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

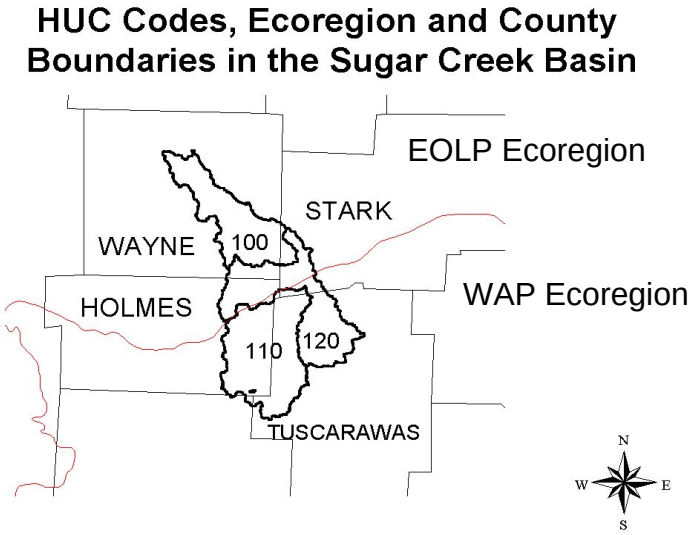


Table 2. Hydrologic Unit Codes (HUC) in the Sugar Creek Basin

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]

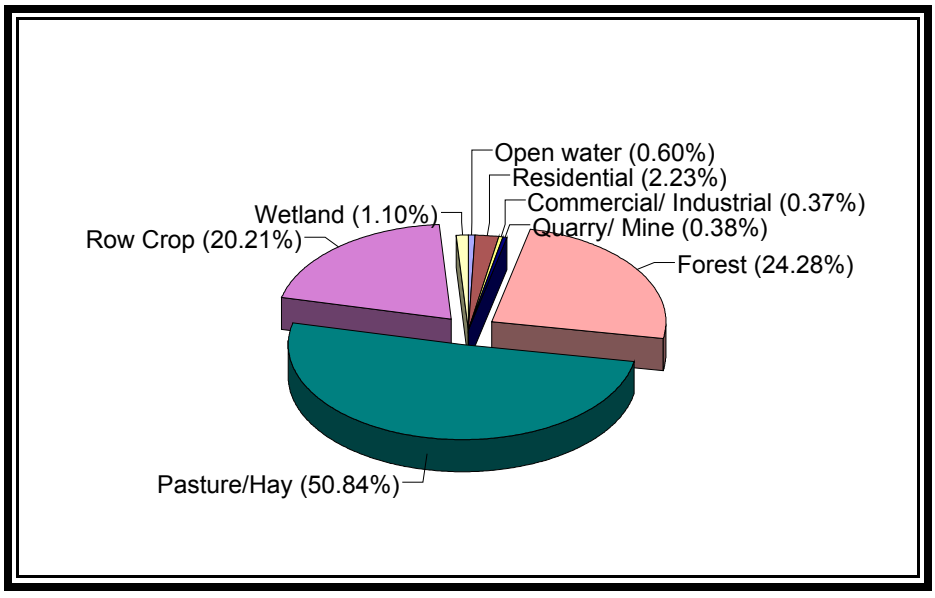
[A] Number of animals [B] Million $ sales [C] Bushels [D] Tons

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.

