-round. The 2008 and 2009 winter occurrences are one justification for this application. Further justification comes from the fact that the blended raw drinking water for Blanchester is somewhat disconnected from elevated stream sources. Section 2.2. documents the suspected reasons for this disconnect. To make this TMDL applicable year-round, the LDC is presented across all flow regimens.

4. Results

This section presents the results of the TMDL allocations.

4.1. Nutrient TMDL allocations

As explained in subsection 3.2.1, the nutrient TMDLs are calculated by shifting the distribution of existing pollutant loads. Figures 15 and 16 illustrate this concept, with the blue lines on each panel of these figures representing the TMDL. To present a single TMDL value for each watershed, average values from these distributions are calculated. The various allocations are also calculated at this average point in the TMDL reduced distributions. While this facilitates the simple reporting of these TMDLs, the distribution of loads reduced to meet the nutrient targets should be considered the actual goal of this effort. The TMDL distribution figures for each watershed are presented in Appendix 1. Results tables showing various percentiles of the allocation distributions presented as annual and/or daily expressions are available upon request from Ohio EPA.

Table 14 shows the results of the TP allocation for major groups and the total TMDL for each watershed. Table 15 shows the same for TN. Results in Table 14 and Table 15 are rounded to the nearest integer of kg/year. Tables 16 and 17 present the WLAs for each watershed broken down by major permitted categories for TP and TN, respectively. Several of these WLA categories are based on general permits. The discharging facilities and facility-based stormwater individual-permitted facilities are further subdivided, with the WLAs listed for each facility in Table 18. Results in Tables 16, 17, and 18 are rounded to the nearest tenth of kg/year. The same average facility-based WLAs from Table 18 are presented in Table 19 in the units of kg/day rounded to the nearest hundreths of kg.

As explained in Section 3.2.5, upstream allocations had to be accounted for in downstream nutrient TMDL watersheds. In essence, allocations are carried on to the downstream TMDLs wherever this occurs. Because of this, the WLA for individual discharging facilities and individual stormwater facilities in Tables 16 and 17 do not sum to the rows for the same assessment units in Table 18. The map in Figures 2 and 3 and Table 13 can be used to determine which upstream nested nutrient TMDL watersheds drain to downstream receiving ones. For example, in order to account for all of the phosphorus individual discharging facilities' WLA for the 11 02 assessment unit on Table 16, the sum of all phosphorus individual discharging facilities' WLAs from Table 18 for its upstream watersheds (assessment units 10 02, 10 03, 10 06, 11 01, and 11 02) must be calculated.

Table 14. Average annual TP TMDL total allocations in kg/year.

Assessment Unit	Narrative Description	Background	Load allocation	Wasteload allocation	Explicit MOS	AFG	TMDL TOTAL
10 01	Turtle Creek	1,357	496	8	28	11	**1,900**
10 02	Headwaters EK LMR	2,076	636	135	42	17	**2,907**
10 03	Headwaters Dodson Ck	1,067	354	42	22	9	**1,493**
10 04	Anthony Run-Dodson Ck	2,479	884	43	50	20	**3,478**
10 05	West Fork East Fork LMR	1,824	673	1	37	15	**2,549**
10 06	Glady Creek-EK LMR	9,708	2,796	883	198	79	**13,663**
11 01	Solomon Run-EK LMR	13,043	3,801	1,139	266	107	**18,356**
11 02	Fivemile Creek-EK LMR	15,518	3,855	2,030	316	127	**21,847**
11 03	Todd Run-EK LMR	17,218	4,450	2,068	351	140	**24,227**
12 01	Poplar Creek	1,965	712	17	40	16	**2,750**
12 02	Cloverlick Creek	5,559	1,964	95	112	45	**7,775**
12 03 – Partial	Ulrey Run	170	0	138	5	2	**314**
	Back Run	180	0	142	5	2	**328**
	Slabcamp Run	238	88	0	5	2	**333**
12 04 – Partial	Backbone Creek	546	174	39	11	5	**775**
13 01	Headwaters Stonelick Ck	1,230	367	110	26	10	**1,742**
13 02	Brushy Fork	1,077	266	144	22	9	**1,517**
13 03	Moores Fork-Stonelick Ck	2,311	708	201	49	20	**3,289**
13 05 – Partial	Hall Run	383	7	142	8	3	**542**

Table 15. Average annual TN TMDL total allocations in kg/year.

Assessment Unit	Narrative Description	Background	Load allocation	Wasteload allocation	Explicit MOS	AFG	TMDL TOTAL
10 01	Turtle Creek	9,806	5,637	142	311	125	**16,021**
10 02	Headwaters EK LMR	16,539	8,355	1,394	525	210	**27,023**
10 03	Headwaters Dodson Ck	8,947	4,883	389	284	114	**14,617**
10 04	Anthony Run-Dodson Ck	18,591	10,489	463	589	236	**30,369**
10 05	West Fork East Fork LMR	15,964	9,347	49	506	202	**26,069**
10 06	Glady Creek-EK LMR	80,098	38,091	9,205	2,543	1,017	**130,953**
11 01	Solomon Run-EK LMR	102,427	48,404	12,080	3,253	1,301	**167,465**
11 02	Fivemile Creek-EK LMR	123,442	47,757	25,149	3,920	1,568	**201,836**
11 03	Todd Run-EK LMR	133,190	52,605	26,060	4,230	1,692	**217,777**
12 01	Poplar Creek	14,368	8,013	452	456	182	**23,471**
12 02	Cloverlick Creek	38,226	21,215	1,300	1,213	485	**62,438**
12 03 – Partial	Ulrey Run	1,960	39	1,118	62	25	**3,204**
	Back Run	1,500	0	1,134	53	21	**2,708**
	Slabcamp Run	1,765	1,035	5	56	22	**2,884**
12 04 – Partial	Backbone Creek	4,757	2,159	655	151	61	**7,782**
13 01	Headwaters Stonelick Ck	9,970	4,768	1,131	317	127	**16,313**
13 02	Brushy Fork	9,273	4,031	1,464	295	118	**15,182**
13 03	Moores Fork-Stonelick Ck	20,850	9,652	2,651	661	265	**34,079**
13 05 – Partial	Hall Run	3,599	41	2,084	114	46	**5,884**

Table 16. Average annual TP TMDL wasteload allocations by major category in kg/year.

Assessment Unit	Narrative Description	Indi. Dis. facilities	General Dis. HSTS	MS4	Indi. SW facilities	Gen. SW facilities	Gen. Const. SW	WLA TOTAL
10 01	Turtle Creek	0.0	0.3	0.0	8.1	0.0	0.0	**8.4**
10 02	Headw. EK LMR	134.8	0.3	0.0	0.0	0.0	0.3	**135.4**
10 03	Headw. Dodson Ck	37.0	0.2	0.0	0.0	4.7	0.0	**41.8**
10 04	Anthony Rn-Dodson Ck	37.0	1.8	0.0	0.0	4.7	0.0	**43.4**
10 05	WK EK LMR	0.0	0.8	0.0	0.0	0.0	0.0	**0.8**
10 06	Glady Ck-EK LMR	863.1	6.4	0.0	8.1	4.7	0.3	**882.5**
11 01	Solomon Rn-EK LMR	1,111.9	13.4	0.0	8.1	4.7	0.6	**1,138.7**
11 02	Fivemile Ck-EK LMR	1,983.0	25.5	7.8	8.1	4.7	0.6	**2,029.6**
11 03	Todd Run-EK LMR	1,983.0	41.7	23.1	8.1	4.7	7.5	**2,068.1**
12 01	Poplar Creek	0.0	8.1	0.0	0.0	0.0	9.2	**17.3**
12 02	Cloverlick Creek	77.8	17.5	0.0	0.0	0.0	0.0	**95.3**
12 03 – Partial	Ulrey Run	138.3	0.0	0.0	0.0	0.0	0.0	**138.3**
	Back Run	141.7	0.0	0.0	0.0	0.0	0.0	**141.7**
	Slabcamp Run	0.0	0.2	0.0	0.0	0.0	0.0	**0.2**
12 04 – Partial	Backbone Creek	0.0	2.8	31.9	1.5	0.0	2.4	**38.6**
13 01	Headw. Stonelick Ck	103.7	6.1	0.0	0.0	0.0	0.0	**109.8**
13 02	Brushy Fork	138.3	5.2	0.0	0.0	0.0	0.1	**143.5**
13 03	Moores Fk-Stonelick Ck	182.5	18.2	0.0	0.0	0.0	0.0	**200.8**
13 05 – Partial	Hall Run	0.0	0.3	137.1	0.0	0.0	4.1	**141.5**

Table 17. Average annual TN TMDL wasteload allocations by major category in kg/year.

Assessment Unit	Narrative Description	Indi. Dis. facilities	General Dis. HSTS	MS4	Indi. SW facilities	Gen. SW facilities	Gen. Const. SW	WLA TOTAL
10 01	Turtle Creek	0.0	49.5	0.0	92.4	0.0	0.0	**141.9**
10 02	Headw. EK LMR	1348.0	41.9	0.0	0.0	0.0	3.8	**1,393.7**
10 03	Headw. Dodson Ck	295.9	28.7	0.0	0.0	64.7	0.0	**389.2**
10 04	Anthony Rn-Dodson Ck	295.9	102.2	0.0	0.0	64.7	0.0	**462.8**
10 05	WK EK LMR	0.0	49.1	0.0	0.0	0.0	0.0	**49.1**
10 06	Glady Ck-EK LMR	8556.9	486.8	0.0	92.4	64.7	3.8	**9,204.6**
11 01	Solomon Rn-EK LMR	11045.5	869.4	0.0	92.4	64.7	7.5	**12,079.6**
11 02	Fivemile Ck-EK LMR	23488.9	1,392.9	98.5	92.4	64.7	11.5	**25,148.8**
11 03	Todd Run-EK LMR	23488.9	2,036.7	281.3	92.4	65.5	95.7	**26,060.5**
12 01	Poplar Creek	0.0	345.8	0.0	0.0	0.0	106.2	**452.0**
12 02	Cloverlick Creek	622.2	677.5	0.0	0.0	0.0	0.0	**1,299.6**
12 03 – Partial	Ulrey Run	1106.1	3.1	8.5	0.0	0.0	0.0	**1,117.7**
	Back Run	1133.7	0.0	0.0	0.0	0.0	0.0	**1,133.7**
	Slabcamp Run	0.0	5.1	0.0	0.0	0.0	0.0	**5.1**
12 04 – Partial	Backbone Creek	0.0	180.9	421.2	20.3	0.0	32.1	**654.5**
13 01	Headw. Stonelick Ck	829.6	301.3	0.0	0.0	0.0	0.0	**1,130.8**
13 02	Brushy Fork	1106.1	356.0	0.0	0.0	0.0	1.8	**1,463.9**
13 03	Moores Fk-Stonelick Ck	1617.6	1,031.1	0.0	0.0	0.0	2.4	**2,651.2**
13 05 – Partial	Hall Run	0.0	63.9	1,961.4	0.0	0.0	59.1	**2,084.5**

Table 18. Average annual TP and TN facility-based permitted treatment plants and stormwater wasteload allocations in kg/year. Stormwater facilities are shaded because they sum to a different column in Tables 16 and 17.

