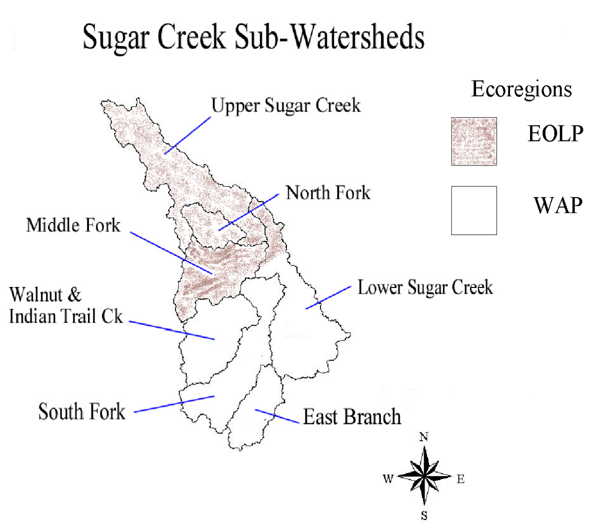
Total Maximum Daily Loads for the Sugar Creek Basin

Final Report

Prepared by

Ohio Environmental Protection Agency
Division of Surface Water

September 2002



Basin: Sugar Creek, in the Tuscarawas River Basin
Study Area: Whole watershed; listed segments are highlighted in Table 1 and Figure 3 of this report.
Goal: Attainment of the appropriate Aquatic Life Use
Major Causes: Sedimentation, habitat alteration and nutrient enrichment.
Major Sources: Agricultural runoff, streambank modification, lack of riparian vegetation, faulty septic systems, and municipal/industrial discharges.
Measure: Total phosphorus, total nitrogen, biological and habitat indices
Restoration Options: Agricultural runoff controls, fencing livestock, habitat protection and restoration, riparian improvements, septic system improvements, point source controls, and public education & outreach

CONTENTS

APPENDICES

TABLES

FIGURES

PLATES

ACKNOWLEDGMENTS

The following Ohio EPA staff deserve special recognition for their important contributions to this project:

Biology and Chemical Water Quality - Joann Montgomery (SEDO) and Robert Davic (NEDO)
Ecology and Habitat issues - Brian Alsdorf and Marty Knapp (EAS)
Nonpoint Source Issues - Dan Imhoff (SEDO) and Mark Bergman (NEDO)
Point Source Issues - Dean Stoll (NEDO) and Jennifer Witte (SEDO)
Water Quality Standards - Chris Skalski
GIS support - Dale White
Project Leader and Modeling - Eric Piñeiro

The following individuals provided useful comments during internal and external review of the draft documents: Maan Osman, Trinka Mount, John Kessler, Gail Hesse, Mike Gallaway, Cathy Alexander, Jim Bonta and Alice McKenney . Indispensable assistance in data reduction and analysis was provided by Denise Lees. Barb Wooldridge is commended for her efforts in preparing the document for web publication.

This evaluation and report would not have been possible without the additional assistance of the many full and part time staff in the field, and the chemistry analyses provided by the Ohio EPA Division of Environmental Services.

The efforts and support of the following stakeholder groups and individuals are acknowledged: East Branch Sugar Creek Watershed Planning project, Sugar Creek/Wayne Co SWCD watershed coordinator (Eric Schultz), North Fork Sugar Creek Task Force, and the Sugar Creek Partners (Smithville area).

Executive Summary

The Sugar Creek watershed covers 357 square miles in northeast Ohio in Wayne, Stark, Holmes, and Tuscarawas counties. The mainstem is 45 miles long and flows from the north near Smithville to the south where it joins the Tuscarawas River near Dover. More than 70% of the basin's land is devoted to agricultural uses including dairy, beef and poultry confined feeding operations, row crops, and forage production. Ohio EPA conducted a comprehensive biological, chemical and bacteriological assessment of the Sugar Creek basin during the summer of 1998. The 1998 Sugar Creek study area included the mainstem from RM 42.8 (near Smithville) to the mouth, including all tributaries with a drainage area of five square miles. Habitat evaluations were determined using Ohio EPA's QHEI (habitat) index. Survey results showed that most locations surveyed throughout the basin failed to meet the assigned aquatic life uses.

The extent of **NON** attainment throughout most of the watershed distinguished Sugar Creek as one of the most degraded basins in Ohio. **The most significant causes of aquatic life habitat impairment in the Sugar Creek basin are sediments/siltation, habitat alteration and nutrient enrichment.** The recreational use of the waterbodies are also being impaired by widespread exceedances of bacterial water quality criteria. Although this report doesn't include TMDLs for bacteria (due to insufficient data), many of the management practices recommended for sediment and nutrient load reductions are expected to lower bacteria loads as well. After the management practices are implemented, the Sugar Creek watershed will be reassessed to verify if bacteria counts are still excessive. The possible impact of abandoned mines on Sugar Creek will also be assessed during future surveys.

The goal of the Sugar Creek TMDL is to achieve full attainment of the applicable biological and chemical water quality standards for all impaired segments, included the 303 (d) listed ones. While only 7 segments are included in the 1998 303 (d) list, additional information about unlisted segments is included in the appendices. The absence of listed segments in some of the subwatersheds is explained by the fact that the 1998 TMDL list was based on limited data collected prior to 1998. When the 303(d) list is revised (in 2002), it is likely that all the subwatersheds will have listed segments, based on the results of the basin wide assessment conducted in 1998-99.

The parameters addressed in the Sugar Creek TMDL are Sediment and Nutrients (Total Phosphorus and Nitrate +Nitrite). **Since good habitat is needed to achieve the applicable biological and chemical water quality standards, this report includes an evaluation of habitat conditions in the Sugar Creek basin, and recommends desirable habitat score targets.** Ohio EPA currently does not have statewide numeric criteria for nutrients but potential targets have been identified using a technical report entitled *Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams* (OEPA, 1999). The recommended nutrient targets used in this TMDL are based on that document. It is important to note that these nutrient targets are not codified in Ohio's water quality standards and therefore there is a certain degree of flexibility as to how they can be used in a TMDL setting. It is the biocriteria and not the nutrient targets that will be measured to determine full attainment of water quality standards. The nutrient targets vary by drainage area, helping compensate for lower upstream flow.

Sedimentation from agricultural activities and streambank erosion may be the key factor preventing the attainment of biological standards. It is clear that sedimentation affects all downstream segments, and must be controlled starting with the headwater streams. A Maumee River tributary showed a 50% sediment load reduction after farmers gradually adopted conservation tillage. Ohio EPA recommends that watershed groups set a goal of having 50% of their cropland under no-till or conservation tillage. This goal is based on the results observed in tributaries to the Maumee River (USGS, 2000). A 30% sediment load reduction is recommended as a feasible goal that should boost biological criteria scores in the Sugar Creek basin.

Nutrient and sediment loading in the Sugar Creek basin was simulated using the Generalized Watershed Loading Function or GWLF model. The complexity of this model falls between that of detailed, process-based simulation models and simple export coefficient models which do not represent temporal variability. Point source loads were also included in the simulations, using design flows and permit limits. The model was calibrated for the whole watershed, and used to determine loads for each subwatershed. The calibrated model was used to estimate background nutrient and sediment loads.

Various watershed groups in the Sugar Creek basin have been awarded Section 319 grants to prepare and implement watershed plans. Ohio EPA will provide technical support to help them implement management practices recommended in this TMDL report. A participatory approach for development of watershed groups is successfully being promoted by OARDC (Ohio Agricultural Research and Development Center) in the Sugar Creek basin. This approach will be applied by OARDC to other subwatersheds in the Sugar Creek basin to form stakeholder groups.

Nutrient loads from point sources are being reduced through the NPDES permit process. The implementation of a basinwide total phosphorus limit of 1 mg/l for point source dischargers has already started, and will continue as permits are renewed. Although point source limits are subject to a compliance schedule, it is expected that most point sources will meet the recommended phosphorus effluent limits within 5 years. Point source load reductions for NO_3 + NO_2 are only recommended for one subwatershed (North Fork) for which point sources are the main sources of nitrogen. For other subwatersheds, top priority should be given to nitrogen load reductions from failing septic systems, crop production and livestock activities. Although this report focuses on the listed segments, the basinwide recommendations will protect headwater and effluent dominated tributaries and result in a considerable nutrient load reduction.

Ohio EPA recommends that habitat improvements aimed at achieving the QHEI (habitat) index goal of 60 be implemented within 5 years from the date of this TMDL report. This will assure that the management practices will be in place before the existing watershed coordinator grant ends. Some riparian improvements have already been installed in the East Branch and Upper Sugar Creek subwatersheds.

1.0 INTRODUCTION

The Clean Water Act (CWA), Section 303(d), requires States to list and prioritize waters for which effluent limitations are not stringent enough to achieve applicable water quality standards. Commonly referred to as the "impaired waters list" or "303(d) list", the most recent Ohio edition was prepared by Ohio EPA in 1998. Table 1 shows the seven stream segments that were identified as impaired, as well as unlisted segments in other areas of the Sugar Creek basin.

The 1998 303(d) list was based on data available through about 1994. A comprehensive biological/water quality survey was conducted in the Sugar Creek basin during 1998 and 1999. Due to the limited scope of previous assessments, the segments included in the 1998 303(d) list comprise a small fraction of the total drainage area of the basin. This report includes information beyond the requirements of that list, covering essentially the whole basin. More details about the segments that were not included in the 1998 list are available (Ohio EPA, 2000).

The Clean Water Act and USEPA regulations require that Total Maximum Daily Loads (TMDLs) be developed for all segments on the section 303(d) lists. The requirements of a TMDL are described in Title 40 Code of Federal Regulations (CFR) sections 130.2 and 130.7 and section 303(d) of the Clean Water Act, as well as in various guidance documents (e.g., USEPA, 1991; USEPA, 1997). A TMDL is defined as "the sum of the individual wasteload allocations for point sources and load allocations for nonpoint sources and natural background" such that the capacity of the waterbody to assimilate pollutant loadings is not exceeded. A TMDL is also required to be developed with seasonal variations and must include a margin of safety that addresses the uncertainty in the analysis. A TMDL is expressed using the following equation:

$$TMDL = WLA + LA + (MOS)$$

where WLA = wasteload allocation, LA = load allocation, and MOS = margin of safety. The MOS is in parenthesis because it can be incorporated into the TMDL either explicitly or implicitly. The MOS is incorporated explicitly when it is expressed directly in the TMDL loadings. The MOS is incorporated implicitly when it is expressed through conservative assumptions used in the analysis.

Table 1. Summary of Sugar Creek watershed areas included in this TMDL report

Waterbody Segment Description/[HUC Code *]	**Major Causes [A]**	**1998 303(d) list**	**1998 survey [B]**	**TMDL Done**	**Comments**
Upper Sugar Creek					
Sugar Creek (Headwaters to Middle Fork) [05040001-100] RM 45.0 to 19.4	Organic Enrichment/DO (H)	✓		☺	No TMDL needed for D.O. based on 1998 assessment
	Habitat alteration (H)		✓	Yes	
	Siltation (H)		✓	Yes	
	Nutrients (M)		✓	Yes	
	Wetlands (H)		✓	No	Impairment due to natural conditions
	Pathogens (H)		✓	No	Insufficient data to quantify; BMPs recommended
Little Sugar Creek [05040001-100] RM 10.6 to 0.0	Organic Enrichment/DO(H)	✓		☺	No TMDL needed for D.O. based on 1998 assessment
	Habitat alteration (H)		✓	Yes	
	Siltation (H)		✓	Yes	
	Nutrients (M)		✓	Yes	
	Pathogens (H)		✓	No	Insufficient data to quantify; BMPs recommended
North Fork					

Waterbody Segment Description/[HUC Code *]	Major Causes [A]	1998 303(d) list	1998 survey [B]	TMDL Done	Comments
North Fork Sugar Ck [05040001-100] RM 6.8 to 0.0	Nutrients (H)	✓	✓	Yes	
	Organic Enrichment/DO (H)	✓		☺	No TMDL needed for D.O. based on 1998 assessment
	Habitat Alteration (H)	✓	✓	Yes	
	Pathogens (H)	✓	✓	No	Insufficient data to quantify; BMPs recommended
	Siltation (H)		✓	Yes	
	Unionized ammonia (M)	✓		☺	No TMDL needed for NH3-N based on 1998 assessment
Middle Fork					
Middle Fork Sugar Ck. [05040001-120] RM 15.0 to 0.0	Wetlands (H)		✓	No	Impairment due to natural conditions
	Siltation (M)		✓	Yes	
	Nutrients (H)		✓	Yes	
	Pathogens (H)		✓	No	Insufficient data to quantify; BMPs recommended
Lower Sugar Creek					
Elm Run [05040001-120] RM 3.0 to 0.0	Habitat alteration (H)		✓	Yes	
	Siltation (H)		✓	No	Urban influence not fully assessed
	Flow alteration (M)		✓	No	Due to ubiquitous use of drainage tiles
	Pathogens (H)		✓	No	Insufficient data to quantify; BMPs recommended
Sugar Creek (M Fork to South Fork) [05040001-120] RM 19.4 to12.3	Wetlands (H)		✓	No	Impairment due to natural conditions
	Siltation (H)		✓	Yes	
	Nutrients (M)		✓	Yes	

Waterbody Segment Description/[HUC Code *]	**Major Causes** [A]	**1998 303(d) list**	**1998 survey** [B]	**TMDL Done**	**Comments**
	Pathogens (H)		✓	No	Insufficient data to quantify; BMPs recommended
Sugar Ck: S Fork to Tuscarawas R. [05040001-120] RM 12.3 to 0.0	Wetlands (H)		✓	No	Impairment due to natural conditions
	Siltation (M)	✓	✓	Yes	
Broad Run [05040001-120] RM 6.0 to 0.0	Habitat alteration (H)		✓	Yes	
	Siltation (H)		✓	Yes	
	Nutrients (M)		✓	Yes	
	Flow alteration (M)		✓	No	Due to ubiquitous use of drainage tiles
	Pathogens (H)		✓	No	Insufficient data to quantify; BMPs recommended
Turkeyfoot Run [05040001-120] RM 3.3 to 0.0	pH (H)		✓	No	Additional data required
Cherry Run [05040001-120] RM 3.74 to 0.0	pH (H)		✓	No	Additional data required
Goettge Run [05040001-120] RM 5.14 to 0.0	pH (H)	✓		☺	No TMDL needed for pH based on 1998 assessment
	Siltation (H)		✓	No	No excessive sediments observed
	Metals (H)		✓	No	No criteria available for elevated metals (manganese/iron)
Brandywine Ck [05040001-120] RM 3.50 to 0.0	Siltation (H)	✓		Yes	
	Metals (H)		✓	No	No criteria available for elevated metals
	Pathogens (H)		✓	No	Insufficient data to quantify; BMPs recommended

Waterbody Segment Description/[HUC Code *]	**Major Causes** [A]	**1998 303(d) list**	**1998 survey** [B]	**TMDL Done**	**Comments**
South Fork Sugar Creek					
South Fork Sugar Creek [05040001-110] RM 22.7 to 6.6	Habitat alteration (H)		✓	Yes	
	Siltation (H)		✓	Yes	
	Nutrients (M)		✓	Yes	
	Flow alteration (M)		✓	No	Due to ubiquitous use of drainage tiles
	Pathogens (H)		✓	No	Insufficient data to quantify; BMPs recommended
South Fork Sugar Creek [05040001-110] RM 6.6 to 0.0	Wetlands (H)		✓	No	Impairment due to natural conditions
	Siltation (H)		✓	Yes	
	Nutrients (M)		✓	Yes	
	Pathogens (H)		✓	No	Insufficient data to quantify; BMPs recommended
Brush Run [05040001-110] RM 3.0 to 0.0	Habitat alteration (H)		✓	Yes	
	Siltation (H)		✓	Yes	
	Nutrients (M)		✓	Yes	
	Pathogens (H)		✓	No	Insufficient data to quantify; BMPs recommended
Troyer Valley Creek [05040001-110] RM 3.20 to 0.0	Ammonia (H)		✓	Yes	
	Metals (H)		✓	No	No criteria available for manganese and iron
	Nutrients (H)		✓	Yes	
	Habitat alteration (H)		✓	Yes	
	Siltation (H)		✓	Yes	

Waterbody Segment Description/[HUC Code *]	Major Causes [A]	1998 303(d) list	1998 survey [B]	TMDL Done	Comments
	Pathogens (H)		✓	No	Insufficient data to quantify; BMPs recommended
Trib. to S. Fork Sugar Ck (RM 14.15) [05040001-110] RM 4.7 to 0.0	Habitat alteration (H)	✓	✓	Yes	
	Siltation (H)	✓		Yes	
	Organic Enrichment/D.O.	✓		☺	No TMDL needed for D.O. based on 1998 assessment
	Unionized ammonia	✓		No	Insufficient data to quantify; BMPs & limits recommended
	Nutrients (H)	✓		Yes	
	Thermal Modifications	✓		No	Insufficient data to quantify; BMPs recommended
	Flow alteration (M)		✓	No	Due to ubiquitous use of drainage tiles
	Pathogens (H)		✓	No	Insufficient data to quantify; BMPs recommended
East Branch Sugar Creek					
East Branch [05040001-110] RM 9.70 to 0.0	Habitat alteration (H)		✓	Yes	
	Siltation (H)		✓	Yes	
	Nutrients (H)		✓	Yes	
	Flow alteration (H)		✓	No	Due to ubiquitous use of drainage tiles
	Pathogens (H)		✓	No	Insufficient data to quantify; BMPs recommended
Pleasant Valley Creek [05040001-110] RM 4.9 to 0.0	Habitat alteration (H)		✓	Yes	
	Siltation (H)		✓	Yes	
	Organic Enrichment (H)		✓	Yes	

Waterbody Segment Description/[HUC Code *]	**Major Causes** [A]	**1998 303(d) list**	**1998 survey** [B]	**TMDL Done**	**Comments**
	Flow alteration (M)		✓	No	Due to ubiquitous use of drainage tiles
	Pathogens (H)		✓	No	Insufficient data to quantify; BMPs recommended
Walnut and Indian Trail Creeks					
Walnut Creek [05040001-110] RM 11.1 to 0.0	Habitat alteration (H)		✓	Yes	
	Siltation (H)		✓	Yes	
	Nutrients (M)		✓	Yes	
	Pathogens (H)		✓	No	Insufficient data to quantify; BMPs recommended
Goose Creek [05040001-110] RM 4.7 to 0.0	Habitat alteration (H)		✓	Yes	
	Siltation (H)		✓	Yes	
	Nutrients (M)		✓	Yes	
	Pathogens (H)		✓	No	Insufficient data to quantify; BMPs recommended
Indian Trail Creek [05040001-110] RM 8.10 to 0.0	Habitat alteration (H)		✓	Yes	
	Siltation (H)		✓	Yes	
	Nutrients (H)		✓	Yes	
	Pathogens (H)		✓	No	Insufficient data to quantify; BMPs recommended

[A] H: high; M: moderate

[B] Observed during 1998 biological and chemical assessment; indicates that waterbody and cause could be included in 2002 303(d) list.

* The HUC (Hydrologic Unit Code) identifies larger portions of the Sugar Creek watershed, and are shown in Figure 1. The Water Body ID Code is given to each segment of a stream or river. First two characters (OH) indicate 'Ohio', next two digits indicate one of 93 subbasins (e.g., 13 = Sugar Creek), remainder identifiers the specific segment. The upper and lower river miles are the boundaries of the WBID segment. Rivers are "miled" from their mouth in an upstream direction.

2.0 WATERBODY OVERVIEW

2.1. Study Area Description

The Sugar Creek Watershed covers 357 mi^2 in the northeast Ohio counties of Holmes, Stark, Tuscarawas and Wayne. Larger communities include: Brewster, Dover, Smithville, Strasburg and Sugarcreek. The mainstem is forty five miles long and flows from the north near Smithville to the south were it joins the Tuscarawas River near Dover. The Beach City lake is a flood control reservoir completed in 1937. The dam is located in Sugar Creek near river mile 12.3, and controls a drainage area of 300 square miles. The lake extends upstream into Holmes, Stark and Tuscarawas counties. This reservoir is almost 100% filled with sediments.

The watershed lies in two ecoregions. The northern half is in the glaciated Erie and Ontario Lake Plain (EOLP). The major tributaries draining this part of the basin are the Middle Fork, Little Sugar Creek, and the North Fork The glaciated portion is characterized by rolling hills and valleys. The southern half of the watershed is in the unglaciated Western Allegheny Plateau (WAP). The unglaciated portion has steeper topography with coal and clay deposits. Figure 1 shows the location of the watershed relative to its surrounding counties and the two ecoregions, and identifies the three hydrologic units. Table 2 lists the three Hydrologic Unit sub-basins in the Sugar Creek basin and their main waterbodies and drainage areas.

Figure 1. Ecoregion, county and Hydrologic Unit Code boundaries for the Sugar Ck basin

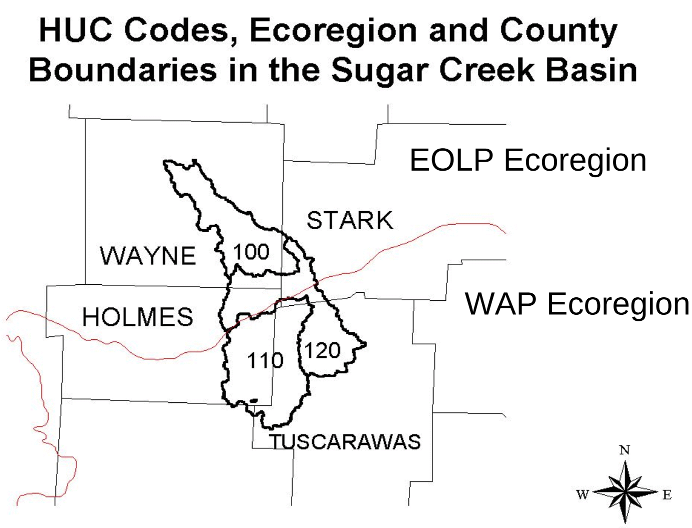


Table 2. Hydrologic Unit Codes (HUC) in the Sugar Creek Basin

HUC Code	Description	Major Tributaries	Area (mi^2)	% Total
05-040001-100	Sugar Creek, headwaters to upstream of Middle Fork	Little Sugar Creek, North Fork	97.3	27.3
05-040001-110	South Fork	East Branch, Indian Trail Ck, Walnut Ck	137.8	38.7
05-040001-120	Sugar Creek, from Middle Fork to mouth, excluding South Fork	Middle Fork	121.4	34.0

More than 70% of the basin's land is devoted to agricultural uses including: dairy, beef and poultry confined feeding operations, row crops, forage production and fruit. According to 1998-99 USDA agricultural statistics, the counties in the Sugar Creek basin were major producers of livestock and certain crops. Table 3 summarizes some of those statistics, including how the counties rank for each activity among Ohio's eighty eight counties (USDA, 2000).

Table 3. Number of Animals/Statewide Rank for the Sale or production of Selected Agricultural Products for Counties in the Sugar Creek Basin

County	All cattle & Calves [A]	Milk Cows [A]	Hogs & Pigs [A]	Sheep & Lambs [A]	Poultry/ other [B]	Oats [C]	Hay [D]
Wayne	79400 [1]	31300 [1]	39200 [10]	3000 [5]	25.7	677800 [1]	133500 [1]
Holmes	41700 [3]	15800 [3]	30300 [14]	2200 [12]	39.8	600600 [2]	117800 [2]
Tuscarawas	29900 [4]	9600 [5]	10000 [45]	1400 [29]	15.8	134400 [17]	84500 [5]
Stark	25200 [9]	9400 [7]	9000 [51]	1100 [38]	19.2	298400 [4]	71300 [10]

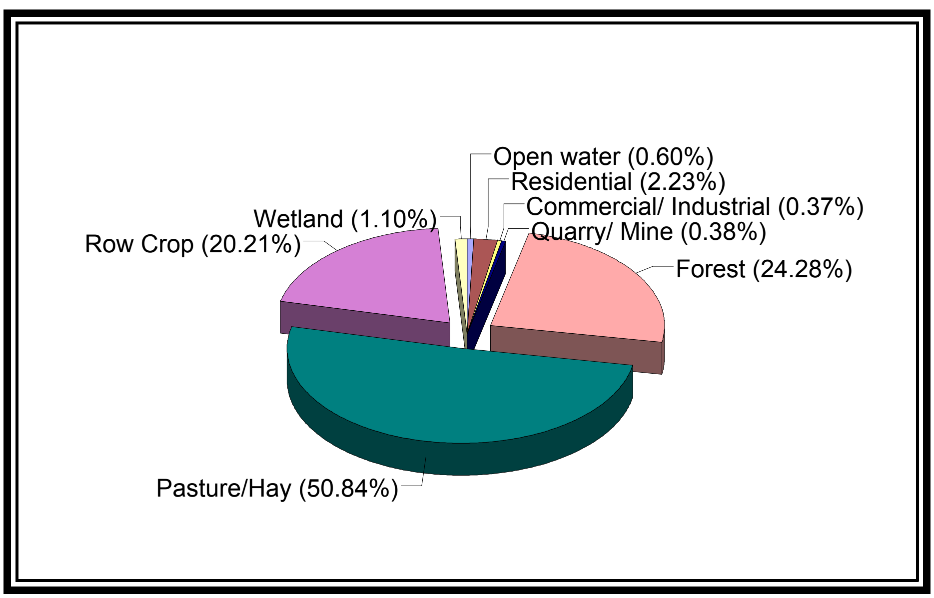
[A] Number of animals [B] Million $ sales [C] Bushels [D] Tons

Although the information shown above is based on counties, it illustrates the relative economic importance of these activities. No county-wide animal unit statistics are available for poultry, but their sales amounts indicate that they provide a significant amount of income to the counties. Thus, agricultural activities are important to the economy in this basin; any remediation measures proposed to be implemented should take into account both the environmental benefits and possible economic impact. The involvement of local stakeholders in the development of implementation plans for this watershed is strongly encouraged. There is one regulated CAFO (Confined Animal Feeding Operation) in the basin, located in the East Branch.

