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2008 Biological and Water Quality Study of the Ohio Tributaries to the Shenango River

Including Pymatuning Creek, Yankee Creek, and Little Yankee Creek

Ashtabula, Trumbull, and Mahoning Counties

John R. Kasich, Governor
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Biological and Water Quality Study of the Ohio Tributaries to the Shenango River

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Watersheds 05030302 01, 03, and 06

Ashtabula, Trumbull, and Mahoning Counties, Ohio

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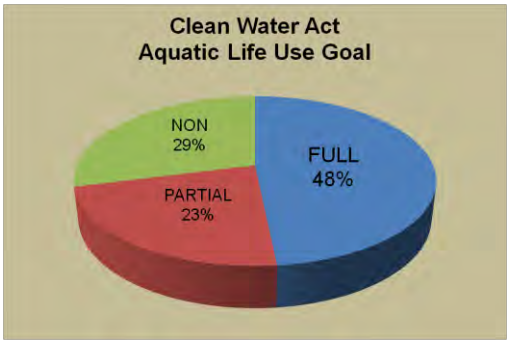
SUMMARY



Rivers and streams in Ohio support a variety of uses such as recreation and water supply, as well as the support of aquatic life. Ohio EPA evaluates each stream to determine the appropriate use designation and to also determine if the use is meeting the goals of the federal Clean Water Act. Twelve streams in the Ohio Tributaries to the Shenango River watershed, located in southern Ashtabula, Trumbull, and northern Mahoning counties, were evaluated for aquatic life and recreation use potential in 2008 (see Table 3 for sampling locations). The Ohio Tributaries to the Shenango River watershed is comprised of four distinct sub-watersheds, all of which drain into the Shenango River in Pennsylvania. These sub-watersheds include the direct Pymatuning Reservoir tributaries, Pymatuning Creek, Yankee Creek and Little Yankee Creek.

Watershed-wide, biological communities were sampled and assessed at 31 sites (Table 1, Figure 1). Of these, 15 sites (48%) were meeting the designated or recommended aquatic life use, seven (23%) were in partial attainment, and nine (29%) were in non-attainment. Biological performance and mechanisms for impairment were geographically variable. In the northern watershed, only 38% of the sites assessed in the Pymatuning Reservoir tributaries and Pymatuning Creek sub-watersheds were fully meeting the prescribed Warmwater Habitat (WWH) biocriteria. In the southern basin, 60% of the sites assessed in the Yankee and Little Yankee Creek watersheds were fully meeting the prescribed biological criteria.

By and large, the predominating factor affecting biological performance basin-wide was macrohabitat quality. Most of the streams in the northern basin contained naturally limiting habitat features that preclude the support of functional WWH communities. Among these features are a lack of coarse substrate material and the absence of mixed current speeds. The low gradients that typify these streams do not provide the energy needed to form and maintain complex channel features, and therefore are simple and “swamp-like” in nature. Pymatuning Creek itself is a virtual poster child of these phenomena, as all but two sites sampled on the mainstem failed to fully meet WWH criteria due to these natural habitat deficiencies. Similar results were garnered for Pymatuning Creek during the last survey in 1994. No collections of the clubshell mussel (*Pleurobema clava*) were made during the 2008 survey. This federally endangered mussel was previously collected in the headwater region of Pymatuning Creek during an independent study in 1994.

Conversely, superior habitat quality was abundant in both the Yankee and Little Yankee Creek watersheds. Due to the urban/suburban nature of these watersheds, sites with underperforming biological communities tended to be affected by anthropogenic disturbances rather than natural sources. Lowhead dam impoundments and urban runoff affected three of the six impaired sites encountered in these sub-watersheds. Underscoring the higher quality of Yankee and Little Yankee Creeks was the collection of coldwater macroinvertebrate assemblages at Yankee Creek RM 6.5, Little Yankee Creek RM 9.56, Mud Run RM 2.1 and Little Deer Creek RM 0.4. *Psilotreta indecisa*, a cold water-adapted and state-threatened caddisfly, was collected at Yankee Creek RM 6.5 and represents the only species of interest collected among both the fish and macroinvertebrates in the entire survey.

While biological water quality was variable in the Ohio Tributaries to the Shenango River study area, recreational water quality, as measured by elevated *E. coli* bacteria levels, was consistently poor among all four sub-watersheds. Of the 32 sites that were sampled for bacteria, 28 (87%) were found to be exceeding the Primary Contact Recreation (PCR) use criteria (Table 5). Failing home sewage treatment systems and agricultural activities are likely sources of bacteria in the rural, less developed areas of the watershed. Most of the bacteria exceedences in the study area are attributable to these two sources. However, streams within the major population centers of Andover, Hubbard and Brookfield likely receive excessive bacteria loads from either poorly treated sanitary waste from NPDES regulated facilities, contaminated urban runoff, or both.

Table 1. Aquatic life use attainment status for stations sampled in the Ohio Tributaries to the Shenango River, PA basin based on data collected July-October 2008. The Index of Biotic Integrity (IBI), Modified Index of well being (MIwb), and Invertebrate Community Index (ICI) are scores based on the performance of the biotic community. The Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat to support a biotic community. All sampled streams lie within the Erie-Ontario Lake Plain (EOLP) ecoregion and are all currently assigned the Warmwater Habitat (WWH) aquatic life use, except as indicated.

Location	Sample RM^	Drain. (mi²)	IBI	MIwb[a]	ICI[b]	QHEI[c]	Attainment Status[d]	Causes	Sources
HUC 0503010201: Pymatuning Reservoir Tributaries									
Gravel Run @ Pymatuning Lake Road	1.27[H]	5.3	38[ns]	NA	F*	65.0	**PARTIAL**	Wetland habitat	Natural
Wade Creek @ US 6; ust Andover WWTP	2.80	2.8	--	--	LF*	--	n/a	Low quality benthic community due to siltation related to local riparian removal and urban runoff.	
Wade Creek @ US 6; dst Andover WWTP	1.82[H]	3.1	28*	NA	LF*	69.0	**NON**	Wetland habitat Nutrient/organic enrichment	Natural Municipal wastewater discharge
Black Creek @ Pymatuning Lake Road	1.43[H]	5.2	28*	NA	F*	70.5	**NON**	Wetland habitat	Natural
McMichael Creek @ Pymatuning Lake Road	1.26[H]	6.3	38[ns]	NA	G	70.5	FULL		
HUC 0503010203: Pymatuning Creek Watershed									
Pymatuning Creek @ US 6	30.38[H]	11.8	34*	NA	F*	55.0	**NON**	Wetland habitat	Natural
Pymatuning Creek @ Dodgeville Road	29.10[H]	15.9	38[ns]	NA	MG[ns]	65.5	FULL		
Pymatuning Creek @ US 322	24.50[W]	35.0	37[ns]	7.2*	52	46.0	**PARTIAL**	Wetland habitat	Natural
Pymatuning Creek @ Underwood Road	22.70[W]	43.0	36[ns]	7.6[ns]	G	46.0	FULL		
Pymatuning Creek @ State Route 87	17.78[B]	66.0	--	--	4*	--	**(NON)**	Low dissolved oxygen Wetland habitat	Natural
Pymatuning Creek @ State Route 7; dst storm sewer #2	15.80[B]	96.0	27*	6.4*	18*	61.0	**NON**	Low dissolved oxygen Wetland habitat	Natural
Pymatuning Creek @ State Route 88	8.40[B]	135.0	34*	8.1*	34	64.0	**PARTIAL**	Low dissolved oxygen Wetland habitat	Natural
Pymatuning Creek @ PA state line at Orangeville	1.94[B]	148.0	31*	8.1*	24*	60.5	**NON**	Low dissolved oxygen Wetland habitat Flow alterations	Natural Dam/Impoundment
Sugar Creek @ State Route 88	5.72[H]	9.0	24*	NA	LF*	54.0	**NON**	Organic enrichment Sedimentation/siltation Low dissolved oxygen	Livestock Channelization
Sugar Creek @ Burnett Road	0.92[H]	19.9	44	NA	46	77.0	FULL		
Stratton Creek @ Webber Road	4.21[H]	9.1	44	NA	E	61.5	FULL		
Stratton Creek @ Kinsman-Nickerson Road	0.70[H]	17.1	52	NA	VG	68.5	FULL		
HUC 0503010206: Yankee Creek/Little Yankee Creek Watersheds									
Yankee Creek @ State Route 305	11.34[H]	14.8	34*	NA	LF*	44.5	**NON**	Low dissolved oxygen Wetland habitat	Natural

Location	Sample RM^	Drain. (mi²)	IBI	MIwb[a]	ICI[b]	QHEI[c]	Attainment Status[d]	Causes	Sources
Yankee Creek @ County Road 361A	6.50[W]	33.0	48	8.6	VG	76.5	FULL		
Yankee Creek @ Addison Road; ust Brookfield WWTP	1.23[W]	44.0	41	8.9	40	75.0	FULL		
Yankee Creek @ US 62; dst Brookfield WWTP	0.30[B]	45.7	39[ns]	8.6 [ns]	14*	64.0	**PARTIAL**	Flow alterations	Dam/Impoundment (on Shenango R. dst. confluence)
South Branch Yankee Creek @ Warner Road	1.54[H]	9.0	46	NA	F*	87.0	**PARTIAL**	Unknown	Unknown
Little Yankee Creek @ Albright-McKay Road	10.99[H]	8.0	38[ns]	NA	G	75.0	FULL		
Little Yankee Creek @ Stewart-Sharon Road	9.56[H]	11.0	31*	NA	48	66.0	**PARTIAL**	Impairment unknown	Source unknown
Little Yankee Creek @ Chestnut Ridge Road	7.95[H]	15.6	40	NA	MG[ns]	76.0	FULL		
Little Yankee Creek @ Valley Mould Dam Pool	5.00[W]	29.8	--	--	14*	--	**(NON)**	Low dissolved oxygen Sedimentation/siltation	Dam/impoundment
Little Yankee Creek @ Mill Street; ust Hubbard WWTP	4.70[W]	30.8	40	8.6	32 [ns]	79.0	FULL		
Little Yankee Creek dst Hubbard WWTP	4.40[W]	30.9	37[ns]	8.6	34	75.5	FULL		
Little Yankee Creek @ Chestnut Ridge Road	1.58[W]	41.2	44	8.1	42	74.5	FULL		
Mud Run ust Hubbard @ Harding Park	2.1	2.6	--	--	MG[ns]	--	n/a		
Mud Run @ North Main Street	0.2[H]	5.2	40	NA	LF*	57.0	**PARTIAL**	Sedimentation/siltation	Urban runoff
Mud Run @ North Main Street near mouth	0.07[H]	8.1	38[ns]	NA	--	35.5	(FULL)		
Little Deer Creek @ State Route 304	0.40[H]	7.6	40	NA	50	67.5	FULL	Comment: Recommended CWH aquatic life use	

^ - [H]= Headwater; [W]= Wading
a- MIwb is not applicable to headwater streams with drainage areas ≤ 20 mi^2.
b- A narrative evaluation of the qualitative sample based on attributes such as EPT taxa richness, number of sensitive taxa, and community composition was used when quantitative data was not available or considered unreliable. VP=Very Poor, P=Poor, LF=Low Fair, F=Fair, MG=Marginally Good, G=Good, VG=Very Good, E=Exceptional
c - Narrative habitat evaluations are based on QHEI scores for wading sites (Excellent ≥75, Good: 60-74, Fair: 45-59, Poor: 30-44, Very Poor <30) and headwater sites (Excellent ≥70, Good: 55-69, Fair: 43-54, Poor: 30-42, Very Poor <30).
d- Attainment is given for the proposed status when a change is recommended.
ns- Nonsignificant departure from biocriteria (≤4 IBI or ICI units, or ≤0.5 MIwb units).
*- Indicates significant departure from applicable biocriteria (>4 IBI or ICI units, or >0.5 MIwb units). Underlined scores are in the Poor or Very Poor range.