Assessment Unit (where facility dischargers to)	Permit	Facility Name	Waste type	TP WLA	TN WLA
10 01	1IJ00050	Martin Marietta Materials Lynchburg Plant	Stormwater	8.1	92.4
10 02	1PA00005	New Vienna	Discharge	117.5	1175.2
	1PZ00029	Snow Hill	Discharge	17.3	172.8
10 03	1PG00100	Rolling Acres	Discharge	34.6	276.5
	1PX00122	High Co Inc.	Discharge	2.4	19.4
10 06	1PB00105	Lynchburg	Discharge	691.3	6913.0
11 01	1PD00024	Fayetteville	Discharge	248.9	2488.7
11 02	1PB00034	Williamsburg	Discharge	871.0	12443.3
12 02	1PX00059	Locust Ridge Healthcare	Discharge	34.6	276.5
	OHS000005	One small sanitary general permitted facility	Discharge	43.2	345.6
12 03 – Ulrey Run	1PV00034	Forest Creek MHP	Discharge	138.3	1106.1
12 03 – Back Run	1PX00096	Woodland Christian Camp	Discharge	20.7	165.9
	1PV00002	Holly Towne MHP	Discharge	121.0	967.8
12 04 – Backbone Rn	1IN00289	Arch Materials LLC	Stormwater	1.5	20.3
13 01	1PP00020	Stonelick State Park Campgrounds	Discharge	103.7	829.6
13 02	1PT00077	Clermont NE Local Schools	Discharge	138.3	1106.1
13 03	1PA00106	Newtonsville Area	Discharge	78.8	788.1

Table 19. Average annual TP and TN facility-based permitted treatment plants and stormwater wasteload allocations in kg/day. Stormwater facilities are shaded because they sum to a different column in Tables 16 and 17.

Assessment Unit (where facility dischargers to)	Permit	Facility Name	Waste type	TP WLA	TN WLA
10 01	1IJ00050	Martin Marietta Materials Lynchburg Plant	Stormwater	0.02	0.25
10 02	1PA00005	New Vienna	Discharge	0.32	3.22
	1PZ00029	Snow Hill	Discharge	0.05	0.47
10 03	1PG00100	Rolling Acres	Discharge	0.09	0.76
	1PX00122	High Co Inc.	Discharge	0.007	0.05
10 06	1PB00105	Lynchburg	Discharge	1.89	18.93
11 01	1PD00024	Fayetteville	Discharge	0.68	6.81
11 02	1PB00034	Williamsburg	Discharge	2.38	34.07
12 02	1PX00059	Locust Ridge Healthcare	Discharge	0.09	0.76
	OHS000005	One small sanitary general permitted facility	Discharge	0.12	0.95
12 03 – Ulrey Run	1PV00034	Forest Creek MHP	Discharge	0.38	3.03
12 03 – Back Run	1PX00096	Woodland Christian Camp	Discharge	0.06	0.45
	1PV00002	Holly Towne MHP	Discharge	0.33	2.65
12 04 – Backbone Rn	1IN00289	Arch Materials LLC	Stormwater	0.04	0.06
13 01	1PP00020	Stonelick State Park Campgrounds	Discharge	0.28	2.27
13 02	1PT00077	Clermont NE Local Schools	Discharge	0.38	3.03
13 03	1PA00106	Newtonsville Area	Discharge	0.22	2.16

4.2. Atrazine TMDL allocations

Section 3.3 explains that the atrazine TMDL for the impaired village of Blanchester public drinking water use is calculated at the blended raw water intake of the drinking water plant. A LDC has been developed to express loads across the hydrograph. Figure 18 presents the LDC with a red curve representing TMDL loading capacity at the target the 3.0 µg/L concentration limit across the normalized flow duration interval. The blue line shows the 31.9 µg/L concentration MDL. The black horizontal lines show the TMDL loading capacity at the median flow condition for each flow regime. The diamond figures plot the calculated load for each observed atrazine concentration from raw intake water sample collected by the Syngenta Atrazine Monitoring Program. The diamonds filled in with orange indicate days when samples were collected, and the O'Bannon Creek gage streamflow contained 66% or greater runoff, according to the HYSEP baseflow separation algorithm. The box plots within each flow regime show the distribution of calculated loads for the concentration observations. Figure 19 presents the same information as Figure 18, except it does not include the diamonds of calculated loads from the sample observations.

Similar to the Figure 9 concentration duration curve of the same observations (in Section 2.2), these LDCs show that elevated observations occurred throughout the hydrograph. The addition of the MDL load curve on the LDCs helps put the needed reduction into context. Since the MDL was calculated using the existing distribution of concentrations, this line is generally the maximum allowable concentration that can occur to expect the 90-day average 3.0 µg/L concentration limit to be met.

This TMDL is expressed using a flow-variable application. The complete red line curve on the two LDC figures is to be considered the official TMDL. However, Table 20 reports the allocations at the median flow within each flow regime to present loading values.

Table 20. Blanchester public drinking water supply use atrazine TMDL results in kg/day.

TMDL and duration intervals	High 0-10%	Wet weather 10-40%	Normal range	Dry weather	Low 90-100%
Total Maximum Daily Load	**11.39**	**1.35**	**0.49**	**0.18**	**0.07**
Wasteload Allocation	0.00	0.00	0.00	0.00	0.00
Load Allocation	10.25	1.21	0.44	0.16	0.06
Margin-of-Safety	1.14	0.13	0.05	0.02	0.01
Allowance for future growth	0.00	0.00	0.00	0.00	0.00

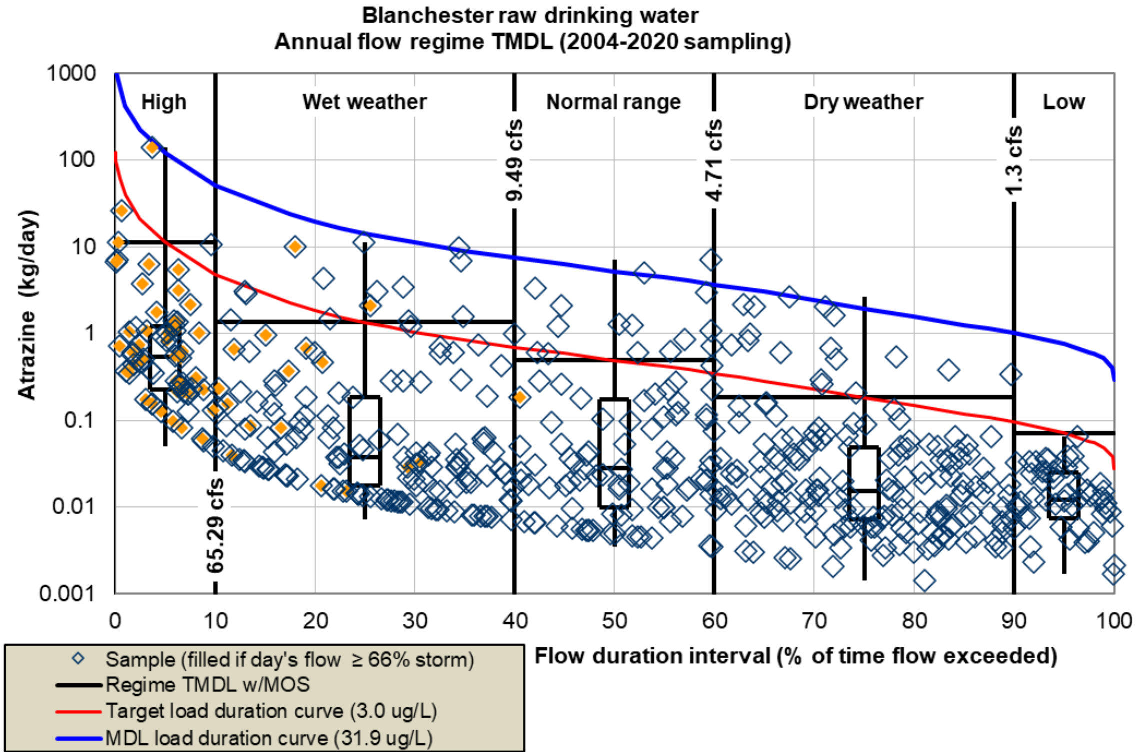

Figure 18. Blanchester public drinking water supply use atrazine TMDL LDC, including calculated loads for samples collected by the Syngenta Atrazine Monitoring Program from October 2004 through January 2020.

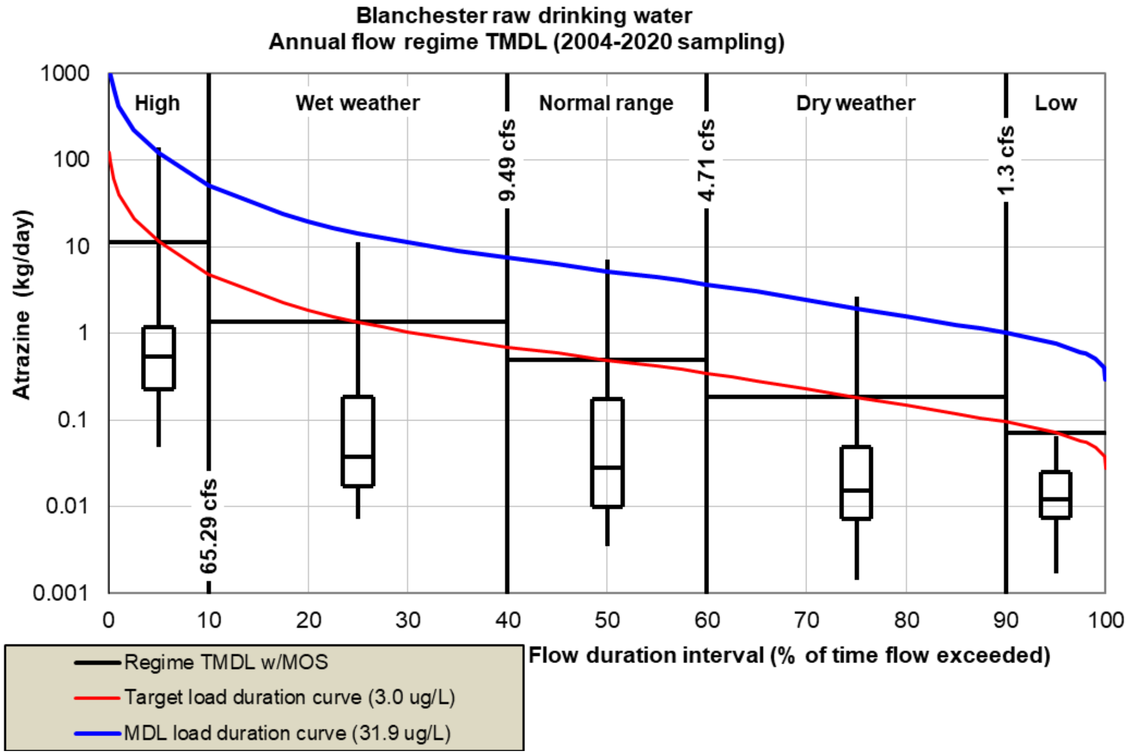

Figure 19. Blanchester public drinking water supply use atrazine TMDL LDC without the calculated loads for samples collected by the Syngenta Atrazine Monitoring Program from October 2004 through January 2020.

5. Preliminary implementation plan

5.1. Overview of adaptive management and technical requirements

The implementation plan is the strategy to meet load and wasteload allocations needed to restore the impaired conditions of the watershed (OAC 3745-2-12). According to the ORC section 6111.562, the preliminary modeling results must include the preliminary implementation plan establishing specific actions, schedules, and monitoring proposed to effectuate a TMDL. Within the preliminary modeling results, the implementation plan will present the framework for implementation for feedback from stakeholders. With that feedback and through additional outreach, the complete implementation strategy will be developed for the draft TMDL report. The TMDL development process in Ohio leverages adaptive management. Figure 20 presents a conceptual model of what that process looks like.

The TMDL process began with the assessments that identified impairments in the East Fork LMR. The development of the TMDL includes an initial implementation strategy to meet load and wasteload allocations needed to restore the impaired conditions of the East Fork LMR. A component of that strategy in a system like this one where there are still unknown or poorly known processes (such as in stream phosphorus cycling for example) is a process of adaptive management.

Adaptive management starts with setting goals or establishing milestones to provide clear targets for implementation measures. Implementing the strategy is given equal weight in the graphic, but it is the most resource-intensive part of the process that involves many local, state, and federal agencies, nonprofit organizations, and individuals. To inform adaptive management, monitoring of the watershed is needed to link implementation to the desired environmental response. Evaluation of the information is needed by defining metrics that turn monitoring data into information. Then that information is used to adjust the strategy if necessary.

The preliminary implementation plan will lay out the framework for the initial strategy and propose ideas for implementation actions, monitoring, evaluating progress, and adjusting the strategy moving forward. This preliminary implementation plan includes a history of watershed planning in East Fork Little Miami River, a description of current funding programs, watershed planning tools, innovative practices, recommendations for future practices, and the monitoring strategy.