Figure 2 shows the major land uses for the whole basin. Figures 1 and 2 in appendix A illustrate land use and its distribution for other sub-watersheds in the basin, while Table 2 in the same appendix displays additional details about land use and drainage area for various subwatersheds. The 1998 biological and water quality surveys provided an opportunity to assess the impact of agricultural and other activities on the water bodies. Observed aquatic resource degradation from agriculture included direct manure and urine discharge to streams, milking waste discharged by pipe to streams, dumping of fruit processing waste into streams, direct habitat alteration by dredging and cattle walking in streams, and lack of wooded riparian corridor.

Strip mining of coal and clay has a negative impact on some Sugar Creek tributaries. Strip mining involves removing overbearing soil and minerals, removing the clay and or coal and replacing the overburden. Before the mid 1970s, reclamation after mining was not required by law. Unreclaimed mine land contributes sediments, metals and acid water to the streams.

Figure 2: Land use distribution in the Sugar Creek basin



The main industries that contribute to the nutrient loads in the basin are four cheese plants, one whey processing plant, two poultry processing plants, and a rendering plant that processes poultry and other animal by-products. There are ten municipal/county WWTPs (excluding package plants) discharging to Sugar Creek or tributaries. Table 4 lists the point sources in the Sugar Creek basin.

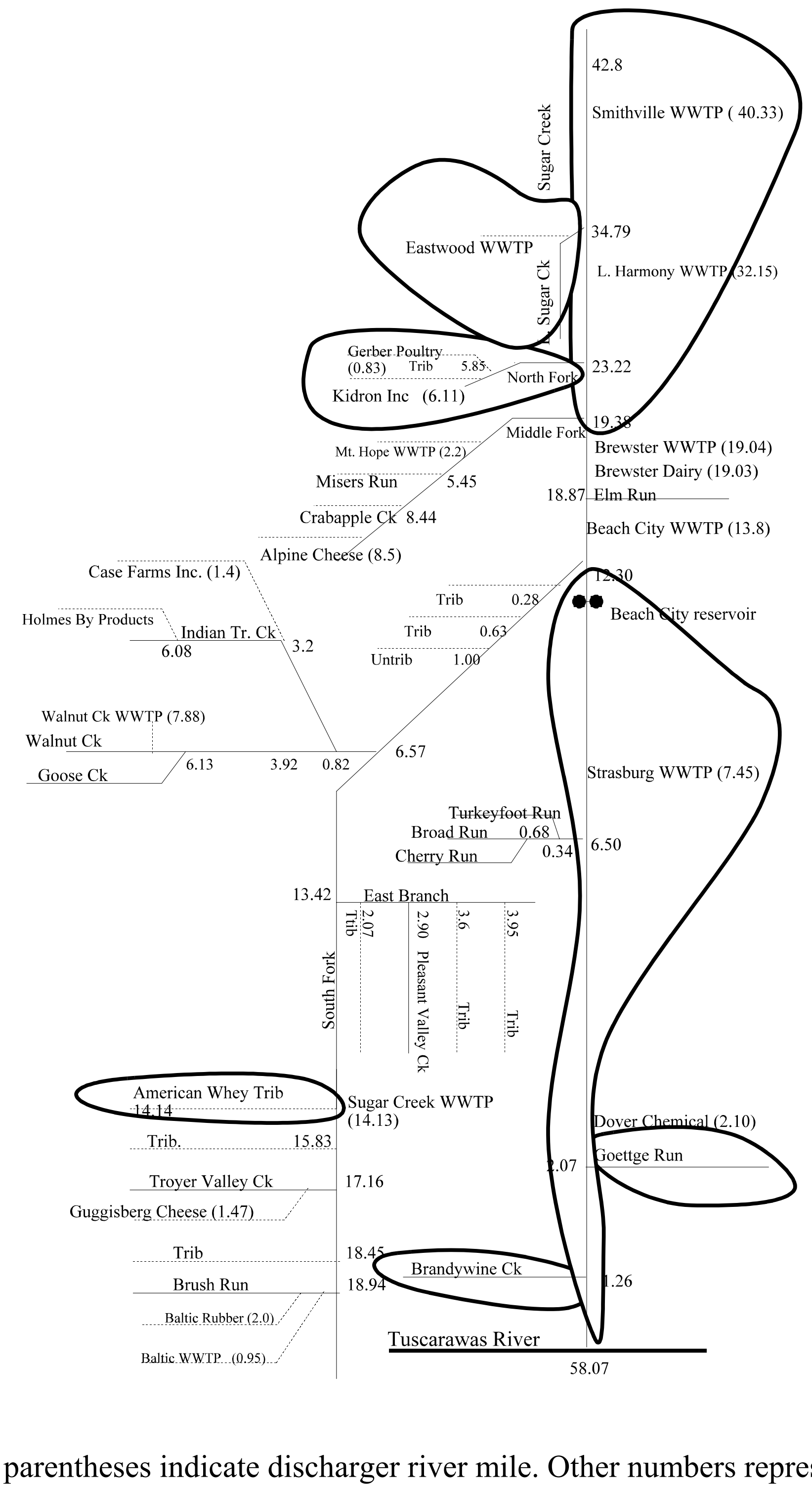
Table 4. NPDES permitted dischargers in the Sugar Creek basin

Entity	Flow (MGD)	Receiving Stream	River Mile Tributary	River Mile Mainstem
Smithville WWTP	0.30	Sugar Creek		40.33
Eastwood WWTP	0.060	Unnamed trib (RM 2.67) to Little Sugar Creek	0.8	34.79
Harmony Lake WWTP	0.036	Sugar Creek		32.15
Gerber Poultry	0.25	North Fork Sugar Creek	5.85	23.22
Mt. Hope WWTP	0.22	Middle Fork Sugar Creek	2.2	19.38
Alpine Cheese Co.	0.22	Middle Fork Sugar Creek	8.5	19.38
Brewster WWTP.	0.665	Sugar Creek		19.05
Brewster Dairy	0.30	Sugar Creek		19.04
Beach City WWTP	0.20	Sugar Creek		13.8
Baltic Rubber Co.	0.02	Brush Run (2.0) to South Fork Sugar Creek	18.94	12.3
Baltic WWTP	0.01	Brush Run (0.95) to South Fork Sugar Creek	18.94	12.3
Guggisberg Cheese	0.014	Troyer Valley Creek (1.47) to South Fork Sugar Ck	17.16	12.3
Sugarcreek WWTP	0.50	South Fork Sugar Creek	14.15	12.3
American Whey	0.065	Unnamed trib (0.19) to South Fork Sugar Creek	14.10	12.3
Holmes County Walnut Creek WWTP	0.090	Unnamed trib (0.1)to Walnut Creek (7.88) to South Fork Sugar Creek	6.57	12.3
Holmes By-Products	NA	Unnamed trib (0.6) to Indian Trail Creek (6.08) to Walnut Creek (0.82) to South Fork Sugar Creek	6.57	12.3
Troyer's Trail Bologna	0.005	Unnamed trib (0.25) to Indian Trail Creek (5.42) to Walnut Creek (0.82) to South Fork Sugar Creek	6.57	12.3
Case Farms Inc	0.50	Unnamed trib to Indian Trail Creek (6.57) to Walnut Creek (0.82) to South Fork Sugar Creek	6.57	12.3
Strasburg WWTP	0.225	Sugar Creek		7.45
Alpine Hills (camp)	NA	Unnamed trib to Broad Run	6.0	6.5
Broad Run Cheese	NA	Broad Run	6.0	6.5
Dover Chemical Co.	4.0	Sugar Creek		2.1
Kimble Landfill	NA	Brandywine Creek	2.0	1.26

According to Ohio EPA estimates, septic systems serve over 33,000 people in the basin and are significant nutrient and bacteria sources.

Figure 3 shows a schematic of Sugar Creek and its major tributaries, including most point source dischargers. Due to space limitations, some small dischargers are not shown in the schematic. The listed segments have been outlined.

Figure 3. Schematic of Sugar Creek and tributaries.

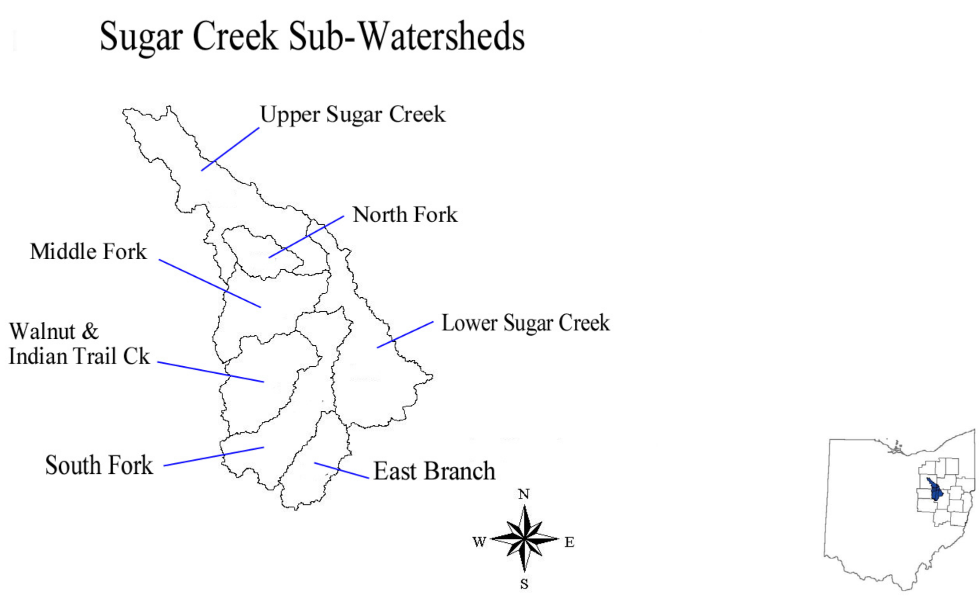


Numbers in parentheses indicate discharger river mile. Other numbers represent tributary or mainstem river miles

Most of the mining activity in the Sugar Creek basin has occurred in the southern portion of the watershed. The South Fork and the East Branch have active and abandoned (both reclaimed and unreclaimed) mining sites. Other waterbodies affected by mining activities are Broad Run (includes Turkeyfoot Run and Cherry Run), Goettge Run and Brandywine Creek, tributaries to Sugar Creek that enter the creek downstream of Strasburg. The elevated concentrations of manganese, iron, and aluminum that were observed in many of those tributaries indicate impact from inactive mines (mines abandoned pre-1972). There are numerous areas of old underground and surface mining that continue to be a pollution source to Sugar Creek. According to Ohio Department of Natural Resources staff, there is relatively little active mining going on in the Sugar Creek watershed. (Ohio DNR, 2000). This statement is supported by land use data indicating that 0.38% of the land use is classified as quarry/mine.

To facilitate preparation of the TMDL, the Sugar Creek basin was divided into seven sub-watersheds (for nonpoint source modeling purposes) based on the following factors:
1. Ecoregion: Two sub-basins are located in the Erie Ontario Lake Plain (EOLP), and five in the Western Allegheny Plateau (WAP) ecoregion.
2. Resolution vs. simplicity: Splitting basin into 7 areas provides more detail than could be obtained from determination of a single load for the whole basin.
3. Data availability: Desire to simulate loads for subwatersheds where historical water quality data was available (North Fork) or represented special cases (East Branch, a subwatershed with no point source impacts).
4. Stakeholder groups: Existence of watershed/stakeholder groups (North Fork, East Branch) desiring more detailed information to assist them with development of implementation plans.
5. Hydrologic Units: The selected subwatersheds fall within the three units identified by their "eleven digit hydrologic unit code" in Figure 1.
Figure 4 shows the seven subwatersheds for which nonpoint source modeling was done. More details about the nonpoint source model used are given in appendix A.

Figure 4. Sugar Creek subwatersheds for nonpoint source modeling



2.2 Biological and Water Quality Assessment

2.2.1 Use Designation/Use Attainment

The Ohio Water Quality Standards are established to determine if a particular stream, river, or lake is achieving Clean Water Act (CWA) goals of being fishable and swimmable. The Ohio Water Quality Standards (WQS) are contained in Chapter 3745-1 of the Ohio Administrative Code (OAC). The WQS define a set of uses a water has the potential to support. These uses are divided into two broad groups: uses that are applicable to the health of aquatic life and uses that are not aquatic life oriented but are generally associated with human activities and interests such as drinking water or agricultural water supply. The WQS also establish levels of pollutants that will protect each of these uses, and provides a way to measure fish and aquatic insect communities to gage if the water body is achieving its potential.

In other words, the WQS designates a use or uses to each stream in Ohio. Different streams will have different designated uses (not all streams have the same use but all streams do have some defined or designated use). The WQS then sets benchmarks (or numeric criteria) for each different use which can be used to determine if a particular stream, river or lake is suitable for supporting its designated uses. If a stream, river or lake does not meet the benchmarks established in the WQS, it is in "non attainment", whereas if the stream, river or lake is meeting the benchmarks, it is in "full attainment". Table 5 provides an overview to the general components of the WQS.

In the Sugar Creek basin, the aquatic life use designations that apply to various segments are Warmwater Habitat (WWH) and Modified Warmwater Habitat (MWH). Waters designated as WWH are capable of supporting and maintaining a balanced integrated community of warmwater aquatic organisms. Waters designated as MWH have been found incapable of supporting and maintaining a balanced, integrated, and adaptive community of warmwater organisms due to irretrievable modifications of the physical habitat. Attainment of aquatic life uses is measured in two ways. First, the criteria in the WQS for various pollutants are compared to measurements taken from the water to determine WQS attainment for specific pollutants. The second way attainment is determined is by directly measuring fish and aquatic insect populations to see if they are comparable to those seen in least impacted areas of the same ecological region and aquatic life use. Attainment benchmarks from these least impacted areas are established in the WQS in the form of "biocriteria", which are then compared to the measurements obtained from the study area. If measurements of a stream do not achieve the three biocriteria indices (fish: Index of Biotic Integrity (IBI) and modified Index of Well-being (MIwb); aquatic insects: Invertebrate Community Index (ICI)) the stream is considered in "non attainment". If the stream measurements achieve some of the biological criteria, but not others, the stream is said to be in "partial-attainment". A stream that is in "partial attainment" is not achieving its designated aquatic life use, while a stream that meets all of the biocriteria benchmarks, it is said to be in full attainment.

Table 5. Summary of the Components and Some Examples of Ohio's Water Quality Standards.

<table>
<tr><th>WQS Components</th><th>Examples of:</th><th>Description</th></tr>
<tr><td>Beneficial Use Designation</td><td>1. Water supply
• Public (drinking)
• Agricultural
• Industrial

2. Recreational contact
• Beaches (Bathing waters)
• Swimming (Primary Contact)
• Wading (Secondary Contact)

3. Aquatic life habitats (partial list):
• Exceptional Warmwater (EWH)
• Warmwater (WWH)
• Modified Warmwater (MWH)
• Limited Resource Water (LRW)

4. State Resource Water</td><td>Designated uses reflect how the water is potentially used by humans and how well it supports a biological community. Every water in Ohio has a designated use or uses; however, not all uses apply to all waters (they are water body specific).

Each use designation has an individual set of numeric criteria associated with it, which are necessary to protect the use designation. For example, a water that was designated as a drinking water supply and could support exceptional biology would have more stringent (lower) allowable concentrations of pollutants than would the average stream.

Recreational uses indicate whether the water can potentially be used for swimming or if it may only be suitable for wading.</td></tr>
<tr><td rowspan="3">Numeric Criteria</td><td>1. Chemical</td><td>Represents the concentration of a pollutant that can be in the water and still protect the designated use of the waterbody. Laboratory studies of organism's sensitivity to concentrations of chemicals exposed over varying time periods form the basis for these.</td></tr>
<tr><td>2. Biological
Measures of fish health:
♦ Index of Biotic Integrity
♦ Modified Index of Well Being
Measure of bug (macroinvertebrate) health:
‣ Invertebrate Community Index</td><td>Indicates the health of the instream biological community by using these three indices (measuring sticks). The numeric biological criteria (biocriteria) were developed using a large database of reference sites.</td></tr>
<tr><td>3. Whole Effluent Toxicity (WET)</td><td>Measures the harmful effect of an effluent on living organisms (using toxicity tests).</td></tr>
<tr><td>Narrative Criteria

(Also known as 'Free Froms')</td><td colspan="2">General water quality criteria that apply to all surface waters. These criteria state that all waters shall be free from sludge, floating debris, oil and scum, color and odor producing materials, substances that are harmful to human, animal or aquatic life, and nutrients in concentrations that may cause algal blooms.</td></tr>
</table>

An aquatic life use attainment table (Table 6) is constructed based on the sampling results and is arranged from upstream to downstream and includes the sampling locations indicated by river mile, the applicable biological indices, the use attainment status (*i.e.,* Full, partial, or non), the Qualitative Habitat Evaluation Index (QHEI), and a sampling location description.

Physical habitat was evaluated using the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA for streams and rivers in Ohio (Rankin 1989, 1995). Various attributes of the habitat are scored based on the overall importance of each to the maintenance of viable, diverse, and functional aquatic faunas. The type(s) and quality of substrates, amount and quality of instream cover, channel morphology, extent and quality of riparian vegetation, pool, run, and riffle development and quality, and gradient are some of the habitat characteristics used to determine the QHEI score which generally ranges from 20 to less than 100. The QHEI is used to evaluate the characteristics of a stream segment, as opposed to the characteristics of a single sampling site. As such, individual sites may have poorer physical habitat due to a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. QHEI scores from hundreds of segments around the state have indicated that values greater than 60 are *generally* conducive to the existence of warmwater faunas whereas scores less than 45 generally cannot support a warmwater assemblage consistent with the WWH biological criteria. Scores greater than seventy five frequently typify habitat conditions which have the ability to support exceptional warmwater faunas.

Ohio EPA conducted a comprehensive biological, chemical and bacteriological assessment of the Sugar Creek basin during the summer of 1998. Details of the sampling methodology and location of monitoring sites are found in a separate document (Biological and Water Quality Study of Sugar Creek - 1998, OEPA Technical Report MAS/1999-12-4). The 1998 Sugar Creek study area included a mainstem reach beginning at RM 42.8 (Schellin Rd., near Smithville) and extending downstream to the mouth and sites on all tributaries with a drainage area of at least five square miles. A total of seventy six biological and chemical sample stations were visited. Effluent samples were also collected at ten entities.

Most locations surveyed throughout the basin failed to meet assigned aquatic life uses. Exceptions were associated with physiographic features which influenced groundwater flow in some areas (particularly the Middle Fork). Nonpoint source pollution impinged on water quality and aquatic communities throughout the basin.

The extent of **NON** attainment throughout most of the watershed distinguished Sugar Creek as one of the most degraded basins in Ohio. Agricultural land use has promoted siltation and habitat degradation across most of the watershed. Polluted runoff from agricultural and mining sources further acted to suppress aquatic life use attainment. Table 6 shows the use attainment status as well as the QHEI (habitat) score of each sampling site in the Sugar Creek basin.

Table 6. Aquatic life use attainment status for the Sugar Creek basin based on biological sampling conducted during July through September, 1998.

RIVER MILE Fish/Invert.	IBI	MIwb	ICI[a]	QHEI	Attainment Status[b]	Site Location
Sugar Creek	*Erie Ontario Lake Plain (EOLP) - WWH Use Designation*					
42.8	26*	NA	G	50.0	**NON**	Schellin Rd.
40.2	42	NA	G	53.0	FULL	CR 502
38.1	40	7.5[ns]	MG[ns]	47.0	FULL	Back Rd.
34.9	32*	6.2*	--	44.5	(**NON**)	McQuaid Rd.
34.6	33*	7.1*	44	72.5	PARTIAL	Kansas Rd.
26.8	32*	5.8*	G	65.0	**NON**	West Lebanon Rd.
23.0	25*	4.7*	38	42.5	**NON**	Alabama Ave.
19.3	13*	3.8*	44	51.5	**NON**	SR 93, Dst. N. Fork
17.6	19*	4.1*	26*	71.0	**NON**	Dst. Brewster Dairy and WWTP
13.7	23*	4.1*	40	78.5	**NON**	From park/ Dst. Beach City WWTP
	Western Allegheny Plateau (WAP) - WWH Use Designation					
12.0	32*	7.8*	38	58.0	PARTIAL	From dam access road
7.2	37[ns]	8.2[ns]	42	77.5	FULL	Dst. Strasburg WWTP
3.7	41	7.8*	42	91.0	PARTIAL	CR 80, Ohio Ave.
1.8	35*	5.8*	36	73.5	**NON**	SR 516 & 39
0.6	37*	7.0*	38	74.0	PARTIAL	SR 39
Little Sugar Creek	*Erie Ontario Lake Plain (EOLP) - WWH Use Designation*					
4.9	21*	NA	44	40.0	**NON**	Kansas Rd.
0.8	40	NA	VG	49.0	FULL	McQuaid Rd.
Little Sugar Creek Tributary at RM 0.5						
	(*Erie Ontario Lake Plain (EOLP) - WWH Use Designation Recommended*)					
1.1	34*	NA	MG[ns]	44.5	PARTIAL	McQuaid Rd.
North Fork Sugar Creek	*Erie Ontario Lake Plain (EOLP) - WWH Use Designation*					
5.4	36[ns]	NA	MG[ns]	63.5	FULL	Zuercher Rd.
3.1	40	NA	G	47.0	FULL	CR 94
1.3	34*	NA	G	48.0	PARTIAL	T-105, W. Lebanon Rd.
Middle Fork Sugar Creek	*Erie Ontario Lake Plain (EOLP) - WWH Use Designation*					
12.3	42	NA	G	40.0	FULL	From T-654
10.3	44	NA	G	46.5	FULL	T-669
7.6	44	8.7	G	60.0	FULL	T-606
1.7	35*	6.2*	50	58.5	PARTIAL	Welty Rd
Crabapple Creek	*Erie Ontario Lake Plain (EOLP) - WWH Use Designation*					
2.9	38[ns]	NA	G	45.0	FULL	T-357
0.3	44	NA	G	42.5	FULL	T-606

Table 6. (continued)