BIOCRITERIA – EOLP ECOREGION		
INDEX - Site Type	WWH	EWH
IBI: Headwater/Wading	40/38	50/50
MIwb: Wading	7.9	9.4
ICI	34	46

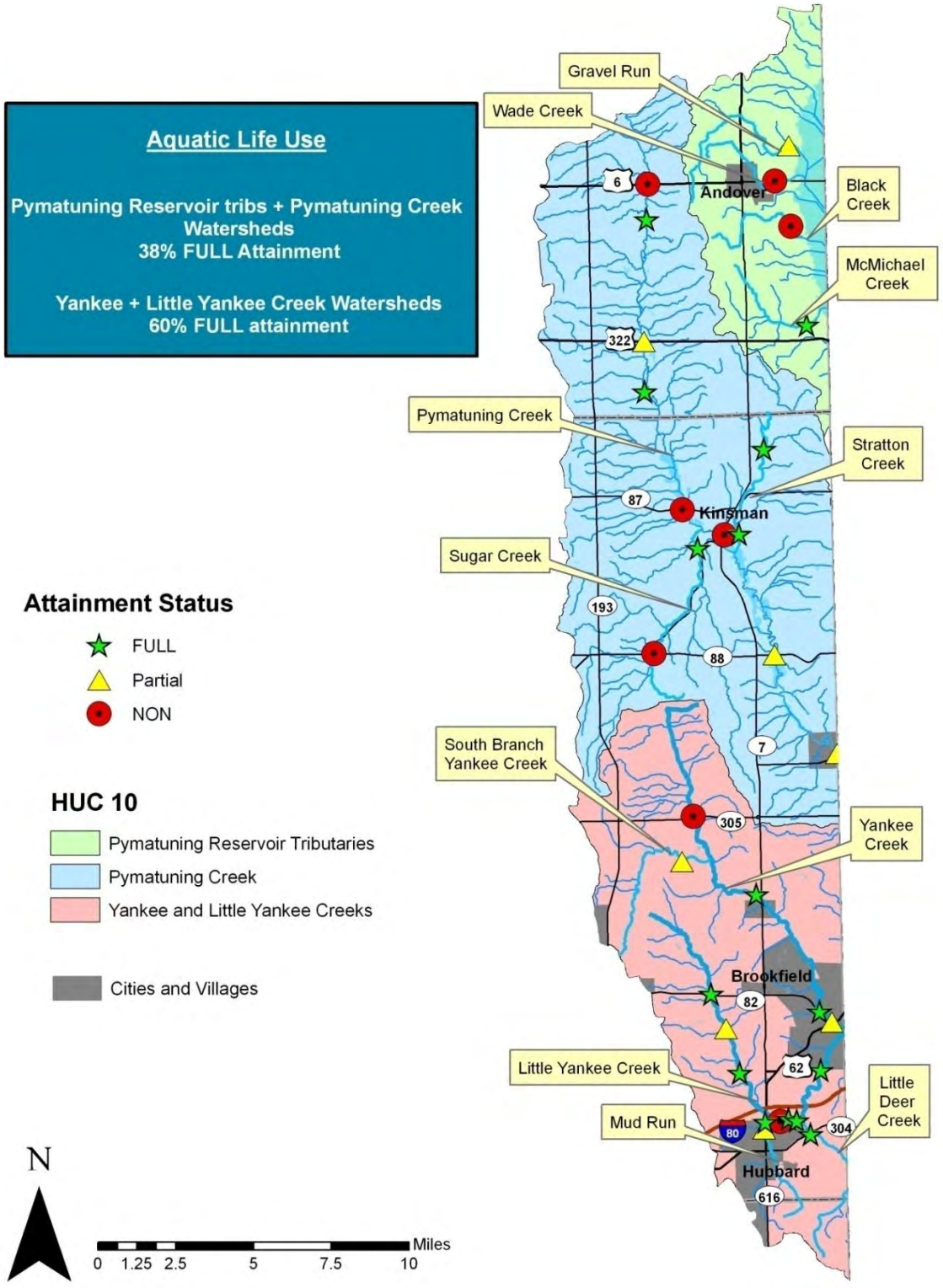


Figure 1. Map of the Ohio Tributaries to the Shenango River study area, showing sampling locations and biological attainment status.

RECOMMENDATIONS

The streams in the Ohio Tributaries to the Shenango River study area currently listed in the Ohio Water Quality Standards (WQS) are assigned the Warmwater Habitat (WWH) aquatic life use. Wade Creek and Mud Run are not listed in the Ohio Water Quality Standards. The aquatic life use designations of Pymatuning, Sugar, Yankee, Little Yankee and Little Deer Creeks have been previously verified. All the other streams were originally designated for aquatic life uses in the 1978 Ohio WQS. The techniques used then did not include standardized approaches to the collection of instream biological data or numerical biological criteria. This study used biological data to evaluate and establish aquatic life uses for a number of streams in the Ohio Tributaries to the Shenango River study area.

Twelve streams in the Ohio Tributaries to the Shenango River study area were evaluated for aquatic life and recreation use potential in 2008 (Table 2). Significant findings include the following.

- Three streams have an existing, verified WWH aquatic life use that should be maintained. Biological monitoring conducted on Sugar, Yankee, and Little Yankee Creeks confirmed the appropriateness of the WWH aquatic life use.

- Pymatuning Creek is currently assigned the WWH aquatic life use. In spite of its failure to consistently achieve WWH biocriteria due to natural limitations, the WWH aquatic life use is currently the most appropriate aquatic life use for this stream and therefore should be retained.

- Five streams are currently listed in the Ohio WQS that have an unverified WWH aquatic life use. Biological sampling conducted on Gravel Run and Black, McMichael, Stratton, and South Branch Yankee Creeks verified that the WWH aquatic life use designation is appropriate for all of these streams.

- Two streams – Wade Creek and Mud Run - that are not listed in the Ohio WQS were included as part of the 2008 sampling effort. Biological monitoring indicated that the WWH aquatic life use is appropriate and is appropriate and should be recommended for Wade Creek and the lower segment of Mud Run from RM 1.12 to its confluence with Little Yankee Creek.

- Biological sampling indicated the presence of four coldwater macroinvertebrate taxa at Little Deer Creek RM 0.4 and five coldwater macroinvertebrate taxa at Mud Run RM 2.1. Based upon the presence of these taxa, all of Little Deer Creek and Mud Run from its headwaters to RM 1.12 are recommended for the Coldwater Habitat (CWH) aquatic life use.

Pymatuning Creek should be assigned the Primary Contact Recreation Class A use from RM 15.88 (State Route 7) to the Pennsylvania border (RM 1.94). All remaining streams or stream segments in this study should retain or be assigned the Primary Contact Recreation Class B use. All 12 streams should retain or be assigned the Agricultural Water Supply and Industrial Water Supply uses.

Wade Creek exhibited impacts associated with the surrounding urban landscape – primarily sedimentation and siltation due to runoff and nutrient enrichment related to the Andover WWTP effluent discharge. Very little riparian canopy was observed along Wade Creek. Restoration of a full riparian corridor to this stream would help to control the amount of runoff received by Wade Creek, and may also serve to improve nutrient assimilation. Compliance issues at the Andover WWTP should also be addressed in order to reduce nutrient loadings to Wade Creek.

Although QHEI scores suggest that Pymatuning Creek should be capable of supporting biological communities that are commensurate with the WWH aquatic life use, biological indices have failed to consistently meet the associated criteria during both the 1994 and 2008 surveys. The atypical channel and substrate deficiencies associated with low gradient wetland streams like Pymatuning Creek preclude the attainment of WWH criteria. When the various biometrics employed by Ohio EPA were initially derived, they were calibrated to the “typical” conditions found throughout Ohio’s five ecoregions. As a result, Pymatuning Creek and other similar wetland streams in Ohio rarely meet WWH standards due to their intrinsic natural limitations. Therefore, it would be beneficial to develop properly calibrated biological criteria that account for

the unique features and limits of low gradient, wetland streams in Ohio. The ability to characterize true biological impairment would assist with implementing pollution abatement strategies in Pymatuning Creek and other similar wetland streams.

The headwaters of Sugar Creek are affected by low dissolved oxygen, sedimentation/siltation, and organic enrichment due to channelization and livestock pasturage. Restoring the stream channel to a natural, sinuous state and the exclusion of livestock from the stream should significantly improve resource quality.

The cause(s) and source(s) of impairment to South Branch Yankee Creek could not be ascertained in 2008. However, the macroinvertebrate community collected from the natural substrates at RM 1.54 indicted an effect of nutrient enrichment. A Datasonde© placed at this location in 2009 recorded wide diurnal dissolved oxygen swings, which also indicates nutrient enrichment as a cause of impairment. Several wastewater package plants are located in this subwatershed, as well as home sewage treatment systems. It is recommended that a further investigation be conducted to determine if any of these sources are responsible for the impairment to this stream.

An old industrial dam on Little Yankee Creek RM 4.96 impounds at least a mile of the stream within the city of Hubbard, resulting in non-attainment of biological criteria in the affected reach. Since the dam currently serves no purpose to local industry, it is recommended that a feasibility study regarding its removal be initiated. Removal of the dam would restore Little Yankee Creek to a natural, free-flowing state and thus greatly improve resource quality.

Dam on Little Yankee Creek, RM 4.96

Sedimentation/siltation due to a combination of urban runoff and backwater from the dam on Little Yankee Creek has resulted in biological impairment to the benthos of lower Mud Run. Removal of the dam on Little Yankee Creek would provide relief to the lower reach of Mud Run. Additional storm water controls should be initiated within the city of Hubbard to control both the rate and amount of runoff received by Mud Run.

The Ohio Tributaries to the Shenango River watershed also experienced high bacteria loads that resulted in widespread non-attainment of recreation use criteria, due mostly to the effects of failing home sewage treatment systems, agricultural runoff, and untreated/poorly treated wastewater from both municipal and package wastewater treatment plants (WWTPs). In order to reduce bacteria loadings in the watershed, it is recommended that:

- Failing home sewage treatment systems be identified and repaired or replaced where needed;
- Manure-laden agricultural runoff be controlled via best management practices; and
- WWTPs reduce treatment bypasses and improve permit compliance.

Table 2. Beneficial use designations for the Ohio Tributaries to the Shenango River study area.

Water Body Segment	Use Designations													Comments
		Aquatic Life Habitat						Water Supply			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
Little Yankee creek		+							+	+		+		
Little Deer creek						▲			+	+		+		
Mud Run – headwaters to East liberty Street (RM 1.12)						▲			▲	▲		▲		
- East Liberty Street (RM 1.12) to the mouth		▲							▲	▲		▲		
Yankee creek		+							+	+		+		
South branch		*/+							*/+	*/+		*/+		
Pymatuning creek		+							+	+		+		
Mill creek		*							*	*		*		
Stratton creek		*/+							*/+	*/+		*/+		
Maple creek		*							*	*		*		
Sugar creek		+							+	+		+		
Berry creek		*							*	*		*		
Clear creek		*							*	*		*		
McMichael creek		*/+							*/+	*/+		*/+		
Black creek		*/+							*/+	*/+		*/+		
Wade Creek		▲							▲	▲		▲		
Gravel run		*/+							*/+	*/+		*/+		

SRW=State Resource Water; WWH=Warmwater Habitat; EWH=Exceptional Warmwater Habitat; MWH=Modified Warmwater Habitat; SSH=Seasonal Salmonid Habitat; CWH=Coldwater Habitat; LRW=Limited Resource Water; PWS=Public Water Supply; AWS=Agricultural water Supply; IWS=Industrial Water Supply; BW=Bathing Waters; PCR=Primary Contact Recreation; SCR=Secondary Contact Recreation

INTRODUCTION

During 2008, Ohio EPA conducted a water resource assessment of 12 streams in the Ohio Tributaries to the Shenango River (PA) watershed. This study included direct and indirect tributaries to the Shenango River that are completely or mostly contained within Ohio in Ashtabula, Trumbull, and northern Mahoning counties. The boundaries of the study area were delineated through the use of USGS's hydrologic system, and thus correspond to the following three 10-digit Hydrologic Unit Codes (HUCs):

- 0503010201 – Pymatuning Reservoir Tributaries
- 0503010203 – Pymatuning Creek
- 0503010206 – Yankee Creek and Little Yankee Creek

Ohio Tributaries to the Shenango River study area.

HUC 0503010201 is comprised of several small streams that drain into the impounded portion of the Shenango River known as the Pymatuning Reservoir. The streams that were sampled included Black Creek, Gravel Run, McMichael Creek, and Wade Creek. HUC 0503010203 is the Pymatuning Creek watershed. Pymatuning Creek from its headwaters to the Ohio/Pennsylvania state line was sampled, along with its tributaries Sugar Creek and Stratton Creek. HUC 0503010206 includes the Yankee Creek and Little Yankee Creek subwatersheds. In the Yankee Creek watershed, Yankee Creek and South Branch Yankee Creek were sampled, while Little Yankee Creek, Mud Run and Little Deer Creek were sampled in the Little Yankee Creek watershed.