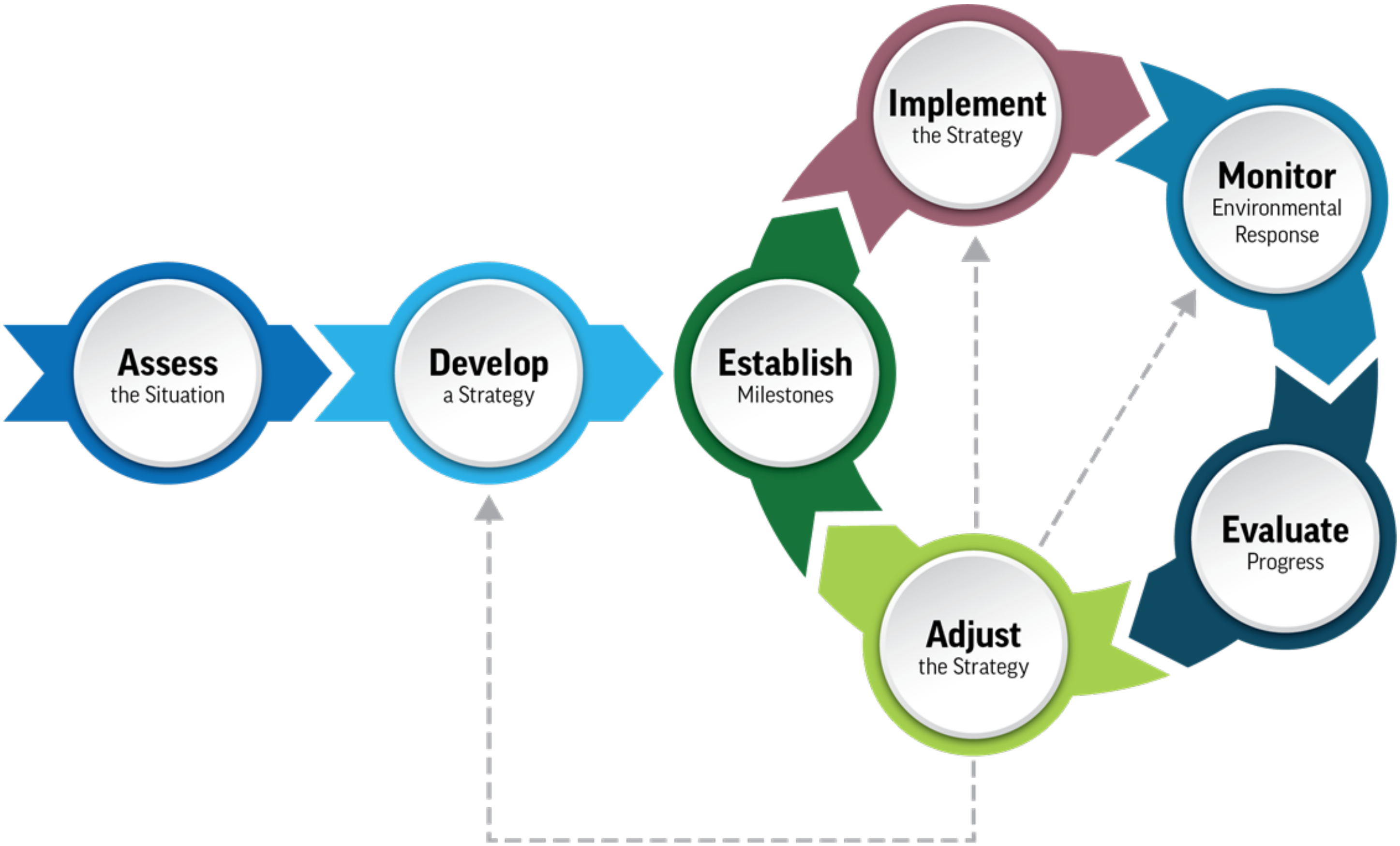

Figure 20. Conceptualization of TMDL implementation with adaptive management.

5.2. History of East Fork Little Miami River watershed planning

The East Fork Little Miami River (LMR) is considered an exceptional water resource in Ohio. The watershed supports a variety of uses, including Exceptional Warmwater Fisheries Habitat, swimming, boating, and fishing. The East Fork LMR serves as a major public water supply source for several communities, including Clermont County and the village of Blanchester. The East Fork Watershed Collaborative (EFWC) was formed in 2001 as an informal watershed group that includes representatives from the SWCDs and other local government agencies, along with representatives from community groups and individual citizens. Figure 20 shows major developments in the East Fork LMR since the formation of the EFWC. These partners recognized a need to develop a comprehensive, grassroots approach to improve water quality in the East Fork LMR. Initial funding provided by the Ohio Department of Natural Resources Watershed Coordinator Grant Program allowed local partners to develop this successful watershed program. Watershed Action Plans describe the watershed characteristics and stream conditions, causes and sources of water quality impairments, and recommendations to address the impairments. Five Watershed Action Plans were developed and approved between 2003 and 2009 for the East Fork Watershed for the following watersheds, which can be found on ***Ohio EPA's Watershed Action Plans Page***:

- ***East Fork Headwaters Watershed Management Plan***
- ***Middle East Fork Watershed Action Plan***

- ***Lower East Fork Watershed Management Plan***
- ***Stonelick Creek Watershed Action Plan***
- ***East Fork Lake Tributaries Watershed Management Plan***

EFWC has, in the past, worked with its partners to implement projects based on recommendations included in historical watershed action plans. However, they have been supplanted with nonpoint source pollution implementation strategies (NPS-IS) [also known as Nine-Element plans], which focus on strategic project development and implementation to address beneficial use impairments caused by nonpoint sources at the smaller HUC-12 WAU scale.

U.S. EPA's Office of Research and Development (ORD) began studying the East Fork LMR Watershed in 2006 and takes a whole system approach to determining how to best manage water quality in this large multi-use watershed. The success of the research relies on effective partnerships with other stakeholders in the system regarding water quality. To better serve the watershed, stakeholders from local, state, and federal agencies responsible for water quality protection and management established the East Fork Watershed Cooperative (EFWCoop). The EFWCoop includes affiliates from U.S. EPA, U.S. Army Corps of Engineers, U.S. Department of Agriculture, Ohio EPA, local soil and water conservation districts, and utility operators and water quality protection offices.

In 2008, Ohio EPA sampled Harsha Lake for atrazine, measuring elevated levels. This resulted in the public drinking water supply beneficial use to be listed as impaired for the 2010 Integrated Report and continues to be listed as impaired in the 2022 report (Ohio EPA 2022). Harmful algal blooms in Harsha Lake started to increase in severity and frequency around this time, and the first cyanotoxin-producing bloom was documented in 2012 (Ohio EPA 2014).

Ohio EPA studied the East Fork LMR watershed in 2012 and released the corresponding biological and water quality report in 2014. Half the sites sampled were listed as impaired for aquatic life use due to nutrient and organic enrichment (Ohio EPA 2014). Harsha Lake was listed as impaired for aquatic life use and public drinking supply use due to algal toxins as well. In 2020, Ohio EPA released its loading analysis plan (LAP), which is the third step in the TMDL process, to propose the actions and methods to address the impairments in the East Fork LMR (Ohio EPA 2020).

In 2014, U.S. EPA ORD began a water quality trading feasibility study using the SWAT model. A barrier to water quality trading in East Fork LMR is trading at the watershed scale, which leads to fewer willing participants. More participants in a market leads to a more successful water quality trading market. At the time of the study, U.S. EPA ORD found there was not enough interest to make water quality trading feasible. This is discussed further in section 5.5.2.

U.S. EPA ORD currently uses the SWAT model alongside the agriculture conservation planning framework (ACPF) to perform cost-effectiveness studies of nonpoint source BMPs. The ACPF provides a watershed approach and set GIS tools designed to find conservation opportunities across different landscapes. The ACPF model identifies site-specific opportunities to install conservation practices across small watersheds. The model shows that wetlands should be the focus of BMPs (personal communication). Since using this model, several stream and wetland restoration projects have been implemented or are under construction (Figure

21). The East Fork LMR has a very active stakeholder group. Since the watershed program began, collaboration between local, state, and federal partners has worked together to see several projects implemented (Figure 21, points highlighted in blue). The programs that fund and support these implementation projects are discussed in detail in section 5.3.

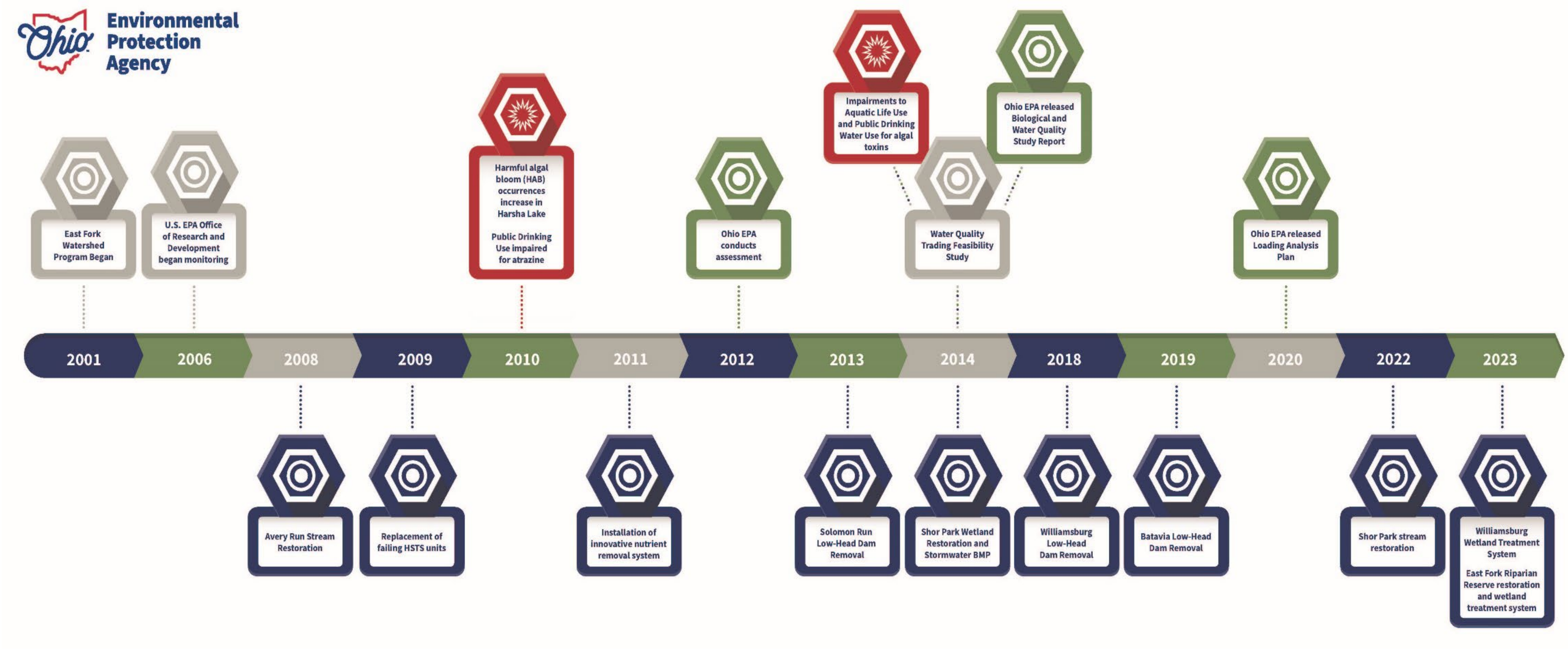

Figure 21. The timeline of major developments in the East Fork Little Miami River (LMR) begins with the formation of the East Fork Watershed Collaborative. Points highlighted in red indicate impairments in East Fork LMR. Points highlighted in green are actions conducted by Ohio EPA. Points highlighted in blue indicate activities and projects implemented to improve East Fork LMR water quality. BMP = best management practices, HSTS = home sewage treatment systems.