RIVER MILE Fish/Invert.	IBI	MIwb	ICI[a]	QHEI	Attainment Status[b]	Site Location
Middle Fork Sugar Creek Tributary at RM 6.0						
(*Erie Ontario Lake Plain (EOLP) - WWH Use Designation Recommended*)						
0.2	40	NA	G	51.5	FULL	T-659
Misers Run *Erie Ontario Lake Plain (EOLP) - WWH Use Designation*						
0.2	42	NA	--	56.5	(FULL)	From lane off T-659
Middle Fork Sugar Creek Tributary at RM 3.25						
(*Erie Ontario Lake Plain (EOLP) - WWH Use Designation Recommended*)						
0.5	38^{ns}	NA	--	57.0	(FULL)	T-314, Alabama Ave.
Elm Run *Erie Ontario Lake Plain (EOLP) - WWH Use Designation*						
1.7	32*	NA	MG^{ns}	55.0	PARTIAL	Harmon Ave.
0.5	30*	NA	--	32.5	(**NON**)	Kings Highway
South Fork Sugar Creek						
(*Western Allegheny Plateau (WAP) - MWH Use Designation Recommended*)						
21.1	20*	NA	F	34.5	PARTIAL	CR 114
19.0	18*	NA	F	27.0	PARTIAL	T-173
15.3	20*	5.3*	MG	27.0	PARTIAL	CR 47
13.9	28	7.1	F*	27.5	PARTIAL	T-355
13.3	29	5.7*	28	47.0	PARTIAL	CR 73
Western Allegheny Plateau (WAP) - WWH Use Designation						
7.5	27*	4.4*	34^{ns}	45.0	**NON**	Barrs Mills Rd
6.4^{B}	20*	2.9	34^{ns}	50.0	**NON**	CR 94
3.6^{B}	26*	4.5*	10*	50.0	**NON**	T-62
Brush Run *Western Allegheny Plateau (WAP) - WWH Use Designation*						
2.5	28*	NA	F*	51.5	**NON**	Shrock Rd.
0.4	28*	NA	P*	25.5	**NON**	Dst. WWTP
Brush Run Tributary at RM 1.54						
(*Western Allegheny Plateau (WAP) - LRW Use Designation Recommended*)						
0.1	12*	NA	--	38.0	(**NON**)	Entrance to abandoned mine
Troyer Valley Creek *Western Allegheny Plateau (WAP) - WWH Use Designation*						
1.0	22*	NA	P*	34.0	**NON**	SR 93
South Fork Sugar Creek Tributary at RM 15.83						
(*Western Allegheny Plateau (WAP) - WWH Use Designation Recommended*)						
1.1	22*	NA	--	39.5	(**NON**)	CR 71
South Fork Sugar Creek Tributary at RM 14.1						
(*Western Allegheny Plateau (WAP) - WWH Use Designation Recommended*)						
0.2	20*	NA	--	22.0	(**NON**)	CR 73
0.1	28*	NA	--	35.0	(**NON**)	Dst. Ohio Whey
East Branch (South Fork Sugar Creek)						
(*Western Allegheny Plateau (WAP) - WWH Use Designation*						
5.5	24*	NA	G	44.5	**NON**	CR 48

Table 6. (continued)

RIVER MILE Fish/Invert.	IBI	MIwb	ICI[a]	QHEI	Attainment Status[b]	Site Location
(*Western Allegheny Plateau (WAP) - MWH Use Designation Recommended*)						
5.0	24	NA	G	40.5	FULL	CR 52
3.3	22*	NA	--	43.5	(**NON**)	CR 46
1.7	26	3.4*	P*	23.0	PARTIAL	T-348
East Branch Tributary at RM 3.6						
(*Western Allegheny Plateau (WAP) - WWH Use Designation Recommended*)						
0.7	24*	NA	--	34.0	(**NON**)	Driveway from T-336
Pleasant Valley Creek *Western Allegheny Plateau (WAP) - WWH Use Designation*						
0.2	24*	NA	F*	30.0	**NON**	From T-339
East Branch Tributary at RM 2.07						
(*Western Allegheny Plateau (WAP) - WWH Use Designation Recommended*)						
0.7	20*	NA	--	37.0	(**NON**)	T-?
South Fork Sugar Creek Tributary at RM 11.3						
(*Western Allegheny Plateau (WAP) - WWH Use Designation Recommended*)						
0.2	20*	NA	--	36.0	(**NON**)	T-354
Walnut Creek						
(*Western Allegheny Plateau (WAP) - MWH Use Designation Recommended*)						
7.9	30	NA	G	27.0	FULL	Old SR 39
6.4	22*	NA	G	25.0	PARTIAL	T-444
4.5	30	5.7*	G	25.5	PARTIAL	CR 172
(*Western Allegheny Plateau (WAP) - WWH Use Designation*)						
0.6	23*	3.2*	G	47.0	**NON**	Lane from CR 94
Goose Creek (*Western Allegheny Plateau (WAP) - WWH Use Designation*						
0.3	18*	NA	G	26.5	**NON**	T-419
Walnut Creek Tributary at RM 3.92						
(*Western Allegheny Plateau (WAP) - WWH Use Designation Recommended*)						
0.4	34*	NA	--	33.5	(**NON**)	CR 168
Indian Trail Creek (*Western Allegheny Plateau (WAP) - WWH Use Designation*						
6.4	34*	NA	E	51.0	PARTIAL	T-414
5.9	30*	NA	--	63.5	(**NON**)	From T-41?
5.6	22*	NA	VG	41.5	**NON**	Ust. SR 515
5.3	12*	NA	--	49.0	(**NON**)	Dst. Troveris Trail Bologna
3.8	28*	NA	--	52.0	(**NON**)	Ust. Case Farms
2.6	30*	NA	VG	59.5	PARTIAL	T-66
Indian Trail Creek Tributary at RM 6.08						
(*Western Allegheny Plateau (WAP) - WWH Use Designation Recommended*)						
0.4	12*	NA	F*	50.5	**NON**	From T-41?
South Fork Sugar Creek Tributary at RM 1.0						
(*Western Allegheny Plateau (WAP) - WWH Use Designation Recommended*)						
0.7	26*	NA	--	64.0	(**NON**)	T-447

Table 6. (continued)

RIVER MILE Fish/Invert.	IBI	MIwb	ICI[a]	QHEI	Attainment Status[b]	Site Location
Broad Run			(*Western Allegheny Plateau (WAP) - WWH Use Designation*)			
2.8	30*	NA	F*	39.0	**NON**	CR 80, Dst. Trib at RM 2.85
0.2	32*	NA	P*	70.0	**NON**	T-425
Cherry Run (*Western Allegheny Plateau (WAP) - WWH Use Designation Recommended*)						
0.2	12*	NA	--	60.5	(**NON**)	CR 78
Turkeyfoot Run (*Western Allegheny Plateau (WAP) -WWH Use Designation*)						
0.2	12*	NA	P*	67.0	**NON**	CR 78
Goettge Run			(*Western Allegheny Plateau (WAP) - WWH Use Designation*)			
0.3	22*	NA	P*	61.0	**NON**	Davis St.
Brandywine Creek *Western Allegheny Plateau (WAP) - WWH Use Designation*)						
2.0	30*	NA	--	31.5	(**NON**)	T-374
0.2	32*	NA	F*	44.5	**NON**	T-211

* Significant departure from ecoregion biocriterion; poor and very poor results are underlined.
ns Nonsignificant departure from biocriterion (≤4 IBI or ICI units; ≤0.5 MIwb units).
a Narrative evaluation used in lieu of ICI (E=Exceptional; G=Good; MG=Marginally Good; F=Fair; P=Poor).
b Use attainment status based on one organism group is parenthetically expressed.
NA Not Applicable. The MIwb is not applicable to headwater sites.
B Boat site. Headwater - wading criteria apply to all other sites.

IBI: Index of Biotic Integrity
MIwb: Modified Index of Well-Being
ICI: Invertebrate Community Index

Table 7. Narrative ranges, WWH (bold), and MWH (italics) biocriteria for the Eastern Corn Belt and Erie Ontario Lake Plains ecoregions. Exceptional (EWH biocriteria), very good (EWH nonsignificant departure), poor and very poor evaluations are common statewide. For WWH, the ranges of marginally good and nonsignificant departure are the same.

IBI			MIwb		ICI	Narrative Evaluation
Headwater	Wading	Boat	Wading	Boat	All	
50-60	50-60	48-60	≥9.4	≥9.6	46-60	Exceptional
46-49	46-49	44-47	8.9-9.3	9.1-9.5	42-44	Very Good
Erie Ontario Lake Plain						
40-45	**38**-45	**40**-43	**7.9**-8.8	**8.7**-9.0	**34**-40	Good
36-39	34-37	36-39	7.4-7.8	8.2-8.6	30-32	Marginally Good
28-35	28-33	26-35	5.9-(*6.2*) 7.3	6.4-8.1	14-(*22*) 28	Fair
Western Allegheny Plateau						
44-45	**44**-45	**40**-43	**8.4**-8.8	**8.6**-9.0	**36**-40	Good
40-43	40-43	36-39	7.9-8.3	8.1-8.5	32-34	Marginally Good
28-39	28-39	26-35	5.9-(*6.2*) 7.8	6.4-8.0	14-(*22*) 30	Fair
18-(*24*) 27	18-(*24*) 27	16-(*24*) 25	4.5-5.8	5.0-(*5.8*) 6.3	2-12	Poor
12-17	12-17	12-15	0-4.4	0-4.9	<2	Very Poor

2.2.2 Previous Studies

Although the 1998 Ohio EPA survey was the first comprehensive biological and water quality assessment conducted in the Sugar Creek basin, there had been several other studies of smaller areas of the basin by Ohio EPA and other agencies.

A USEPA study of the Beach City reservoir done in 1973 as part of the National Eutrophication survey found that the lake was eutrophic due to high phosphorus loadings. About 90% of the phosphorus loadings were attributed to non-point sources (USEPA, 1975). Another report, prepared for the US Corps of Engineers, concluded that by 1993 approximately 95% of the minimum pool capacity of the Beach City reservoir had been depleted by sedimentation. The sedimentation rate was estimated to be 104 acre-feet per year, or 0.36 acre-foot per year per square mile of drainage area. This sediment was deposited between November 1936 and September 1993 (Dames & Moore, 1995). Since the reservoir is almost completely full of sediments, its efficiency as a sediment trap has been significantly reduced, and a larger portion of the sediments from Sugar Creek and tributaries will likely be transported downstream and into the Tuscarawas River.

The USDA-Soil Conservation Service prepared a "Watershed Plan and Environmental Assessment for the East Branch of Sugar Creek Watershed, Ohio". The study was intended to reduce sedimentation of the East Branch, which was reducing channel capacity and exacerbating flooding problems. The report recommended installation of sediment basins and permanent conversion of cropland to cover crops (hay). The water quality impact of siltation was not a major consideration in the study, and the recommendations were not expected to affect water quality (USDA, 1986). Recent information from NRCS staff indicates that the sediment basins were overwhelmed by the large amount of sediment coming from the fields (Tuscarawas NRCS, 2000).

Ohio EPA prepared a Biological and Water Quality Study of the North Fork Sugar Creek, based on field work conducted in 1993. The study documented violations of dissolved oxygen and fecal coliform water quality criteria, as well as excessive nutrient concentrations (particularly ammonia and phosphorus). The nutrient enrichment was attributed to a combination of point sources and unsewered areas (Ohio EPA, 1994).

Another report was prepared by U.S. EPA regarding chlorinated paraffins in Sugar Creek The study found chlorinated paraffins in stream sediments and in mussels downstream of the Dover Chemical wastewater lagoon discharge. This discharge occurs at River Mile 1.7, near the confluence with the Tuscarawas River. The study concluded that Dover Chemical was the likely source of the chlorinated paraffins. However, since the lagoon serves as a sink, no direct temporal relationship could be drawn between the paraffin concentration found in Sugar Creek and the paraffin produced by Dover Chemical during the time of the field study (USEPA,1988).

A biological and water quality assessment was performed in 1991 by Ohio EPA in the lower four miles of Sugar Creek, including Goettge Run and Brandywine Creek. It recommended additional monitoring of sediments downstream of Dover Chemicals to look for presence of chlorinated paraffins and other chemicals manufactured by Dover Chemicals. Eberhart Coal, a coal tipple (loading) facility discharging to Goettge Run was also targeted for additional study, since a notable increase in sediment bed load and coal fines was observed downstream from that facility (Ohio EPA, 1992).

A recent report prepared by NEFCO (Northeast Ohio Four County Regional Planning and Development Organization) contains inventories and maps of point and non-point sources, land use and other data for the upper third of Sugar Creek (the part of the basin lying within Wayne and Stark counties). It identifies sub-basins having highly erodible soils; shows result of habitat assessment done by NEFCO; has inventories of potential pollutant sources including animal husbandry operations, semi-public non-discharging systems, etc. It provides information that will be very useful to local watershed groups as they develop and implement restoration activities. (NEFCO, 2000).

2.3 Causes and Sources of Impairment

The determination of impairment in rivers and streams in Ohio is straightforward – the numeric biocriteria are the principal arbiter of aquatic life use attainment and impairment. The rationale for using biocriteria has been extensively discussed elsewhere (Karr, 1991; OEPA, 1987a,b; Yoder, 1989; Miner and Borton, 1991; Yoder, 1991).

Ohio EPA relies on an interpretation of multiple lines of evidence including water chemistry data, sediment data, habitat data, effluent data, biomonitoring results, land use data, and biological response signatures to describe the causes (e.g., nutrients) and sources (e.g., municipal point sources, septic systems) associated with observed impairments. Thus the initial assignment of principal causes and sources of impairment that appear on the 303(d) list do not represent a true "cause and effect" analysis, but rather represent the association of impairments (based on response indicators) with stressor and exposure indicators whose links with the biosurvey data are based on previous research or experience with analogous situations and impacts. The reliability of the identification of probable causes and sources is increased where many such prior associations have been identified (OEPA, 1999). Table 8 at the end of this sub-section lists the causes and sources of impairment for Sugar Creek basin segments.

The Sugar Creek basin has been affected by decades of intensive agricultural and mining activities, which has resulted in the current situation where few stream segments attain their aquatic life used designations. The extent of the modifications to the landscape have been large enough that several stream segments in the South Fork, East Branch and Walnut Creek are proposed to be reclassified as Modified Warmwater Habitat (MWH) because restoration to Warm Water Habitat status seems unfeasible. Other Sugar Creek basin stream segments which had been previously unclassified are also being assigned use designations. On September 19, 2001 Ohio EPA filed proposed revisions to twenty-one rules in OAC Chapter 3745-1 rules affecting beneficial use designations for many segments in the basin. The comment period ended on November 5, 2001.

Although there are numerous point sources dispersed across the basin, in most cases their impact on the stream is masked by the deleterious effect of siltation, habitat and flow alteration, and nutrient enrichment from agricultural/livestock activities. Table 8 shows the causes and sources of impairment, and their estimated magnitude, for listed and unlisted Sugar Creek segments. The numbers for "Miles Attaining Use" have been updated to reflect information not available when the 303(d) list was prepared. Permitted point sources are discussed in subsection 2.1.

The most significant causes of aquatic life habitat impairment in the Sugar Creek basin are habitat alteration, sediments/siltation, and nutrient enrichment. The recreational use of the waterbodies may also be impaired as evidenced by the number of samples exceeding the bacterial water quality criteria.

Since there are so many sources contributing to the stream impairments, it is difficult to ascertain which of them are the most significant. Agriculture, crop production, pasture land, removal of the riparian vegetation and streambank destabilization all rank high, followed by channelization, flow regulation/modification and mining activities. A few point sources are having local impacts and are being addressed through permit limits recommended in this report. The major sources of bacterial contamination are likely to be livestock with free access to the streams, and runoff from lands where manure has been applied. As shown earlier in Table 3, the counties in the area have a very high number of livestock. There are many failing septic systems in the basin which are also contributing to the bacterial problem. Ohio EPA estimates that a population of 33,477 inhabitants is being served by residential septic systems in the Sugar Creek basin. (See Table 10 of appendix A for more details).

Sedimentation from agricultural activities and streambank erosion may be the key factor preventing the attainment of biological standards. The silt smothers benthic organisms, thus interfering with the creek's ability to assimilate nutrients. It also is a poor substrate for desirable fish species. The excessive siltation also promotes the need for "ditch maintenance" by county workers to keep the waterways flowing freely and prevent flooding of agricultural lands. The periodic ditch maintenance further reduces the quality of the benthic community, by destroying the instream habitat. In addition to its impact on the habitat, sediments carry phosphorus attached to silt particles. It is clear that sedimentation affects all downstream segments, and must be controlled starting with the headwater streams.

Although Ohio EPA's stream surveys identified high bacteria counts, the samples were not collected frequently enough to determine loads accurately (i.e., only three samples were collected at most sites during the summer). Local health departments have been notified about Ohio EPA's findings. Future watershed assessments will look at the bacteria problem more thoroughly once the management practices recommended in this report are implemented. Additional recommendations will be given at that time if deemed necessary. Causes and sources for each listed segment are discussed below.

2.3.1 Sugar Creek (Headwaters to Middle Fork)

More than 80% of the land in this part of the basin is devoted to agricultural activities (57% pasture and 27% row crops). **Poor habitat and siltation** were the main causes of impairment, although **nutrient enrichment** and **wetlands** are also having some impact on the use attainment. Wetlands often show lower biological scores because the low velocity facilitates silt deposition, and those reaches have lower reaeration coefficients. These conditions limit the diversity of biota to those that can tolerate this environment. Wetlands are considered a natural limitation for this segment. A positive impact was attributed to the Smithville WWTP near the headwaters, despite it being a source of nutrients. The results of the biological surveys indicated that dilution and continuous flow from this plant were helpful to the fish and macroinvertebrate community as long as the discharge water quality was as good as the ambient condition in the creek.

High bacteria counts are common throughout this reach, especially downstream of the confluence with Little Sugar Creek. While insufficient data was available to quantify loads, some of the recommendations aimed at reducing erosion and nutrients will also reduce bacteria in this segment. **Agricultural activities, lack of riparian vegetation, and streambank modification are the major sources of impairment**. According to data collected by NEFCO, this segment has 192 livestock operations (mostly dairies), excluding 102 operations reported in Little Sugar Creek (NEFCO, 2000).

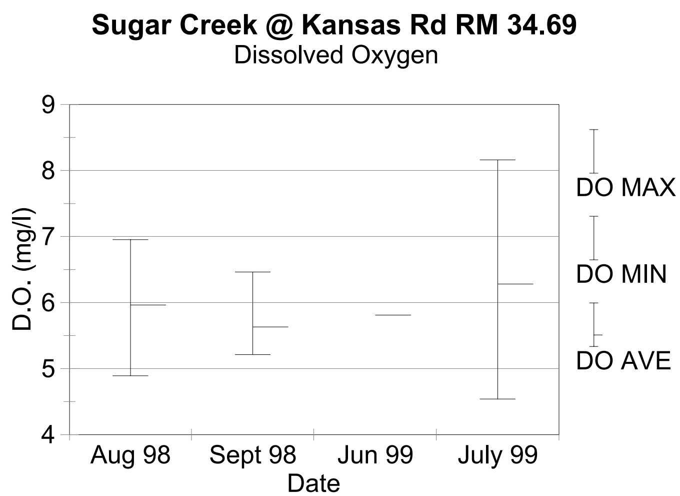
Downstream from Little Sugar Creek, the water quality impact from point sources is insignificant, as there is only one point source (Lake Harmony WWTP; 0.036 MGD). **Dissolved oxygen (D.O.) data collected in this reach showed no violations of the acute D.O. WQS (4 mg/l); long term D.O. monitors (Datasondes ®) showed that the average D.O. WQS of 5 mg/l was not violated**. **This segment had been listed for nutrient enrichment/ D.O. in the 1998 303(D) list.** Figures 5 and 6 show results of D.O. and temperature monitoring measured hourly during forty eight hour periods. The tendency for higher average instream temperatures from upstream to downstream (Figure 5) serves as an indicator of open canopy (no shading) along the creek. The higher temperature reduces oxygen solubility in the water column, thus reducing the stream's capacity to assimilate nutrients. This is relevant for the reach downstream of Brewster, which receives significant point source nutrient loads.

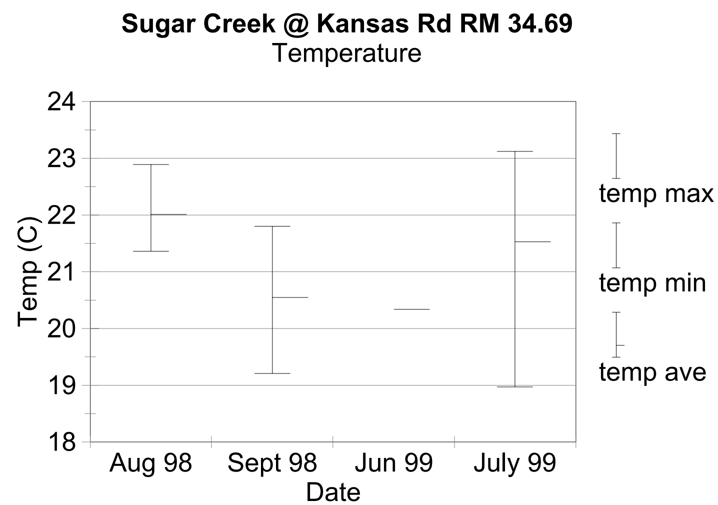
The median concentration of nitrate+nitrite in this reach was 3.57 mg/l based on forty six samples collected during 1998-99 surveys. Only the North Fork had a higher median concentration among the listed segments. Most of the nitrate load is believed to be from nonpoint sources (see Section 4.4.1). The target nitrate + nitrite concentration for this segment is 1.0 mg/l. The median concentration of phosphorus was 0.23 mg/l, compared to a target concentration of 0.1 mg/l. Ohio EPA has been in contact with Wayne County environmental control department staff, which has been very responsive regarding the need to lower nutrient concentrations in this segment, as well as the North Fork. The recommended phosphorus effluent limits of 1 mg/l will lower the existing point source phosphorus load by more than 50%.

2.3.2 North Fork Sugar Creek

The North Fork was mainly polluted downstream from Kidron and from an unnamed tributary at RM 5.85 which receives Gerber Poultry effluent. The highest median concentrations of phosphorus and nitrates basin wide were measured in this segment during 1998. The median concentration of NO_3+NO_2 was 3.7 mg/l, while for total phosphorus the median was 0.46 mg/l. Point source discharges comprise about 34% of the annual dissolved nitrogen (NO_3 + NO_2 + NH_3-N) loads estimated for the North Fork, and about 22% of the total phosphorus. Despite this loading, biological performance here was marginally good. Habitat in this segment was better due in part to high gradient in the headwaters and influence from groundwater flows. Plate 1 (top photo) shows the North Fork near RM 5.4, close to the proposed location of the Kidron WWTP. That photo shows a boulder and cobble stream, providing good aeration. Fecal coliforms ranged from 11,000 to 310,000 colonies/100ml at this site. Possible sources of coliforms are livestock with free access to the stream, and faulty septic systems. The lower photo shows the North Fork at RM 3.14 (county road 94). Bank erosion and livestock tracks are evident. Fecal coliforms ranged from 7,200 to 29,000 colonies/100ml at this site. This creek has a high assimilative capacity for nutrients, and met its use designation at two of the three monitored sites. However, the lower part of the creek has lower gradient and failed to meet its use designation. Silt and nutrients generated upstream are deposited along the lowest two miles of the creek. The habitat (QHEI) scores were also lower downstream of RM 3.1.

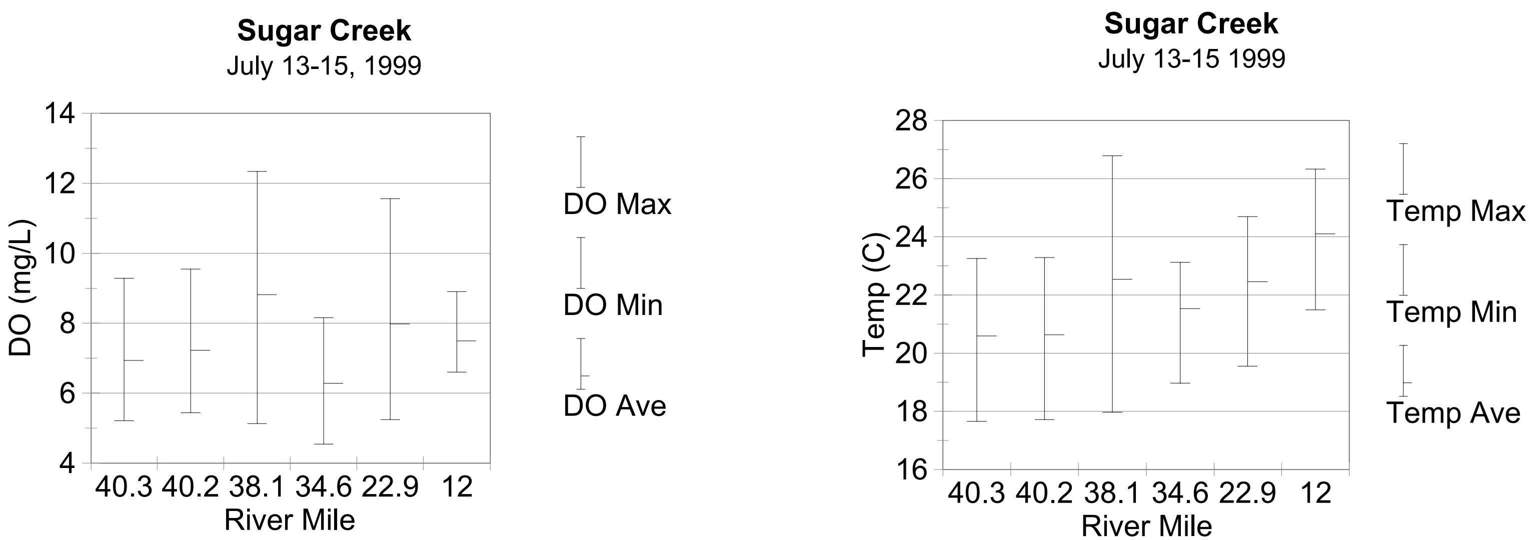
Figure 5. Range of Dissolved Oxygen and Temperature Measured in Sugar Creek at Kansas Rd (RM 34.69) During 1998-99





Hourly Measurements Performed during forty eight Hours Each Time, Except for June 1999 (grab sample)

Figure 6. Range of Dissolved Oxygen and Temperature Measured at Various Upper Sugar Creek Sites On July 1999



Hourly Measurements Were Performed During forty eight Hours Each Time

Plate 1.

