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≥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 substrate variable includes an assessment of sediment quality and quantity, thus providing a numeric target for sedimentation. The riparian characteristics 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.

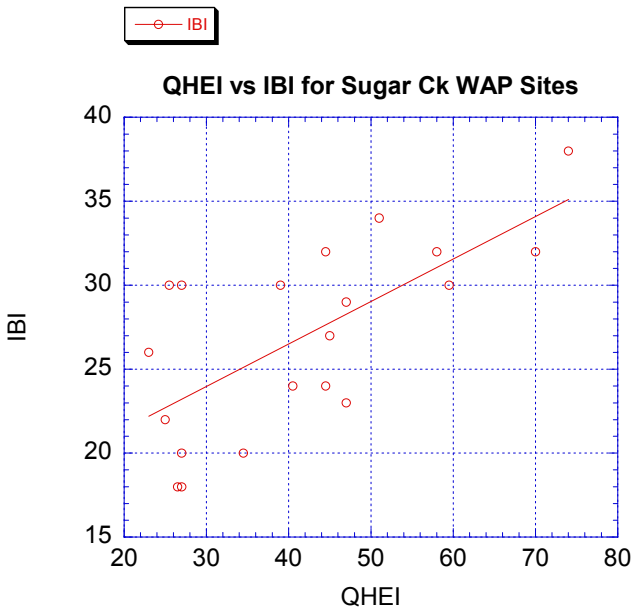


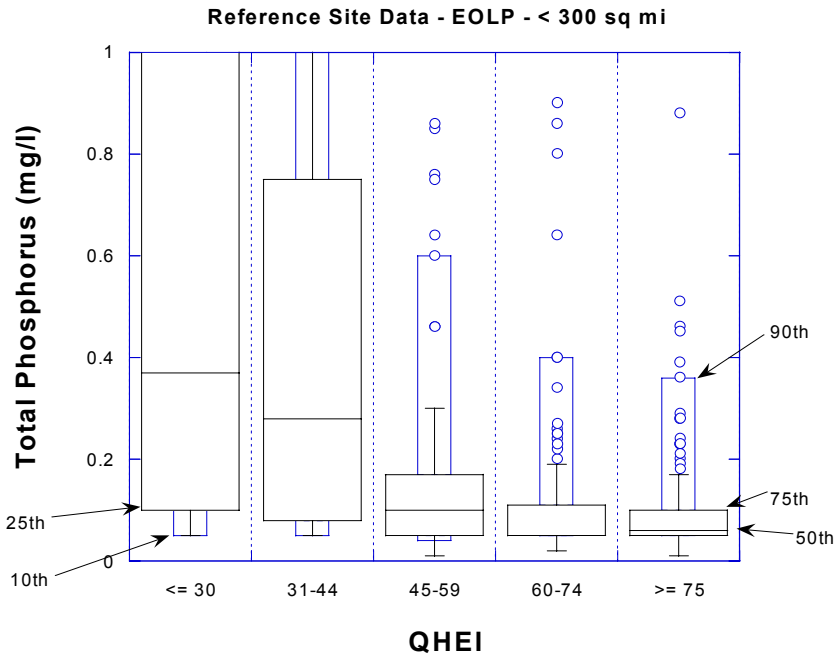
Figure 12. QHEI vs IBI indices for Sugar Creek sites in the WAP ecoregion

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



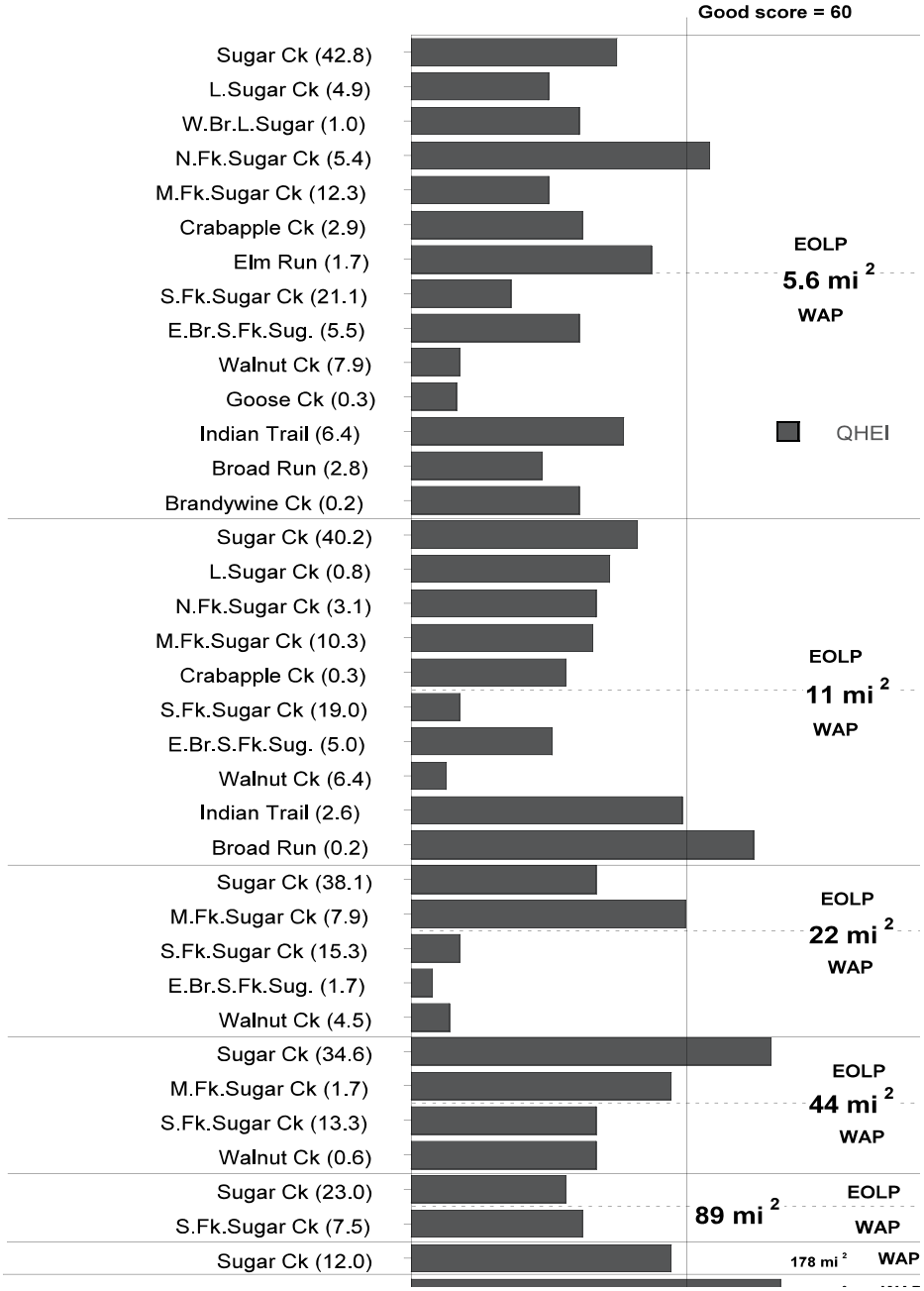


Figure 14. QHEI (Habitat) Scores for Sugar Creek and tributaries (1998) The sites are grouped by ecoregion and size of drainage area.

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
Listed waterbodies						
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%
Unlisted waterbodies						
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.