5.3. Current programs and practices

There are several federal and state programs that support the implementation of projects to address impairments caused by nonpoint sources. These programs support these projects through watershed planning tools (e.g. NPS-IS), technical assistance, or providing funding opportunities. The following subsections will discuss these programs (section 5.3.1 and section 5.3.2) and the projects they have supported in the East Fork LMR (section 5.3.4).

5.3.1. Federal programs

The U.S. Department of Agriculture's Natural Resource Conservation Service (NRCS) has multiple programs that work with private landowners to protect their natural resources while promoting the agricultural economy. Several NRCS standard practices address water quality regarding nutrients, such as nutrient management plans and associated BMPs. Nutrient management is the management of nutrients and soil amendments to maximize their economic benefit while minimizing their environmental impact. Nutrient management plans include the 4Rs of nutrient stewardship – using the right nutrient source at the right rate and at the right time in the right place. Nutrient management plans establish a baseline for understanding nutrient needs on a farm as well as establish the plan for how the 4Rs can be successfully implemented for an individual field and producer.

Environmental Quality Incentives Program (EQIP) - NRCS' conservation program that helps farmers, ranchers, and forest landowners integrate conservation into working lands. EQIP provides technical and financial assistance to agricultural producers and forest landowners to address natural resource concerns such as improving air and water quality, conserving ground and surface water, increasing soil health, reducing soil erosion and sedimentation, improving or creating wildlife habitat, and mitigating against drought and increasing weather volatility. Over the last four fiscal years, more than 51,000 acres have been enrolled in and have received funding for practices through the EQIP program (Table 21).

NRCS' National Water Quality Initiative – this initiative is a partnership between NRCS, state water quality agencies, and U.S. EPA to identify and address impaired water bodies through voluntary conservation. NRCS provides targeted funding for financial and technical assistance in small watersheds most in need and where farmers can use conservation practices to make a difference. Conservation systems include practices that promote soil health, reduce erosion, and lessen nutrient runoff, such as filter strips, cover crops, reduced tillage, and manure management.

Table 21. Nutrient-focused EQIP practices by HUC-12 watershed assessment unit for fiscal years 2018-2022.

HUC 12	Practice	Amount	Monetary Obligation
050902021001 - Turtle Creek			
	Cover Crop	488.8 acres	$26,815.18
	Nutrient Management	179.2 acres	$424.70
	Nutrient Management Plan - Written	1	$4,874.78
050902021002 - Headwaters of East Fork Little Miami River			

	Cover Crop	12 acres	$608.04
	Tree/Shrub Establishment	4.6 acres	$2,698.48
050902021003 - Headwaters of Dodson Creek			
	Cover Crop	407.3 acres	$12,197.56
050902021004 - Anthony Run - Dodson Creek			
	Conservation Cover	3.4 acres	$1,752.00
	Cover Crop	638.4 acres	$35,619.45
	Nutrient Management	375.9 acres	$2,560.16
	Prescribed Grazing	78 acres	$1,714.04
	Subsurface Drain	420 feet	$667.80
	Tree/Shrub Establishment	0.6 acres	$876.00
050902021005 - West Fork of East Fork Little Miami River			
	Cover Crop	88.6 acres	$4,428.70
	Nutrient Management	176.6 acres	$7,046.00
050902021006 - Glady Creek - East Fork Little Miami River			
	Cover Crop	2009.1 acres	$109,909.45
	Nutrient Management	743 acres	$10,328.93
	Nutrient Management Plan - Written	1	$0.00
	Tree/Shrub Establishment	4.5 acres	$445.50
	Multi-species Cover Crop	354 acres	$4,556.00
050902021101 - Solomon Run - East Fork Little Miami River			
	Agrichemical Handling Facility	1	$5,836.80
	Conservation Cover	2 acres	$538.99
	Cover Crop	2463.3 acres	$150,407.76
	Nutrient Management	4397.1 acres	$76,447.43
	Nutrient Management Plan - Written	1	$2,943.79
	Prescribed Grazing	118.5 acres	$2,982.66
	Multispecies Cover Crops	4257.7 acres	$53,878.71
050902021102 - Fivemile Creek - East Fork Little Miami River			
	Cover crop	10174 acres	$591,321.35
	Nutrient Management	7274.3 acres	$230,645.20
	Stream Crossing	1	$2,601.72
050902021103 - Todd Run - East Fork Little Miami River			
	Cover Crop	262.8 acres	$13,316.08
050902021201 - Poplar Creek			
	Prescribed Grazing	78.5 acres	$2,555.17
050902021202 - Cloverlick Creek			
	Cover Crop	1309.7 acres	$73,642.19
	Drainage Water Management	42 acres	$196.56
	Nutrient Management	728 acres	$13,423.13
	Subsurface Drain	101 feet	$192.91
050902021204 - Backbone Creek - East Fork Little Miami River			

	Cover Crop	218.8 acres	$10,918.12
	Nutrient Management	132.7 acres	$5,293.40
050902021301 - Headwaters of Stonelick Creek			
	Conservation Cover	16.5 acres	$15,892.42
050902021302 - Brushy Fork			
	Agrichemical Handling Facility	1	$7,038.72
	Cover Crop	3778.4 acres	$234,138.92
	Nutrient Management	4792.9 acres	$112,768.44
	Prescribed Grazing	31.1 acres	$1,205.44
050902021303 - Moores Fork - Stonelick Creek			
	Conservation Cover	2 acres	$2,411.94
	Cover Crop	1903.8 acres	$119,215.95
	Nutrient Management	2598.8 acres	$99,513.04
050902021304 - Lick Fork - Stonelick Creek			
	Cover Crop	232.7 acres	$6,967.04
Total Monetary Obligations for Nutrient-Focused Practices			**$2,063,816.65**

*Other practices funded by EQIP in the study area, such as grassed waterways and access roads, may also contribute to a reduction in nutrients if stacked with other water treatment and retention practices.

NRCS' Conservation Innovation Grants (CIG) - a competitive program that funds and supports the development of new tools, approaches, practices, and technologies to further natural resource conservation on private lands. Through creative problem solving and innovation, CIG partners work to address the nation's water quality, air quality, soil health, and wildlife habitat challenges, all while improving agricultural operations. One project in the East Fork LMR has been funded by the NRCS' CIG grant.

NRCS' Regional Conservation Partnership Program (RCPP) - a partner-driven, locally led approach to conservation. The RCPP brings together partners and producers to find innovative ways to tackle issues like protecting soil health, mitigating water quality/quantity concerns, and protecting wildlife. NRCS provides technical and financial assistance for partners to develop projects that deliver solutions to natural resource challenges.

Conservation Reserve Program (CRP) - a land conservation program administered by USDA Farm Service Agency. In exchange for a yearly rental payment, farmers enrolled in the program agree to remove environmentally sensitive land from agricultural production and plant species that will improve environmental health and quality.

The U.S. Department of Housing and Urban Development's **Community Development Block Grant (CDBG)** Program - provides annual grants on a formula basis to states, cities, and counties to develop viable urban communities by providing decent house and a suitable living environment and by expanding economic opportunities, principally for low- and moderate-income persons. This program could help fund projects in the East Fork LMR for repair and replacing failing septic systems.

319 Grant Program – this program started under federal Clean Water Act amendments in 1987, which created the national program to control nonpoint source pollution. Since 1990, Ohio EPA has annually applied for, received, and distributed Section 319 grant funds to address NPS caused water quality impairment to Ohio's surface water resources. Section 319(h) implementation grant funding is targeted to Ohio waters where NPS pollution is a significant cause of aquatic life use impairments. The cornerstone of Ohio's 319 program is working with watershed groups, ODA, ODNR, local SWCDs, county engineers, and others who are implementing locally developed watershed management plans and restoring surface waters impaired by NPS pollution.

Clean Water State Revolving Fund (CWSRF) program - a federal-state partnership that provides low-cost financing to communities for a wide range of water quality infrastructure projects, including municipal wastewater facilities, nonpoint source pollution control, decentralized wastewater treatment systems, stormwater runoff mitigation, green infrastructure, estuary protection, and water reuse.

5.3.2. State programs

Nonpoint Source Implementation Strategy (NPSIS) [also known as Nine-element watershed plans] - identifies critical areas, organizes stakeholders, sets local goals and objectives for conservation practice implementation, identifies implementers and funding sources, and most importantly, develops ready-to-go projects and conservation practice adoption activity. These also establish project eligibility for federal funding (Ohio EPA, 2020). These are written for HUC-12 WAUs, which range in area from 15 to 43 square miles and are a key mechanism for identifying load reduction opportunities. The East Fork LMR has four NPS-ISs written and approved by the Ohio EPA, identifying key areas of concern. The East Fork Collaborative is currently working on an NPS-IS for Backbone Creek – East Fork Little Miami River (050902021204) WAU.

- ***East Fork Little Miami River – Glady Creek 050902021006 050902021006)*** – This NPS-IS addresses issues in the Glady Creek WAU. These critical areas are impacted by nutrient runoff from agricultural lands, habitat impairment, and *E. coli* contamination. Restoration strategies for these impairments include the implementation of agricultural BMPs, habitat restoration, and rehabilitation of failing septic systems. The NPS-IS also includes a preservation aspect, with a goal to maintain impervious land cover under 10% by purchasing land for conservation easements.
- ***East Fork Little Miami River – Solomon Run (050902021101)*** – This NPS-IS addresses issues in the following critical areas in the Solomon Run WAU: Indian Creek, Lower Saltlick Creek, Glady Run, Howard Run, and East Fork Little Miami River. Many of the areas of concern in this NPS-IS have a goal of reducing nutrient loads at Harsha Lake. The restoration strategy to meet this goal is the implementation of agricultural BMPs. In addition to nutrient load reduction, the areas of concern have habitat impairments. The restoration strategy for these impairments is the establishment of riparian buffers and stream channel restoration via bioengineering methods.
- ***East Fork Little Miami River – Fivemile Creek (050902021102)*** – This NPS-IS addresses issues in Fivemile Creek and Pleasant Run. These critical areas are impacted by habitat impairment, nutrient runoff from agricultural lands, and *E. coli* contamination. Restoration strategies for these critical areas include habitat restoration, rehabilitation failing septic systems, and

implementation of agricultural BMPs. The NPS-IS also includes a preservation aspect, with a goal to maintain impervious land cover under 10% by purchasing land for conservation easements.

- ***East Fork Little Miami River – Salt Run (050902021305)*** – This NPS-IS addresses issues in Hall Run, Wolfpen Run, Shayler Run, Avey's Run, and Lower East Fork of Salt Run. These stream segments referred to as critical areas, are impacted by habitat impairments, stormwater runoff, and *E. coli* contamination. Restoration strategies for these critical areas include stormwater detention basins, habitat restoration, and replacement of failing HSTS systems.

H2Ohio – Launched by Governor Mike DeWine, this initiative was first funded by the General Assembly for the 2020-21 biennium with an investment of $172 million. Initiatives include promoting agricultural management practices and natural infrastructure and addressing failing home septic systems. Three projects in the East Fork LMR have been funded by H2Ohio.

Clean Ohio Green Space Conservation Program – administered by Ohio Public Works, this program is dedicated to environmental conservation, including acquisition of green space and the protection and enhancement of river and stream corridors. One project in East Fork LMR has received funding through this program.

Ohio EPA Surface Water Improvement Fund (SWIF) – SWIF was created in 2008 to provide grant funding to applicants such as local governments, park districts, conservation organizations for implementation of specific projects that address nonpoint source pollution and/or stormwater runoff. One project in East Fork LMR has been funded by the Ohio EPA SWIF.

Ohio EPA Water Pollution Control Loan Fund (WPCL) – this program offers financial and technical assistance to public or private applicants for the planning, design, and construction of a wide variety of projects to protect or improve the quality of Ohio's rivers, streams, lakes, and other water sources.