Biological, chemical, and bacteriological data were collected at 36 total sampling locations throughout the study area (Table 3). Five of the sampling stations were located in HUC 0503010201, 14 were located in HUC 0503010203, and the remaining 17 were located in HUC 0503010206. Three major National Pollutant Discharge Elimination System (NPDES) permitted facilities discharge sanitary wastewater into the watershed. Effluent samples were collected from all three facilities, including the Andover Wastewater Treatment Plant (WWTP), the Brookfield WWTP, and the Hubbard WWTP. All of the biological, chemical, and bacteriological results can be downloaded from the Ohio EPA GIS interactive maps via the following link: http://www.epa.ohio.gov/dsw/gis/index.aspx .

Specific objectives of the evaluation were to:

- Establish the present biological conditions in the Ohio Tributaries to the Shenango River watershed by evaluating fish and macroinvertebrate communities;
- Identify the relative levels of organic, inorganic, and nutrient parameters in the sediments and surface water;
- Evaluate influences from NPDES discharges;
- Assess physical habitat influences on stream biotic integrity;
- Determine recreation water quality;
- Compare present results with historical conditions, and
- Determine beneficial use attainment status and recommend changes if appropriate.

The Ohio Tributaries to the Shenango River watershed is located in the Erie-Ontario Lake Plain (EOLP) ecoregion. All streams in the study area except for Mud Run and Wade Creek are designated Warmwater Habitat (WWH), Primary Contact Recreation (PCR), Agricultural Water Supply (AWS) and Industrial Water Suppy (IWS) in the Ohio Water Quality Standards (WQS). Mud Run and Wade Creek do not have beneficial uses assigned to them. The data collected in this study will be used to assign appropriate beneficial uses to these streams.

The findings of this evaluation may factor into regulatory actions taken by the Ohio EPA (e.g. NPDES permits, Director's Orders, or the Ohio Water Quality Standards (OAC 3745-1), and may eventually be incorporated into State Water Quality Management Plans, the Ohio Nonpoint Source Assessment, Total Maximum Daily Loads (TMDLs) and the biennial Integrated Water Quality Monitoring and Assessment Report (305[b] and 303[d] report).

Table 3. Sampling locations in the Ohio Tributaries to the Shenango River study area.

Stream	River Mile	Drain. Area[a]	Location	Sampling Type[b]	Latitude	Longitude
Black Creek	1.43	5.2	Pymatuning Lake Rd.	C,B,F,M	41.5861	-80.5417
Gravel Run	1.27	5.3	Pymatuning Lake Rd.	C,B,F,M	41.6235	-80.5419
McMichael Creek	1.26	6.3	Pymatuning Lake Rd.	C,B,F,M	41.5402	-80.5333
Wade Creek	2.74	2.8	U.S. Rt. 6	C,B,M	41.6078	-80.5622
Wade Creek	2.73	3.0	Andover WWTP Effluent	C,B	41.3030	-80.5567
Wade Creek	1.82	3.1	U.S. Rt. 6	C,B,F,M,D	41.6072	-80.5509
Pymatuning Creek	30.38	11.8	U.S. Rt. 6	C,B.F,M,D,T	41.6069	-80.6297
Pymatuning Creek	29.10	15.9	Dodgeville Rd.	C,B,F,M	41.5908	-80.6308
Pymatuning Creek	24.50	35.0	U.S. Rt. 322	C,B,F,M	41.5339	-80.6342
Pymatuning Creek	22.70	43.0	Underwood Rd.	C,B,F,M,D	41.5106	-80.6344
Pymatuning Creek	17.78	66.0	St. Rt. 87	C,B,F,M,D	41.4553	-80.6125
Pymatuning Creek	15.80	96.0	Dst Storm Sewer #2/SR 7	C,B.F,M,D,T	41.4431	-80.5869
Pymatuning Creek	15.70	96.0	Dst Septic outfalls/SR 7	C,B	41.4430	-80.5853
Pymatuning Creek	15.20	96.0	Dst. Kinsman, Adj. SR 7	C,B,D	41.4384	-80.5884
Pymatuning Creek	8.40*	135.0	St. Rt. 88	C,B.F,M,D,T	41.3869	-80.5575
Pymatuning Creek	1.94	148.0	PA state line at Orangeville	C,B.F,M,D,T	41.3400	-80.5194
Sugar Creek	5.72	9.0	St. Rt. 88	C,B,F,M	41.3886	-80.6318
Sugar Creek	0.92	19.9	Burnett Rd.	C,B,F,M	41.4375	-80.6036
Stratton Creek	4.21	9.1	Webber Rd.	C,B,F,M	41.4828	-80.5613
Stratton Creek	0.70	17.1	Kinsman-Nickerson Rd.	C,B,F,M	41.4436	-80.5779
Yankee Creek	11.34	14.8	SR 305, W of Hartford	C,B,F,M	41.3125	-80.6097
Yankee Creek	6.50	33.0	Co. Rd. 361A	C,B,F,M	41.2758	-80.5719
Yankee Creek	1.23	44.0	Ust Brookfield WWTP @ CR 1017	C,B,F,M,D	41.2206	-80.5344
Yankee Creek	0.42	45.5	Brookfield WWTP Effluent	C,B	41.2155	-80.5270
Yankee Creek	0.3	45.7	Dst. Brookfield WWTP/US 62	C,B,F,M,D	41.2142	-80.5250
South Branch Yankee Creek	1.54	9.0	Warner Rd.	C,B,F,M	41.2916	-80.6173
Little Yankee Creek	10.99	8.0	Albright-McKay Rd.	C,B,F,M	41.2300	-80.6010
Little Yankee Creek	9.56	11.0	Stewart Sharon Rd.	C,B,F,M	41.2136	-80.5922
Little Yankee Creek	7.95	15.6	Chestnut Ridge Rd.	C,B,F,M	41.1929	-80.5844
Little Yankee Creek	5.0	29.8	Access via 4-wheeler path by RR tracks	C,B,O,S,M	41.1699	-80.5602
Little Yankee Creek	4.70	30.8	Ust Hubbard WWTP @ Mill St.	C,B,F,M,D	41.1711	-80.5550
Little Yankee Creek	4.59	30.9	Hubbard WWTP Effluent	C,B	41.1705	-80.5534
Little Yankee Creek	4.4	30.9	Dst. Hubbard WWTP @ 1st RR Bridge	C,B,F,M	41.1703	-80.5500
Little Yankee Creek	1.58	41.2	Chestnut Ridge Road	C,B,F,M,D	41.1934	-80.5344
Mud Run	2.1	2.6	Harding Park, ust Hubbard	M	41.1448	-80.5611
Mud Run	0.2*	8.1	North Main St., ust trib	F,M	41.1694	-80.5698
Mud Run	0.07	8.1	North Main St.	C,B,F	41.1697	-80.5692
Little Deer Creek	0.40	7.6	St. Rt. 304	C,B,F,M	41.1636	-80.5417

a - Drainage area , mi^2
b - C=Chemistry, B=Bacteria, F=Fish, M=Macroinvertebrates, D=Datasonde©, T=Fish Tissue
* - River mile listed is the point of record. Alternative location points exist for this station, but are considered representative of the point of record.
Green=HUC 0503010201 Blue=HUC 0503010203 Pink=HUC 0503010206

STUDY AREA DESCRIPTION

Although all of the Shenango River tributaries evaluated as part of this survey are contained wholly within the Erie-Ontario Lake Plain (EOLP) ecoregion, a glaciated portion of the Allegheny Plateau (Omernik and Gallant 1988), each of the principal river systems arises in, drains, and course through contrasting landforms. Influences of local and subregional topography are multifaceted and effectively establish basic elements of, or limits to, channel form and function, substrate composition, and hydrology. Of equal importance and also directly related to topography is the degree to which the landscape is or has been manipulated to suit various human uses. In modern times, the most pervasive and influential anthropogenic modifications are attendant to efforts to improve drainage, which directly affects stream power, channel form, and hydrology. These natural and artificial features in turn can have a direct effect upon the diversity, composition, and functional organization of associated fish and aquatic benthic macroinvertebrate communities.

Pymatuning Creek arises in southeast Ashtabula County and flows south for a total of 33.8 miles through northeastern Trumbull County before crossing the state line into Pennsylvania, where it joins the Shenango River. For most of its length it courses through a well established ancient pre-glacial valley that likely drained north prior to the onset of the ice age (Shanks 1942). During the late Wisconsin epoch, the valley served as a glacial outlet, reversing stream flow southward again and thus establishing the basic form of the contemporary drainage network. The modern drainage divide between the Laurentian and Mississippian basins for the Pymatuning, as well as adjacent waters, is defined by the Cleveland end moraine, formed by the Grand River lobe of the late-Wisconsin ice sheet (Trautman 1981 and Richards et al. 1999).

Through the northern half of the watershed, the upland topography of the Pymatuning Creek basin is derived from a combination of a high relief, hummocky end moraine, interspersed with numerous kames and kame terraces ((Richards et al. 1999). Here, glacial melt water reclaimed the old pre-glacial valley and presently the stream originates within and actually courses through the eastern latitudinal margin of the Cleveland end moraine. Despite the hilly, high relief, and dissected nature of the uplands, Pymatuning Creek itself is a sluggish, low gradient, rheopalustrine (flowing swamp) stream type. This apparent contradiction (high relief uplands and swampy lowlands) is a result of the great age and maturity of its pre-glacial valley. This channel form imposes strict limitations on aquatic faunal associates, as palustrine or related low gradient riverine habitats typically offer limited habitat complexity and a naturally stressful or chemically reduced environment (e.g., lower pH, low dissolved oxygen (DO), and high background ammonia). It must be emphasized that even under pristine conditions, streams of this type in Ohio almost universally support simple fish communities in comparison to typical riverine waters.

Moving further south, the lower half of the mainstem is still contained within the wide, pre-glacial valley, but drain level to gently rolling terrain of late-Wisconsin ground moraine. Despite this, the change in upland land forms (from end moraine in the north, to ground moraine further south) the Pymatuning still retains its low gradient, rheopalustrine channel form, hydrology and associated natural limitations. In general, the naturally poor drainage of the basin, but particularly in the lower reach through Trumbull County, necessitated much artificial surface and subsurface drainage to facilitate and support agricultural and other more intensive human land use (USDA 1986 and 2003; Office of Trumbull Co. Engineer pers. com.).

Waters that comprise the Yankee and Little Creek basins arise in and drain the southeastern quadrant of Trumbull County. Yankee Creek flows for 14.8 miles, and Little Yankee Creek for 13.2 miles, both in a general south to southeasterly direction, where they nearly converge to debouche to the Shenango River. Generally, the channel and associated habitat features of the Yankee and Little Yankee Creek basins are vastly different in comparison to those of the Pymatuning. Like the Pymatuning, Yankee and Little Yankee creeks drain and largely parallel late Wisconsin-aged end moraine and associated glacial features. However, unlike the Pymatuning, the relief of the uplands, in many ways, is directly communicated to the valleys, resulting in channel form and function more typical of the ecoregion. Specifically, streams or stream segments of both Yankee and Little Yankee creeks are younger in form, showing considerably higher gradient and all associated riverine features that stem from greater stream power: elaborate channel development and diverse and well-sorted coarse substrates. As a result,

ambient biological potential of these waters, in the absence of significant anthropogenic stress, is typically much greater than that observed on the Pymatuning mainstem.

The suite of tributaries to the Pymatuning Reservoir (impounded Shenango River headwaters) drain a landscape similar in composition to that observed farther south in Yankee and Little Yankee basins, namely, a mix of Wisconsin-aged ground and end moraine, with localized kame features and alluvial deposits (Richards et al 1999).

In addition to glacial geology and topography, land cover also plays a significant role in water quality and biological potential. While the underlying geological features of a watershed cannot be altered, impacts to resource quality due to land uses offer opportunities for mitigation when applicable. Figure 2 displays the land use for the Ohio Tributaries to the Shenango River watershed. As evident in the figure, forest, row crop agriculture, and developed land are the predominant land uses throughout most of the watershed. The exception is the Pymatuning Creek watershed (HUC 0503010203), where both row crop agriculture and livestock pasturage combined comprise nearly half of the watershed, and developed land is sparse.

Although not densely populated, the watershed does include a few smaller population centers that are large enough to yield a significant impact on their respective watersheds. These include Andover (population 1214) in the Wade Creek watershed, Kinsman (population 3487 including surrounding townships) in the Pymatuning Creek watershed, Brookfield (population 1288) in the Yankee Creek watershed, Masury (population 2618) in the Yankee and Little Yankee Creek watersheds, and Hubbard (population 7630) in the Little Yankee Creek watershed. According to US Census Bureau data, there has been a slight population decline in the past decade, thereby reducing the notion of imminent and rampant urbanization. However, the lack of development in this watershed has also allowed for a lack of centralized sewer systems in much of the study area, thus risking exposing local waterways to the effects of septic system failures.