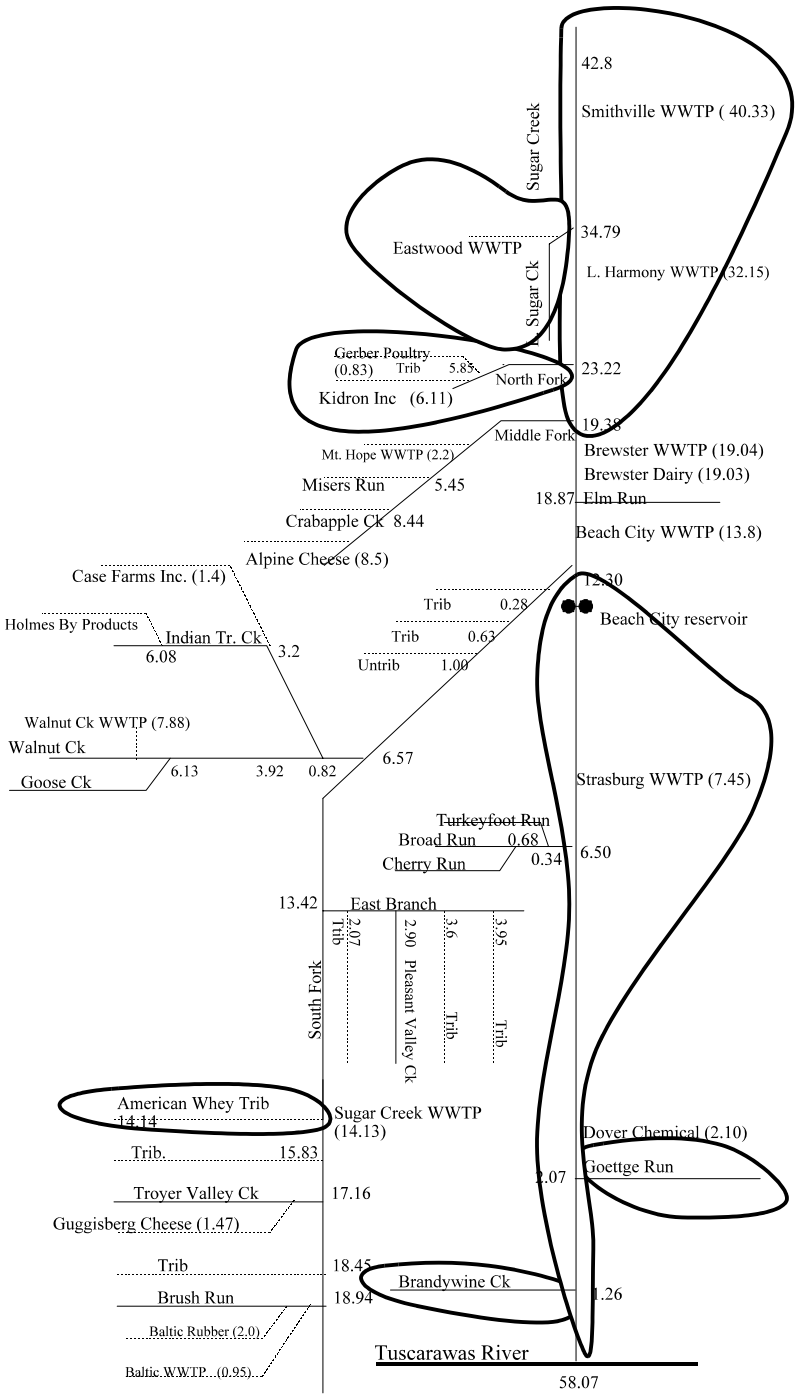
Table 4. NPDES permitted dischargers in the Sugar Creek basin

Entity	Flow (MGD)	Receiving Stream	River Mile	
			Tributary	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.