Ohio EPA Water Resource Restoration Sponsor Program (WRRSP) – the goal of the WRRSP is to counter the loss of ecological function and biological diversity that jeopardize the health of Ohio's water resources. To achieve this goal, the WRRSP provides funding for projects that specifically target the protection and restoration of high-quality streams and wetlands. Interest monies from the WPCLF is used to fund these projects. Two projects in the East Fork LMR have been funded by the Ohio EPA WRRSP.

Ohio Department of Health's Harmful Algal Bloom Research Initiative (HABRI) – this program was created in the aftermath of the 2014 Toledo water crisis to provide near-term solutions for the issues surrounding HABs. The program solicits research projects from Ohio's universities that address critical needs and knowledge gaps.

5.3.3. Local programs

Septic System Rehabilitation Financing Program (SSRFP) – The purpose of this program is to assist low-income households throughout Clermont County in addressing malfunctioning or incomplete on-site sewage disposal systems to prevent or abate public health nuisances by providing funds and technical assistance to qualifying applicants.

5.3.4. Grants and conservation expenditures

Since 2011, East Fork LMR has received over $9 million in grant funding (Table 22). These grants come from both federal and state programs, as described in the previous section, as well as some private sector grants, such as the Duke Energy Foundation. Though not all grants and corresponding projects address nutrient management, a large portion address nutrient management. As seen in Table 22, all the grants subcategorized as "Agricultural Grants" are either nutrient removal wetlands or Nutrient Management BMPs, which totals almost $4 million.

Table 22. Grants and conservation expenditures with corresponding projects in the East Fork Little Miami River Watershed from 2011 to 2022.

East Fork Watershed Grants and Conservation Expenditures Received - 2011 to 2022			
Agricultural Grants	**Agency**	**Project**	**Amount**
Conservation Innovation Grant	USDA-NRCS	Cover Crops / Ag BMP	$69,695
Regional Conservation Partnership Program	USDA-NRCS	Cover Crops/ Nutrient Mgt	$367,000
East Fork EQIP Years 1-3	USDA-NRCS	Cover Crops/ Nutrient Mgt	$900,000
National Water Quality Initiative - Five Mile Creek (2013-2019)	USDA-NRCS	Cover Crops/ Nutrient Mgt	$871,722
National Water Quality Initiative - 2021-2023	USDA-NRCS	Cover Crops/ Nutrient Mgt	$426,527
Ag Conservation Menu website	Ohio EPA	Ag BMP one-stop web site	$17,141
Fish Habitat Partnership #1	US Fish & Wildlife Service	Williamsburg wetland, ACPF model	$158,950
Fish Habitat Partnership #2	US Fish & Wildlife Service	Williamsburg wetland	$144,000
H2Ohio	Ohio DNR	Nutrient removal wetlands, ACPF model	$290,000
Reservoirs Program	US Fish & Wildlife Service	Williamsburg wetland	$40,000
Duke Energy Foundation	Duke Energy	Williamsburg wetland	$30,000
Duke Energy Foundation	Duke Energy	HABs and Nitrate Sensing	$23,450
Section 319	Ohio EPA	Williamsburg wetland	$199,960
Harmful Algal Bloom Research Initiative	Ohio DHE	Nutrient removal wetland monitoring	$151,325
Clean Ohio Grant	Ohio Public Works	Riparian Reserve wetland/stream restoration	$300,000
Total Agricultural Grants			**$3,989,770**
Stream Restoration Grants			
Water Resource Restoration Sponsorship Program	Ohio EPA	Williamsburg Lowhead Dam Removal	$673,000
Water Resource Restoration Sponsorship Program	Ohio EPA	Batavia Lowhead Dam Removal	$783,000
Fish Habitat Partnership	US Fish & Wildlife Service	Batavia Lowhead Dam Removal	$65,000
Section 319	Ohio EPA	O'Bannon Creek Tributary Restoration	$90,458

Section 319	Ohio EPA	Avey's Run / Shor Park Restoration	$135,080
Water Resource Restoration Sponsorship Program	Ohio EPA	Lower East Fork Restoration	$3,592,784
Total Restoration Grants			**$5,339,322**
Planning Grants			
Section 319	Ohio EPA	Watershed Plan Development	$25,000
SWCD Watershed Program Grant, 2019-2022	Ohio Dept. of Ag	Watershed Project Planning	$155,154
Total Planning Grants			**$180,154**
Conservation Expenditures, 2011 to 2022			**$9,509,246**

East Fork LMR has had dedicated EQIP funds for Five Mile Creek WAU since 2013. Ohio NRCS and the Clermont, Brown, Clinton, and Highland Soil and Water Conservation Districts (SWCDs) will utilize $426,527 to implement core water quality practices in the Glady Creek, Solomon Run, and Five Mile Creek WAUs. Additionally, most of the HUC-12 WAUs (14 of 16) of East Fork LMR have had nutrient-focused EQIP practices implemented in the last four fiscal years. In total, over $2.2 million of EQIP funding has been allocated to the East Fork LMR, and 90% ($2.06 million) are for nutrient-focused practices (Table 21, Figure 21). Other EQIP practices may reduce nutrient loads; however, only practices that specifically state nutrient reduction in Ohio's Conservation Practice Standard handbook were included in Table 21.

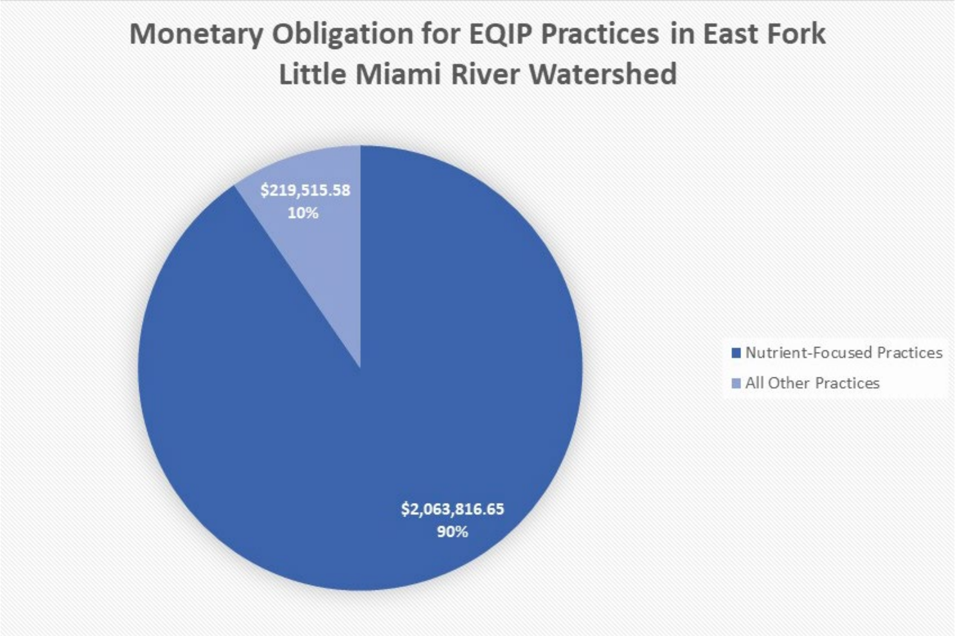

Figure 22. Monetary Obligations dedicated to EQIP practices for fiscal years 2018-2022.

East Fork LMR has received five Section 319(h) grants and one SWIF grant. These grants funded stream restoration projects in Salt Run-East Fork LMR (1305) and Glady Creek-East Fork LMR (1006), as well as home sewage treatment system projects in the Headwaters of Dodson Creek (1003), Anthony Run-Dodson Creek

(1004), and Turtle Creek (1001). Most of these projects address nutrient impairment by restoring the natural stream channel.

Ohio EPA's WRRSP funded two projects in the East Fork LMR to remove low-head dams. These projects address beneficial use impairments due to habitat and flow alteration, which will also indirectly address nutrients. In 2022, Clermont SWCD received funds from the Ohio EPA WRRSP for continued stream restoration in the lower East Fork LMR. As of 2023, Cardinal Land Conservancy is seeking funds to preserve the wetlands of Harsha Lake.

East Fork LMR has received funding through H2Ohio for three projects. One of the main goals of H2Ohio is to restore natural infrastructure through the creation or restoration of nutrient-filtering wetlands. All three projects focused on wetland projects, with two creating new wetland systems and the third investigating the feasibility of creating certain land types into wetlands.

5.3.5. Examples of completed implementation projects

The East Fork LMR has had ten projects successfully funded and implemented or in the process of being implemented. These projects include stream restorations, wetland restorations, rehabilitation of home sewage treatment systems, and dam removals. Many of these projects address impairments due to habitat, such as riparian buffer restoration, stream stabilization, and dam removals. Though the immediate deliverable is a restored habitat, these projects help reduce nutrients. Other projects, such as HSTS rehabilitation and wetland creation and restoration, explicitly address nutrients. The following are completed projects with a brief description of the project:

- ***Avey's Run Stream Restoration***
  - This project addressed beneficial use impairments due to habitat by restoring 1,800 linear feet of Avey's run and stabilizing more than 1,200 linear feet of previously eroded banks. More than 300 native trees and shrubs were planted along the restoration site. This project was funded by Ohio EPA's Section 319(h) grant.
- ***Solomon Run Low-Head Dam Removal***
  - This project addressed beneficial use impairments due to habitat/flow with the removal of the Solomon Run low-head dam, restoration of approximately 2,400 linear feet of stream, and installation of two in-stream habitat structures. Impairments due to sedimentation were also addressed with the removal of accumulated sediments from the former dam pool. This project was funded by Ohio EPA's Section 319(h) grant.
- ***Highland County East Fork Watershed Water Quality Improvement Project***
  - This project addressed beneficial use impairments due to bacteria and nutrient loads from failing HSTS. Funding was used for failing system replacement, homeowner education, enhanced site development guidelines, and general oversight to significantly improve HSTS performance within the watershed. This project provided cost-share for the replacement of 18 failing HSTS units. This project was funded by Ohio EPA's Section 319(h) grant.
- ***Shor Park Stream Restoration, Wetland Restoration, and Stormwater BMP Demonstration***

  - Shor Park had two projects funded by Ohio EPA's Section 319(h) grant and SWIF grant. These projects addressed beneficial use impairments due to habitat, stormwater runoff, and nutrients. The projects restored 550 linear feet of stream, stabilized 200 linear feet of streambank, and restored riparian areas with native grass and shrub plantings. These projects installed two bioswales totaling approximately 2,100 square feet and a 2,000 square foot bioretention cell to manage stormwater runoff from the 72-car parking lot. Additionally, they restored 5.2 acres of forested wetlands, 2.1 acres of emergent wetland, and approximately two acres of wet prairie at Shor Park.
- ***Williamsburg Wetland Treatment System***
  - This project created a three-acre wetland treatment system at the former Williamsburg reservoir to reduce nutrient loads to Harsha Lake. Construction for this project was completed in January 2023, and monitoring of the project's efficacy will begin. The Williamsburg reservoir was also funded by USFWS Fish Passage Grant, Section 319 (h), and H2Ohio.
- ***Williamsburg and Batavia Low-Head Dam Removals***
  - The dams were removed in 2018 (Williamsburg) and 2019 (Batavia) to address the public safety concerns of low-head dams and improve the stream habitat. These projects received funding from the Ohio EPA WRRSP. The Batavia Low-Head Dam was partially funded through U.S. Fish and Wildlife Service.
- ***East Fork Riparian Nature Preserve Wetland Treatment System***
  - This project, funded by H2Ohio, will address beneficial use impairments due to habitat and nutrients. The design of this project will reestablish the natural stream channel and reconnect it with the floodplain with wetland pockets throughout the area. Excavated material will be used to create an ephemeral wetland for amphibian habitat. The projected completion date is fall of 2023.
- ***William H. Harsha Lake: Wetland Treatment Train Feasibility Study***
  - The study, funded by H2Ohio, investigated the feasibility of using existing dove fields as wetlands in the East Fork Park and Wildlife Area. The study wrapped up in November of 2022. It was determined that developing wetlands on the production fields would be an opportunity to treat a large amount of nutrients entering Harsha Lake, but the required construction and future operation and maintenance costs are substantial, so ODNR Parks and Watercraft, Wildlife, and H2Ohio are discussing more cost-effective watershed opportunities.