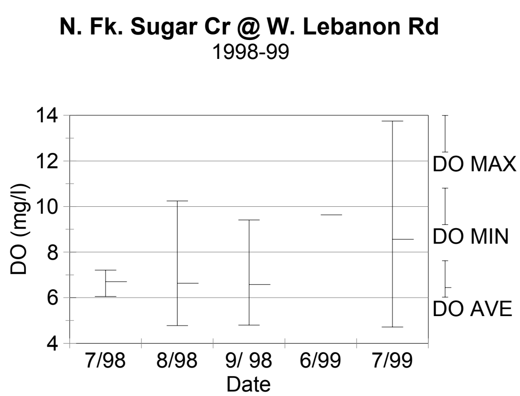
North Fork at Zuercher Rd., RM 5.4. Note the rocky bottom and riffles, which provide good reaeration throughout the reach. The slope is about 43 ft/mile for the next mile of creek. Livestock have access to the creek near this point. Fecal coliforms ranged from 11,000 to 310,000 at this site.

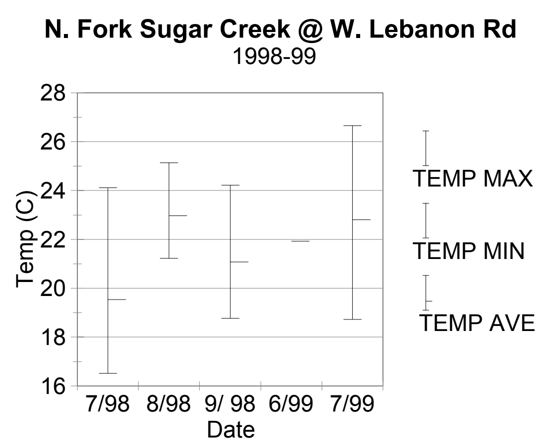
North Fork at CR 94., RM 3.14. Note the bank erosion on right side, livestock tracks on left side of photo. Bank vegetation is mostly limited to grass. Slope is about 12 ft/mile for the next mile. Fecal coliforms ranged from 7,200 to 29,000 at this location.

Nutrients, habitat alteration and siltation are the major causes of aquatic life use impairment in the North Fork. The highest average bacteria counts in the EOLP (Erie Ontario Lake Plains) ecoregion were measured in this creek, due to a combination of runoff, failing septic systems and free access of livestock to the stream. Dissolved oxygen violations that had been recorded during 1993 had virtually disappeared by 1998, due to a combination of point source upgrades, higher dilution flow, and elimination of a poor quality point source discharge. (See Figure 7). Ohio EPA recommends that D.O. and ammonia be de-listed as causes of impairment for this segment. The high pH and temperature in the creek increase the risk for ammonia water quality standard violations if the nutrient loads are not kept in check. One violation of the ammonia WQS was reported in 1998, which may have been due to runoff impacts (rainfall was measured during the period). A wide diurnal range in summer D.O. and pH was measured, indicating algal influence due to nutrient enrichment. The wide range in temperature variation (shown in Figure 7) also illustrates the effect of lack of shade along the creek upstream of West Lebanon Road (RM 1.3). **Influence from pastureland and lack of riparian vegetation are major sources of impairment, in addition to the point source and septic system influence.**

Ohio EPA estimates that a population of approximately 2827 inhabitants is served by residential septic systems in this subwatershed. (See Table 10 of appendix A for more details). Pathogens are a documented health problem in the North Fork that should improve after the proposed Kidron WWTP is in place. Another possible source of nutrients and bacteria is the Kidron Auction, although the impact may only occur following storm events. This auction house is located in Kidron, near river mile 6.5. Livestock are auctioned there once a week, with attendance of numerous horse-drawn carriages from Amish families in the area. The parking area could be contributing to bacterial and nutrient loads to the North Fork if the manure is not properly managed.

Figure 7. Range of D.O. and Temperature Measured in North Fork Sugar Creek at West Lebanon Rd (RM 1.3) 1998-99.





2.3.3 Little Sugar Creek

Habitat alteration and siltation were the major causes of aquatic life use impairment in this sub-basin. Nutrients were considered to have moderate impact on aquatic life. Nutrient concentrations were slightly high (median = 0.14 mg/l) for phosphorus, but fairly low (median = 0.63 mg/l) for nitrate + nitrite. Sediment analyses indicated extremely elevated levels of iron and lead according to the Kelly and Hite classification system, but were not considered to be impairing the biology. Although the 1998 D.O. grab samples indicated no violations to the average D.O. WQS of 5 mg/l, the Datasonde® multiparameter monitors that were deployed three times during 1998-99 showed two excursions below 4 mg/l. The wide diurnal range in D.O. and pH observed during July 1999 indicates possible algal influence due to excessive nutrients. These plots are shown in Figure 8. The Wayne Co.- Eastwood WWTP and three trailer park package plants are located in this subwatershed. A new county WWTP is being designed that will replace the Eastwood WWTP, eliminate two or three of the package treatment plans, and possibly serve some unsewered areas (J. Herman, personal communication, July 2001).

During the 1998 surveys, the Little Sugar Creek reach located closest to the headwaters (RM 10.6 to 4.9) did not meet its use designation, and had a low habitat (QHEI) score. The segment located closest to the mouth (RM 4.9 to RM 0.0) met its warmwater habitat use designation. **The major sources of impairment in this segment are pastureland, crop production, lack of riparian vegetation, streambank modification and agriculture.** According to data compiled by NEFCO, there are 102 animal husbandry operations in this subwatershed, most of which are dairy operations (NEFCO, 2000). Plate 2 (panoramic view) show examples of a dairy farm, free livestock access to the stream, and eroded banks seen in a tributary to Little Sugar Creek. The bottom photo shows an example of better habitat observed in some portions of Little Sugar Creek, particularly downstream of river mile 4.2.

Figure 8. Range of pH and Temperature Measured in Little Sugar Creek at McQuaid Rd (RM 0.3) During 1998-99.

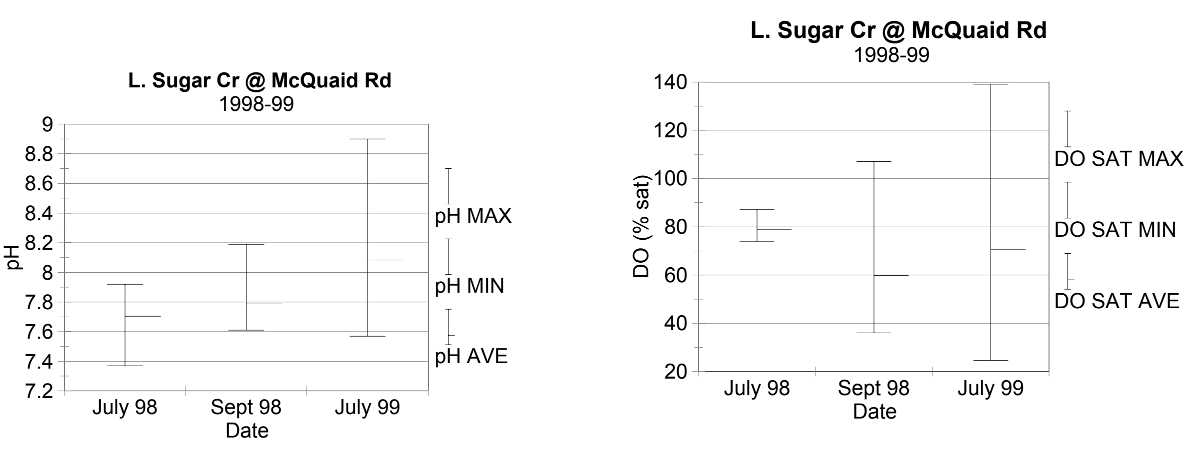


Plate 2. Photographs of tributary to Little Sugar Ck near McQuaid Road The panoramic view shows lack of riparian vegetation, eroded banks and free access of livestock to creek.

The lower photo shows the Little Sugar Creek near RM 4.2, with better habitat than what was observed in the upstream reach.

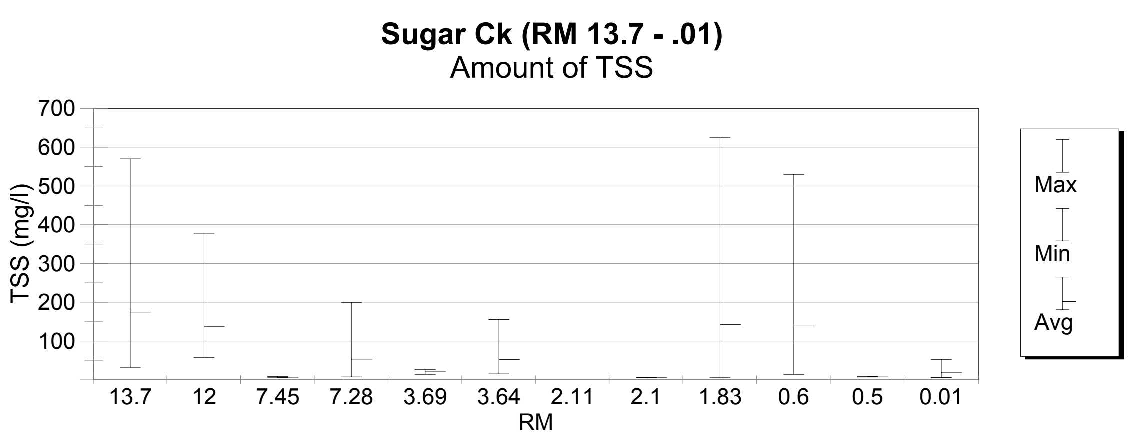
2.3.4 Sugar Ck: South Fork to Tuscarawas River (RM 12.3 to RM 0.0)

This segment lies downstream of the Beach City reservoir. Wetlands and siltation are the main causes of impairment in this segment, which also has two major point source dischargers (the Strasburg WWTP and Dover Chemical). A surprising amount of silt existed in the stream downstream of the dam. Dams often starve streams of bedload material. The opposite was true in Sugar Creek. The quantity of silt which covered downstream substrates was high. As documented earlier, this dam is completely full of silt, which may explain why it is no longer efficiently trapping sediments generated upstream. Figure 9 shows the concentration of Total Suspended Solids (TSS) measured at various sites in this segment from 1989-1999. The maximum values usually correspond to high flow events when extremely high sediment loads flow downstream. In addition to TSS, high concentrations of total phosphorus, iron and other metals were observed in this reach, presumably associated to high flow events as well. The median concentration of nutrients was fairly high, showing 1.46 mg/l for NO3+NO3 and 0.37 mg/l for total phosphorus.

The Strasburg WWTP was a source of nutrient enrichment but better downstream habitat compensated for this influence and full attainment was observed downstream from its outfall. Closer to the mouth, the stream achieved full and partial attainment upstream from Dover Chemical, but declined to non attainment immediately downstream. This condition has existed for decades, and may be associated to chlorinated paraffins present in the sediments, as mentioned in subsection 2.2.2. The major sources of impairment in this segment besides the point sources mentioned above are agriculture, pasture land and crop land.

Broad Run is a significant tributary (20 mi^2) to this segment and shows some impact from mining activities in tributaries (Turkeyfoot Run and Cherry Run), in addition to the problems stated above.

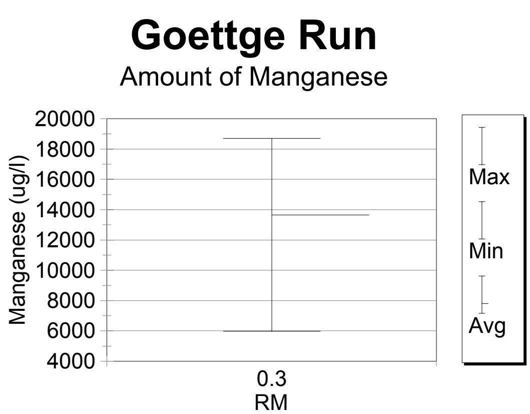
Figure 9. Range of Total Suspended Solids Measured in Sugar Creek Downstream of the Beach City Dam (1998-99)

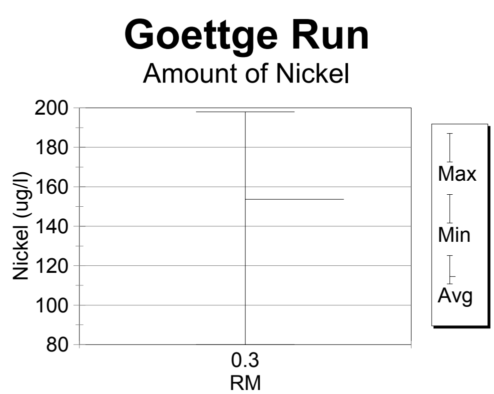


2.3.5 Goettge Run

The surveys conducted in 1998 by Ohio EPA examined only 1 station (near the mouth) in Goettge Run, due to its small drainage area (4.6 mi^2). According to all data available, the only WQS violation in Goettge Run was for E. coli. The biological scores were poor, and well under the threshold required to meet the WWH use designation. This subwatershed drains dense residential development and abandoned strip mining areas. Ohio DNR data indicates there no active coal mines in this subwatershed (Ohio DNR, 2001). The major cause of impairment in this listed segment is Acid Mine Drainage (AMD), as indicated by elevated manganese (ave = 13600 ug/l) and sulfate (ave = 728 mg/l) concentrations. Nutrient concentrations are within the recommended targets, and so are the habitat (QHEI) index scores. Elevated concentrations of zinc, nickel and iron were also measured, and some of the parameters are shown in Figure 10. No metals water quality standard violations were recorded, although Ohio WQS have no criteria for manganese. For comparison, TMDLs for AMD-impacted areas in West Virginia have used a manganese monthly average target of 950 ug/l, which includes a 5% margin of safety. **The major sources of impairment are abandoned mines.** There are no known point sources discharging to Goettge Run. A coal tipple (loading) facility that had been targeted for study in an Ohio EPA 1992 study (Eberhart Coal) has since gone bankrupt. All the equipment was removed, and the site was reclaimed by the Ohio Department of Natural Resources (Ohio EPA, 2001a).

Figure 10. Range of Metals Concentrations Measured in Goettge Run (RM 0.3) During 1998 Surveys





2.3.6 Brandywine Creek

Brandywine Creek drains 5.5 mi^2 of rural residential, agricultural and strip mining land. **The major causes of aquatic life impairment in this listed segment are siltation and metals**. Survey data indicates that the agricultural WQS for iron (5000 ug/l) was exceeded. Bacteria counts ranged from 2500 to 4500 colonies/100ml. One high concentration of suspended solids (206 mg/l) was measured during a high flow event in August 1998. During the same event, high total iron (17, 000 ug/l) and aluminum (9430 ug/l) concentrations were measured in water samples. The 1998 survey showed poor habitat scores at the two sites assessed in this tributary (QHEI scores averaged 38). The target habitat score is 60. Nitrate levels are within the recommended target, but the total phosphorus concentration (0.18 mg/l) is above the recommended target (0.08 mg/l). **The major sources of impairment are mining/surface mining, although agricultural activities and septic systems are possibly having an impact**. The Kimble sanitary landfill, which had been listed as a possible source of impairment in the 1998 303(d) list is now reported to be in compliance with its permit to control storm water runoff.

2.3.7 Unnamed tributary to South Fork Sugar Creek at RM 14.15

This tributary is representative of the problems facing the South Fork. **The main causes of aquatic life impairment are habitat alteration, siltation, and nutrients**. Ammonia had been included as a cause of impairment in the 1998 303(d) list, but data collected during 1998 indicate a median value of 0.48 mg/l, which complies with water quality standards. One excursion above the NH3-N average WQS of 0.8 was detected after a period of rain. The 1998 303d list also mentions thermal modifications and habitat alteration as causes of impairment. High instream temperatures were measured in 1993 and are likely due to lack of shade. Livestock have been observed in the stream, contributing to habitat degradation, bacteria contamination and nutrient loads. Habitat (QHEI) index scores averaged 28.5 (target is 60). **The major impairment sources are agricultural/pasture land (livestock), removal of the riparian vegetation, and a point source** (American Whey, previously called Ohio Whey) which discharges 3.56 kg/day of total suspended solids, and 1.86 kg/day of total phosphorus to this small tributary. Total suspended solids concentrations downstream from American Whey ranged from 9 to 330 mg/l. The high concentrations were measured during high flow, and represent a significant load. There might be some influence from mining activities or urban runoff, because high values of total iron (10400 ug/l) and zinc (315 ug/l) were measured during periods of high flow. The median concentration of nitrate + nitrite was 1.29 mg/l, while the median total phosphorus was 0.6 mg/l, based on data collected during 1998. Figure 11 shows the range of total phosphorus measured in this tributary during the 1998 surveys.

Figure 11. Total Phosphorus Concentrations in Unnamed Tributary to Sugar Creek (RM 14.15) near mouth.

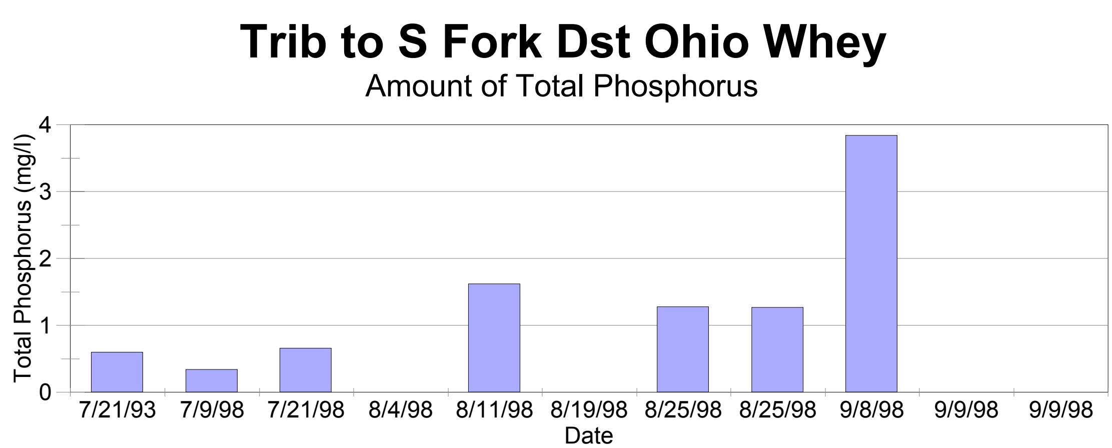


Table 8. Causes and Sources of Impairment in the Sugar Creek Basin

Waterbody Segment Description/[HUC-11 Code]/{Water Body ID}	**Segment Listed in 1998 303d**	**Causes [A]**	**Sources [A]**	**Aquatic Use**	**Miles Attaining Use (1998)**		
					Full	**Partial**	**Not**
Upper Sugar Creek							
Sugar Creek (Headwaters to Middle Fork) [05040001-100] {OH13 20} RM 45.0 to 19.4	Yes	*Organic Enrichment/DO (H)* **Habitat alteration (H)** **Siltation (H)** **Nutrients (M)** **Wetlands (H)** **Pathogens (H)**	Pasture Land (H/**H**) **Non-irrigated crop production (H)** **Agriculture (H)** **Riparian vegetation removal (H)** **Streambank modification (H)** **Other (H)** **Natural (H)** **Channelization (M)** **Flow regulation/modification (M)**	WWH	5.50	7.50	12.6
Little Sugar Creek [05040001-100] {OH13 22} RM 10.6 to 0.0	Yes	*Organic Enrichment/DO(H)* **Habitat alteration (H)** **Siltation (H)** **Nutrients (M)** **Flow alteration (L)** **Pathogens (H)**	Pasture Land(H/ **H**) **Non-irrigated crop production (H)** **Agriculture (H)** **Riparian vegetation removal (H)** **Streambank modification (H)** **Channelization (M)** **Flow regulation/modification (M)**	WWH	4.00		6.60
North Fork							

Waterbody Segment Description/[HUC-11 Code]/{Water Body ID}	**Segment Listed in 1998 303d**	**Causes** [A]	**Sources** [A]	**Aquatic Use**	**Miles Attaining Use (1998)**		
					Full	**Partial**	**Not**
North Fork Sugar Creek [05040001-100] {OH13 21} RM 6.8 to 0.0	Yes	Nutrients (H) *Organic Enrichment/DO (H)* Habitat Alteration (H) Pathogens (H/) **Siltation (H)** *Unionized ammonia (M)* **Flow alteration (L)**	Pasture Land(H) *Feedlots (H)* *Animal Holding areas (H)* *Septic tanks(H)* Channelization (H/ **M**) Removal of riparian vegetation (H/) **Flow regulation/modification (M)** **Point Source (M)** Minor Ind. Point Source (M)	WWH	4.8	2.00	0.00
Middle Fork							
Middle Fork Sugar Creek [05040001-120] RM 15 to 0.0	No	**Habitat alteration (H)** **Siltation (H)** **Nutrients (M)** **Flow alteration (L)** **Pathogens (H)**	**Agriculture (H)** **Non-irrigated crop production (H)** **Pasture Land (H)** **Riparian vegetation removal (H)** **Streambank modification (H)** **Channelization (M)** **Flow regulation/modification (M)**	WWH	13.0	2.00	
Lower Sugar Creek							
Elm Run [05040001-120] RM 3.0 to 0.0	No	**Habitat alteration (H)** **Siltation (H)** **Flow alteration (M)** **Nutrients (L)** **Pathogens (H)**	**Pasture Land (H)** **Non-irrigated crop production (H)** **Agriculture (H)** **Riparian vegetation removal (H)** **Streambank modification (H)** **Channelization (H)** **Flow regulation/modification (H)**	WWH		2.0	1.0

Waterbody Segment Description/[HUC-11 Code]/{Water Body ID}	**Segment Listed in 1998 303d**	**Causes [A]**	**Sources [A]**	**Aquatic Use**	**Miles Attaining Use (1998)**		
					Full	**Partial**	**Not**
Sugar Creek (M Fork to South Fork) [05040001-120] RM 19.4 to12.3	No	**Wetlands (H)** **Siltation (H)** **Nutrients (M)** **Pathogens (H)**	**Other (H)** **Natural (H)** **Agriculture (H)** **Non-irrigated crop production (H)** **Pasture Land(H)**	WWH			7.1
Sugar Creek: South Fork to Tuscarawas River [05040001-120] {OH13 1} RM 12.3 to 0.0	Yes	**Wetlands (H)** Siltation (H)/ **M)** **Metals (L)** **Pathogens (L)**	Major Industrial Point Source (H) **Point Source (H)** **Agriculture (M)** **Non-irrigated crop production (M)** **Pasture Land (M)** **Mining/Surface Mining (L)**	WWH	3.50	7.70	1.1
Lower Sugar Creek (cont.)							
Broad Run [05040001-120] RM 6.0 to 0.0	No	**Habitat alteration (H)** **Siltation (H)** **Nutrients (M)** **Flow alteration (M)** **Pathogens (H)**	**Agriculture (H)** **Non-irrigated crop production (H)** **Pasture Land (H)** **Riparian vegetation removal (H)** **Streambank modification (H)** **Channelization (M)** **Flow regulation/modification (M)** **Mining/Surface Mining (M)**	WWH			6.0
Turkeyfoot Run [05040001-120] RM 3.3 to 0.0	No	**pH (H)**	**Mining/Surface Mining (H)**	WWH			3.3

Waterbody Segment Description/[HUC-11 Code]/{Water Body ID}	Segment Listed in 1998 303d	Causes [A]	Sources [A]	Aquatic Use	Miles Attaining Use (1998)		
					Full	Partial	Not
Cherry Run [05040001-120] RM 3.74 to 0.0	No	**pH (H)**	**Mining/Surface Mining (H)**	WWH			3.7
Goettge Run [05040001-120] {OH13 1.1} RM 5.14 to 0.0	Yes	*pH (H)* *Siltation (H)* **Metals (H)**	Mining/Surface Mining (H) *Industrial Point Sources (H)*	WWH			5.1
Brandywine Creek [05040001-120] {OH13 2} RM 3.50 to 0.0	Yes	*Siltation (H)* **Metals (H)** **Pathogens (H)**	*Landfills (M)* *Unknown source (M)* **Mining/Surface Mining (H)**	WWH			6.0
South Fork Sugar Creek							
South Fork Sugar Creek [05040001-110] RM 22.7 to 6.6	No	**Habitat alteration (H)** **Siltation (H)** **Nutrients (M)** **Flow alteration (M)** **Pathogens (H)**	**Agriculture (H)** **Non-irrigated crop production (H)** **Pasture Land (H)** **Riparian vegetation removal (H)** **Streambank modification (H)** **Channelization (M)** **Flow regulation/modification (M)** **Mining/Surface Mining (L)**	MWH (RM 22.7 to 11.2) WWH (RM 11.2-6.6)		11.5	 4.6
South Fork Sugar Creek [05040001-110] RM 6.6 to 0.0	No	**Wetlands (H)** **Siltation (H)** **Nutrients (M)** **Pathogens (H)**	**Other (H)** **Natural (H)** **Agriculture (H)** **Non-irrigated crop production (H)** **Pasture Land (H)**	WWH (RM 11.2 to 0.0)			6.6