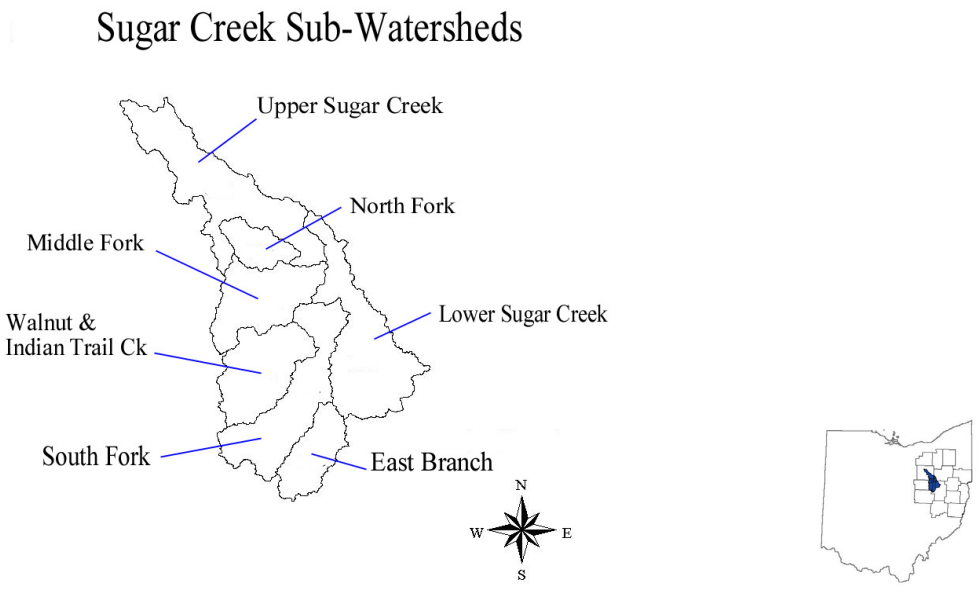


Numbers in parentheses indicate discharger river mile. Other numbers represent tributary or mainstem river miles

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.

WQS Components	Examples of:	Description
Beneficial Use Designation	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	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.
Numeric Criteria	1. Chemical	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.
	2. Biological *Measures of fish health:* ♦ Index of Biotic Integrity ♦ Modified Index of Well Being *Measure of bug (macroinvertebrate) health:* ‣ Invertebrate Community Index	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.
	3. Whole Effluent Toxicity (WET)	Measures the harmful effect of an effluent on living organisms (using toxicity tests).
Narrative Criteria (Also known as 'Free Froms')	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.	

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).

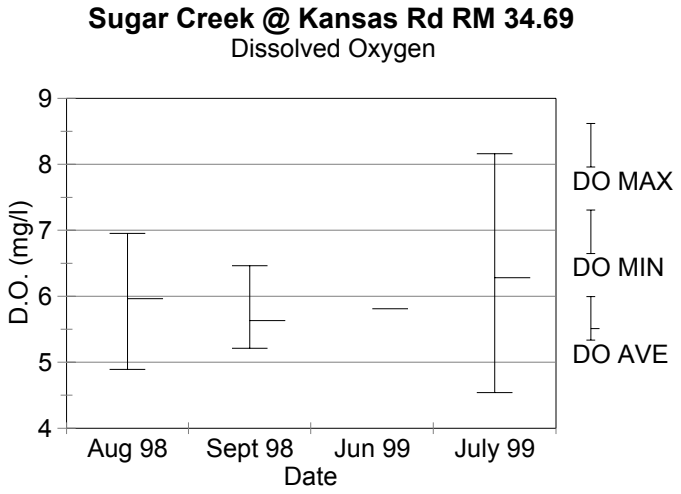
Downstream from Little Sugar Creek, the water quality impact from point sources is insignificant, as there is only one point source (Lake Harmony WWTP; 0.036 MGD). **Dissolved oxygen (D.O.) data collected in this reach showed no violations of the acute D.O. WQS (4 mg/l); long term D.O. monitors (Datasondes ®) 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.

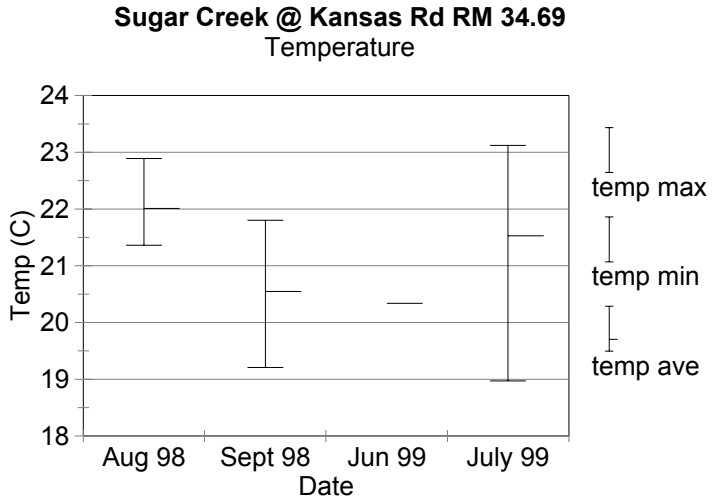
The median concentration of nitrate+nitrite in this reach was 3.57 mg/l based on forty six samples collected during 1998-99 surveys. Only the North Fork had a higher median concentration among the listed segments. Most of the nitrate load is believed to be from nonpoint sources (see Section 4.4.1). The 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 NO3+NO2 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 (NO3 + NO2 + NH3-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.