5.4. Innovative practices

Innovative, science-based approaches to addressing water quality impairments is important to successfully restore beneficial uses to Ohio's waters. Using innovative approaches helps develop the best tools to address impairments or find most cost-effective means to implement projects. East Fork LMR has used or may use these approaches to continue addressing issues in the watershed.

5.4.1. NRCS conservation innovation grant project

As mentioned in section 5.3.1, the NRCS CIG is a competitive program that supports the development of new tools, approaches, practices, and technologies to further natural resource conservation on private lands. This grant was awarded in 2011 to develop and study a new conservation approach to protecting surface runoff in an agricultural setting. A retrofitted urban stormwater basin was installed in Jackson Township, Clermont County, to collect and treat runoff from agricultural fields by removing sediment, phosphorus, nitrogen, and other pollutants. Monitoring has shown that the system removes 30% of the total nitrogen and phosphorus annual load.

5.4.2. REGROW

REGROW is a private data analytics company whose mission is to make resilient agriculture ubiquitous. Their vision is for agriculture to be driven by science and technology to restore the global environmental balance. The company recently developed a tool called Operational Tillage Information System (OpTIS) that uses data from satellites to map and monitor cover crop development. An algorithm is being added that uses available information on BMP implementation (e.g., edge-of-field BMPs, cover crops, and tillage and fertilizer use information). This data may be used to establish priority areas and identify ways to reduce nutrient loadings.

5.5. Recommended next steps/future implementation

5.5.1. H2Ohio Rivers

Ohio Governor Mike DeWine created the H2Ohio Rivers Initiative for the Ohio 2023-2024 budget cycle. H2Ohio Rivers is a comprehensive approach to improving the quality and the health of Ohio's rivers. One of the goals of the H2Ohio Rivers initiative is to implement a river restoration program for large river tributaries and preserve the rivers in Ohio that are already in good health. This would include expanding ODA's state/federal Conservation Reserve Enhancement Program (CREP). CREP is a land conservation program that gives incentives to farmers and landowners who take marginal agricultural land and agree to preserve those properties in a manner that restores wildlife habitat, prevents nutrient runoff, and enhances water quality. H2Ohio Rivers is another potential funding source for implementation projects in the East Fork LMR.

5.5.2. Suggested NPS-IS development

Ohio's nonpoint source management plan encourages strategies that focus on the major sources of nutrients and the factors influencing their availability and transport to water resources. Three focus areas of Ohio's nonpoint source management plan are upland management (i.e., management of agricultural land), riparian management, and failing onsite treatment systems (Ohio EPA, 2020). The following recommended NPS-ISs could focus heavily on those focus areas to reduce nonpoint source pollutants, such as nutrients, herbicides, and bacteria, into East Fork LMR.

Ohio EPA recommends NPS-ISs be written for the following HUC-12 WAUs (Figure 22):

- Anthony Run- Dodson Creek (HUC-12: 050902021004)
- West Fork of East Fork Little Miami River (HUC-12: 090902021005)
- Headwaters of Stonelick Creek (HUC-12: 050902021301)

NPS-ISs for these HUC-12 WAUs would ideally, through strategic development and implementation of projects, address nutrient sources, in some cases, atrazine sources and bacteria sources. Many of the recommended BMPs to reduce nutrients in runoff and drainage water may also aid in the reduction of the herbicide atrazine. Approved NPS-ISs for these WAUs are vehicles for all opportunities of funding (including §319 program nonpoint source funding opportunities). Some of these WAUs, such as Stonelick Creek (1301), have communities that are considered "disadvantaged," which will give them a higher priority for certain funding sources, including the nonpoint source (Section 319) grant fund and the clean water state revolving fund. Disadvantaged communities are determined by a combination of variables that may include low income, high poverty, high unemployment, and exposure to pollutant and environmental hazards.

The Anthony Run – Dodson Creek WAU (050902021004) aquatic life use is impaired due to nutrient enrichment. It is noted in the East Fork LMR Biological and Water Quality Report that the biological assemblages would still not meet their beneficial use due to the marginal habitat quality documented (Ohio EPA 2014). Though habitat would limit the aquatic life's beneficial use, BMPs, such as reestablishing riparian buffers, would address both nutrients and habitat. Dodson Creek showed clear signs of nutrient enrichment, and Anthony Run drains extensive agricultural fields with no riparian buffer, contributing to increased nutrient loadings into Anthony Run. An NPS-IS addressing nutrient loadings in Dodson Creek and Anthony Run would help reduce nutrient loadings into East Fork LMR and Harsha Lake. Anthony Run – Dodson Creek WAU recreational use is also impaired due to *E. coli* concentrations, though no definitive links to direct sources of human origin were apparent. An NPS-IS for this WAU could focus on strategies that implement riparian buffers and agricultural BMPs, such as saturated buffers and grass waterways, to reduce field runoff.

West Fork of East Fork LMR WAU (050902021005) aquatic life use, recreation use, and public drinking water supply use is impaired. Though the impairment of aquatic life use is primarily due to habitat, the recommendations of BMPs to address nutrient loadings in this stream segment would also address habitat impairments. Recreational use is impaired due to *E. coli* concentrations. Drinking water use is impaired due to atrazine, which is a nonpoint source of agricultural water. The East Fork Headwaters Watershed Management Plan specifically suggests that failing septic systems need to be addressed in the West Fork and Hales Branch. Riparian buffers would also address nonpoint source issues in the Hales Branch. The NPS-IS would ideally focus on strategies that would implement water management, including retention features, drainage water management, saturated buffers and riparian buffers, and addressing failing septic systems. These strategies may reduce nutrients, *E. coli*, and atrazine in the West Fork WAU. The following paragraphs describe the issues and recommendations from the East Fork Headwaters Watershed Action Plan (East Fork Headwaters WAP).

> "Visual inspection of the stream below its confluence with A.E. Patton County Ditch suggests that organic enrichment and high nutrients from failing septic systems are causing impairment of the West Fork upstream of the Westboro Reservoir. Also, the West Fork is notable for having the longest channelized segment of any major tributary of the East Fork, adjacent to Jonesboro Road near Frazier Road...Connect all homes in Midland and Westboro with septic systems to the new Midland-Martinsville wastewater treatment plant.

> The lack of livestock exclusion fencing in these areas [Hales Branch] could also contribute to high nutrient loadings as livestock enters the stream…Unconnected riparian corridors are another potential problem in the stream. Discontinuous wooded riparian buffers could result in increased non-point source pollution. An effective riparian buffer can control erosion and nutrient enrichment, reducing in-stream loading."

The Headwaters of Stonelick Creek WAU (050902021301) are impaired for aquatic life use primarily due to nutrients and organic enrichment. The sources of the impairment are agricultural-related stresses and failing home septic systems. Drinking water use is impaired due to atrazine, which is also an agricultural nonpoint source. The Stonelick Creek Watershed Action Plan specifically addresses cropland in the Locust Creek and Hunter Creek subwatersheds as contributing to the impairment in the upstream reaches of Stonelick Creek. The NPS-IS would ideally focus on strategies that would implement water management, including retention features and drainage water management, including saturated buffers and riparian buffers in Locust Creek and Hunter Creek. Water retention BMPs and other types of agricultural buffers are more efficient at removing nutrients and herbicides when practices are "stacked" from the in-field to the edge of the field and streams. Implementation of these practices would reduce nutrient and atrazine loadings into Stonelick Creek.

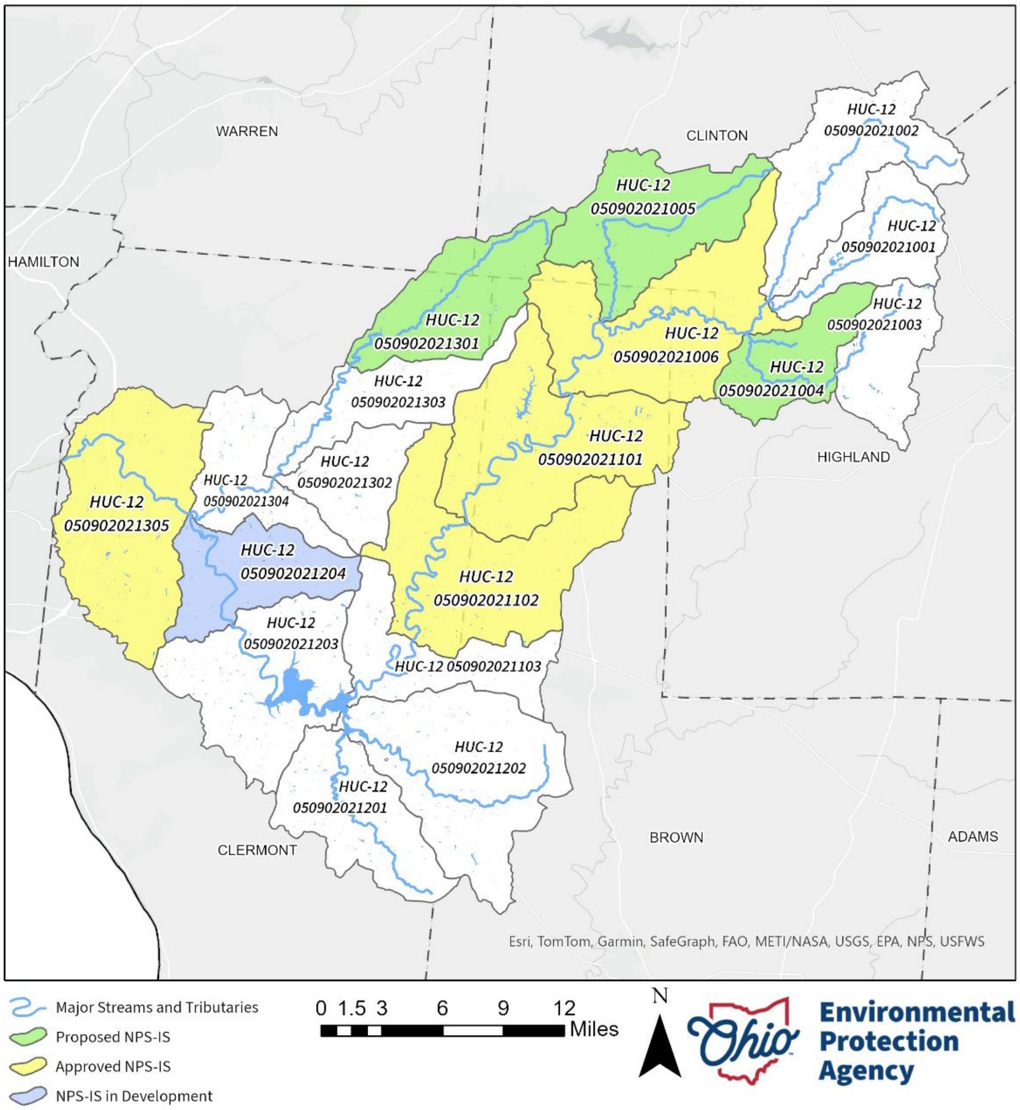

Figure 23. HUC-12 Watershed Assessment Units (WAU) in the East Fork Little Miami River with Nonpoint Source Implementation Strategies (NPS-IS).

5.5.3. NPS-IS projects

The projects listed in Table 23 have been developed by stakeholders and are included in existing approved NPS-ISs. These are included as project summary sheets in Section 4 of each approved NPS-IS. Table 23 is a compilation of the projects listed in these summary sheets and indicates whether the project has been completed or partially completed. NPS-ISs are living documents that can be updated as projects are completed or as new potential projects are found. Fivemile Creek WAU and Glady Creek WAU have both been updated since the original NPS-IS was approved. It is encouraged for stakeholders to continue working on projects listed in NPS-ISs, continually look for potential new projects, and update the NPS-ISs when potential projects are found.

Table 23. Projects listed in the currently approved East Fork LMR NPS-IS. Projects are listed in order by HUC-12 WAU with a description of the lead organization, estimated cost, potential/actual funding sources, and if completed.