Waterbody Segment Description/[HUC-11 Code]/{Water Body ID}	Segment Listed in 1998 303d	Causes [A]	Sources [A]	Aquatic Use	Miles Attaining Use (1998)		
					Full	Partial	Not
Brush Run [05040001-110] RM 3.0 to 0.0	No	**Habitat alteration (H)** **Siltation (H)** **Nutrients (M)** **Flow alteration (L)** **Pathogens (H)**	**Agriculture (H) /Pasture Land (H)** **Non-irrigated crop production (H)** **Riparian vegetation removal (H)** **Streambank modification (H)** **Channelization (M)** **Flow regulation/modification (M)** **Point Source (M)** **Minor municipal point source (M)** **Mining/Surface Mining (H)**	WWH			3.0
Troyer Valley Creek [05040001-110] RM 3.20 to 0.0	No	**Ammonia (H)** **Metals (H)** **Nutrients (H)** **Habitat alteration (H)** **Siltation (H)** **Flow alteration (L)** **Pathogens (H)**	**Point Source (H)** **Minor industrial point source (H)** **Mining/Surface Mining (H)** **Agriculture (H) /Pasture Land (H)** **Non-irrigated crop production (H)** **Riparian vegetation removal (H)** **Streambank modification (H)** **Channelization (M)** **Flow regulation/modification (M)**	WWH			3.2
South Fork Sugar Creek (cont.)							
Tributary to South Fork Sugar Creek (RM 14.15) [05040001-110] {OH13 9.3} RM 4.7 to 0.0		**Habitat alteration (H)** **Siltation (H)** **Nutrients (H)** **Flow alteration (M)** **Pathogens (H)**	**Agriculture (H) /Pasture Land (H)** **Non-irrigated crop production (H)** **Riparian vegetation removal (H)** **Streambank modification (H)** **Channelization (M)** **Flow regulation/modification (M)** **Point Source (H)** **Minor industrial point source (H)**	WWH			4.7
East Branch Sugar Creek							

Waterbody Segment Description/[HUC-11 Code]/{Water Body ID}	**Segment Listed in 1998 303d**	**Causes [A]**	**Sources [A]**	**Aquatic Use**	**Miles Attaining Use (1998)**		
					Full	**Partial**	**Not**
East Branch [05040001-110] RM 9.70 to 0.0	No	**Habitat alteration (H) Siltation (H) Nutrients (H) Flow alteration (H) Pathogens (H)**	**Agriculture (H) Non-irrigated crop production (H) Pasture Land (H) Riparian vegetation removal (H) Streambank modification (H) Channelization (M) Flow regulation/modification (M) Mining/Surface Mining (H)**	MWH (RM 5.5 to 0.0) WWH (RM 9.7 to 5.5)	0.5	3.3	1.7 4.2
Pleasant Valley Creek [05040001-110] RM 4.9 to 0.0	No	**Habitat alteration (H) Siltation (H) Organic Enrichment (H) Flow alteration (M) Pathogens (H)**	**Agriculture (H) /Pasture Land (H) Non-irrigated crop production (H) Riparian vegetation removal (H) Streambank modification (H) Channelization (M) Flow regulation/modification (M)**	WWH			4.9
Walnut and Indian Trail Creeks							
Walnut Creek [05040001-110] RM 11.1 to 0.0	No	**Habitat alteration (H) Siltation (H) Nutrients (M) Flow alteration (L) Pathogens (H)**	**Agriculture (H) Non-irrigated crop production (H) Pasture Land (H) Riparian vegetation removal (H) Streambank modification (H) Channelization (M) Flow regulation/modification (M)**	MWH (upst RM 0.6) WWH (dst 0.6)	4.0	6.5	0.6

Waterbody Segment Description/[HUC-11 Code]/{Water Body ID}	Segment Listed in 1998 303d	Causes [A]	Sources [A]	Aquatic Use	Miles Attaining Use (1998)		
					Full	Partial	Not
Goose Creek [05040001-110] RM 4.7 to 0.0	No	**Habitat alteration (H)** **Siltation (H)** **Nutrients (M)** **Flow alteration (L)** **Pathogens (H)**	**Agriculture (H)** **Non-irrigated crop production (H)** **Pasture Land (H)** **Riparian vegetation removal (H)** **Streambank modification (H)** **Channelization (M)** **Flow regulation/modification (M)**	WWH			4.7
Indian Trail Creek [05040001-110] RM 8.10 to 0.0	No	**Habitat alteration (H)** **Siltation (H)** **Nutrients (H)** **Flow alteration (L)** **Pathogens (H)**	**Agriculture (H)** **Non-irrigated crop production (H)** **Pasture Land (H)** **Riparian vegetation removal (H)** **Streambank modification (H)** **Channelization (M)** **Flow regulation/modification (M)** **Land Disposal (H)** **Industrial land treatment (H)**	WWH		5.1	3.0

H - High; M - Moderate; L - Low

[A] Causes & Sources in **bold**: were identified in 1998 survey; <u>underlined</u>: were identified both in 303(d) list and 1998 survey; in *italics*: identified in 303(d) only

3.0 Problem Statement

The large number of sources of impairment in the Sugar Creek basin makes it imperative to choose a goal that, when reached, will unequivocally show that the existing constraints have been overcome. **The goal of the Sugar Creek TMDL is to achieve full attainment of the applicable biological and chemical water quality standards**. As indicated in section 2.2, the major causes of non-attainment are excessive sedimentation, habitat alteration, and nutrient enrichment.

The parameters selected for the Sugar Creek TMDL are **Sediment and Nutrients (Total Phosphorus and Nitrate +Nitrite)**. Recognizing the importance of good habitat to achieve the applicable biological and chemical water quality standards, we have also included an evaluation of **habitat** condition in the Sugar Creek basin. **Ohio EPA staff believe that nutrient load reductions must be accompanied by significant improvements in habitat before the affected segments will be able to attain their use designation.** Many of the management practices recommended for sediment load reduction (grass and forest buffer strips, wetland restoration, fencing livestock off the streams, etc) frequently improve stream habitat. Riparian vegetation may increase shade (lowering stream temperatures) and provide leaf litter that helps support aquatic macro invertebrates. Those improvements combined with the sediment load reduction should considerably improve the odds of meeting the biological water quality standards. Preliminary data from the Maumee River basin (another basin in northwest Ohio) shows significant improvement in biological indices following a 58% drop in erosion rates between the mid 1970's and 1998. During that period, conservation tillage in crop fields increased (on average) from 5 to 50% (USGS 2000).

Nutrients, except under unusual circumstances, rarely approach concentrations in the ambient environment that are toxic to aquatic life. U.S. EPA (1976) concluded that “levels of nitrate nitrogen at or below 90 mg/l would not have [direct] adverse effects on warmwater fish." However, nutrients, while essential to the functioning of healthy aquatic ecosystems, can exert negative effects at much lower concentrations by altering trophic dynamics, increasing algal and macrophyte production (Sharpley et al. 1994), increasing turbidity (via increased phytoplanktonic algal production), decreasing average dissolved oxygen concentrations, and increasing fluctuations in diurnal dissolved oxygen and pH. Such changes are caused by excessive nutrient concentrations that contribute to shifts in species composition away from functional assemblages of intolerant species, benthic insectivores and top carnivores (e.g., darters, insectivorous minnows, redhorse, sunfish, and black basses) typical of high quality warmwater streams towards less desirable assemblages of tolerant species, niche generalists, omnivores, and detritivores (e.g., creek chub, bluntnose minnow, white sucker, carp, green sunfish) typical of degraded warmwater streams (OEPA, 1999).

3.1 Target Identification

The establishment of instream numeric targets is a significant component of the TMDL process. The numeric targets serve as a measure of comparison between observed instream conditions and conditions that are expected to restore the designated uses of the waterbody. The TMDL identifies the load reductions and other actions that are necessary to meet the target, thus resulting in the attainment of applicable water quality standards.

Numeric targets are derived directly or indirectly from state narrative or numeric water quality standards. In Ohio the applicable numeric targets are the appropriate biocriteria (see section 2.2.1). Determinations of current use attainment are based on a comparison of biological scores to the appropriate criteria, just as the success of any implementation actions resulting from the TMDLs will be evaluated by observed improvements in biological scores.

Ohio EPA currently does not have statewide numeric criteria for nutrients but potential targets have been identified in a technical report entitled *Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams* (OEPA, 1999). This document provides the results of a study analyzing the effects of nutrients on the aquatic assemblages of Ohio streams and rivers. The study reaches a number of conclusions and stresses the importance of habitat and other factors, in addition to instream nutrient concentrations, as having an impact on the health of biologic communities. The study also includes suggested targets for nitrate+nitrite concentrations and total phosphorus concentrations based on observed concentrations at reference sites. Reference sites are relatively unimpacted sites that are used to define the expected or potential biological community within an ecoregion

The nutrient target values selected for the Sugar Creek basin are shown in Table 9. Because of the expected inter-relationship of nutrient processing and aquatic habitat conditions, the Ohio EPA has taken an adaptive approach to establishing nutrient targets. The reader is referred to *Legal and Technical Basis for Nutrient Target Values Used in TMDL Projects, DSW Water Quality Standards Guidance #4, November 27, 2000* for a general discussion of the approach being used. This TMDL project first considered the suggested ecoregion specific targets for nitrate+nitrite and total phosphorus. However, this watershed is split between two ecoregions and four counties. To simplify implementation and load reduction estimates, we used the statewide nutrient targets for both of the ecoregions in the basin (see Table 9). (EPA, 1999). Achieving the reductions necessary to meet these targets will be challenging, but within reasonable expectations of success. The NO_3+NO_2 and total phosphorus target concentrations used in this TMDL project are considered fully protective of the Warmwater Habitat biological criteria. The pertinent facts supporting this statement are provided below.

Table 9. Nutrient and Habitat TMDL Targets for Sugar Creek

Watershed Size (D.A. = Drainage Area)	Ecoregion	NO3+NO2 (mg/l) [1]	Total P (mg/l) [1]	Habitat (QHEI) [2]
Headwaters (D.A. < 20mi^2)	EOLP	1.0	0.08	60
	WAP	1.0	0.08	60
Wadeable (20mi^2 < D.A. < 200 mi^2)	EOLP	1.0	0.10	60
	WAP	1.0	0.10	60
Small Rivers (200 mi^2 < D.A. < 1000 mi^2)	EOLP	1.5	0.17	60
	WAP	1.5	0.17	60

[1] The values for NO3+NO2 and total P are the recommended statewide concentrations for protection of aquatic life.
[2] Values of the QHEI index$\geq$60 are usually correlated with sites that are meeting the WWH use designation
Source: Ohio EPA Technical Bulletin MAS/1999-1-1, January 7, 1999.

Nitrogen
Nitrate+nitrite concentrations in the range of 1.0 to 1.5 mg/l are considered protective of eventual attainment of the Warmwater Habitat biological criteria in the Sugar Creek watershed when the following factors are considered.

- The threshold for observed degradation of WWH communities is in the range of 3-4 mg/l NO_3+NO_2 (OEPA, 1999, page 2).
- A meso-eutrophic boundary value of 1.5 mg/l NO_3+NO_2 has been reported in the literature from a wide range of streams and would be consistent with probable WWH attainment in the Sugar Creek watershed (Dodd, 1998 reported in OEPA, 1999, page 4).

The target values selected (see Table 9) provide an adequate margin of safety and a reasonable expectation that the WWH biocriteria will be met in this given situation. Based on the factors shown above, it is recommended that point source reductions for nitrogen be initially limited to the segments that deviate significantly from the recommended targets.

Phosphorus
Data from the Erie Ontario Lake Plain ecoregion was examined to determine the relative frequency of total phosphorus concentrations and WWH attainment. See Appendix C for a presentation of this data. The target values used (see Table 9) are at the upper limit or threshold where we can reasonably expect attainment of the WWH biocriteria. In other words, other similar sized streams in the ecoregion are attaining the WWH use designation when total phosphorus concentrations are at 0.2 mg/l, but it is very unusual the find WWH attainment at higher TP concentrations. Therefore, the margin of safety provided through the selection of the TP target value is minimal.

Sedimentation and Habitat

Sedimentation (or siltation) was consistently identified as a major cause of impairment in the Sugar Creek basin, together with habitat alteration. According to OAC Rule 3745-1-04, all waters of the state of Ohio shall be free from suspended solids and other substances that enter the waters as a result of human activity and settle to form objectionable sludge deposits, or that will adversely affect aquatic life.

Although total suspended solids (TSS) were measured at most sites, Ohio currently has no statewide numeric criteria that can be used to assess the observed TSS concentrations. For that reason, Ohio EPA's QHEI (Qualitative Habitat Evaluation Index) scores determined for the 1998 Sugar Creek survey sites can be used as surrogates. The QHEI is a quantitative index that combines the scores given to six physical stream/riparian variables, thus yielding a numeric value for a stream's habitat. The variables included in the index are: substrate, instream cover, riparian characteristics, channel characteristics, pool/riffle quality, and gradient/drainage area. It can be used to assess a stream's habitat and determine which of the six variables needs to be improved to reach the QHEI target score. The <u>substrate</u> variable includes an assessment of sediment quality and quantity, thus providing a numeric target for sedimentation. The <u>riparian characteristics</u> variable evaluates information on riparian width, flood plain quality and bank erosion. This variable also provides a numeric value that can be used to track improvements resulting from implementation of management practices. **The QHEI target for the Warmwater Habitat use designation is ≥60. Since habitat is usually strongly correlated with the IBI (Index of Biotic Integrity, a fish index) biocriterion, the QHEI provides a quantitative way to evaluate how habitat issues affect the attainment of the aquatic use designations.** This target represents the median value of several QHEI measurements performed in a given stream segment.

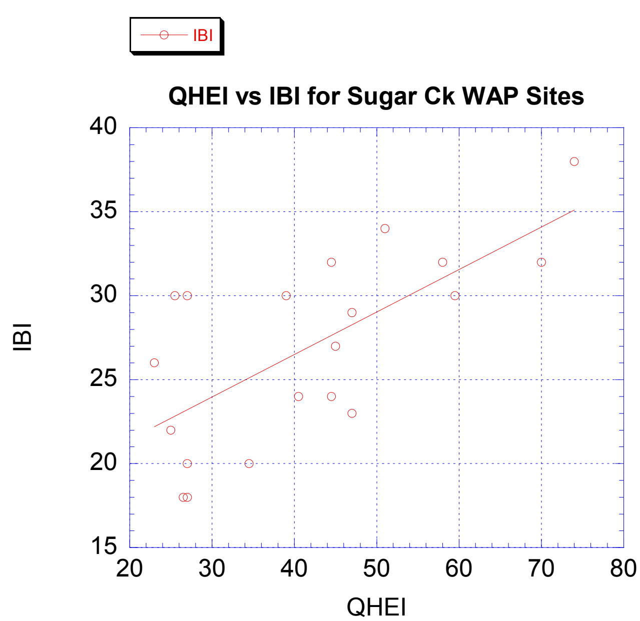


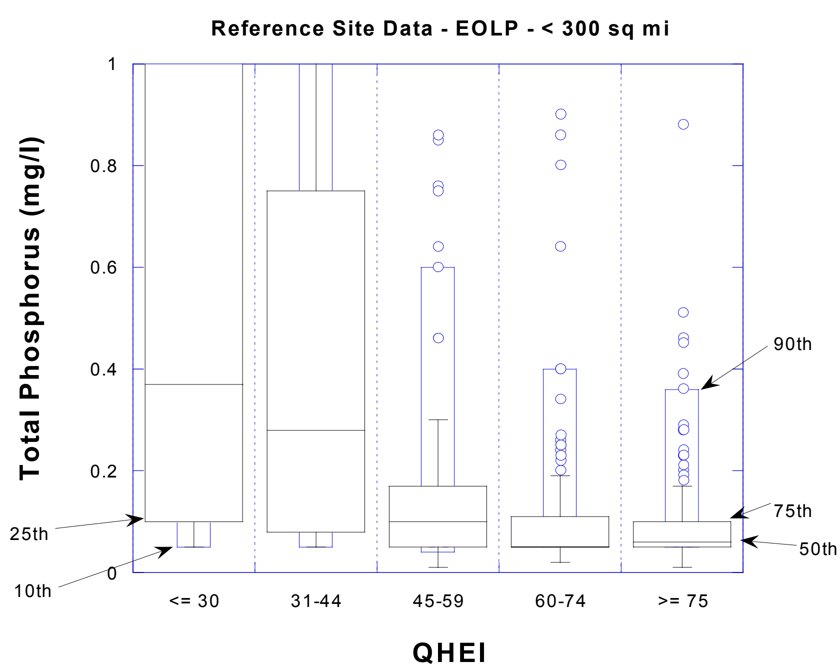
Figure 12. QHEI vs IBI indices for Sugar Creek sites in the WAP ecoregion

Figure 12 shows a plot of QHEI vs IBI for Sugar Creek sites located within the Western Allegheny Plateau ecoregion (southern part of the basin). The plot suggests that increasing the QHEI score is likely to result in an increase of the IBI score. The QHEI is being suggested not as a prescribed limit, but as a way to monitor effectiveness of management practices that aim to improve riparian habitat and reduce sediment loads.

Figure 13 shows the relationship between QHEI (habitat index) and total phosphorus, indicating the tendency for sites with better habitat scores to have lower phosphorus concentration. Figure 14 shows the QHEI scores for Sugar Creek and tributaries, arranged by drainage area and ecoregion. The vertical line in the graph represents the desirable QHEI score of 60. The Habitat (QHEI) index targets for Warmwater Habitat streams in the Sugar Creek basin are shown in Table 9.

Positive results have been observed so far in other Ohio watersheds that have implemented conservation tillage and other conservation practices. The suspended sediment discharge in parts of the Auglaize River basin decreased by 50% between 1970-98 as the acreage under conservation tillage increased to over 50% during the same period (USGS, 2000). It is estimated by some NRCS staff in Wayne and Tuscarawas counties that about 30% of cropland in the watershed are currently under some form of conservation tillage. **A target of 50% cropland in conservation tillage for the Sugar Creek basin should be pursued as an effective way to reduce sediment as well as phosphorus loads.**

Figure 13. QHEI vs total phosphorus for reference sites < 300 mi^2 drainage in the EOLP ecoregion. Boxes represent the 10th, 25th, median, 75th, and 90th percentiles



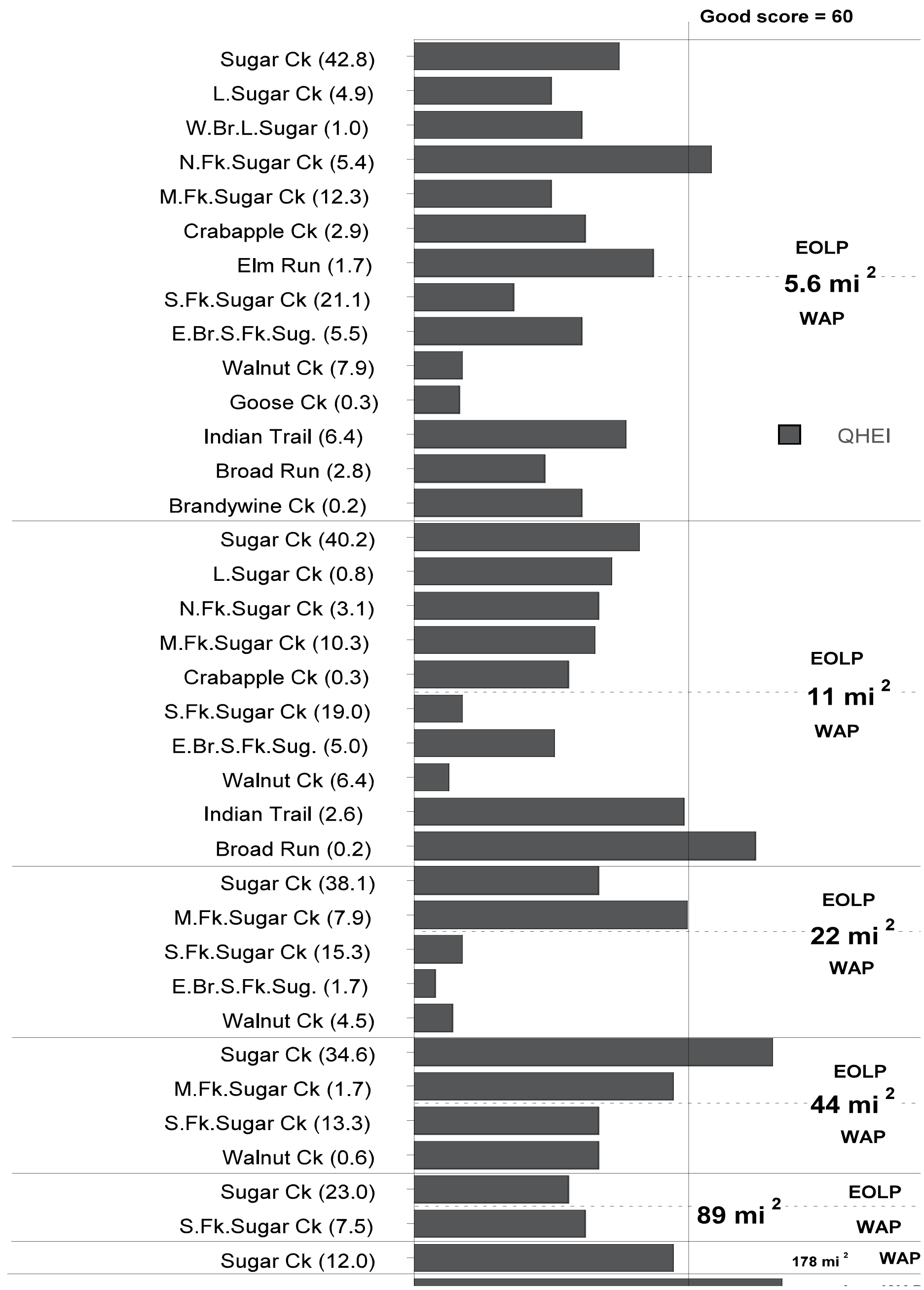


Figure 14. QHEI (Habitat) Scores for Sugar Creek and tributaries (1998) The sites are grouped by ecoregion and size of drainage area.

Comments received from the Ohio Farm Bureau support the use of the QHEI as a tool to evaluate the quality of a stream's habitat. The Bureau suggests that an investigation of the scores for each of the QHEI's individual metrics can be a useful tool to help in the identification of the principal factors limiting habitat quality. The analysis would also lead to the identification of the types of possible remediation actions that could take place. For example, if the riparian/erosion metric scores low, then the proposed remediation actions should focus on stream bank erosion control and riparian buffer establishment. (Ohio Farm Bureau, 2002). Ohio EPA will make the metric scores available to watershed groups to help them prioritize the implementation of management practices.

Nutrient Targets: (Nitrate + Nitrite and Total Phosphorus)

Nutrient targets are necessary to complement the biocriteria and to help evaluate the impact of nutrient loadings. Data from reference sites in Ohio, especially headwater and wading streams, show that total phosphorus during low flow is lower in stream sites with higher quality habitats as measured by the QHEI (Figure 13). The proportion of the phosphorus that is assimilated instream by improving habitat quality versus the proportion of nutrient load kept from reaching the stream compared to poor quality habitats is not known. Further work is needed to examine specifically how instream and riparian habitat mediates nutrient assimilation in Ohio streams.

Since the Sugar Creek basin is split among two ecoregions, there are different biocriteria targets le for each of them. These targets were used as the basis for the Sugar Creek TMDLs. Ohio EPA recognizes that the Sugar Creek basin has been impacted by more than a century of agricultural and mining activities that have reshaped the original watershed. For that reason, the proposed targets for total phosphorus are less restrictive than the values recommended for the WAP and EOLP ecoregions in the Ohio EPA report mentioned above. For phosphorus, the recommended targets for Sugar Creek are the proposed statewide criteria, instead of the ecoregion-specific criteria.

For similar reasons, the proposed nutrient targets for Nitrate + Nitrite-N are the 75th percentile values, rather than the 50th percentile values for each ecoregion. The targets were shown in Table 9. It is important to note that these nutrient targets are not codified in Ohio's water quality standards and therefore there is a certain degree of flexibility as to how they can be used in a TMDL setting. It is the biocriteria and not the nutrient targets that will be measured to determine full attainment of water quality standards.