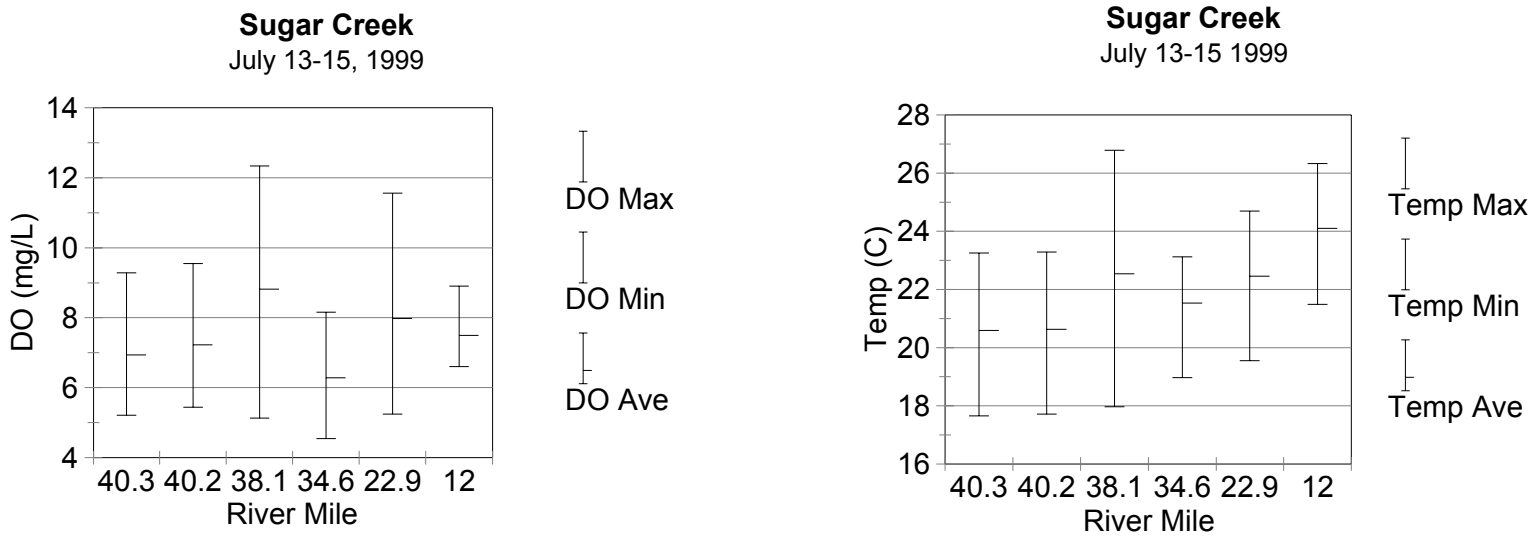
Figure 5. Range of Dissolved Oxygen and Temperature Measured in Sugar Creek at Kansas Rd (RM 34.69) During 1998-99





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.