Project Title	Lead Organization	Estimated Cost	Potential/Actual Funding Source	Completed?
050902021001 - Turtle Creek				
No NPS-IS developed for this HUC-12 WAU.				
050902021002 - Headwaters of East Fork Little Miami River				
No NPS-IS developed for this HUC-12 WAU.				
050902021003 - Headwaters of Dodson Creek				
No NPS-IS developed for this HUC-12 WAU.				
050902021004 - Anthony Run - Dodson Creek				
No NPS-IS developed for this HUC-12 WAU.				
050902021005 - West Fork of East Fork Little Miami River				
No NPS-IS developed for this HUC-12 WAU				
050902021006 - Glady Creek - East Fork Little Miami River				
Agricultural Lands				
Cover Crops	Local SWCDs	$290,000	EQIP, NWQI, RCPP	Partial
Nutrient Management	Local SWCDs	$40,000	EQIP, NWQI, RCPP	Partial
Grassed Waterways	Local SWCDs	$23,000	Ohio EPA 319, CRP, CSP, EQIP, NWQI	
Contour buffer strips	Local SWCDs	$2,000	CRP, CSP, EQIP, NWQI, RCPP	
Water and Sediment Control Basins (WASCOBs)	Local SWCDs	$30,000	Ohio EPA 319, EQIP, NWQI, RCPP	
Water Quality Ponds	Local SWCDs	$217,800	Ohio EPA 319, EQIP, NWQI, RCPP	
Nutrient Removal Wetlands	East Fork Watershed Cooperative	$120,000	ODNR H2Ohio, Ohio EPA 319, EQP, NWQI, RCPP	In Progress
Riparian Zone Improvement	Local SWCDs	$2,250	Ohio EPA 319, CRP, CSP, NWQI, RCPP	
Stream and Riparian Restoration				
EFLMR Riparian Restoration RM 72.8	Local SWCDs	$18,150 - $27,225	EQIP, CSP, RCPP, NWQI, WHIP, Ohio EPA 319, WRRSP, Clean Ohio Fund, H2Ohio	
Sycamore Creek Riparian Restoration RM 0.8	Local SWCDs	$5,610 - $8,415	EQIP, CSP, RCPP, NWQI, WHIP, Ohio EPA 319, WRRSP, Clean Ohio Fund, H2Ohio	
Sycamore Creek Stream Bank Stabilization RM 0.8	Local SWCDs	$50,400	EQIP, CSP, RCPP, NWQI, WHIP, Ohio EPA 319, WRRSP, Clean Ohio Fund	
Upper Sycamore Creek Riparian Restoration	Local SWCDs	$61,050 - $91,575	EQIP, CSP, RCPP, NWQI, WHIP, Ohio EPA 319, WRRSP, Clean Ohio Fund, H2Ohio	
East Fork Riparian Reserve Stream Restoration	Local SWCDs	$400,000 - $600,000	Ohio EPA 319, WRSPP	In Progress
Other Nonpoint Sources				

Septic System Rehabilitation	Clermont SWCD	$280,000	SSRFP, CWSRF, USDA-Rural Development	
Green Space Conservation & Riparian Protection				
Riparian Zone Protection EFLMR (16 miles)	Local SWCDs	$1,743,000	Clean Ohio, WRRSP, H2Ohio	
Riparian Zone Protection – Streams (90 miles)	Local SWCDs	$2,454,000	Clean Ohio, WRRSP, H2Ohio	
050902021101 - Solomon Run - East Fork Little Miami River				
Agricultural Lands				
Cover Crops	Local SWCDs	$153,335	H2Ohio, EQIP, NWQI, RCPP	Partial
Nutrient Management	Local SWCDs	$40,000	H2Ohio, EQIP, NWQI, RCPP	Partial
Grassed Waterways	Local SWCDs	$25,000	Ohio EPA 319, CRP, CSP, EQIP, NWQI	
Water and Sediment Control Basins (WASCOBs)	Local SWCDs	$55,000	Ohio EPA 319, EQIP, NWQI, RCPP	
Water Quality Ponds	Local SWCDs	$217,800	Ohio EPA 319, EQIP, NWQI, RCPP	
Contour buffer strips	Local SWCDs	$1,500 - $2,000	CRP, CSP, EQIP, NWQI, RCPP	
Nutrient Removal Wetlands	East Fork Watershed Cooperative	$300-500,000	ODNR H2Ohio, Ohio EPA 319, EQP, NWQI, RCPP	
Stream and Riparian Restoration				
EFLMR Riparian Reforestation (~200 acres) RM 54.4	Local SWCDs	$600,000-$800,000	EQIP, CSP, RCPP, NWQI, WHIP, Ohio EPA 319, WRRSP, Clean Ohio Fund, H2Ohio	
EFLMR Riparian Reforestation (~100 acres) & In-Stream Restoration (1 mile) RM 47; RM 54	Local SWCDs	$1.5 - 3,000,000	EQIP, CSP, RCPP, NWQI, WHIP, Ohio EPA 319, WRRSP, Clean Ohio Fund, H2Ohio	
Saltlick Creek Riparian Reforestation (10 acres) RM 0.6, 2.5, 4, 5	Local SWCDs	$75,000-$200,000	EQIP, CSP, RCPP, NWQI, WHIP, Ohio EPA 319, WRRSP, Clean Ohio Fund	
Other Nonpoint Sources				
Septic System Rehabilitation	Clermont SWCD	$40,000-60,000	SSRFP, CWSRF, USDA-Rural Development	Partial
Green Space Conservation & Riparian Protection				
Green Space protection	Local SWCDs	1.5-3 M	Clean Ohio, WRRSP, H2Ohio	
050902021102 - Fivemile Creek - East Fork Little Miami River				
Cover Crops	Brown SWCD	$373,000	Ohio EPA 319, EQIP, CSP, RCPP, Fivemile NWQI	Partial
Fertilizer Injections	Brown SWCD	$160,000	Ohio EPA 319, EQIP, CSP, RCPP, Fivemile NWQI	
Conservation Crop Rotation	Brown SWCD	$10,500	Ohio EPA 319, EQIP, CSP, RCPP, Fivemile NWQI	
Grassed Waterways	Brown SWCD	$30,150	Ohio EPA 319, EQIP, CSP, RCPP, Fivemile NWQI	

Contour Buffer Strips	Brown SWCD	$3,900	Ohio EPA 319, EQIP, CSP, RCPP, Fivemile NWQI	
Stream and Riparian Restoration				
Fivemile Creek Restoration RM 0.5	Clermont SWCD	$65,000	Ohio EPA 319, WRRSP, WHIP	
Fivemile Creek Restoration RM 2.3	Clermont SWCD	$65,000	Ohio EPA 319, WRRSP, WHIP	
Pleasant Run Restoration RM 1.4	Clermont SWCD	$65,000	Ohio EPA 319, WRRSP, WHIP	
Pleasant Run Restoration RM 0.4	Clermont SWCD	$65,000	Ohio EPA 319, WRRSP, WHIP	
Riparian Zone Improvement	Clermont SWCD	$181,000	Ohio EPA 319, WRRSP, Clean Ohio Fund, EQIP, CSP, RCPP, NWQI	
Wetland Construction	Clermont SWCD	$1,500,000	Ohio EPA 319, WRRSP, WHIP	✓
Other Nonpoint Sources				
Septic System Rehabilitation	Clermont SWCD	$173,000	SSRFP, CWSRF, USDA-Rural Development	Partial
Green Space Conservation & Riparian Protection				
CECOS Preserve	Clermont SWCD	$500,000	Clean Ohio, WRRSP, H2Ohio	
East Fork Riparian Protection	Clermont SWCD	$3,500,000	Clean Ohio, WRRSP, H2Ohio	
050902021103 - Todd Run - East Fork Little Miami River				
No NPS-IS developed for this HUC-12 WAU				
050902021201 - Poplar Creek				
No NPS-IS developed for this HUC-12 WAU				
050902021202 - Cloverlick Creek				
No NPS-IS developed for this HUC-12 WAU				
050902021204 - Backbone Creek - East Fork Little Miami River				
NPS-IS in development				
050902021301 - Headwaters of Stonelick Creek				
No NPS-IS developed for this HUC-12 WAU				
050902021303 - Moores Fork - Stonelick Creek				
No NPS-IS developed for this HUC-12 WAU				
050902021302 - Brushy Fork				
No NPS-IS developed for this HUC-12 WAU				
050902021304 - Lick Fork - Stonelick Creek				
No NPS-IS developed for this HUC-12 WAU				
050902021305 – East Fork Little Miami River – Salt Run				
Hall Run subwatershed				
Stormwater Detention Basin Retrofits – Phase 1	Clermont SWCD	$100,000	Ohio EPA 319, Private Foundations, Public-Private Partnerships, County MS4 Funds	
Urban Reforestation	Clermont SWCD	$200,000	Ohio EPA 319, Private Foundations	
Hall Run Stream Restoration Near RM 0.2	Clermont SWCD	$250,000	Ohio EPA 319, WRRSP	

Hall Run Riparian Corridor Enhancements	Clermont SWCD	$100,000	Ohio EPA 319, Private Foundations	
Upper Salt and Avey's Run subwatershed				
Restoration of Avey's Run @ Shore Park	Clermont Park District	$225,316	Section 319	✓
Upper Salt Run – Preservation of Dickerson Property	Cardinal Land Conservancy	$200,000	Clean Ohio, WRRSP	
Lower Shayler Creek subwatershed				
Lower Shayler Run Stream Restoration	Clermont SWCD	$1,000,000	WRRSP	
Wolfpen Run subwatershed				
Repair/Replacement of Failing Septic Systems	Clermont Water Resources Department	$525,000	WPCLF, CDBG	Partial
East Fork Little Miami River Main Stem				
EFLMR Stream Bank Restoration at RM 1.2	Clermont SWCD	$750,000	WRRSP	
EFLMR Habitat Restoration Near RM 0.8	Clermont SWCD	$300,000	Ohio EPA 319, WRRSP	

CDBG – Community Development Block Grant
CRP – Conservation Reserve Program
CWSRF – Clean Water State Revolving Fund
EQIP – Environmental Quality Incentives Program
NWQI – National Water Quality Initiative
RCPP – Regional Conservation Partnership Program
SSRFP – Septic System Rehabilitation Financing Program
WHIP – Wildlife Habitat Incentives Program
WPCLF – Water Pollution Control Loan Fund
WRRSP – Water Resource Restoration Sponsor Program

Some of the projects listed in Table 23 are listed as partially completed. These are projects or practices that had a numerical goal set, such as replace or rehabilitate 12 failing HSTSs, in Chapter 3 of the NPS-IS. Projects with these types of goals generally include failing septic systems and agriculture BMPs, such as cover crops. In 2023, Brown County Health Department, Clermont County General Health District, and Highland County General Health District have pursued funds through the Ohio EPA Water Pollution Control Loan Fund for their home sewage treatment system rehabilitation programs.

5.5.4. Water quality trading

Water quality trading is a tool for achieving water quality improvements through programs that allow national pollutant discharge elimination system (NPDES) permit holders (point source) to meet regulatory obligations by using pollutant reductions generated by another wastewater point source or non-point source. The state of Ohio allows for water quality trading following the rules established under OAC-3745-5. There is only one trade in an NPDES permit in Ohio, Alpine Cheese in Holmes County. East Fork LMR was selected to develop a feasibility study for water quality trading. The study found that point sources were unlikely to purchase enough nutrient pollutant reduction from agriculture producers to make a difference in water quality (Lee *et al.* 2022). The Great Lakes Commission received funding for a pilot water quality trading program for phosphorus, called the Erie P Market, but had issues finding participants. An issue facing many water quality trading programs, including Ohio's program, is finding participants. Participation in a water quality trading program can depend on pollution control costs, uncertainty in the pollution control, and discharge limits (Heberling *et al.* 2018). An option to address this issue would be recruiting non-traditional participants, such as citizens or drinking water plants, as explored by Heberling *et al.* (2018). Newburn and Woodward (2012), in their study of the Great Miami River water quality trading program, found that using third-party representatives, such as soil and water conservation districts, was useful in assisting farmers in water quality trading and increased participation. Alpine Cheese partnered with Holmes County Soil and Water Conservation District and Ohio State University to help with their water quality trading agreement. Other states may use the government as a third party. However, Ohio's rules regarding water quality trading put the responsibility of creating the trading plan on the participants.