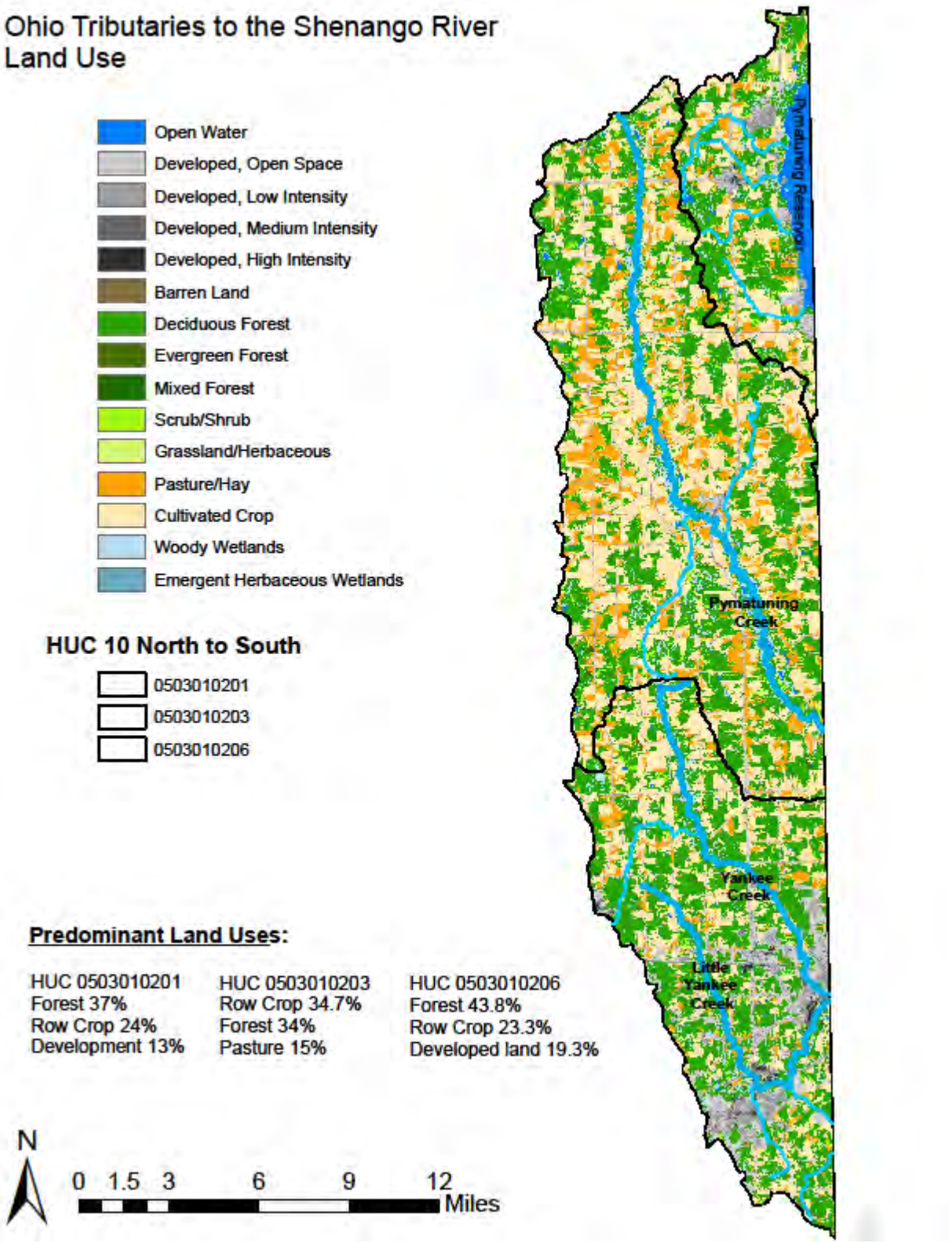


Figure 2. Land use in the Ohio Tributaries to the Shenango River watershed (NLCD, 2001)

RESULTS AND DISCUSSION

Effluent Dischargers

The following paragraphs include figures, summaries and loading information for 11 of the 29 National Pollutant Discharge Elimination System (NPDES) permitted facilities that discharge either sanitary wastewater and/or industrial process water mixed with industrial storm water into the Ohio Tributaries to the Shenango River watershed. These facilities have had significant permit compliance issues, or are major dischargers (greater than 1 million gallons per day). The receiving stream is included in *italics* (listed upstream to downstream on the Pymatuning Creek, Yankee Creek and Little Yankee Creek networks). Table 4 lists most NPDES permitted facilities in the watershed. Each facility is required to monitor their discharges according to sampling and monitoring conditions specified in their NPDES permit and submit Discharge Monitoring Reports (DMR) to Ohio EPA. Summarized effluent results are listed in Appendix Table 7.

In addition to the loadings summaries from the discharges, NPDES violations were evaluated using SWIMS (Surface Water Information Management System), when possible from 1998 through a portion of 2008. SWIMS Violations fall within three categories and are defined as follows:

- A *numeric limit* violation is a violation of a permit limit.
- A *frequency* violation is a failure to monitor the correct number of times for the month.
- A *code* violation is the use of a wrong code or an inappropriate code.

Holiday Camplands STP (Ohio EPA Permit #3PH00029)
Gravel Run RM 1.35
Holiday Camplands STP is located at 4273 North Pymatuning Lake Road, Andover Township, Ohio, and operates a wastewater treatment plant (WWTP) that is designed to treat 0.15 million gallons per day (MGD) of sanitary waste. The facility discharges to Gravel Run Creek at RM 1.35.

Violations of the NPDES permit were reviewed from 2003 to September 2007 for outfall 001. For nearly four years of data evaluated through SWIMS, 76 numeric limit violations were reported, primarily for the following parameters: chlorine, ammonia-N, phosphorus, pH, dissolved oxygen, CBOD-5, and fecal coliform bacteria. Two code violations were reported in 2000 for flow rate. Sixty-three frequency violations were reported from 1999 to 2007 for ammonia-N, total suspended solids (TSS), CBOD-5, pH, fecal coliform bacteria, dissolved oxygen, chlorine, and phosphorus. No DMR data were submitted for 2008.

Andover Village WWTP (Ohio EPA Permit # 3PB0000)
Wade Creek RM 2.73
The Village of Andover's WWTP is located at 500 Rustik Drive, Andover, Ohio. The system consists of screening, influent monitoring, wet well lift station alum addition, diversion chamber with bar screen and oil and grease removal, bubble aeration, clarification, sand filtration, chlorination, post disinfection aeration, and de-chlorination. Plant bypasses, when they occur, consist of screening, diversion to an aerated equalization basin prior to mixing with the plant effluent at the chlorine contact tank. Sludge management consists of aerobic digestion, dewatering with a belt filter press; sludge is land-applied. Decant waters from the sludge process go through a sand filter prior to being returned to the headworks of the plant. Design flow is 0.5 MGD and the facility discharges to Wade Creek at RM 2.73.

Violations of the NPDES permit were reviewed from 1999 to February 2008 for outfall 001. For just over eight years of data evaluated through SWIMS, 643 limit violations were reported, primarily for the following parameters: chlorine, TSS, mercury, ammonia-N, phosphorus, pH, dissolved oxygen, CBOD-5, and fecal coliform bacteria. Three hundred and eighteen code violations were reported from 1999 to 2008, primarily for flow rate, ammonia-N, dissolved oxygen, pH, fecal coliform bacteria, and water temperature. No reporting frequency violations were reported from 1999 to 2008. The facility reported bypasses during times of heavy rain and snow melt, which likely exceeded the design capacity of the plant. The plant has been cited for being in significant non-compliance for TSS, chlorine and manganese.

They are on a compliance schedule for improving the plant. The plant is also under construction for expansion.

Median and peak percentile flows showed significant variance over the period of record (Figure 3). Graphically, the improvements of treating waste by the facility were evident for all conventional parameters.

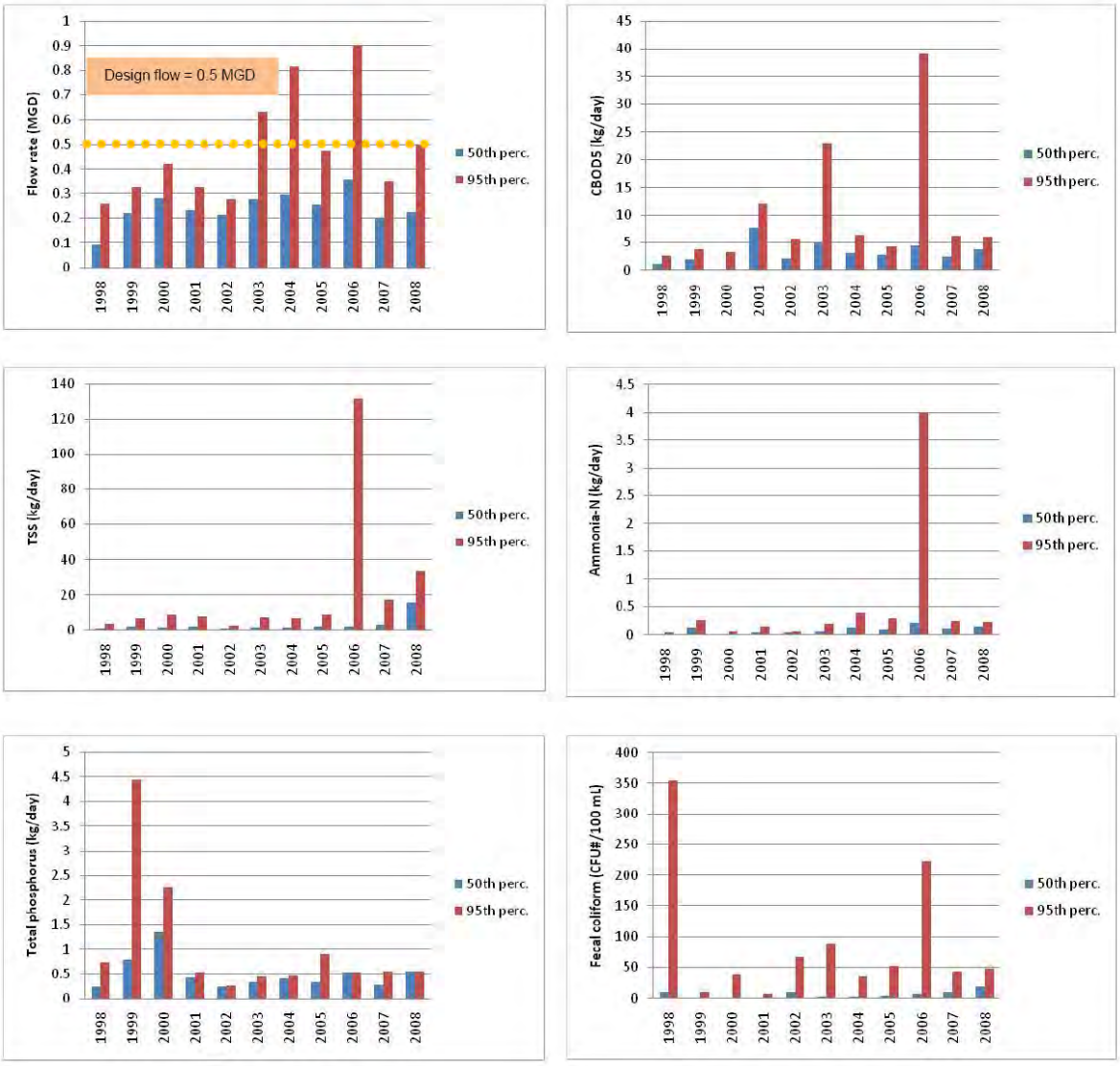


Figure 3. Annual Third-quarter loadings of conduit flow, cBOD5, Total Suspended Solids (TSS), phosphorus and ammonia-N; and concentrations of fecal coliform bacteria at the Andover WWTP in the Ohio Tributaries to the Shenango River study area, 1998-2008.

Scooters Restaurant (Ohio EPA Permit # 3PR00428)
Wade Creek RM 1.35
Scooters Restaurant is located at 6669 State Route 85, Andover Township, Ohio. The system consists of a 1,000 gallon trash trap, 200 gallon equalization tank, 5,000 gpd extended aeration system with clarifier, lift station, dosing chamber, 432 square foot surface sand filtration, chlorine disinfection, and dechlorination. Sludge management consists of sludge removal from a 1,000 gallon aerated sludge holding tank when needed to another POTW. The facility discharges to Wade Creek adjacent to the north side of the facility. No backup power is provided to the facility.