Additionally, Ohio's water quality standards include narrative criteria which states that all the waters of the state shall be free from nutrients entering the waters as a result of human activity in concentrations that create nuisance growths of aquatic weeds and algae (OAC Rule 3745-1-04). **All point sources discharging to any Sugar Creek tributary and the mainstem should have total phosphorus effluent limits of 1 mg/l, in order to reduce phosphorus loadings to Sugar Creek.** The limits could be relaxed during the winter months (December-February). Ohio EPA will provide a compliance schedule to dischargers. Refer to Table 15 for proposed loads.

Ammonia-N

Water quality standards for ammonia-N depend on the stream's pH, temperature and use designation. The specific standards can be found in OAC Rule 3745-1-07, and are designed to protect aquatic organisms from ammonia toxicity. Table 10 shows the thirty day average criteria for ammonia-N for the segments which are listed in the 1998 303(d) list as having ammonia-related impairment. Ammonia had been previously mentioned as a cause of impairment for two of the listed segments (the North Fork and the unnamed tributary to South Fork at RM 14.15). Due to point source improvements in the North Fork, ammonia concentrations are no longer exceeding WQS in that segment. The proposed Kidron WWTP should reduce or eliminate ammonia from faulty septic systems. **The water quality data also indicates that ammonia is no longer a source of impairment in the unnamed tributary to South Fork, RM 14.15.** Instream ammonia levels are provided in Table 10 for several segments located downstream of the listed segments to show that concentrations are well within water quality standards for all those segments.

The results of water quality samples collected in unlisted segments showed that only one segment (Troyer Valley Creek, a tributary to the South Fork Sugar Creek) was exceeding ammonia water quality standards. The violation is due to discharges from a cheese production plant and is being corrected through the entity's NPDES permit.

Table 10. Outside Mixing Zone 30-day Average Ammonia (NH3-N) Water Quality Standards (Summer only) for selected segments.

Waterbody Segment Description/ [HUC-11 Code]	River Mile	NH3-N WQS (mg/l)	Aquatic Use	Instream pH (S.U.) and Temperature (C)			Instream NH3-N (mg/l)	
				pH	Temp	# of samples	Median	# of samples
Sugar Creek (Headwaters to M Fork) [05040001-100]	45.0 to 19.4	1.1	WWH	8.0	22.6	35	0.07	46
North Fork Sugar Ck [05040001-100]	6.8 to 0.0	0.8	WWH	8.2	22.0	21	0.11	47
Sugar Creek (M Fork to) [05040001-120]	19.3 to 0.0	1.5	WWH	7.8	23.0	66	0.09	55
Trib. to South Fork Sugar Ck (RM 14.15) [05040001-110]	4.7 to 0.0	0.8	WWH	8.1	24.9	15	0.48 (mean)	5
South Fork Sugar Ck [05040001-110]	21.1 to 11.2	1.45	MWH	8.0	24.5	30	0.26	66
South Fork Sugar Ck [05040001-110]	11.2 to 0.0	1.0	WWH	7.8	24.0	21	0.26	66

pH, temperature and ammonia-N data based on 1998-99 surveys

Biological Criteria

The biocriteria (mentioned earlier in Table 6) are the ultimate measure of whether a stream is meeting its use designation. Ohio EPA incorporated biological criteria into the Ohio Water Quality Standards (WQS; Ohio Administrative Code Chapter 3745-1) regulations in February 1990 (effective May 1990). These criteria consist of numeric values for the Index of Biotic Integrity (IBI) and Modified Index of Well-Being (MIwb), both of which are based on fish assemblage data, and the Invertebrate Community Index (ICI), which is based on macroinvertebrate assemblage data. Criteria for each index are specified for each of Ohio's five ecoregions, and are further organized by organism group, index, site type, and aquatic life use designation. The specific biocriteria for the two ecoregions present in the Sugar Creek watershed are listed earlier in the report in Table 7 .

3.2 Identification of Deviation from Target

Nutrients (Nitrate + nitrite; total phosphorus)
Table 11 shows median NO3+NO2N and total phosphorus concentrations measured in Sugar Creek and its tributaries, compared with the nutrient targets indicated in Table 9. The observed concentrations for each stream were calculated by taking the median of all samples collected at any site located in that stream during the 1998-99 surveys. Although Goettge Run and Brandywine Creek were not listed for nutrients, their concentrations are included below for information purposes. The table illustrates how some nutrients exceed the targets in some water bodies but not in others.

Table 11. Comparison of Median Nutrient Concentrations to Target Values in Sugar Creek Segments Listed in the 1998 303(d) TMDL List (1998-99 OEPA Survey Data).

Waterbody [HUC-11 Code]	Water shed Size[A]	Aq. Life Use Designation/ [Ecoregion]	NO3+NO2N median conc. (mg/l), [# samples]	NO3+ NO2 Target	Total P median conc. (mg/l), [# samples]	Total P Target
Sugar Creek (Hwaters to M Fork) [05040001-100] RM 45.0-19.4	H, W	WWH/ [EOLP]	3.57 [46]	1.0	0.23 [46]	0.08 -.1
North Fork Sugar Ck [05040001-100]	H	WWH/ [EOLP	3.7 [47]	1.0	0.46 [47]	0.08
Little Sugar Creek [05040001-100]	H	WWH/ [EOLP	0.63 [22]	1.0	0.14 [22]	0.08
Sugar Ck: S Fork to Tuscarawas R [05040001-120] RM 12.3-0.0	W, S	WWH/ [WAP]	1.46 [55]	1.5	0.37 [54]	0.17
Goettge Run [05040001-120]	H	WWH/ [WAP]	0.55 [6]	1.0	0.07 [6]	0.08
Brandywine Ck [05040001-120]	H	WWH/ [WAP]	0.77 [12]	1.0	0.18 [12]	0.08
Trib. To S. Fork Sugar Ck (RM 14.15) [05040001-110]	H	WWH/ [WAP]	1.29 [13]	1.0	0.6 [13]	0.08

[A] Watershed size: H= Headwaters (D.A.< 20 mi^2), W= Wadeable (20 mi^2<D.A.<200 mi^2), S= Small Rivers (200 mi^2<D.A.<1000 mi^2)

For informational purposes, Table 12 compares the instream nutrient concentrations to the recommended nutrient targets for those segments that were assessed but not included in the 1998 303 (d) list. Table 13 shows the percent reductions needed to achieve the recommended nutrient concentration targets in Sugar Creek and its tributaries.

Table 12. Comparison of Nutrient Concentrations to Target Values in other Sugar Creek Segments NOT included in 1998 303(d) TMDL List.

Waterbody [HUC-11 Code]	Water shed Size[A]	Aq. Life Use Designation/ [Ecoregion]	NO3+NO2N median conc. (mg/l), [# samples]	NO3+ NO2 Target (mg/l)	Total P median conc.(mg/l), [# samples]	Total P Target (mg/l)
Sugar Creek (M Fork to South Fork) [05040001-120] RM 19.4-12.3	W	WWH/ [WAP]	1.33 [25]	1.0	0.45 [25]	0.1
Elm Run [05040001-120]	H	WWH/ [EOLP]	1.32 [6]	1.0	0.34 [6]	0.08
Middle Fork Sugar Creek [05040001-120]	W	WWH/ [EOLP]	1.31 [28]	1.0	0.17 [28]	0.1
Broad Run [05040001-120]	H	WWH/ [WAP]	0.61 [23]	1.0	0.085 [23]	0.08
Turkeyfoot Run [05040001-120]	H	WWH/ [WAP]	0.57 [5]	1.0	0.13 [5]	0.08
Cherry Run [05040001-120]	H	WWH/ [WAP]	0.38 [5]	1.0	0.23 [5]	0.08
South Fork Sugar Creek [05040001-110]	W	MWH, WWH[WAP]	1.5 [67]	1.0	0.24 [67]	0.10
Walnut Creek [05040001-110]	H, W	MWH, WWH[WAP]	1.12 [45]	1.0	0.22 [45]	0.10
Indian Trail Creek [05040001-110]	H	WWH [WAP]	2.34 [45]	1.0	0.22 [45]	0.08
East Branch [05040001-110]	H	MWH, WWH[WAP]	1.6 [26]	1.0	0.21 [26]	0.08
Goose Creek [05040001-110]	H	WWH/ [WAP]	0.69 [9]	1.0	0.16 [9]	0.08
Pleasant Valley Creek [05040001-110]	H	WWH/ [WAP]	1.28 [7]	1.0	0.06 [7]	0.08
Troyer Valley Creek [05040001-110]	H	WWH/ [WAP]	1.77 [6]	1.0	1.37 [6]	0.08
Brush Run [05040001-110]	H	WWH/ [WAP]	0.90 [10]	1.0	0.29 [10]	0.08

Watershed size: H= Headwaters (D.A.< 20 $mi^{2)}$, W= Wadeable (20 mi^2<D.A.<200 mi^2), S= Small Rivers (200mi^2<D.A.<1000 mi^2)

Table 13. Concentration Reductions Needed to Achieve Nutrient Biocriteria Targets

Waterbody	NO3+NO2N (mg/l)			Total P (mg/l)		
	Existing	Target	%reduction	Existing	Target	%reduction
<u>Listed waterbodies</u>						
Sugar Ck: Headwaters to Middle Fork	3.57	1.0	-72%	0.23	0.1	-56.5%
North Fork	3.7	1.0	-73%	0.46	0.08	-82.6%
Little Sugar Creek	0.63	1.0	BL	0.14	0.08	-42.9%
Sugar Ck: South Fork to Tuscarawas R	1.46	1.5	BL	0.37	0.17	-54.1%
Goettge Run	0.55	1.0	NL	0.07	0.08	NL
Brandywine Creek	0.77	1.0	NL	0.18	0.08	NL
Trib to S Fork at RM 14.15	1.29	1.0	-22%	0.6	0.08	-86.7%
<u>Unlisted waterbodies</u>						
Sugar Ck (Middle Fork to S Fork	1.33	1.0	-25%	0.45	0.1	-77.8%
Elm Run	1.32	1.0	-24%	0.34	0.08	-76.5%
Middle Fork	1.31	1.0	-24%	0.17	0.1	-41.2%
Broad run	0.61	1.0	BL	0.085	0.08	-5.9%
Turkeyfoot Run	0.57	1.0	BL	0.13	0.08	-38.5%
Cherry Run	0.38	1.0	BL	0.23	0.08	-65.2%
South Fork	1.5	1.0	-33%	0.24	0.1	-58.3%
Walnut Ck	1.12	1.0	-11%	0.22	0.1	-54.5%
Indian Trail Ck	2.34	1.0	-57%	0.22	0.08	-63.6%
East Branch	1.6	1.0	-38%	0.21	0.08	-61.9%
Goose Ck	0.69	1.0	BL	0.16	0.08	-50.0%
Pleasant Valley ck	1.28	1.0	-22%	0.06	0.08	BL
Troyer Valley Ck	1.77	1.0	-44%	1.37	0.08	-94.2%
Brush Run	0.9	1.0	BL	0.29	0.08	-72.4%

BL: Existing concentration is below target level
NL: Not listed for this parameter
Existing concentration represents 50th pctl of available data.

Ammonia-N

The deviation of existing ammonia-N from the target (water quality standard) is presented in Table 10, and shows that the listed segments are meeting the water quality standards. Some tributaries not included in the 1998 303(d) list showed ammonia WQS violations. Additional information about those tributaries is shown in Ohio EPA's watershed report (Ohio EPA, 2000).

Sedimentation, Habitat and Biocriteria

As mentioned in Section 3.1, the QHEI index will be used as a surrogate for sedimentation, as well as an indicator of habitat quality. Table 6 showed the current values for the QHEI and other biological criteria (IBI, ICI, MIwb) at each of the monitoring sites assessed during the 1998 biological surveys. The table indicates whether each segment is attaining its use designation.

3.3 Source Identification

In general, the major sources of nutrients and sediments in the Sugar Creek basin are row crops and pasture land as far as annual loads are concerned. Lack of riparian vegetation, streambank modification, crop production, and other agricultural activities contribute to the non-attainment of the use designation.

However, during low flow periods, the water quality impact of the relatively small wastewater treatment plants located throughout the basin can be locally significant. Among the listed segments, the effluent from the point sources discharging to the North Fork contribute a significant nutrient load (34% of the dissolved nitrogen and 22% of the total phosphorus generated in the North Fork subwatershed). Unsewered areas and failing septic systems are also estimated to contribute nutrient loads which are significant during low flow periods.

Additional details about sources of impairment are covered in section 2.3. The watershed report (Ohio EPA, 2000) gives more details about sources of impairment for segments not included in the 1998 303(d) list.

4.0 TOTAL MAXIMUM DAILY LOADS

A TMDL provides a mechanism to recommend controls required to meet water quality standards. The TMDL calculation is the sum of the wasteload allocations for the point sources and the load allocations for natural background and nonpoint sources in a watershed. In the case of Sugar Creek, the major causes of impairment are habitat related and thus not easily amenable to quantification into loads. Attainment of WQS will require that both pollutant loads and other environmental conditions (such as habitat) be considered if they are identified as causes of impairment. The TMDL calculation must also include an implicit or explicit margin of safety to account for uncertainty regarding the relationship between pollutant load and water quality.

4.1 Calculation Method

Watershed Modeling

Nutrient loading in the Sugar Creek basin was simulated using the Generalized Watershed Loading Function or GWLF model (Haith et al., 1992). The complexity of this model falls between that of detailed, process-based simulation models and simple export coefficient models which do not represent temporal variability. GWLF provides a mechanistic, but simplified simulation of precipitation-driven runoff and sediment delivery. Solids load, runoff, and ground water seepage can then be used to estimate particulate and dissolved-phase pollutant delivery to a stream, based on pollutant concentrations in soil, runoff, and ground water. GWLF has been used for TMDL development in Pennsylvania, Iowa and Arizona, and is a recommended model in USEPA's Protocol for Developing Nutrient TMDLs (USEPA, 1999).

GWLF simulates runoff and streamflow by a water-balance method, based on measurements of daily precipitation and average temperature. Precipitation is partitioned into direct runoff and infiltration using a form of the Natural Resources Conservation Service's (NRCS) Curve Number method (SCS, 1986). The Curve Number determines the amount of precipitation that runs off directly, adjusted for antecedent soil moisture based on total precipitation in the preceding five days. A separate Curve Number is specified for each land use by hydrologic soil grouping. Infiltrated water is first assigned to unsaturated zone storage where it may be lost through evapotranspiration. When storage in the unsaturated zone exceeds soil water capacity, the excess percolates to the shallow saturated zone. This zone is treated as a linear reservoir that discharges to the stream or loses moisture to deep seepage, at a rate described by the product of the zone's moisture storage and a constant rate coefficient.

Flow in streams may derive from surface runoff during precipitation events or from ground water pathways. The amount of water available to the shallow ground water zone is strongly affected by evapotranspiration, which GWLF estimates from available moisture in the unsaturated zone, potential evapotranspiration, and a cover coefficient. Potential evapotranspiration is estimated from a relationship to mean daily temperature and the number of daylight hours.

The user of the GWLF model must divide land uses into "rural" and "urban" categories, which determines how the model calculates loading of sediment and nutrients. For the purposes of modeling, "rural" land uses are those with predominantly pervious surfaces, while "urban" land uses are those with predominantly impervious surfaces. It is often appropriate to divide certain land uses into pervious ("rural") and impervious ("urban") fractions for simulation. Monthly sediment delivery from each "rural" land use is computed from erosion and the transport capacity of runoff, whereas total erosion is based on the universal soil loss equation (USLE) (Wischmeier and Smith, 1978), with a modified rainfall erosivity coefficient that accounts for the precipitation energy available to detach soil particles (Haith and Merrill, 1987). Thus, erosion can occur when there is precipitation, but no surface runoff to the stream; delivery of sediment, however, depends on surface runoff volume. Sediment available for delivery is accumulated over a year, although excess sediment supply is not assumed to carry over from one year to the next. Nutrient loads from rural land uses may be dissolved (in runoff) or solid-phase (attached to sediment loading as calculated by the USLE).

For "urban" land uses, soil erosion is not calculated, and delivery of nutrients to the water bodies is based on an exponential accumulation and washoff formulation. All nutrients loaded from urban land uses are assumed to move in association with solids.

The GWLF model was calibrated to the Sugar Creek River watershed by comparing observed data from 1995 to 2000 to predicted data. The model was calibrated to predict monthly streamflows ($R^2 = 0.87$). Once the model had been calibrated, it was used to predict nutrient loadings during the 1995 to 2000 period for each of the subwatersheds listed as impaired for nutrients. The 1995 to 2000 period was selected because it includes the 1998-99 period during which a comprehensive water quality survey of the basin occurred. Five years were modeled to obtain average loadings in this period to smooth out the effects of unusually wet or dry years. The nutrient loads predicted by GWLF for each subwatershed fell within the range of loads measured by Ohio EPA in each subwatershed. The results of the estimated loadings for each subwatershed are presented in section 4.4 . Refer to Appendix A for more details on the GWLF modeling.

Receiving Stream Modeling

In order to address possible impact of excessive nutrient loads on water quality, the Qual2E dissolved oxygen model was used to simulate the discharge of Gerber Poultry to the North Fork Sugar Creek under various scenarios. One of the scenarios includes a proposed wastewater treatment plant that would discharge to the North Fork Sugar Creek downstream of the point where Gerber Poultry discharges (through a tributary) to the North Fork. The Qual2E model was used to determine if interaction from the two dischargers would cause violations of the WQS for dissolved oxygen and ammonia. The model was calibrated using data collected by Ohio EPA during a 1993 survey. The calibrated model was validated against data collected by a consultant (URS Consultants) during a survey conducted in the North Fork during June of 1998. More details about the D.O. modeling are found in Appendix B.

4.2 Critical Conditions and Seasonality

TMDL development must define the environmental conditions that will be used when defining allowable loads. TMDLs are designed around the concept of a "critical condition." The critical condition is defined as the set of environmental conditions that, if controls are designed to protect, will ensure attainment of objectives for all other conditions. For example, the critical condition for control of a continuous point source discharge is the drought stream flow. Point source pollution controls designed to meet water quality standards for drought flow conditions will ensure compliance with standards for all other conditions. For the Sugar Creek TMDL, the 7Q10 low flow (using yields from USGS gages) was used as the critical condition in those segments where nutrient enrichment had previously been identified as causing a Dissolved Oxygen (DO) impairment. Those segments are identified in Table 1. A 50^{th} percentile annual flow was used to evaluate the impact of point source nutrient load reductions on the instream nutrient targets (phosphorus and NO_3 $+NO_2$).

Nutrient sources in the Sugar Creek watershed arise from a combination of continuous and wet weather-driven sources. The critical condition is expected to be the summer low-flow period because this is the period that is most conducive to algal growth. It is also during the summer when higher temperatures increase the decay rate of instream nutrients, increasing the likelihood of dissolved oxygen standard violations, as well as increased ammonia-N toxicity (because of the low flows). Therefore it is the observed summer concentrations that are compared to the targets and used to estimate the necessary loading reductions.

Seasonality is expressed in the TMDL by using the GWLF model to predict monthly loadings over a multi-year period using actual weather conditions and observed seasonal point source loadings. The estimated loads are therefore reflective of seasonal changes in weather, treatment facility operating practices, and other conditions that can vary over the course of a year (e.g. agricultural practices).

4.3 Margin of Safety (MOS)

The statute and regulations require that a TMDL include a margin of safety to account for any lack of knowledge concerning the relationship between load and wasteload allocations and water quality (CWA § 303(d)(1)(C), 40 C.F.R. § 130.7(c)(1)). EPA guidance explains that the margin of safety (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. If the MOS is implicit, the conservative assumptions in the analysis that account for the MOS must be described. If the MOS is explicit, the loading set aside for the MOS must be identified.

A margin of safety is incorporated implicitly into these TMDLs. There are several areas where an implicit margin of safety is incorporated including: the 303(d) listing process, the target development, the model inputs and application. An explanation for each of these areas is provided below.

4.3.1 TMDL priority 303(d) listing

In Ohio, one way a stream segment is listed on the 303(d) list is for failure to attain the appropriate aquatic life use as determined by direct measurement of the aquatic biological community. Many other regional or state programs rely solely on chemical samples in comparison to chemical criteria to determine water quality and designated use attainment. Relying solely on chemical data does not take into account any of the parameters or other factors for which no criteria exist but that affect stream biology, nor does it account for multiple stressor situations. Therefore, the chemical specific approach misses many biologically impaired streams and may not detect a problem until it is severe. Ohio's approach incorporates an increased level of assurance that Ohio's water quality problems are being identified. Likewise, de-listing requires attainment of the aquatic life use determined by the direct measurement of the aquatic biological community. This provides a high level of assurance (and an implicit margin of safety) that if the TMDL allocations do not lead to sufficiently improved water quality then the segments remain on the list until true attainment is achieved.

4.3.2 Target development

The use of nutrient targets that are based on data from relatively unimpacted reference sites provides an additional implicit safety factor. These data constitute a background concentration of nutrients in a stream; unimpacted streams generally have nutrient levels well below those needed to meet biological water quality standards. As the stream becomes impacted, nutrient levels can rise, but the stream can still meet water quality standards based on other factors such as the presence of good habitat. Once the nutrient levels rise high enough or other factors change which no longer mitigate the effects of nutrients then the biological community is impacted, and the stream is impaired. By using nutrient targets based on data from relatively unimpacted sites (or sites that are conservatively in attainment of biological water quality criteria) the targets themselves are set at a conservative level. In other words, water quality attainment is likely to occur at levels higher than these targets and the difference between this actual level where attainment can be achieved and the selected target is an implicit margin of safety.

A further conservative assumption implicit in the target development lies in the selection of the statistic used to represent the phosphorus target which corresponds to an unimpaired biological community. Since Ohio EPA's evaluation of phosphorus data for generating target values is based on measured performance of aquatic life and since full attainment can be observed at concentrations above this target (reinforcing the concept that habitat and other factors play an important role in supporting fully functioning biological communities), it would be valid to argue that a 95^{th} percentile of these values (to exclude outliers) would be protective of the respective aquatic life use. Instead, Ohio EPA selected the median value associated with measured aquatic life performance. The selection of this statistic is an implicit margin of safety in these TMDLs. Refer to Appendix C for more information on how the nutrient targets were derived.

The habitat targets were selected using a method analogous to the nutrients method. The habitat targets and the specific aspects of the habitat that are degraded as provided with the QHEI model combine to add another layer of potential protection to achieving the WQS by providing additional guidance on an alternate means to reduce the nutrient load to the stream, mitigate the impacts of the nutrients in the stream, and directly improve an aspect of stream ecology vital to the biological community. Ohio EPA's ability to add habitat targets, and provide guidance on the improvement of the habitat is an implicit margin of safety made possible through extensive ecosystem monitoring and analysis, and should be recognized as a margin of safety in these TMDLs.

4.3.3 Model inputs and application

Conservative modeling assumptions also implicitly incorporate a margin of safety into the project for the dissolved oxygen and GWLF model simulations. Some of these conservative assumptions include:

- Setting the point source inputs at the full design or permit value for each discharger (as opposed to using the current discharge flows) or the median, whichever is higher. This incorporates an extra 20 to 30% of the total effluent flow that the system is not currently receiving. Since the Sugar Creek watershed is largely agricultural, population growth is low and it is unlikely that the additional flow will actually be in the system for several decades;

- The use of somewhat high concentrations of phosphorus and dissolved nitrogen in the groundwater contribution to streamflow. The use of this assumption, based on data collected in the mid 1980s, intends to account for impact of tiled agricultural land. Since some conservation practices have been implemented in the past 20 years, the actual groundwater concentrations are probably lower.

- Assuming a low flow condition (7Q10) which has a very small recurrence interval (water quality criteria generally do not apply to flow conditions that have a statistical recurrence interval lower than the lowest 7 day consecutive flow in any 10 year period (the 7Q10); and,

- Using moderately high instream temperatures for the dissolved oxygen simulations.

Individually, these decisions reflect conservatism; taken together, this set of circumstances is unlikely to occur concurrently and therefore, provide an additional buffer to account for uncertainty in the modeling process.

One additional aspect that decreases the uncertainty associated with the wasteload allocations and the resultant water quality is that the point sources usually achieve better quality effluent than they are allowed in their NPDES permits. This is particularly relevant for some of the smaller tributaries or headwater reaches, which are effluent dominated during low flow time periods. A random sampling of Lake Erie Basin dischargers with total phosphorus limits of 1 mg/l showed that on average these facilities discharged at 0.65 mg/l total phosphorus. This is 35% less then their allocation and represents a margin of error for the facility and a margin of safety for the stream.