5.5.5. Practices to address atrazine impairment

The Village of Blanchester public drinking water supply use is impaired due to atrazine. The Village of Blanchester public drinking water supply draws from water sources in the Second Creek (0702) WAU (not part of the East Fork LMR watershed), West Fork of East Fork Little Miami River (1005) WAU, and the Headwaters of Stonelick Creek (1301) WAU. The only known source of atrazine is from agricultural nonpoint sources in the East Fork LMR. There are processes in drinking water plants to reduce atrazine in drinking water, but this implementation plan focuses on addressing nonpoint sources of atrazine.

Following the label guidelines for atrazine will help reduce atrazine. This includes not treating areas within 66 feet of a waterway and not applying the herbicide within 48 hours of expected precipitation. King *et al.* (2012) found significant reductions of atrazine present in the Hoover Reservoir (Columbus, Ohio) when label restrictions were implemented. Furthermore, when BMPs were implemented in addition to following label restrictions, more significant reductions of atrazine were documented.

Many studies have found that buffers (such as filter strips and riparian buffers) and wetlands are the most effective practices for reducing the amount of atrazine loss through surface runoff (Harman et al. 2004; Reichenberger *et al.* 2007). Conservation practices, such as riparian buffers and buffer strips, slow and filter out nutrients, sediment, and pesticides, making these practices effective. Similarly, constructed wetlands have been shown to entrap and process (through plant uptake) herbicides, such as atrazine (Locke *et al.* 2011). Though not the most effective, Harman *et al.* (2004) found that the use of alternative tillage practices and split applications of atrazine between fall and spring was marginally effective. Crop residue on fields and no-tillage agriculture can reduce pesticide runoff compared to conventional agriculture. The residue slows the movement of water over the surface of the field and increases infiltration.

As noted in section 5.5.2., the West Fork of East Fork LMR (1005) and Headwaters of Stonelick Creek (1301) would be good candidate assessment units to prioritize for NPS-IS development. The suggested practices would include water management features, such as saturated buffers, riparian buffers, or conservation cover, to reduce nonpoint source loads. This would address both nutrient and atrazine impairments in these WAUs.

5.6 Point source management

Point sources can be broadly managed as stormwater and individual facilities, which can be regulated by general NPDES permits (stormwater) or individual NPDES permits.

5.6.1. General NPDES permits

Stormwater is managed separately from wastewater treatment facilities because stormwater discharges are managed through a diffuse network of pipes and conveyances rather than a discrete outfall. The discharges are also not continuous and are irregular in nature. Because of this, monitoring stormwater discharges is more challenging than discharges from treatment facilities. This challenge drives the expression of limits for managing stormwater through the implementation of BMPs. These BMPs may focus on managing sources of the pollutant, managing the volume of stormwater discharged from the site, or managing concentrations of the pollutant with filtration practices. Entities covered by general NPDES permits must comply with permit requirements, which may include implementing certain BMPs. Ohio EPA may ensure compliance through the Agency's regulatory authority. Additionally, county health departments, local government agencies, ODH, and SWCDs work with Ohio EPA and TMDL project area stakeholders to reduce pollutant loads through various environmental and compliance programs.

5.6.2. Individual NPDES permits

Recommendations for entities covered by NPDES permits can be implemented through Ohio EPA's regulatory authority. Reductions for TP and TN loads will be necessary at certain facilities according to calculated TMDL allocations where TP and TN contribute to ALU impairments. One way to achieve necessary reductions is through upgrades to WWTPs. Several upgrades to the WWTPs have taken place since the 2012 survey of the East Fork LMR watershed. The following summarizes this work:

- New Vienna WWTP: This plant was identified as a source of impairment in the 2012 stream survey. A plant upgrade was completed in 2014, which included the addition of floating baffles and the replacement of air diffusers and mechanical blowers. Based upon self-monitoring data, the upgrade appears to have resulted in an improved effluent quality. When the NPDES permit for the New Vienna WWTP was renewed in January 2020, Ohio EPA included more restrictive final effluent limits for total suspended solids (TSS) to be consistent with statewide design policy for lagoon treatment systems. The reduced TSS load will, to some extent, lessen the organic load on the receiving stream, which was identified as a cause of impairment. The NPDES permit also restricts discharges from the facility during June – September, which is the time of the year when the aquatic biotic are more susceptible to pollutant-related impacts due to low stream flows and warmer temperatures. During November-April, when the receiving stream has more flow and cooler temperatures, the facility is permitted to discharge at a rate of 90 gallons per minute for every cubic ft per sec of stream flow, which translates to a minimum dilution of one gallon of treated wastewater for every five gallons of stream flow. During seasonal transition months of May and October, the facility must maintain a minimum dilution of one gallon of treated wastewater for every ten gallons of stream flow.
- Locust Ridge Nursing Home: This WWTP was also identified as a source of impairment (low dissolved oxygen). The facility completed a plant rehabilitation project in 2013. The project also included the

addition of ultraviolet light for disinfection as a replacement for the chlorine disinfection. The plant rehabilitation project did not include an increase in hydraulic capacity.

- Williamsburg WWTP: This plant was identified as a source of impairment (organic enrichment) during the 2012 stream survey. The initial upgrade to the Williamsburg WWTP took place in 2010 and was anticipated to help resolve impairments due to discharges with excessive ammonia. In 2013, facility personnel also initiated a chemical addition (alum) to the WWTP, which enabled them to achieve lower total phosphorus (TP) concentrations in their final effluent. The village also completed an additional WWTP upgrade in 2016, which included increasing the average daily design flow from 0.5 million gallons per day (MGD) to 0.9 MGD. At the same time, facility personnel incorporated operational changes that facilitate biological nutrient removal at the WWTP. The current NPDES permit for the Williamsburg WWTP reflects TP limits of 1.0 mg/l for a monthly average concentration and 1.5 mg/l for a weekly average concentration. It should also be noted that the Village of Williamsburg completed a sanitary sewer extension project in 2019. This project was designed to serve unsewered areas that had discharging systems and failing onsite sewage treatment systems.
- Stonelick State Park Campgrounds WWTP: Although not specifically identified as a source of impairment it is noted that upgrades were also completed at this WWTP. The upgrade included the installation of aeration to the lagoon wastewater treatment system.
- The Clermont County Commissioners were issued Director's Findings and Orders in January 2020 to provide wastewater collection and treatment for the former village of Newtonsville. A permit-to-install was obtained for construction of the sewerage and treatment facility in July 2020. The wastewater treatment plant is being designed for an average daily volume of 57,000 gpd. When complete, the sewer project will serve a population of about 400 residents and eliminate 48 discharging household wastewater systems. The orders require completion of the project by 2024.
- Clermont County Board of Developmental Disabilities: The Clermont County Board of Developmental Disabilities facility was a previously unidentified discharger and received an NPDES permit in 2016. Due to the issuance of the NPDES permit and the final effluent discharge limits within the permit, the facility upgraded the WWTP to include an ultraviolet light disinfection system in 2017.

Ohio EPA will continue to work with permit holders to accomplish any needed reduction loadings.

5.7 Monitoring environmental outcomes

The goal of the TMDL project is to restore beneficial uses of East Fork LMR through achieving nutrient and atrazine reductions. The ultimate measure of success is measuring the environmental outcomes that show that the goal is met. That outcome is only expected to be realized when a high level of implementation is achieved, so intermediate measures become important to track progress and inform adaptive management. Monitoring will be conducted through Ohio EPA's routine monitoring, NPDES-permitted facilities routine monitoring, Ohio EPA's Section 319(h) pre- and post-implementation monitoring, H2Ohio project monitoring, and U.S. EPA ORD monitoring program.

Ohio EPA monitored water quality and assessed aquatic community health and use attainment in 1994 and 2012 (Ohio EPA 1995, 2014). The effectiveness of actions based on the TMDL recommendations should be validated through follow-up biological and water quality monitoring. Additionally, monitoring is required to determine if and when formerly impaired segments meet applicable water quality standards. As part of Ohio EPA's routine monitoring strategy, the Little Miami River watershed will be monitored in the next few years.

Pre- and post-implementation monitoring may be conducted for projects selected to receive Section 319(h) funding. Where appropriate, the pre-implementation monitoring will provide baseline biological community and physical habitat quality data for water bodies expected to be restored by the project. Biological community and physical habitat results will be collected at least one to two years after project completion to compare with baseline monitoring results.

Projects funded through the H2Ohio Wetland Grant Program will be routinely monitored by ODNR and their partners to track nutrient reductions and other water quality improvements through the life of the established wetland. Recently, the Lake Erie and Aquatic Research Network (LEARN) has partnered with ODNR on the H2Ohio Initiative's wetland monitoring program to assess the effectiveness and future role of implemented and planned wetland restoration projects. This effort is to not only monitor the effectiveness of wetland efforts but also inform future wetland construction and maintenance. This collaboration will study different types of wetlands to determine which are the most cost-effective for mitigating nutrient runoff to Ohio waters. Additionally, H2Ohio expanded nutrient monitoring to include the Little Miami River and East Fork LMR. H2Ohio funded the installation of nutrient monitoring equipment at the Little Miami River and East Fork LMR pour points and monitoring at these pour points for three years. Ohio EPA is now pursuing funding for continuous monitoring at these stations.

Both U.S. EPA ORD and Clermont County Office of Environmental Quality have routinely sampled the East Fork LMR. U.S. EPA ORD has routinely sampled Harsha Lake since 2009 and expanded its watershed sampling program to support other research, such as the feasibility of water quality trading programs, in 2013.

All NPDES-permitted wastewater treatment facilities are required to routinely sample their effluent as a condition of their permits. Monitoring parameters and frequencies vary and are dedicated to individual permit requirements according to pollutants of concern, plant design flow, and other considerations. In many cases, entities are also required to collect ambient water quality samples upstream and downstream of their discharge location to provide data regarding potential effects on stream water quality. NPDES-permitted discharges are required to report their self-monitoring results to Ohio EPA monthly as a condition of their permits.

Through both project-specific monitoring and routine monitoring, environmental outcomes will be realized and may be used to continue to adjust the implementation strategy.

5.8 Summary

East Fork LMR has an extensive history and activity in watershed planning and project implementation. With the routine monitoring conducted by U.S. EPA ORD and Ohio EPA, and the watershed management plans and NPS-ISs by EFWC, there is a strong understanding of the watershed. Many projects and practices have already been implemented to address the beneficial use impairments caused by nutrients and atrazine through various state and federal programs. This implementation plan encourages the continued enrollment and implementation of these programs. This implementation plan also encourages the development of NPS-ISs for HUC-12 WAUs that contribute to the beneficial use impairments and continually updating current NPS-ISs. NPS-ISs are living documents that can be updated with new projects or adjusted to reflect the most effective practices, which is a key element of adaptive management.

Adjustments to the implementation plan can happen at any time as programs develop. Individual programs get feedback on program effectiveness (e.g., H2Ohio programs). The goal of adaptive management is to accelerate programs that do work while looking for ways to improve or move away from ones that are not having the intended response. Changes in implementation actions could be driven by a metric (e.g., atrazine concentrations or occurrence of HABs) that shows a program is not having a desired outcome, or a metric could show that a practice is showing positive outcomes. State agencies might also adapt to policy changes that require additional implementation.

Not all adaptations to the implementation strategy happen in the same way. The evolution of conservation programs is ‘part of the plan’; these do not require special considerations to improve programs. New research findings or updated analysis of monitoring results might affect the assumptions made to develop the TMDL, which would require additional stakeholder outreach by Ohio EPA. For example, if a change is proposed that affects the technology considered for compliance with NPDES permit limits. If new information suggests changes to the allocations or reasonable assurances, additional federal review and approval may be necessary.

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