Violations of the NPDES permit were reviewed from 2006 to 2007 for outfall 001. For just under one year of data evaluated through SWIMS, 35 numeric limit violations were reported, primarily for the following parameters: chlorine, TSS, ammonia-N, and CBOD-5. No code violations were reported. Thirty-seven reporting frequency violations were reported, only in June of 2007, for odor, turbidity and flow rate. The facility did not submit DMR data for 2008.

ODNR Pymatuning Campground WWTP (Ohio EPA Permit # 3PP00013)
Unnamed tributary to the Shenango River @ RM 67.8
ODNR Pymatuning Campground is located along the east side of South Pymatuning Lake Road, Williamsfield Township, Ohio. The system consists of a trash trap, extended aeration tanks, clarifiers, surface sand filtration, chlorine disinfection, and dechlorination. The facility discharges to an unknown tributary of Pymatuning Reservoir (Shenango River) adjacent to the west side of the facility. No backup power is provided to the facility.

Violations of the NPDES permit were reviewed from 1999 to 2008 for outfall 001. For nearly nine years of data evaluated through SWIMS, 620 numeric limit violations were reported, primarily for the following parameters: chlorine, pH, and ammonia-N. No code violations were reported. Three thousand and sixty-five reporting frequency violations were reported from 1999 to 2008, primarily for the following parameters: chlorine, turbidity, odor, ammonia-N, color, TSS, flow rate, water temperature, pH and color.

Pymatuning Valley Resort (Ohio EPA Permit # 3PR00199)
McMichael Creek RM 0.85
Several wastewater streams are collected in the WWTP sewerage system, including backwash from two pools, concession areas, bathhouses, and individual lots for transient and seasonal campers. The wastewater treatment system consists of a trash trap, aerated equalization tank, extended aeration system with clarifier, wet well/lift station, dosing chamber, slow surface sand filtration, chlorine disinfection, dechlorination, another lift station, final polishing pond, and a metering chamber with a flow totalizer. Sludge management consists of sludge removal from an aerated sludge holding tank when needed to sludge drying beds. Dried sludge is placed into a dumpster for disposal off-site at the Geneva Landfill. No backup power is provided to the facility, and the facility is provided with alarms. The facility discharges to McMichael Creek at RM 0.85, then to Pymatuning Lake east of the facility.

Violations of the NPDES permit were reviewed from 2003 to 2007 for outfall 001. For just over four years of data evaluated through SWIMS, 254 numeric limit violations were reported, primarily for the following parameters: chlorine, TSS, ammonia-N, phosphorus, dissolved oxygen, CBOD-5, and fecal coliform bacteria. Two code violations were reported, for fecal coliform bacteria. Seven hundred and thirty-four reporting frequency violations were reported from 2003 to 2007, primarily for the following parameters: chlorine, turbidity, odor, ammonia-N, color, TSS, flow rate, water temperature, fecal coliform bacteria, and color. No DMR data were submitted for 2008. The facility has been cited several times for dumping their pool water directly into McMichael Creek.

The Inn (Ohio EPA Permit # 3PR00427)
Unnamed tributary to Pymatuning Creek @ RM 30.55
The Inn is located at 4791 U.S. Route 6, Andover Township, Ohio. The system consists of two 1,000 gallon septic tanks in series, a 500 gallon dosing chamber, five peat bio-filters, a chlorine contact tank, dechlorination, and post-disinfection aeration. The system is located behind a house that shares the tavern's address. Septage is removed from the septic tanks when needed and hauled to a publically-

owned treatment works (POTW). The system discharges to an unnamed tributary to Pymatuning Creek adjacent to the north side of the facility.

Violations of the NPDES permit were reviewed from 2007 for outfall 001. For less than one year of data evaluated through SWIMS, 12 numeric limit violations were reported, primarily for the following parameters: ammonia-N, TSS, pH and CBOD-5. No code violations or reporting frequency violations were reported. No DMR data were submitted for 2008.

Jeffco Lakes Campground (Ohio EPA # 3PR00303)
Pymatuning Creek RM 0.45
Jeffco Lakes Campground is located at 6758 Hayes Road, Wayne Township, Ohio. The collection system consists of a sanitary collection system from the campground. A number of the campers have a permanent connection to the collection system. The treatment system consists of a trash trap, extended aeration plant with clarification, dosing tank, surface sand filtration, chlorine disinfection, and dechlorination. Sludge management consists of sludge removal from the aerated sludge holding tank when needed to another POTW. The facility discharges to Pymatuning Creek west of the facility. No backup power is provided to the facility.

Violations of the NPDES permit were reviewed from 2003 to 2007 for outfall 001. For just over four years of data evaluated through SWIMS, 95 numeric limit violations were reported, primarily for the following parameters: TSS, ammonia-N, phosphorus, dissolved oxygen, and CBOD-5. Two thousand and thirty-nine reporting frequency violations were reported from 2003 to 2007, primarily for the following parameters: chlorine, pH, color, water temperature, dissolved oxygen, flow rate, turbidity, and odor. No code violations were reported

Kinsman WWTP (Ohio EPA Permit # 3PH00060)
Sugar Creek RM 0.6 → Pymatuning Creek RM 15.65
The Kinsman WWTP is located at 5915 Burnett East Road, Kinsman Township, Ohio. The plant is designed for an average daily flow of 0.025 MGD. There are 388 residents tied into the plant. The plant is under Consent Orders (2002) to improve the sanitary system by 2012. The plant discharges to Sugar Creek, a tributary of Pymatuning Creek.

Violations for the NPDES permit were reviewed from 2007 to 2008 for outfall 001. For just one year of data evaluated through SWIMS, no numeric limit or code violations were reported. However, 1306 reporting frequency violations were reported in the same time period, primarily for the following parameters: dissolved oxygen, pH, flow rate, CBOD-5, odor, TSS, turbidity, ammonia-N, and water temperature.

The Wyngate Mobile Home Park (Ohio EPA Permit # 3PV00019)
Unnamed Tributary to Yankee Creek @ RM 4.44 →Yankee Creek RM 1.2
The Wyngate Mobile Home Park is located at 479 Warner Road, Brookfield Township, Ohio, and operates an aeration package WWTP (0.055 MGD). The wet-stream treatment components consist of preliminary treatment (trash trap), flow equalization basin, aeration activated sludge treatment process, final settling tank, tertiary sand filtration, and UV disinfection. Sludge handling consists of an aerated sludge holding tank. The plant discharges to an unnamed tributary at RM 4.44. The unnamed tributary discharges to Yankee Creek at RM 1.2.

Violations of the NPDES permit were reviewed from 2001 to 2008 for outfall 001. For nearly seven years of data evaluated through SWIMS, 304 numeric limit violations were reported, primarily for the following parameters: chlorine, TSS, ammonia-N, dissolved oxygen, CBOD-5, and fecal coliform bacteria. One hundred and seven code violations were reported, for the following parameters: chlorine, turbidity, odor, water temperature, CBOD-5, and pH. Nine hundred and fifty-seven reporting frequency violations were reported for the same time period, primarily for the following parameters: chlorine, pH, turbidity, CBOD-5, color, water temperature and odor.

Brookfield WWTP (Ohio EPA # 3PJ00001)
Yankee Creek RM 0.5
The Brookfield WWTP is located at 921 Standard Avenue, Brookfield Township, Ohio. The WWTP was originally constructed in 1962 and was upgraded in 1988 to provide advanced treatment. The plant is designed for an average daily flow of 1.3 MGD and has a peak hydraulic capacity of 4.6 MGD. Wet stream processes include influent pumping, influent screening, aerated grit removal, pre-aeration, aeration, chlorination and de-chlorination. Flows in excess of 4.6 MGD are treated through a swirl concentrator. Solid stream processes include gravity thickening, aerobic digestion, storage and drying. Sludge is ultimately disposed of by either land application or to a landfill. Seventy percent of Brookfield's treatment plant service area is sewered. The sewer system is separate, and transports both domestic and industrial flow. Industrial customers are permitted through Brookfield's pretreatment program. The plant discharges to Yankee Creek at RM 0.5.

Violations of the NPDES permit were reviewed from 2000 to 2008 for outfall 001. For nearly eight years of data evaluated through SWIMS, fifty-eight numeric limit violations were reported, primarily for the following parameters: pH, lead, chlorine, TSS, ammonia-N, dissolved oxygen, CBOD-5, and low-level mercury. Fifty-eight code violations were reported, for the following parameters: chlorine, CBOD-5, pH, ammonia-N, D.O. and fecal coliform bacteria. One thousand, seven hundred and thirty-five reporting frequency violations were reported for the same time period, primarily for the following parameters: chlorine, pH, turbidity, 48-hour Acute Toxicity, 96-hour Acute Toxicity, 7-day Chronic Toxicity, CBOD-5, low-level mercury, sludge weight, and percent sludge solids.

Median and peak percentile flows showed some variance over the period of record (Figure 4). Graphically, the improvements of treating waste by the facility were evident for most conventional parameters, with the exception of total Kjeldahl nitrogen.

City of Hubbard WWTP (Ohio EPA Permit # 3PD00028)
Little Yankee Creek RM 4.59
The Hubbard WWTP is located at 2650 Elmwood Drive Extension, Hubbard, Ohio. The system is a secondary treatment facility that was originally constructed in 1932 and was upgraded in 1989. The average design flow is 2.1 MGD with peak hydraulic capacity of 20 MGD. The facility has an internal bypass which provides for chlorination for incoming flows ranging between 7.5 and 20 MGD. This internal bypass allows excessive flow to circumvent secondary treatment as the excessive flow is routed from the grit channel directly to the chlorine contact basin. The wet stream processes at the WPCF include influent pumping, bar screening, grit removal, multiple channel orbital aeration, secondary clarification, chlorination/de-chlorination, and post aeration. Solid stream processes incorporate sludge conditioning with polymer and dewatering with a horizontal belt filter press. The sewage collection system is comprised of 100% separate sanitary sewers with three lift stations. The plant discharges to Little Yankee Creek at RM 4.59.

Violations of the NPDES permit were reviewed from 1999 to 2008 for outfall 001. For just over eight years of data evaluated through SWIMS, 198 numeric limit violations were reported, primarily for the following parameters: pH, oil and grease, chlorine, low-level mercury, CBOD-5, copper, TSS, zinc, and D.O. Thirty-four code violations were reported, for the following parameters: CBOD-5, D.O. and fecal coliform bacteria. Four thousand, five hundred and ninety-nine reporting frequency violations were reported for the same time period, primarily for the following parameters: fecal coliform bacteria, CBOD-5, ammonia-N, flow rate, TSS, oil and grease, phosphorus, D.O., pH, sludge weight, chlorine, cadmium, lead, zinc, nickel, cyanide, chromium, and toxicity.

Median and peak percentile flows showed some variance over the period of record (Figure 5). Graphically, the improvements of treating waste by the facility were evident for most conventional parameters.