4.4 TMDL Calculations

Necessary loading reductions for Sugar Creek were estimated by comparing the instream 1998-99 summer concentrations to the desired targets (see Section 3.2). For example, if the observed total phosphorus concentration was 0.38 mg/L and the target is 0.19 mg/L, it is assumed that loadings must be reduced by 50%. This approach assumes a direct relationship between loadings and concentrations and a constant assimilation factor (i.e., the instream concentrations of total phosphorus and NO3+NO2 will respond to future changes in loading in the same manner as they respond to current loads). These simplifying assumptions are warranted by the fact that it is the cumulative, rather than the acute, loadings of nutrients that are impairing the biologic communities. Please refer to *Association Between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams* (OEPA, 1999) for a full discussion of the cumulative impacts of nutrients on Ohio rivers and streams. The required load reduction needed to meet the proposed targets varied from segment to segment, as seen in Table 13.

Another important assumption used for these TMDLs deals with the relationship between measures of dissolved nitrogen and NO3+NO2 nitrogen. The instream targets are expressed as NO3+NO2, but the GWLF model outputs loadings as dissolved nitrogen (which includes NO3+NO2, NH4+, and NH3). Since dissolved nitrogen is typically comprised primarily of NO3+NO2 (usually 80-90% based on observed Sugar Creek data), the allowable loads for these TMDLs will be expressed in terms of dissolved nitrogen. However, the estimate of the necessary loading reductions are obtained by comparing the observed instream NO3+NO2 concentrations to the target NO3+NO2 concentrations.

Table 14 shows the existing loads determined using the GWLF model for each subwatershed for dissolved nitrogen, total phosphorus and sediments. Under "existing conditions" the Nonpoint Source (NPS) column includes groundwater, urban, agricultural and natural background loads. The Point Source (PS) column includes the sum of known point source loads in the watershed. The TMDL was determined by multiplying the existing total load by the recommended percent reduction. The TMDL was divided among background conditions, wasteload allocation for point sources (WLA) and load allocations (LA) for nonpoint sources. To determine the background load, the GWLF model was run assuming the watershed was completely covered by forests, instead of cropland, pastureland, and other urban land uses. All the point sources and septic tanks were also excluded, to determine the pollutant loads under "pristine" or pre-settlement conditions. The remaining load was allocated to Nonpoint sources. The percent reductions for nitrogen and phosphorus were set to an appropriate percentage, based on the average reduction needed to meet the nutrient targets shown in Tables 11 and 12.

A 30% reduction in sediment load is viewed as a feasible goal for the Sugar Creek watershed, once the recommendations from the TMDL report (e.g increasing conservation tillage, establish riparian buffers, fence livestock, etc) are funded and implemented. This level of sediment reduction should significantly boost biological scores in the watershed, based on experience with the Auglaize river basin. Information from the USGS indicates that there was a 49.8% reduction in suspended- sediment discharge in the Auglaize River (northwest Ohio) between 1970 and 1998. The report indicates that the reduction in sediment yields may be the result of widespread

Table 14. TMDLs and Allocations For the Sugar Creek Basin

Subwatershed	Existing Conditions			Percent Reduction	TMDL	TMDL Allocations		
	NPS	PS	Total			Natural	WLA	LA
Dissolved Nitrogen (kg/day)								
E Branch	103	0	103	40%	62	13	0	49
Upper Sugar	426	27.3	453	70%	136	37	27.3	72
Lower Sugar	253	102.6	356	0%	356	35	102.6	218
North Fork	77	36.4	113	70%	34	8	21.2	5
Middle Fork	186	13.6	200	25%	150	22	13.6	114
South Fork	338	40.1	378	30%	265	29	28.5	207
Walnut/Indian Tr	222	30.3	252	30%	176	22	26.0	128
Total Phosphorus (kg/day)								
E Branch	24	0	24	60%	10	4	0	6
Upper Sugar	39	5.6	45	60%	18	3	2.6	12
Lower Sugar	47	33	80	50%	40	6	6.2	28
North Fork	14	5.4	19	50%	10	2	3.6	4
Middle Fork	39	11.2	50	40%	30	5	1.0	24
South Fork	59	24.7	84	60%	34	5	2.7	26
Walnut/Indian Tr	30	12.9	43	60%	17	8	2.3	7
Sediments (metric tons/year)								
E Branch	4798	0	4798	30%	3359	896	0	2463
Upper Sugar	3657	13.3	3670	30%	2569	408	13.3	2148
Lower Sugar	9774	115.2	9889	30%	6922	1270	115.2	5537
North Fork	2040	15.4	2055	30%	1439	356	15.4	1067
Middle Fork	6981	4.9	6985	30%	4890	1305	4.9	3580
South Fork	8690	17.0	8707	30%	6095	1158	17.0	4920
Walnut/Indian Tr	5025	15.2	5040	30%	3528	2047	15.2	1466

adoption of conservation tillage (USGS, 2000). Preliminary results from Ohio EPA's biological survey of the Auglaize River basin indicates that most mainstem sites are attaining their use designation.. It should be noted that GWLF simulates sheet and rill erosion, and a multiplier (sediment delivery ratio) determines what percent of that sediment reaches the stream. Bank and gully erosion are not simulated by GWLF, but are taken into account by the QHEI index. The QHEI will be used to guide implementation actions to address bank and gully erosion.

The WLA loads are based on permitted loads at design flow for the point sources in the basin. For total phosphorus, the effluent limits for all point sources were set to 1 mg/l (summer only). "Summer" is defined as the period from March through November. For dissolved nitrogen, only the WLA loads for the North Fork were adjusted by lowering the nitrogen loads, because the point source NO3 + NO2 load is very high compared to all other Sugar Creek subwatersheds. Other dischargers elsewhere in the Sugar Creek basin should monitor their effluent concentration of NO3 + NO2. The existing and proposed phosphorus point source (summer) loads for dischargers in the Sugar creek watershed are shown in table 15.

Table 15. Phosphorus Summer [A] Loads for Point Source Dischargers in the Sugar Creek Basin

Discharger	Design Flow (MGD)	Existing Flow (MGD)	Existing P Load (kg/day)	P Load* @ 1 mg/l (kg/day)	Subwatershed
Smithville WWTP	0.30	0.3	1.2	1.1	Upper Sugar
Eastwood WWTP	0.2 [B]	0.06	0.7	0.76	Upper Sugar
Harmony Lake WWTP	0.036	0.036	0.41	0.14	Upper Sugar
Gerber Poultry	0.80[B]	0.16	4.6	3.0	North Fork
Kidron WWTP (proposed)	0.1	None	none	0.38	North Fork
Mt. Hope WWTP	0.022	0.022	0.25	0.08	Middle Fork
Alpine Cheese Co.	0.022	0.022	8.35	0.08	Middle Fork
Brewster WWTP	0.665	0.391	4.28	2.52	Sugar Creek
Brewster Dairy	0.30	0.30	18.6	1.14	Sugar Creek
Beach City WWTP	0.297	0.15	2.8	1.12	Sugar Creek
Baltic Rubber Co.	0.02	0.02	NA	NA	South Fork
Baltic WWTP	0.1	0.1	2.8	0.38	South Fork
Guggisberg Cheese	0.04[B]	0.014	9.6	0.15	South Fork
Sugarcreek WWTP	0.50	0.5	9.4	1.9	South Fork
American Whey	0.065	0.065	2.88	0.25	South Fork
Walnut Creek WWTP	0.090	0.09	1.0	0.3	Walnut Ck
Holmes By-Products	NA	NA			Indian Trail Ck
Troyer's Trail Bologna	0.005	0.005	0.05	0.02	Indian Trail Ck
Case Farms Inc	0.50	0.50	11.9	1.9	Indian Trail Ck
Strasburg WWTP	0.225	0.225	4.0	1.3	Sugar Creek
Alpine Hills (camp)	NA	NA	0.06	0.02	Sugar Creek
Broad Run Cheese	NA	NA	0.06	0.02	Sugar Creek
Dover Chemical Co.	4.0[B]	1.45	NA	NA	Sugar Creek

[A] March through November

[B] Proposed expansion flow

* At proposed expansion flow or design flow

By request of one of the watershed groups, table 16 has been added to this report, showing the nutrient loads normalized by drainage area. Although this approach may help compare across subwatersheds, it ignores important factors such as habitat, ecoregion, spatial location of point sources in watershed, etc. However, it indicates that the point source nitrogen load per unit of area is highest for the North Fork subwatershed. Details about the allocations for each listed subwatershed are shown following Table 16.

Table 16. Nutrient Loads per Square Mile of Drainage Area for Sugar Creek Subwatersheds

Subwatershed	Existing Conditions				TMDL	TMDL Allocations		
	NPS	PS	Total			Natural	WLA	LA
Dissolved Nitrogen (kg/day/mi^2)								
E Branch	3.65	0	3.65		2.19	0.46	0	1.73
Upper Sugar	5.36	0.34	5.71		1.71	0.47	0.34	0.90
Lower Sugar	4.49	0.70	5.2		3.30	0.46	0.61	2.22
North Fork	4.26	2.02	6.28		1.88	0.44	1.18	0.26
Middle Fork	3.94	0.29	4.23		3.17	0.47	0.29	2.42
South Fork	5.48	0.65	6.13		4.29	0.46	0.46	3.36
Walnut/Indian Tr	4.61	0.63	5.24		3.67	0.46	0.54	2.67
Total Phosphorus (kg/day/mi^2)								
E Branch	0.85	0	0.85		0.34	0.14	0	0.20
Upper Sugar	0.50	0.07	0.57		0.23	0.04	0.03	0.16
Lower Sugar	0.71	0.26	0.97		0.44	0.09	0.05	0.30
North Fork	0.76	0.30	1.06		0.53	0.08	0.20	0.22
Middle Fork	0.82	0.24	1.06		0.63	0.11	0.02	0.51
South Fork	0.96	0.40	1.36		0.54	0.08	0.04	0.42
Walnut/Indian Tr	0.63	0.27	0.89		0.36	0.17	0.05	0.14

4.4.1 Sugar Creek (Headwaters to Middle Fork)

Nonpoint source modeling was performed using the GWLF model (see Appendix A for details). Table 17 shows the annual loads of total phosphorus, dissolved nitrogen, and sediments contributed by various land uses and sources in the Upper Sugar Creek subwatershed (based on model simulation from 1995-2000). Agricultural lands are the main contributors of total phosphorus, suspended sediments (and probably dissolved nitrogen) in this segment. There is insufficient data to determine what portion of the dissolved nitrogen is intercepted by agricultural tiles and routed to the streams (instead of to groundwater). Septic systems are estimated to contribute about 28% of the total phosphorus and 20% of the dissolved nitrogen in this subwatershed. Ohio EPA estimates that a population of approximately 7822 inhabitants is served by residential septic systems in this subwatershed. (See Table 10 of Appendix A for more details). Point source loads contribute about 10% of the total phosphorus, and nearly 7% of the dissolved nitrogen generated in this subwatershed (including dischargers in Little Sugar Creek), based on annual loads.

Table 17. Simulated Distribution of Annual Nutrient Loads and Erosion in Upper Sugar Creek Subwatershed (1995-2000) According to Results of GWLF Nonpoint Source Model

Source	Area (ha)	Dissolved N (t)	Percent N	Total P (t)	Percent P	Sediments (tons/yr)	Sediments %
Row Crop	5742	13.69	8.4%	5.72	35.4%	3100.07	84.5%
Pasture	11388	5.77	3.5%	1.27	7.9%	495.89	13.5%
Forest	2569	0.10	0.1%	0.07	0.4%	51.95	1.4%
Barren	4.3	0.00	0.0%	0.01	0.1%	9.30	0.3%
Open Water	88.8	0.18	0.1%	0.01	0.0%	0	0
Wetland	193.7	0.40	0.2%	0.02	0.1%	0	0
Residential	466.8	0.00	0.0%	0.07	0.5%	0	0
Commercial	87.4	0.00	0.0%	0.10	0.6%	0	0
Groundwater		99.75	61.2%	2.78	17.2%	0	0
Point Source		10.76	6.6%	1.61	10.0%	13.3	0.4%
Septic Systems		32.24	19.8%	4.49	27.8%	0	0
TOTAL		162.90		16.16		3670.51	

(t) = metric ton = 1000 kg
Percentages may not = 100% due to rounding.
Dissolved N = Sum of ammonia-N, NO3+NO2
Total P = Total phosphorus

4.4.2 North Fork Sugar Creek

Table 18 shows the annual loads of total phosphorus, dissolved nitrogen, and sediments contributed by various land uses and sources in the North Fork subwatershed. These loads are based on GWLF simulations for the period 1995-2000. The table provides insight about where the implementation activities should be focused to achieve maximum load reductions. Point sources are providing about 34% of the nitrogen and 22% of the phosphorus load. Septic systems are also a major source of nutrients. This subwatershed also has the highest median concentration of NO2 + NO3 and the largest nitrogen point source load per square mile in the Sugar Creek basin.

Table 18. Simulated Distribution of Annual Nutrient Loads and Erosion in North Fork Sugar Creek Subwatershed (1995-2000) According to Results of Nonpoint Source Model (GWLF)*

Source	Area (ha)	Dis. N (t)	Percent N	Tot. P (t)	Percent P	Sediments	% Sediments
Row Crop	1001.2	2.39	5.9%	2.40	34.3%	1635.53	79.6%
Pasture	2978.7	1.32	3.2%	0.60	8.6%	358.27	17.4%
Forest	594.2	0.02	0.1%	0.06	0.9%	46.27	2.3%
Barren	0	0.00	0.0%	0.00	0.0%	0.00	0.0%
Open Water	3.2	0.01	0.0%	0.00	0.0%	0	
Wetland	13.4	0.03	0.1%	0.00	0.0%	0	
Residential	64.3	0.00	0.0%	0.01	0.2%	0.00	
Commercial	12.5	0.00	0.0%	0.01	0.2%	0.00	
Groundwater		10.98	27.0%	0.62	8.9%		
Point Source		13.91	34.2%	1.56	22.4%	15.4	0.7%
Septic Systems		12.07	29.6%	1.71	24.5%		
TOTAL		40.72		6.98		2055.5	

*All loads as metric tons/year (1000 kg/year)
Dis. N = Sum of ammonia-N, NO3+NO2 Tot. P = Total phosphorus

4.4.3 Little Sugar Creek

There was no specific nonpoint source simulation performed for this subwatershed, as it is included under the upper Sugar Creek segment discussed under subsection 4.4.1. Although insufficient data was available to adequately quantify bacteria, the available information shows indication of bacteria problems. Many of the recommendations given in Section 6 will reduce the bacteria as well as the sediment and total phosphorus loads to the creek. Dissolved nitrogen concentrations do not seem to be a problem in this segment (are within the recommended target of 1 mg/l).

4.4.4 Sugar Creek: South Fork to Tuscarawas River (RM 12.3 to 0.0)

The GWLF nonpoint source model was used to simulate annual nutrient and sediment loads in a reach that includes this segment, as well as the portion of Sugar Creek downstream of Brewster. There are two significant point sources discharging to Sugar Creek in Brewster. Although they are located in a segment not listed in the 1998 303(d) list, these dischargers are having an impact in the creek. About one third of the annual dissolved nitrogen and total phosphorus load is estimated to come from waste water treatment plants. Despite the considerable nitrogen loads from the point sources, the NO3 + NO2 concentrations in this reach of Sugar Creek are within the recommended target of 1.5 mg/l. Table 19 shows the annual loads of total phosphorus, dissolved nitrogen, and sediments contributed by various land uses and sources in the lower Sugar Creek subwatershed, including the point sources mentioned above.

Table 19. Simulated Distribution of Annual Nutrient Loads and Erosion in Lower Sugar Creek Subwatershed (1995-2000) According to Results of GWLF Nonpoint Source Model

Source	Area (ha)	Dis. N (t)	Percent N	Tot. P (t)	Percent P	Sediments (tons/yr)	% Sediments
Row Crop	3819	7.03	5.5%	10.91	37.7%	7849.44	79.4%
Pasture	6396	2.48	1.9%	1.69	5.9%	1117.29	11.3%
Forest	7144.8	0.22	0.2%	0.42	1.5%	324.15	3.3%
Barren	124.4	0.03	0.0%	0.62	2.1%	482.59	4.9%
Open Water	228.3	0.47	0.4%	0.02	0.1%	0	
Wetland	303.7	0.63	0.5%	0.03	0.1%	0	
Residential	1013.8	0.00	0.0%	0.11	0.4%	0.00	
Commercial	168.7	0.00	0.0%	0.20	0.7%	0.00	
Groundwater		49.19	38.4%	1.46	5.1%		
Point Source		40.12	31.3%	9.49	32.8%	115.00	1.2%
Septic Systems		27.97	21.8%	3.96	13.7%		
TOTAL		128.13		28.92		9888.47	

*All loads as metric tons/year (1000 kg/year)
Dis. N = Sum of ammonia-N, NO3+NO2 Tot. P = Total phosphorus

4.4.5 Goettge Run

There was no specific nonpoint source simulation performed for this small (5 mi^2)subwatershed. It is included under the lower Sugar Creek segment discussed under subsection 4.4.5.

4.4.6 Brandywine Creek

Due to its small size (less than 6 mi^2) no individual modeling was done for this subwatershed, although it is included in the nonpoint source simulation performed for the lower Sugar Creek subwatershed. Although insufficient data was available to adequately quantify bacteria, the available information shows indication of bacteria problems. Many of the recommendations given in Section 6 will reduce the bacteria as well as the sediment loads to the creek.

4.4.7 Unnamed tributary to South Fork Sugar Creek at RM 14.15

Due to its small drainage area (about 3 square miles) no individual NPS modeling was done for this subwatershed. However, the GWLF nonpoint source model was used to simulate annual nutrient and sediment loads in the South Fork Sugar Creek, which includes this segment. Table 20 shows the annual loads of total phosphorus, dissolved nitrogen, and sediments contributed by various land uses and sources in the South Fork subwatershed. A point source (American Whey) located in this segment is included in the modeling done for the South Fork subwatershed.

Table 20. Simulated Distribution of Annual Nutrient Loads and Erosion in South Fork Subwatershed (1995-2000) According to Results of GWLF Nonpoint Source Model

Source	Area (ha)	Dis. N (t)	Percent N	Tot. P (t)	Percent P	Sediments (tons/yr)	% Sediments
Row Crop	2500.7	5.24	3.8%	8.31	27.6%	5987.13	68.8%
Pasture	8727.9	4.42	3.2%	3.03	10.1%	1991.37	22.9%
Forest	3680.3	0.15	0.1%	0.19	0.6%	146.28	1.7%
Barren	141.4	0.03	0.0%	0.72	2.4%	565.36	6.5%
Open Water	165.5	0.34	0.3%	0.01	0.0%	0	
Wetland	347.8	0.72	0.5%	0.03	0.1%	0	
Residential	320.2	0.00	0.0%	0.05	0.2%	0.00	
Commercial	51.7	0.00	0.0%	0.06	0.2%	0.00	
Groundwater		89.36	65.6%	7.69	25.5%		
Point Source		15.64	11.5%	7.12	23.6%	17.00	0.2%
Septic Systems		20.34	14.9%	2.88	9.6%		
TOTAL		136.24		30.10		8707.13	

(t) = metric ton = 1000 kg
Percentages may not = 100% due to rounding.
Dissolved N = Sum of ammonia-N, NO3+NO2
Total P = Total phosphorus

5.0 PUBLIC PARTICIPATION

The Sugar Creek basin is split among four counties (Holmes, Stark, Tuscarawas and Wayne). On May 31, 2000, an informational meeting was held in Wooster (Wayne County) Ohio. Representatives from Soil & Water Conservation Districts (SWCD), Natural Resources Conservation Service (NRCS), and Health Departments from the four counties were invited. Other entities represented were the Northeast Ohio Four County Regional Planning & Development Organization (NEFCO), Ohio Department of Natural Resources (ODNR), Ohio Agricultural Research and Development Center (OARDC), East Branch Sugar Creek watershed task force, North Fork Sugar Creek watershed task force and several members of the farming community. The meeting was sponsored by Ohio EPA's Division of Surface Water to share the results of the biological and water quality surveys performed in the Sugar Creek basin during 1998-99, provide information about the TMDL process, and request that the four counties collaborate in applying for a watershed coordinator grant for the whole basin. The meeting was very successful in several ways:

- The OARDC "adopted" the Sugar Creek basin as a pilot project to test its "participatory approach" to organize watershed groups. This approach was subsequently applied successfully in the upper Sugar Creek (Smithville) area and will be tried in other subwatersheds in the basin.

- Although the four counties could not agree on having a single watershed coordinator, two applications were submitted for the position. The application from Wayne county was approved, and a watershed coordinator for the upper Sugar Creek subwatershed (HUC05040001-100) was funded. The coordinator is working on development of an implementation plan.

- Ohio EPA received valuable feedback from those attending the meeting, which was useful in developing presentations brought to watershed groups later on.

Ohio EPA has stayed in touch with the existing watershed groups, providing information and asking for feedback on the draft TMDL report. The following watershed groups meet regularly:

East Branch Sugar Creek watershed task force: Ohio EPA has stayed in touch with this group by phone and e-mail through Alice McKenney, a Tuscarawas county SWCD watershed specialist that facilitates the group's meetings. Ohio EPA staff has met with the group (March 5, 2001) to discuss the draft TMDL report and listen to group members' concerns regarding implementation of the TMDL report recommendations. This group meets regularly and is in the process of completing a watershed plan for the East Branch.

North Fork Sugar Creek watershed task force: Ohio EPA stays in touch with this group through Eric Schultz, the watershed coordinator (Wayne county SWCD) for the upper Sugar Creek subwatershed. Ohio EPA staff attended a meeting (March 9, 2001) with the watershed coordinator and representatives from Wayne and Stark SWCD, NRCS, Health departments, and other regional organizations. Among the topics discussed were the draft TMDL report recommendations, sources of funds for implementation of management alternatives, and coordination among state and local agencies.

Upper Sugar creek (Smithville) watershed group (Sugar Creek Partners): Ohio EPA has stayed in touch with this group by phone and e-mail through Richard Moore, an Ohio State University professor who's leading the OARDC team that facilitated the formation of this group. This group is promoting environmental stewardship by organizing family activities that include biological and water quality monitoring demonstrations to educate stakeholders. These activities also build fellowship among neighbors, thus improving the group's ability to reach consensus on watershed planning decisions. A Sugar Creek "Family Day" was held on July 23, 2002 and included a biological sampling demonstration offered by Ohio EPA staff.

Plate 4. Robert Davic (Ohio EPA-NWDO) gives a stream biology presentation at Sugar Creek Partners "Family Day" activity.

6.0 IMPLEMENTATION AND MONITORING RECOMMENDATIONS

6.1 Implementation Strategies

Pursuant to the regulations at 40 CFR 130.6, states are to develop water quality management plans to implement water quality control measures such as TMDLs. There are two subwatersheds (East Branch and North Fork) within the Sugar Creek basin that are receiving grants that should facilitate the development of such plans. Information provided in this TMDL report should assist watershed groups and local government organizations develop implementation plans and justify requests for additional funds to implement control measures.

The major causes of impairment in this basin are related to agricultural activities that are contributing large sediment and nutrient loads to Sugar Creek and its tributaries, although a few point sources are exerting significant influence in the receiving water bodies. Nutrient loads from point sources are being reduced through the NPDES permit process. The implementation of a basinwide total phosphorus limit of 1 mg/l for point source dischargers has already started, and will continue as permits are renewed. Although point source limits are subject to a compliance schedule, it is expected that most point sources will meet the recommended phosphorus effluent limits within 5 years. Point source load reductions for NO_3 + NO_2 are only recommended for one subwatershed (North Fork) for which point sources are the main sources of nitrogen. For other subwatersheds, top priority should be given to nitrogen load reductions from failing septic systems, crop production and livestock activities. The recreational use of the waterbodies is also being impaired by widespread exceedances of bacterial water quality criteria. Although this report doesn't include TMDLs for bacteria (due to insufficient data), many of the management practices recommended for sediment and nutrient load reductions are expected to lower bacteria loads as well. After the management practices are implemented, the Sugar Creek watershed will be reassessed to verify if bacteria counts are still excessive. The possible impact of abandoned mines on Sugar Creek will also be assessed during future surveys.

The following activities are some examples of management practices that should result in significant load reductions in listed segments and the areas downstream from them:

1. Improve manure management practices
2. Implement conservation tillage/no-till in 50% of cropland to lower sediment and total phosphorus
3. Convert cropland to pasture or forest
4. Establish buffer strips/riparian forest buffers
5. Fence livestock off the stream
6. Bring habitat (QHEI index) score up to an average of 60 through riparian improvements and appropriate sediment reduction measures
7. Implement an initial basin wide effluent phosphorus limit of 1 mg/l for point sources
8. Identify and upgrade/eliminate faulty septic systems
9. Locate and reclaim abandoned strip mines
10. Set load limits for manganese and iron, once criteria are developed for those parameters

Ohio EPA intends to reassess the Sugar Creek watershed several years from now, once restoration measures are implemented. Information regarding available sources of funds for planning and implementation of TMDL goals has been circulated by Ohio EPA among the local entities in Wayne, Tuscarawas, Holmes and Stark counties.