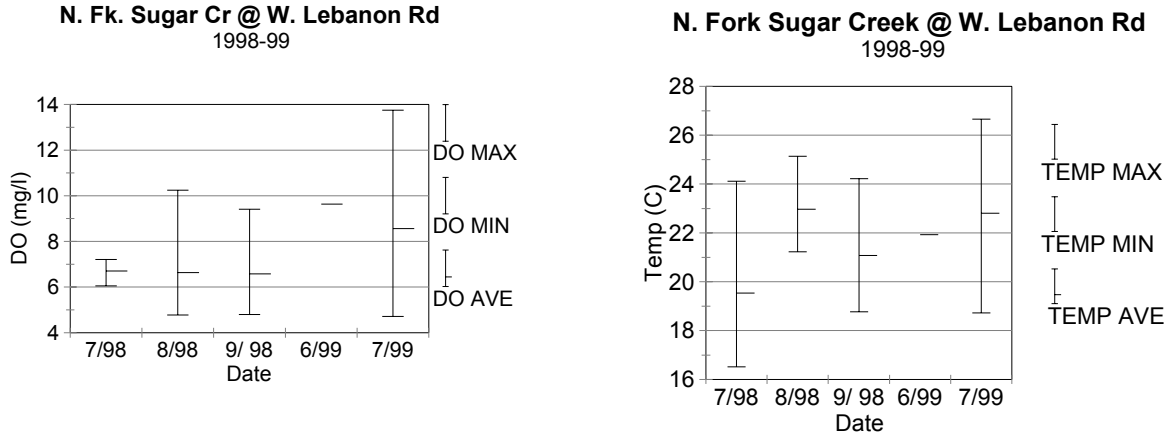
North Fork at Zuercher Rd., RM 5.4. Note the rocky bottom and riffles, which provide good reaeration throughout the reach. The slope is about 43 ft/mile for the next mile of creek. Livestock have access to the creek near this point. Fecal coliforms ranged from 11,000 to 310,000 at this site.

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.

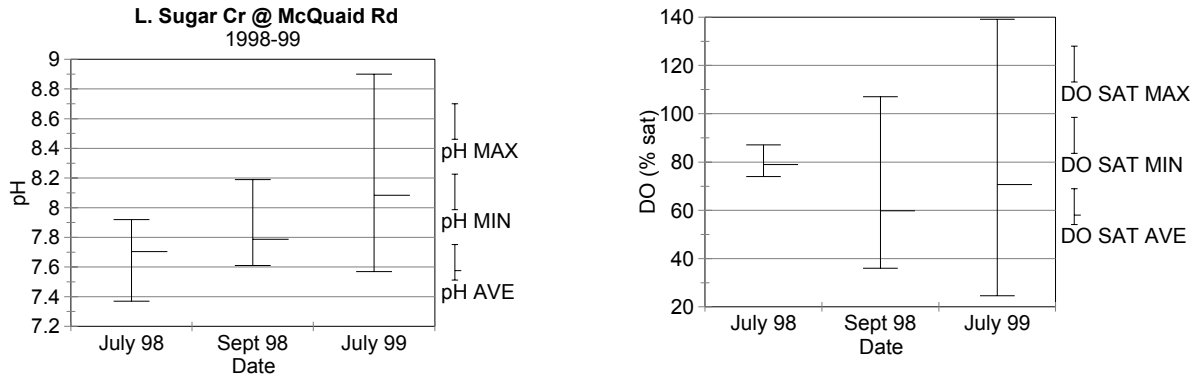


Plate 2. Photographs of tributary to Little Sugar Ck near McQuaid Road The panoramic view shows lack of riparian vegetation, eroded banks and free access of livestock to creek.

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

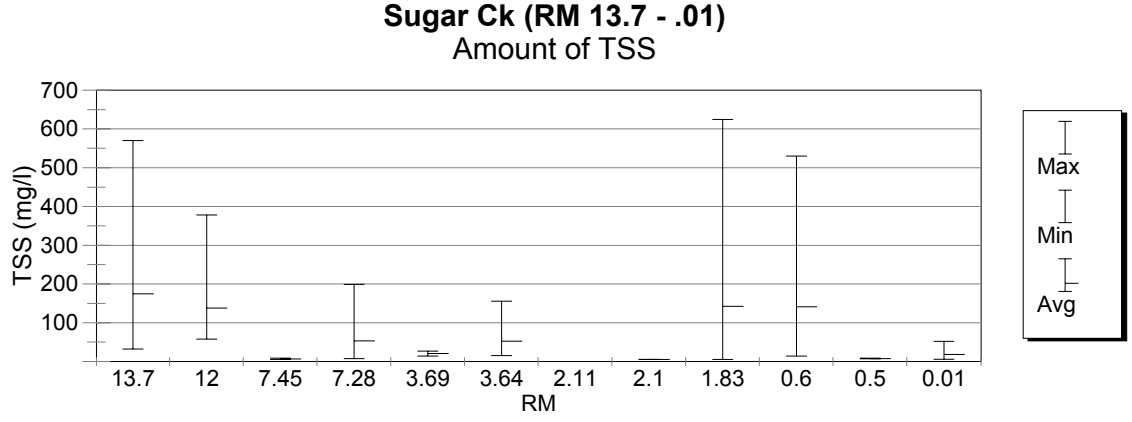
2.3.4 Sugar Ck: South Fork to Tuscarawas River (RM 12.3 to RM 0.0)

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.