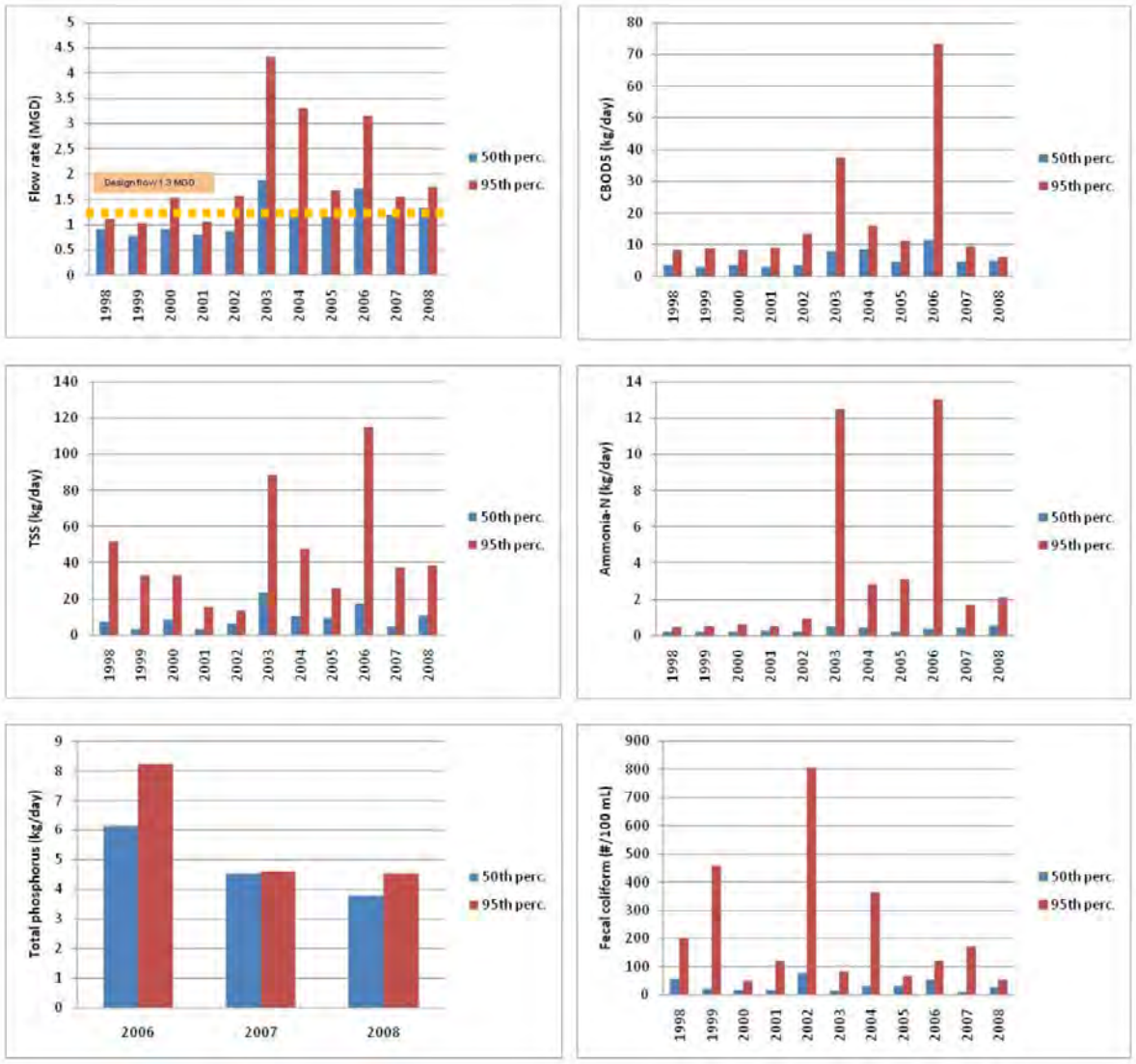


Figure 4. Annual Third-quarter loadings of conduit flow, cBOD5, Total Suspended Solids (TSS), phosphorus and ammonia-N; and concentrations of fecal coliform bacteria at the Brookfield WWTP in the Ohio Tributaries to the Shenango River study area, 1998-2008.

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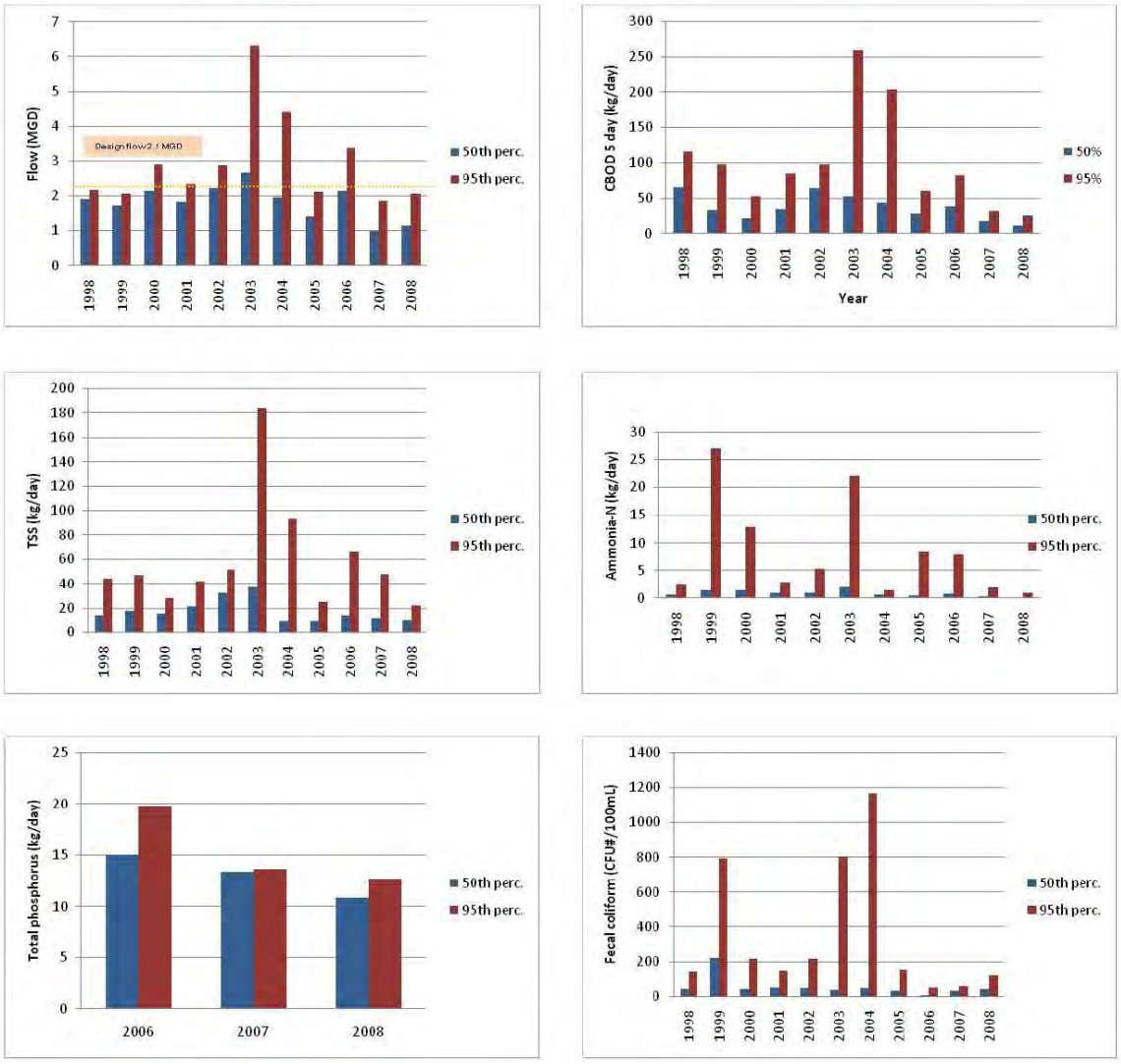


Figure 5. Annual Third-quarter loadings of conduit flow, cBOD5, Total Suspended Solids (TSS), phosphorus and ammonia-N; and concentrations of fecal coliform bacteria at the Hubbard WWTP in the Ohio Tributaries to the Shenango River study area, 1998-2008.

Table 4. NPDES permitted facilities located in the Ohio Tributaries to the Shenango River study area, 2008.

Receiving Stream/River Mile	Facility	Permit #	Design Flow (MGD)	Ave. Daily Flow(MGD)
Gravel Run RM 1.35	Holiday Camplands STP	3PH00029*ED	0.150	0.063
Wade Creek RM 2.73	Andover WWTP	3PB00000*GD	0.500	0.365
Wade Creek RM 1.35	Scooters Restaurant	3PR00428*AD	0.005	262 gpd
McMichael Creek RM 0.85	Pymatuning Valley Resort	3PR00199	0.115	0.003
Shenango River RM 68.38	Pymatuning State Park WTP	3IV00029*BD	0.001	0.0043
Unnamed trib. to Shenango River @ RM 67.80, RM 0.5	ODNR Pymatuning Campground WWTP	3PP00013*DD	0.080	0.011
Pymatuning Creek RM 12.1	Joseph Badger Local School	3PT00122*AD	0.025	0.0067
Pymatuning Creek RM 3.9	Joseph Badger Meadows Camp	3PR00198*BD	0.020	0.0043
Unnamed trib to Pymatuning Creek @ RM 30.55, RM 0.8	The Inn	3PR00427	0.001	100 gpd
Pymatuning Creek RM 0.45	Jeffco Lakes Campground	3PR00303*BD	0.013	162 gpd
Sugar Creek RM 1.0	Boyds Kinsman Home	3PR00208*BD	0.0057	0.0013
Sugar Creek RM 0.6	Kinsman WWTP	3PH00060	0.025	--
Stratton Creek RM 1.05	Times Square Restaurant	3PR00294*AD	0.001	416 gpd
Stratton Creek RM 0.9	Kinsman Land Co. LLC / Kinsman IGA	3PR00225*BD	0.0015	341 gpd
Stratton Creek RM 0.8	Colonial Tea Room	3PR00365*AD	0.0012	318 gpd
Stratton Creek RM 0.7	Kinsman Pizza	3PR00330*AD	750 gpd	461 gpd
Unnamed trib. to Yankee Creek @ RM 1.2, RM 4.44	Wyngate Mobile Home Park	3PV00019	0.055	0.048
Yankee Creek RM 12.0	Briarfield of Cortland	3PR00166*CD	0.0116	0.0031
Yankee Creek RM 0.6	ODOT Brookfield Maintenance Outpost	3PP00042*AD	0.0015	--
Yankee Creek RM 0.5	Brookfield WWTP	3PJ00001	1.3	2.1
South Branch Yankee Creek RM 8.55	Meadowbrook Manor Nursing Home	3PR00250*BD	0.009	0.0054
South Branch Yankee Creek RM 6.6	Tri-city Mobile Homes Inc. DBA Four Seasons MHP	3PV00025*CD	0.035	0.012
South Branch Yankee Creek RM 4.83	Mack Industries of Pennsylvania Inc.	3IN00343*AD	--	0.0155
South Branch Yankee Creek RM 2.1	Neal Elementary School	3PT00086*AD	0.010	0.001
Little Yankee Creek RM 13.6	Baldauf 4-Plex Apartments	3PW00031*AD	0.001	0.001
Little Yankee Creek RM 11.15	Brookfield Acres MHP	3PV00056*CD	0.065	0.032
Little Yankee Creek RM 5.99	Ellwood Engineering Castings Co.	3IM00002*DD	0.014	340 gpd
Little Yankee Creek RM 4.59	Hubbard WWTP	3PD00028*ID	2.1	1.7
Little Yankee Creek RM 2.9	ODOT Rest Area 4-10	3PP00025*ED	0.01	0.0044

Recreation Use

Water quality criteria for determining attainment of the recreation use are established in the Ohio Water Quality Standards (Table 7-13 in OAC 3745-1-07) based upon the quantities of bacteria indicators (*Escherichia coli*) present in the water column.

Escherichia coli (*E. coli*) bacteria are microscopic organisms that are normally present in large numbers in the feces and intestinal tracts of humans and other warm-blooded animals. *E. coli* typically comprises approximately 97 percent of the organisms found in the fecal coliform bacteria bacteria of human feces (Dufour 1977). There is currently no simple way to differentiate between human and animal sources of coliform bacteria in surface waters, although methodologies for this type of analysis are becoming more feasible. These microorganisms can enter water bodies where there is a direct discharge of human and animal wastes, or may enter water bodies along with runoff from soils where these wastes have been deposited.

Pathogenic (disease-causing) organisms are typically present in the environment in such small amounts that it is impractical to monitor every type of pathogen. Fecal indicator bacteria by themselves, including *E. coli*, are usually not pathogenic. However, some strains of *E. coli* can be pathogenic, capable of causing serious illness. Although not necessarily agents of disease, fecal indicator bacteria such as *E. coli* may indicate the potential presence of pathogenic organisms that enter the environment through the same pathways. When *E. coli* are present in high numbers in a water sample, it invariably means that the water has received fecal matter from one or multiple sources. Swimming or other recreation-based contact with water having a high *E. coli* count may result in ear, nose, and throat infections, as well as stomach upsets, skin rashes, and diarrhea. Young children, the elderly, and those with depressed immune systems are most susceptible to infection.

Streams in the Ohio Tributaries to the Shenango River watershed are designated as primary contact recreation (PCR) use in OAC Rule 3745-1-25. Water bodies with a designated recreation use of PCR "...are suitable for one or more full-body contact recreation activities such as, but not limited to, wading, swimming, boating, water skiing, canoeing, kayaking, and scuba diving" [OAC 3745-1-07 (B)(4)(b)]. There are three classes of PCR use to reflect differences in the potential frequency and intensity of use. Streams designated PCR Class A support, or potentially support, frequent primary contact recreation activities. Streams designated PCR Class B support, or potentially support, occasional primary contact recreation activities. Streams designated as PCR Class C support, or potentially support, infrequent primary contact recreation activities. The Pymatuning Creek mainstem is designated PCR Class B from the headwaters to RM 15.8 in Kinsman; from RM 15.87 to the Pennsylvania state line, Pymatuning Creek is classified as PCR Class A. All other streams assessed in the survey are designated Class B PCR waters.

The *E. coli* criterion that applies to PCR Class A streams is a geometric mean of ≤126 colony forming units (cfu)/100 ml. The *E. coli* criterion that applies to PCR Class B streams is a geometric mean of ≤161 cfu/100 ml. The criterion that applies to PCR Class C streams is a geometric mean of ≤206 cfu/100 ml. The geometric mean is based on two or more samples and is used as the basis for determining the attainment status of the recreation use.