The seven listed segments are itemized below, showing specific load reduction and habitat improvement recommendations for each.

6.1.1 Sugar Creek (Headwaters to Middle Fork)

A very positive development in this part of the basin is the formation of a watershed group near the headwaters (Smithville area), organized with assistance from the Ohio Agricultural Research and Development Center (OARDC). Most group members are farmers or landowners in the area. The group members received information about the habitat and water quality problems in Sugar Creek, and discussed options that suit their needs and meet the TMDL goals. Landowners are planning to enroll part of their land in the Conservation Reserve Program. The combined farms of the twelve farmer team members have over 8 miles of potential contiguous CRP buffers. More details about this particular group is available in subsection 6.2. Ohio EPA is collaborating with OARDC to provide technical assistance to this and other proposed watershed groups

Some of the load reduction and habitat improvement options recommended for this reach are:
-Improve manure management practices
-Implement conservation tillage/no-till in 50% of cropland to lower sediment and total phosphorus load
-Convert cropland to pasture or forest
-Establish buffer strips/riparian forest buffers
-Fence livestock off the stream
-Bring habitat (QHEI index) score up to an average of 60 through riparian improvements/appropriate sediment reduction measures
-Identify and upgrade faulty septic systems
-Limit point source nutrient loads. The following summer loads are recommended for the main dischargers in this reach:

Discharger	Flow (MGD)	NO_3+NO_2-N	Total phosphorus
Smithville WWTP	0.3	monitor	1.1 kg/day (1 mg/l)
Harmony Lake WWTP	0.036	monitor	0.1 kg/day (1 mg/l)

6.1.2 North Fork Sugar Creek

A North Fork watershed group has been meeting regularly and is expected to develop an implementation plan to address many of the nonpoint source problems affecting the segment. More details are given in subsection 6.2. Ohio EPA has been providing technical assistance and information about sources of funding to assist this group with its efforts.

Some of the load reduction options recommended for this segment are:
-Improve manure management practices in livestock holding facilities
-Implement conservation tillage/no-till in 50% of cropland to lower sediment and total phosphorus load
-Establish buffer strips/riparian forest buffers
-Bring habitat (QHEI index) score up to an average of 60 through riparian improvements and appropriate sediment reduction measures.
-Fence livestock off the stream (already being partially implemented)
-Upgrade/elimination of faulty septic systems (a treatment plant is already being designed)
-Limit point source nutrient loads. The following summer loads are recommended for the main dischargers in this reach:

Discharger	Flow (MGD)	NO_3+NO_2-N	Total phosphorus
Kidron WWTP*	0.1	3.79 kg/day (10 mg/l)	0.38 kg/day (1 mg/l)
Gerber Poultry	0.8	15.1 kg/day (5 mg/l)	3.0 kg/day (1 mg/l)

* proposed

6.1.3 Little Sugar Creek

Although this segment does not currently have a watershed group, there are plans underway to organize stakeholders (Moore, 2001). In addition, Little Sugar Creek is part of the upper Sugar Creek subwatershed, which has a watershed coordinator in place. Ohio EPA staff communicate regularly with the watershed coordinator and will continue providing technical assistance as needed.

Some of the load reduction& habitat improvement options recommended for this reach are:
-Improve manure management practices
-Fence livestock off the stream
-Establish buffer strips/riparian forest buffers
-Bring habitat (QHEI index) score up to an average of 60 through riparian improvements and appropriate sediment reduction measures
-Implement conservation tillage/no-till in 50% of cropland to lower sediment and total P load
-Convert cropland to pasture or forest
-Identify and upgrade faulty septic systems
-Limit point source phosphorus loads; monitor effluent NO_3+NO_2-N.

The following summer loads are recommended for the main discharger in Little Sugar Ck:

Discharger	Flow (MGD)	NO_3+NO_2-N	Total phosphorus
Eastwood WWTP	0.2	monitor	0.76 kg/day (1 mg/l)

6.1.4 Sugar Ck: South Fork to Tuscarawas River (RM 12.3 to 0.0)

There are no stakeholder groups in this subwatershed. A significant portion of the phosphorus load originates from point source discharges.

Examples of load reduction options recommended for this segment are:
-Implement conservation tillage/no-till in 50% of cropland to lower sediment and total P load
-Establish buffer strips/riparian forest buffers
-Identify and upgrade faulty septic systems
-Limit all point source phosphorus loads based on 1 mg/l effluent concentration. Nitrate-N concentrations in this segment are already below the recommended target, but ammonia limits are also recommended to avoid dissolved oxygen standard violations.

The following summer average loads are recommended for the main dischargers in this reach:

Discharger	Flow (MGD)	NO_3+NO_2-N	NH_3-N	Total P*
Brewster Dairy	0.3	monitor	6.8 kg/day (6 mg/l)	1.14 kg/day
Brewster WWTP	0.665	monitor	15.1 kg/day (6 mg/l)	2.5 kg/day
Beach City WWTP	0.3	monitor	1.9 kg/day (1.7 mg/l)	1.1 kg/day
Strasburg WWTP	0.338	monitor	1.28 kg/day (1 mg/l)	1.3 kg/day

* All point sources limited to 1 mg/l total phosphorus

6.1.5 Goettge Run

There are no stakeholder groups and no known point sources in this five square mile subwatershed. A watershed located nearby (Huff Run) with similar problems has a watershed coordinator and a very active watershed group. Lessons learned from that watershed could be applied to Goettge Run.

Some of the options recommended for this segment are:
-Conduct additional monitoring during high flows to assess urban and mine runoff impact
-Locate and reclaim abandoned strip mines
-Promote formation of watershed group to interact and learn from experience of adjacent watersheds facing similar problems
-Encourage citizen monitoring to expand water quality data available
-Set load limits for manganese and iron, once criteria are developed for those parameters

6.1.6 Brandywine Creek

There are no known stakeholder groups in this small watershed.

Some of the options recommended for this segment are:
-Locate and reclaim abandoned strip mines
-Promote formation of watershed group to interact and learn from experience of adjacent watersheds facing similar problems
-Conduct additional monitoring during high flows to assess urban and mine runoff impact
-Set load limits for total iron, once criteria are developed
-Implement conservation tillage/no-till in 50% of cropland to lower sediment load
-Establish buffer strips/riparian forest buffers
-Identify and upgrade faulty septic systems
-Bring habitat (QHEI index) score up to an average of 60 through riparian improvements and appropriate sediment reduction measures.

6.1.7 Unnamed tributary to South Fork Sugar Creek at RM 14.15

This tributary is small enough that it could be a good case study for a local watershed group to plan and implement restoration activities. A combination of point source load reductions, management practices to reduce impact of runoff from pasture/agricultural lands, and restoration of riparian vegetation should allow this segment to attain its use designation.

Some of the same habitat improvement and nutrient reduction strategies recommended for this segment are listed below.

Some of the load reduction options recommended for this segment are:
-Improve manure management practices
-Fence livestock off the stream to lower nutrient, bacteria and habitat impact
-Establish buffer strips/riparian forest buffers to lower sediment load and increase shade
-Monitor for impact of mining activities/urban runoff
-Bring habitat (QHEI index) score up to an average of 60 through riparian improvements and appropriate sediment reduction measures
-Transfer discharge from American Whey directly to the South Fork Sugar Creek
-Limit point source nutrient loads. The following summer loads are recommended for the main dischargers in this reach. Limits for other dischargers to the South Fork and its tributaries are also shown below:

	Recommended Nutrient Loads (as kilograms/day)			
Discharger	Flow (MGD)	NO_3+NO_2-N	Total P	NH_3-N
American Whey	0.065	monitor	0.25 (1mg/l)	0.25 (1 mg/l)
Sugar Creek WWTP [A]	0.5	monitor	1.9 (1mg/l)	4.4 (2.3 mg/l)
Guggisberg Cheese [A]	0.04	monitor	0.15 (1mg/l)	0.15 (1mg/l)
Baltic WWTP [A]	0.1	monitor	0.38 (1mg/l)	0.6 (1mg/l)
Case Farms [A]	0.5	monitor	1.89 (1mg/l)	2.8 (1.5 mg/l)
Troyer's Trail Bologna [A]	0.005	monitor	0.02 (1mg/l)	0.03 (2 mg/l)
Walnut Ck WWTP [A]	0.09	monitor	0.34 (1mg/l)	0.68 (2mg/l)

[A] Discharges to a different tributary or to the South Fork Sugar Creek

6.2 Reasonable Assurances

USEPA guidance calls for reasonable assurances when TMDLs are developed for waters impaired by both point and nonpoint sources and for waters impaired solely by nonpoint sources. The purpose of including reasonable assurances is for US EPA to be confident that the identified activities will in fact be implemented and will have the desired results. Reasonable assurances for reductions in nonpoint source loadings may be non-regulatory, regulatory, or incentive-based, and should be consistent with applicable laws and programs. Because Ohio EPA does not have direct authority/jurisdiction over many of the identified nonpoint sources, it will be important to coordinate activities with those governmental agencies that do (e.g., county health departments, municipalities, Department of Agriculture offices). Reasonable assurances for nonpoint source activities can be strengthened by having signed memorandums of agreement, relying on entities with proven track records of performance, and/or documenting that the required funding levels are available.

The following is a summary of regulatory, non regulatory and incentive based actions applicable to or recommended for the Sugar Creek basin:

Regulatory:
- basin wide phosphorus limit of 1 mg/l for NPDES dischargers
- regulation of existing CAFOs in the watershed (already in place)
- new requirements for household sewage treatment systems (statewide requirement)
- sewage sludge disposal standards to regulate sludge application rates (statewide)

Non-regulatory:
- formation of stakeholder groups to promote implementation of TMDL recommendations
- educate stakeholder groups (involves SWCDs, OSU-Extension, Ohio EPA, NRCS, etc)
- periodic stream monitoring (Ohio EPA, watershed groups) to measure progress

Incentive-based
- appoint watershed coordinators to prepare & undertake implementation plans
- provide 319 grants for implementation of conservation tillage, buffers, and other management options
- provide 319 grants and other loans for septic system improvements

- provide loans for WWTP and riparian/habitat improvements

The implementation of the phosphorus limit of 1 mg/l for point source dischargers has already started, and will continue as permits are renewed. Although point source limits are subject to a compliance schedule, it is expected that most point sources will meet the recommended phosphorus effluent limits within 5 years. Ohio EPA recommends that habitat improvements aimed at achieving the QHEI (habitat) index goal of 60 be implemented within 5 years from the date of this TMDL report. This will assure that the management practices will be in place before the existing watershed coordinator grant ends.

In the Sugar Creek basin there are several watershed groups that have been active or are in the process of being formed. The East Branch Sugar Creek has a locally led Watershed Task Force that has been meeting since August 1998. In 1999-2000 this group secured funding from the Ohio Department of Natural Resources, Division of Soil and Water for a vegetated riparian buffer strip demonstration project. In spring of 2001, the first thirty five acres of riparian buffer strips were installed in the watershed. This represents approximately ten miles of stream bank buffers, out of about fifty miles of streambanks in the East Branch subwatershed. Buffers have a minimum average width of twenty five feet. Also in 2001, the group received a grant for water quality monitoring equipment and began local water quality monitoring. (McKenney, 2001). This group was also awarded a nonpoint source grant ($115,500, including local match) for development of a watershed plan for the East Branch. Ohio EPA will continue to support this local effort, providing technical assistance for the water quality monitoring project and serving on the planning project’s Technical Advisory Committee.

The North Fork Sugar Creek has a watershed group (the North Fork Task Force) that has been meeting regularly since March 2000 and is developing a watershed plan to address the nonpoint source problems affecting the segment. Ohio EPA has been providing technical assistance and information about sources of funding to assist this group with their efforts. Point source issues in the North Fork are already being addressed through the NPDES permit process. In addition, a proposed wastewater treatment plan for Kidron is being designed and should significantly reduce the bacterial and nutrient impact from unsewered areas in that sub-watershed.

The uppermost reach of the Sugar Creek (HUC 100) has a watershed coordinator that has been guaranteed funds ($252,100) for seven years. This steady funding will provide continuity and improve the opportunities for success of implementation plans developed by the local watershed groups. The reaches included in the coordinator’s project area are the Sugar Creek (mainstem from headwaters to Middle Fork), Little Sugar Creek, and the North Fork Sugar Creek, mostly located within Wayne County. The coordinator (a Wayne county SWCD employee) is working closely with other local and state agencies (including Ohio EPA) to improve water quality in this subwatershed. A 319 grant has been conditionally approved to help defray the costs of implementation of many of the management options recommended in this TMDL report. The total amount of that grant is approximately $814,000 (including state and local matching funds).

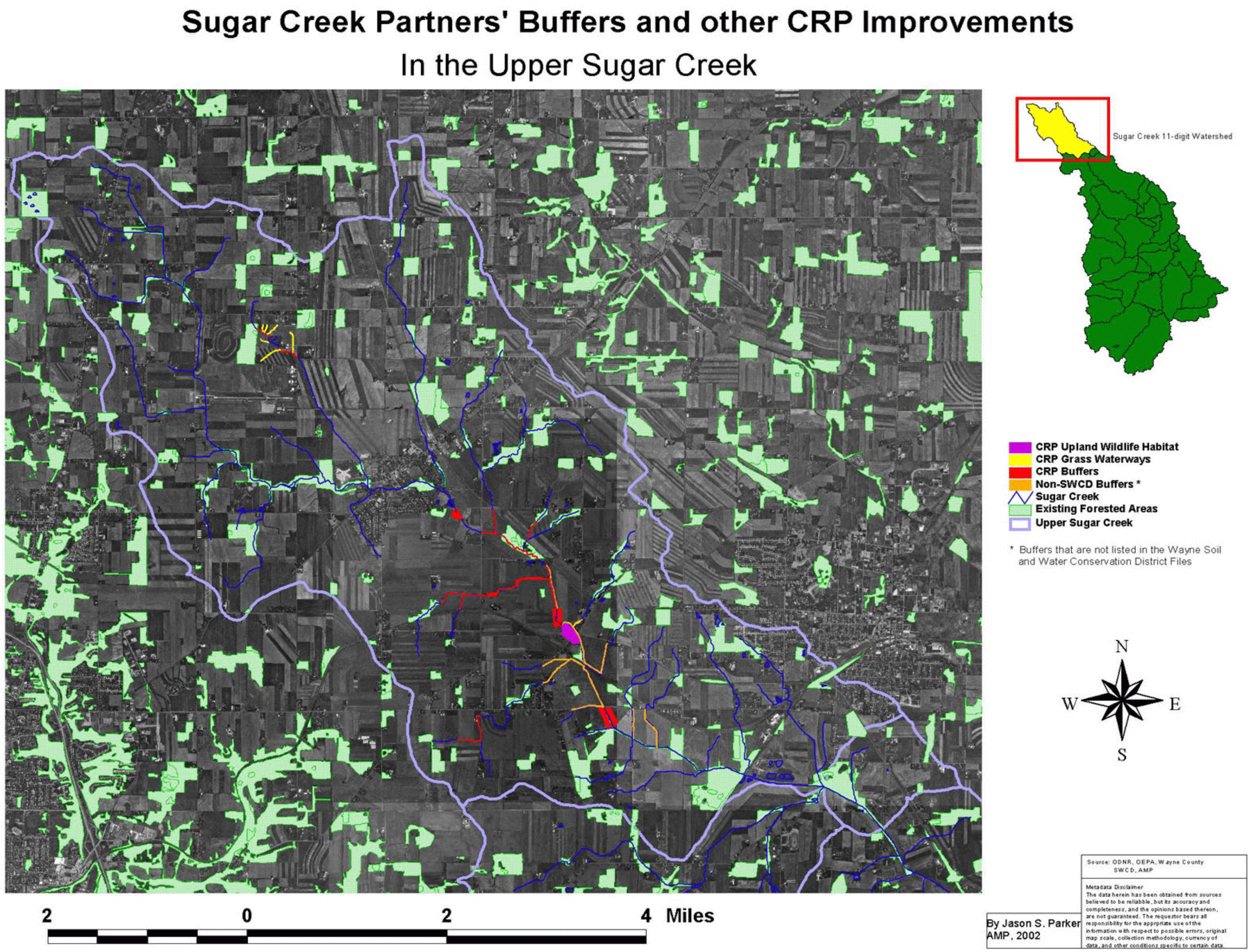
A recent report prepared by NEFCO (Northeast Ohio Four County Regional Planning and Development Organization) contains inventories and maps of point and non-point sources, land use and other data for this subwatershed of Sugar Creek. It identifies sub-basins having highly erodible soils; shows result of habitat assessment done by NEFCO; has inventories of potential pollutant sources including animal husbandry operations, semi-public non-discharging systems, etc. It provides information that will be very useful to local watershed groups as they develop and implement restoration activities. (NEFCO, 2000).

The unnamed tributary to South Fork Sugar Creek is partly affected by a point source that is being addressed through the NPDES permit process. The nonpoint source impacts can best be tackled by local stakeholders. Ohio EPA will continue working closely with Ohio State University-extension and OARDC, who are encouraging and promoting the formation of local watershed groups in the Sugar Creek basin. Ohio EPA is making 319 grants available for planning and implementation. Ohio EPA expects implementation (or watershed action) plans to be in place for the Upper Sugar Creek , North Fork, and Little Sugar Creek sub-watersheds within the next two to three years. A plan for the East Branch (unlisted watershed) should also be ready within that period. The combined drainage area covered by these subwatersheds represent 35% of the basin's drainage area.

Development of stakeholder groups throughout the basin is important for implementation of TMDL recommendations. At least one of the existing watershed groups has developed an effective way to recruit stakeholders. It relies on a participatory approach promoted by OARDC (Ohio Agricultural Research and Development Center) staff. This approach starts with one (or more) conservation-oriented stakeholders that owns property adjacent to the stream. That person recruits a neighbor, who contacts other neighbors to form a watershed group. OARDC staff provide support during the organizational stages to facilitate the initial meetings, and also communicate local habitat and water quality data provided by Ohio EPA. Since its inception in mid-2000, members of this group have agreed to devote several miles of contiguous property as wildlife corridors along the creek (are currently seeking matching funds to defray the cost of this management practice). Plate 4 shows the extent of existing riparian buffers in this segment, and is one of the tools used by this watershed group to track progress. They are also monitoring water quality to pinpoint water quality problems. The procedure (the "Sugar Creek method") followed to develop this watershed group will be applied by OARDC to other subwatershed in the Sugar Creek basin (Little Sugar Creek and South Fork) to form stakeholder groups.

Nutrient loads from point sources are being reduced through the NPDES permit process. A basin wide total phosphorus limit of 1 mg/l will considerably reduce the point source phosphorus load. Additional reductions may be required and phased-in over several years, if the stream nutrient concentrations remain high. Nitrogen reductions should be recommended on a case by case basis, taking into account the existing biological scores downstream of the discharger, the difference between the instream concentration and proposed nitrogen targets for that segment, and the proportion of point source to non point source load in the subwatershed. This report recommends nitrogen point source reductions for one of the seven listed segments (North Fork Sugar Creek).

Plate 4. Location of Existing Riparian Buffers in Sugar Creek near Smithville



References

Dames & Moore, 1995. Beach City Lake: Report on the 1993 Sedimentation Survey, Muskingum River Basin, Sugar Creek, Ohio for U.S. Army Corps of Engineers.

Haith, D.A. and D.E. Merrill. 1992. GWLF, Generalized Watershed Loading Functions, version 2.0, User's Manual. Dept. of Agricultural & Biological Engineering, Cornell University, Ithaca, NY.

Herman, J. Wayne County Environmental Services, personal communication, July 2001.

Karr, J.R. 1991. Biological integrity: A long-neglected aspect of water resource management. *Ecological Applications*. 1(1):66-84.

McKenney, A. Tuscarawas Soil and Water Conservation District, e-mail communications, November 2001.

Miner, R. and D. Borton. 1991. Considerations in the development and implementation of biocriteria. Water Quality Standards for the 21st Century, U.S. EPA Office of Science and Technology, Washington, D.C.

Moore, R. Ohio State University-Wooster, personal communication, November 2001.

NEFCO, 2000. Sugar Creek Watershed Comprehensive Watershed Management Plan Phase I, Northeast Ohio Four County Regional Planning and Development Organization.

OEPA. 1987a. Biological criteria for the protection of aquatic life. Volume I. The role of biological data in water quality assessments. Division of Water Quality Monitoring and Assessment, Surface Water Section, Columbus, Ohio.

OEPA. 1987b. Biological criteria for the protection of aquatic life. Volume II. Users manual for biological field assessment of Ohio surface waters. Division of Water Quality Monitoring and Assessment, Surface Water Section, Columbus, Ohio.

Ohio DNR, 2000. Tom Hines, Ohio Department of Natural Resources, Division of Mineral Resources Management, personal communication, March 2000.

Ohio DNR, 2001. 2000 Report on Ohio Mineral Industry, Ohio Dept of Natural Rresources, Division of Geological Survey, Columbus, Ohio, 2001.

Ohio EPA, 1992. Investigations of Biological Communities and Toxic Impacts in Sugar Creek and Selected Tributaries. Ohio EPA technical report EAS/1992-7-3.

Ohio EPA, 1994. Biological and Water Quality Study of the North Fork Sugar Creek, Wayne County. Ohio EPA technical report SWS/1994-12-17.

Ohio EPA, 1999. Association between Nutrients, Habitat, and the Aquatic Biota in Ohio Rivers and Streams, Ohio EPA Technical Bulletin MAS/1999-1-1.

Ohio EPA, 2000. Biological and water Quality Study of Sugar Creek, 1998.Wayne, Stark, Holmes and Tuscarawas Counties, Ohio. OEPA Technical Report MAS/1999-12-4.

Ohio EPA, 2001a. Jennifer Witte, Ohio EPA, Division of Surface Water, Southeast District Office, personal communication, November 2001.

Ohio EPA, 2001b. Information about schedule of training on biocriteria and Qualitative Habitat Evaluation Index are available in the Ohio EPA website at: http://www.epa.state.oh.us/dsw/whatsnew.html

Ohio Farm Bureau, 2002. Review and Comment on Sugar Creek Basin TMDL Report, Larry Antosch/John Fisher, Ohio Farm Bureau Federation, January 14, 2002 (e mail).

Rankin, E. T. 1989. The qualitative habitat evaluation index (QHEI), rationale, methods, and application. Ohio Environmental Protection Agency, Division of Water Quality Planning and Assessment, Ecological Assessment Section, Columbus, Ohio.

Rankin, E. T. 1995. The use of habitat indices in water resource quality assessments, pp. 181-208. in *Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making*, Davis, W.S. and Simon, T.P. (eds.), Lewis Publishers, Boca Raton, FL.

SCS. 1986. Urban Hydrology for Small Watersheds. Technical Release No. 55 (second edition). Soil Conservation Service, U.S. Department of Agriculture, Washington, DC.

Sharpley, A. N., Chapra, S. C., Wedepohl, R., Sim, J. T., Daniel, T. C. and K. R. Reddy. 1994. Managing agricultural phosphorus for protection of surface waters: Issues and options. *Journal of Environmental Quality*. 23: 437-451.

Tuscarawas County NRCS. According to Tuscarawas County NRCS staff (Ray Rummell) the sediment basins were not as effective in controlling sediment as had been expected. Possibly the capacity/ retention time was insufficient to allow for adequate settling of sediments, Personal Communication, 2000.

USDA, 1986. Watershed Plan and Environmental Assessment for East Branch of Sugar Creek Watershed, Ohio, US Department of Agriculture, Soil Conservation Service, July 1986.

USDA, 2000. Ohio Agricultural Statistics: county profiles for Holmes, Tuscarawas, Stark and Wayne counties were accessed through http://www.nass.usda.gov/oh/profiles/

USEPA, 1975. Report on Beach City Reservoir, Stark and Tuscarawas Counties, Working Paper no. 394, U.S. EPA National Eutrophication Survey.

USEPA 1976. Quality criteria for water. U.S. Environmental Protection Agency. Office of Water. Washington, D. C.

USEPA. 1991. Guidance for water quality-based decisions: the TMDL process, EPA 440/4-91-001. Office of Water. U.S. Environmental Protection Agency.

USEPA. 1997. Technical guidance manual for developing total maximum daily loads Book 2: Streams and rivers. Part 1: Biochemical oxygen demand/ dissolved oxygen and nutrients/eutrophication. EPA 823-B-97-002. Office of Water.

USGS, 2000. Status and Trends in Suspended-Sediment Discharges, Soil Erosion, and Conservation Tillage in the Maumee River Basin—Ohio, Michigan, and Indiana, Water-Resources Investigations Report 00-4091.

Yoder, C.O. 1991. Answering some concerns about biological criteria based on experience in Ohio. In Gretchin H. Flock, editor. *Water Quality Standards 21st Century*. Proceedings of a National Conference. U.S. EPA, Office of Water, Washington, DC.