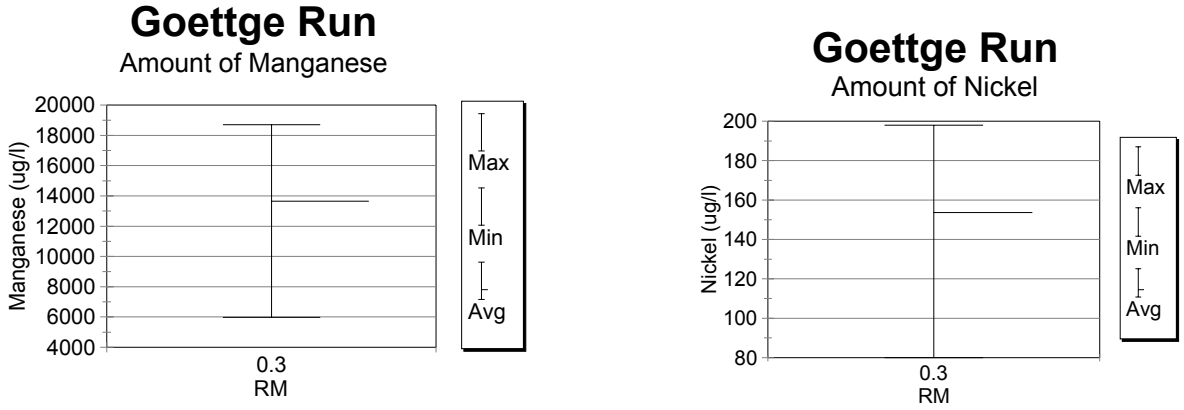
Figure 9. Range of Total Suspended Solids Measured in Sugar Creek Downstream of the Beach City Dam (1998-99)



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.

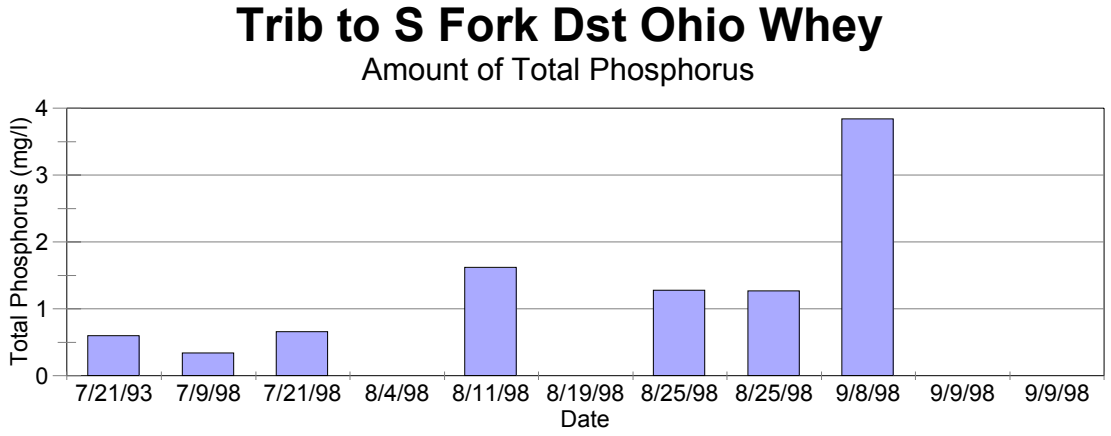


Table 8. Causes and Sources of Impairment in the Sugar Creek Basin

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; underlined: were identified both in 303(d) list and 1998 survey; in *italics*: identified in 303(d) only