Summarized bacteria results are listed in Table 5 and the complete dataset is reported in Appendix Table 1. Downloadable bacteria results are also available from the Ohio EPA geographic information systems (GIS) interactive maps at the following link: http://www.epa.ohio.gov/dsw/gis/index.aspx.

Thirty-one locations in the watershed were sampled for *E. coli* four to eight times between May 8 and September 18, 2008. Evaluation of *E. coli* results revealed that 28 of the 32 locations sampled failed to attain the applicable recreation use criterion (Table 5). Because of the rural nature of most of the study area, centralized sewer systems are rare and therefore most homes located outside of the major population centers of Andover, Hubbard, Masury, and Brookfield treat their sanitary waste via home sewage treatment systems (HSTS). Therefore, failing HSTS are suspected as a source of *E. coli* in the Pymatuning Reservoir tributaries, the Pymatuning Creek headwaters, Pymatuning Creek in and downstream from Kinsman, and in the headwaters of both Yankee Creek and Little Yankee Creek.

The large percentage of land dedicated to row crop agriculture and livestock pasturage may also contribute to the excessive levels of bacteria in the watershed. As indicated in Figure 2, row crop agriculture accounts for roughly one quarter of both the Pymatuning Reservoir tributaries and Yankee/Little Yankee Creek watersheds' land use. Roughly half of the land in the Pymatuning Creek watershed is dedicated to row crop agriculture and livestock pasturage. As a result of these activities, manure-laden runoff from farm fields or pasture, animal feedlots, and/or unrestricted livestock access to stream channels could also contribute *E. coli* bacteria to many of the streams that are located within or downstream from agricultural operations.

In addition to failing HSTS and agriculture, poorly treated sanitary waste from NPDES-regulated facilities may also be sources of bacteria to the streams in which they discharge. The Holiday Camplands and the Pymatuning Valley Resort WWTPs, which discharge to Gravel Run and McMichael creeks, respectively, have recorded violations of their NPDES permit limits for bacteria. The Kinsman WWTP, which discharges to Sugar Creek, has documented treatment bypasses in response to heavy wet weather events. Multiple package WWTPs discharge into the waters upstream of South Branch Yankee Creek RM 1.54 and may be sources of bacteria to this location. Treatment bypasses and limit violations have also been documented at the Andover, Brookfield, and the Hubbard WWTPs. Untreated or poorly treated sanitary waste from these entities affect the lower reaches of Wade Creek, Yankee Creek, and Little Yankee Creek, respectively.

Failing septic systems accounted for many of the bacteria exceedences in the study area.

Finally, urban runoff is also a likely source of bacteria in lower Yankee Creek, middle Little Yankee Creek, and lower Mud Run. All three of these stream reaches are within the municipal limits of Brookfield, Masury, or Hubbard and are susceptible to contaminated runoff during precipitation events.

Table 5. Recreation beneficial use attainment table for 32 locations in the Ohio Tributaries to the Shenango River watershed, May 1 through October 31, 2008.

Note: All *E. coli* values are expressed as colony forming units (cfu) per 100 ml of water. Bold red values exceed applicable criteria.

Location	River Mile	Rec Class*	# Samples	Geometric Mean†	Attainment Status	Potential Source(s) of Bacteria
Pymatuning Reservoir Tributaries						
Black Creek @ Pymatuning Lake Rd.	1.43	B	5	**467**	**NON**	Failing home sewage treatment systems (HSTS); agriculture
Gravel Run @ Pymatuning Lake Rd.	1.27	B	5	**311**	**NON**	Failing HSTS; WWTP discharge; agriculture
McMichael Creek @ Pymatuning Lake Rd.	1.26	B	5	**361**	**NON**	Failing HSTS; WWTP discharge
Wade Creek @ US 6 (ust Andover WWTP)	2.8	B	5	**501**	**NON**	Failing HSTS; agriculture
Wade Creek @ US 6 (dst Andover WWTP)	1.82	B	5	**671**	**NON**	WWTP discharge; failing HSTS
Pymatuning Creek						
Pymatuning Creek @ US 6	30.38	B	5	**203**	**NON**	Failing HSTS; agriculture
Pymatuning Creek @ Dodgeville Rd.	29.10	B	5	154	FULL	
Pymatuning Creek @ US 322	24.50	B	5	**389**	**NON**	Agriculture
Pymatuning Creek @ Underwood Rd	22.70	B	5	**672**	**NON**	Agriculture
Pymatuning Creek @ SR 87	17.78	B	5	**195**	**NON**	Agriculture
Pymatuning Creek @ SR 7, dst. storm sewer #2	15.80	A	6	**235**	**NON**	Failing HSTS
Pymatuning Creek S. of Kinsman, adj SR 7	15.20	A	5	**202**	**NON**	Failing HSTS
Pymatuning Creek @ SR 88	8.40	A	5	**818**	**NON**	Agriculture; failing HSTS
Pymatuning Creek @ PA state line at Orangeville	1.94	A	6	76	FULL	
Sugar Creek @ SR 88	5.72	B	5	**328**	**NON**	Agriculture; failing HSTS
Sugar Creek @ Burnett Road	0.92	B	5	**300**	**NON**	Agriculture; failing HSTS; WWTP discharge
Stratton Creek @ Weber Road	4.21	B	5	**270**	**NON**	Failing HSTS
Stratton Creek @ Kinsman-Nickerson Road	0.70	B	5	85	FULL	
Yankee Creek						
Yankee Creek @ SR 305, W of Hartford	11.34	B	5	**466**	**NON**	Agriculture
Yankee Creek @ CR 361A	6.50	B	5	**350**	**NON**	Failing HSTS
Yankee Creek @ Addison Road	1.23	B	6	**665**	**NON**	Urban runoff; failing HSTS
Yankee Creek dst Brookfield WWTP	0.30	B	5	**300**	**NON**	WWTP discharge; urban runoff
South Branch Yankee Creek @ Warner Road	1.54	B	5	**406**	**NON**	WWTP discharge; failing HSTS
Little Yankee Creek						
Little Yankee Creek @ Albright-McKay Road	10.99	B	5	**450**	**NON**	Failing HSTS

Location	River Mile	Rec Class*	# Samples	Geometric Mean†	Attainment Status	Potential Source(s) of Bacteria
Little Yankee Creek @ Stewart-Sharon Road	9.56	B	5	**280**	**NON**	Failing HSTS
Little Yankee Creek @ Chestnut Ridge Rd	7.95	B	4	136	FULL	
Little Yankee Creek Valley Mould dam pool	5.00	B	5	**515**	**NON**	Urban runoff; failing HSTS
Little Yankee Creek @ Mill Street	4.70	B	6	**1002**	**NON**	Urban runoff; failing HSTS
Little Yankee Creek @ 1st RR bridge dst Hubbard WWTP	4.40	B	5	**259**	**NON**	WWTP discharge; failing HSTS
Little Yankee Creek @ Chestnut Ridge Road	1.58	B	5	**209**	**NON**	WWTP discharge; failing HSTS; agriculture
Little Deer Creek @ SR 304	0.40	B	5	**701**	**NON**	Agriculture; failing HSTS
Mud Run @ North Main Street	0.07	B	5	**624**	**NON**	Urban runoff; failing HSTS

* Recreation class may include primary contact recreation classes (A, B or C); bathing waters (BW); or secondary contact recreation (SCR).
† Attainment status is determined based on the seasonal geometric mean. The status cannot be determined at locations where fewer than two samples were collected during the recreation season.

Water Chemistry

Surface water chemistry samples were collected from the Ohio Tributaries to the Shenango River study area (Table 3) from May 1 through October 31, 2008 at 34 locations. Stations were established in free-flowing sections of the stream and were primarily collected at bridge crossings. Surface water samples were collected using appropriate containers, preserved and delivered to Ohio EPA's Environmental Services laboratory for analysis. Samples were preserved using appropriate methods, as outlined in the Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (Ohio EPA 2009). Interactive maps of surface water chemical data, downloadable to excel files, are available at the following link: http://www.epa.ohio.gov/dsw/gis/index.aspx.

The Ohio Tributaries to the Shenango River Watershed area streams did not have United States Geological Survey (USGS) gage stations with current data at the time of the study, therefore, the USGS gage data from Mahoning River near Lowellville, Ohio was used to show flow trends in the watershed area in 2008 (Figure 6). Dates when water samples and bacteria samples were collected in the study area are noted on the graph. Both water and bacteria samples captured a variety of flow conditions in the study area during the field season. Bacteria samples were collected during the recreation use season (May through October) and were typically collected during lower flows.

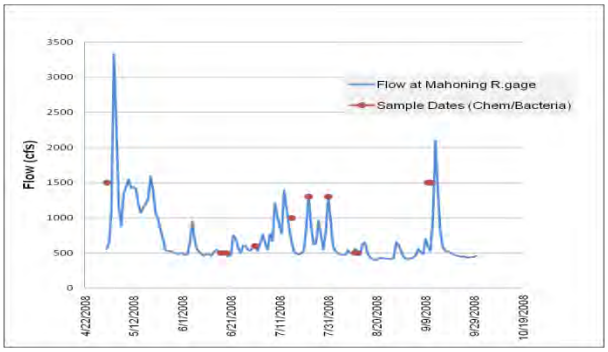


Figure 6. Flow conditions in the Ohio Tributaries to the Shenango River study area, 2008.

Surface water samples were analyzed for metals, bacteria, pH, temperature, conductivity, dissolved oxygen, percent saturation, and suspended and dissolved solids (Appendix Tables 1 and 2). Nutrients were also measured at each water sampling location, and included ammonia-N, nitrate+nitrite-N, total phosphorus, and total Kjeldahl nitrogen (TKN). A summary of nutrient data is presented in Table 7. All parameters which were in exceedence of the Ohio Water Quality Standards (WQS) criteria are reported in Table 6. Bacteriological samples were collected from all 34 locations, and the results are reported in the Recreation Use section. Datasonde© continuous monitors were also placed at seven locations in 2008 and at four in 2009 to monitor hourly levels of dissolved oxygen, pH, temperature and conductivity (Figure 8) during a 48-hour period. Raw and summarized Datasonde© data are available in Appendix tables 4, 5, and 6.

Table 6. Exceedences of Ohio Water Quality Standards criteria (OAC3745-1) for chemical/physical parameters measured in the Ohio Tributaries to the Shenango River study area, 2008. Bacteria exceedences are presented in Table 5 in the Recreation Use section.

Location	RM	Parameter(s)
Pymatuning Creek @ St. Rt. 87	17.78	Dissolved oxygen (1.58, 2.23, 2.44, 1.31 mg/L)[a]
Pymatuning Creek dst. storm sewer #2 @ SR 7	15.80	Dissolved oxygen (3.1, 3.05, 3.95, 3.90, 3.85, 3.56, 3.56, 3.83, 3.72, 3.87, 3.81, 3.78 mg/L)[a]; 4.21 mg/L[b]
Pymatuning Creek, S. of Kinsman, adj SR 7	15.20	Dissolved oxygen (3.48, 3.05 mg/L)[a]
Pymatuning Creek @ SR 88	8.40	Dissolved oxygen, 3.7 mg/L[a]
Pymatuning Creek @ PA state line at Orangeville	1.94	Dissolved oxygen, 3.31 mg/L[a]
Sugar Creek @ SR 88 (E. of Johnstown)	5.72	Dissolved oxygen, 3.86 mg/L[a]; 4.9 mg/L[b]
Yankee Creek @ SR 305	11.34	Dissolved oxygen, 3.57mg/L[a]
Little Deer Creek @ SR 304	0.40	Dissolved oxygen (4.79, 4.37 mg/L)[a]
Mud Run @ North Main Street	0.20	Dissolved oxygen (3.78, 3.27, 3.03, 2.91, 2.9, 2.94, 3.0, 3.02, 3.06, 3.14, 3.39 mg/L)[a]

[a] – Exceedence of the aquatic life use Outside Mixing Zone Maximum water quality criterion (below minimum for dissolved oxygen)
[b] - Exceedence of the aquatic life use Outside Mixing Zone Average water quality criterion (below 24-hour average for dissolved oxygen)

Pymatuning Reservoir Tributaries

Chemical water quality in the Pymatuning Reservoir tributaries was most influenced by WWTPs and failing septic systems in the watershed. In Gravel Run RM 1.27, elevated mean concentrations of ammonia and TKN could be attributed to poor treatment of sanitary waste from the Holiday Campground WWTP, which discharges just upstream at RM 1.35. Failing home sewage treatment systems could be an additional source of these elevated nutrients. Wade Creek also showed signs of poorly treated sanitary waste, with elevated mean concentrations of nitrate+nitite-N and chloride at RM 1.82. The Andover WWTP discharges upstream at RM 2.73 and had very high concentrations of these parameters in their effluent. Elevated concentrations of sodium and chloride (Appendix Table 2) were also evident in McMichael Creek RM 1.26. Since there are no known dischargers upstream from this location, the source of these parameters may be from failing home sewage treatment systems (salt from water softeners); however, instream nutrients were quite low.

Pymatuning Creek Watershed

The low gradient, wetland nature of Pymatuning Creek led to numerous WQS exceedences for dissolved oxygen in the lower reach of the stream (Table 6). All sites from RM 17.78 to RM 1.94 had at least one dissolved oxygen measurement that was below the minimum criterion of 4.0 mg/L for WWH streams. This lower reach of the stream was generally sluggish and therefore provided little turbulence that would allow for higher instream dissolved oxygen. Conversely, in the upper reach of Pymatuning Creek (RMs 30.38-22.70), stream gradient was slightly higher, allowing for sparsely developed riffles that provided movement to the stream. Thus, dissolved oxygen levels were maintained above the WWH standard.

Datasonde© continuous monitors were placed at RMs 22.7, 15.8, and 1.94 in 2008 and were left in the stream for a two-day period to record hourly readings of dissolved oxygen, conductivity, temperature, and pH (Figure 8). As evident in the figure, a broad range of dissolved oxygen values were captured during the sampling period at RM 22.7. This broad range of concentrations reflects saturated daytime concentrations and low nighttime concentrations which are an effect of algal respiration. Algae were indeed abundant at this sampling location (Figure 7) and indicate nutrient enrichment from the surrounding agricultural landscape. A lack of riparian corridor in this reach exacerbates the algal growth. The Datasonde© readings at RM 15.8 further confirm the effects of low stream gradient, as there were numerous readings below the WWH criterion of 4.0 mg/L. Although Pymatuning Creek RM 1.94 is impounded by a dam at the Pennsylvania state line, nothing unusual was detected. However, a few dissolved oxygen values were close to the WWH minimum.

Figure 7. Pymatuning Creek, RM 22.7.

Channelization of the Sugar Creek headwaters at RM 5.92 resulted in a monotonous and motionless stream and allowed for general low dissolved oxygen, with one value below the WWH criterion of 4.0 mg/L. Nutrient parameters were generally within expected concentrations at this location in spite of livestock being observed in the stream. Datasondes© were placed at this location in 2009 and found that general low dissolved oxygen was more problematic than broad dissolved oxygen swings that are associated with nutrient enrichment, as the 24-hour average for dissolved oxygen was below the WWH criterion of 5.0 mg/L. Improving the habitat in this reach would help to raise instream dissolved oxygen to appropriate levels. Elevated nitrate+nitrite-N and TKN were detected at the lower Sugar Creek site at RM 0.92 and are likely due to a combination of agricultural runoff and failing home sewage treatment systems.

Yankee Creek Watershed

Two of the four sites sampled on Yankee Creek had either chemical WQS exceedences or elevated nutrients. *Y*ankee Creek RM 11.34 resembles Pymatuning Creek in terms of possessing low-gradient, wetland habitat. As such, that location had numerous exceedences of the WQS for dissolved oxygen. The

lowermost site at RM 0.3 is located just downstream from the Brookfield WWTP, which discharges at RM 0.42. Elevated concentrations of nitrate+nitrite-N and phosphorus were detected at this site and is likely attributable to the WWTP discharge. This reach is also impounded due to a lowhead dam on the Shenango River downstream from Yankee Creek's confluence with the river. The impounded conditions may affect the stream's ability to transport and assimilate nutrient loads from the WWTP.

While there were no elevated or exceeded chemical parameters at South Branch Yankee Creek RM 1.54 in 2008, a Datasonde© was placed at this location in 2009 to further investigate a cause of impairment to the macroinvertebrate community. A broad range of dissolved oxygen levels were recorded (minimum of 4.63 mg/L, maximum of 9.77 mg/L) which was attributed to decaying organic matter at the deployment site.

Little Yankee Creek Watershed

There were no exceedences of WQS criteria on Little Yankee Creek (Table 6). There were, however, a few areas that had elevated nutrients (Table 7). Elevated mean concentrations of phosphorus were recorded at Little Yankee Creek RM 7.65. This area is unsewered, and it is also located just downstream from the Coalburg Lake outlet. Septic system failures or contaminated discharge from the lake may be contributing to the elevated phosphorus at this location. Phosphorus was also elevated at RM 4.4, which is downstream from the city of Hubbard's WWTP discharge. Although improvements have been made at the plant, treatment bypasses do occur and may be partly responsible for elevated phosphorus in this reach.

Datasonde© continuous monitors were deployed to Little Yankee Creek RMs 4.7 and 1.58 in 2008 (Figure 8). Large dissolved oxygen swings were noted at RM 4.70, which is located just downstream from an old industrial dam at RM 4.96. Large clumps of algae were observed on the substrates just below the spillway of the dam, indicating nutrient loads that originate in the backwaters created by the dam (phytoplankton, urban runoff). Dissolved oxygen swings were less pronounced at RM 1.58, although supersaturated daytime values were recorded. This area may be recovering from nutrient inputs from the Hubbard WWTP. An additional Datasonde© was placed on Little Yankee Creek RM 9.56 in 2009 in order to investigate a potential cause of impairment to the fish community at this location. All values were steady and did not show anything unusual.

There were no WQS exceedences or elevated parameters of concern in Mud Run, one of the principal tributaries to Little Yankee Creek. However, an impaired macroinvertebrate community was collected at Mud Run RM 0.2 in 2008 and therefore a Datasonde© was placed there in 2009 in order to ascertain a cause of the impairment. Pronounced dissolved oxygen swings were noted at this location (Figure 8). Mud Run flows through the city of Hubbard, making it prone to the effects urban runoff. This stream is also susceptible to becoming impounded in the lower reach after heavy rain events due to the backwater effect from the dam on Little Yankee Creek. Both of these phenomena could explain the variances in dissolved oxygen that were recorded by the Datasonde©.

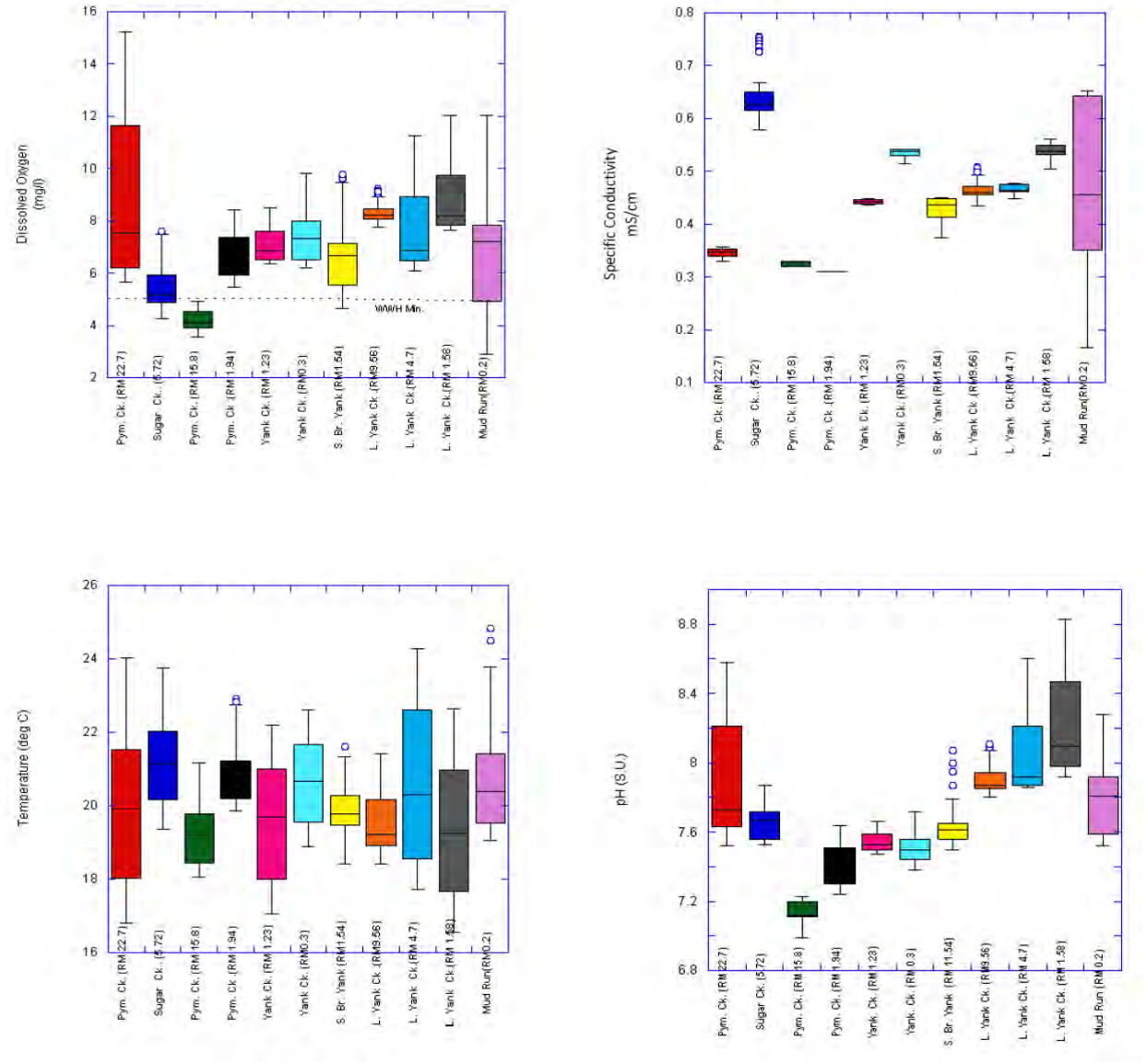


Figure 8. Box and whisker plots of dissolved oxygen, conductivity, temperature, and pH as recorded by Datasonde© continuous monitors during 2008 and 2009.

Table 7. Summary statistics for select nutrient water quality parameters sampled in the Ohio Tributaries to the Shenango River Watershed study area, 2008. The 90th percentile value from reference sites from the Erie-Ontario Lake Plain (EOLP) ecoregion is shown for comparison. Values above reference conditions are shaded.

		Ammonia—N mg/L	Nitrate+Nitrite-N mg/L	Phosphorus-T mg/L	Total KJEL Nitrogen mg/L
Reference Value (headwater/ wading)		**0.19/0.125**	**2.701/1.817**	**0.214/0.200**	**1.080/0.900**
Stream	**River Mile***	**Mean**	**Mean**	**Mean**	**Mean**
Pymatuning Reservoir Tributaries					
Black Creek, Pymatuning Lake Road	1.43[H]	0.05	0.47	0.05	0.612
Gravel Run, Pymatuning Lake Road	1.27[H]	0.21	1.65	0.09	1.04
McMichael Creek, Pymatuning Lake Road	1.26[H]	0.05	0.02	0.05	0.6
Wade Creek, Ust. Andover WWTP. U.S. Rt. 6	2.8[H]	0.06	0.7	0.04	0.4
Wade Creek, Andover WWTP Effluent	2.73	0.05	12.72	0.5	0.656
Wade Creek, Dst Andover WWTP. U.S. Rt. 6	1.82[H]	0.05	4.3	0.1	0.5
Pymatuning Creek Watershed					
Pymatuning Creek, U.S. Rt. 6	30.38[H]	0.06	0.5	0.05	0.6
Pymatuning Creek, Dodgeville Rd.	29.10[H]	0.07	0.7	0.06	0.6
Pymatuning Creek, US 322	24.50[W]	0.07	0.51	0.07	0.4
Pymatuning Creek, Underwood Rd.	22.70[W]	0.1	0.8	0.1	0.5
Pymatuning Creek, St. Rt. 87	17.78[W]	0.8	0.4	0.1	0.8
Pymatuning Creek, Dst. Storm Sewer #2 SR 7	15.80[W]	0.1	0.5	0.1	0.8
Pymatuning Creek, S. of Kinsman, adj SR 7	15.20[W]	0.9	0.5	0.1	0.8
Pymatuning Creek, St. Rt. 88	8.40[W]	0.08	0.6	0.1	.07
Pymatuning Creek @ PA state line at Orangeville	1.94[W]	0.06	0.5	0.08	0.62
Stratton Creek, Weber Road	4.21[H]	0.06	1.32	0.04	0.92
Stratton Creek, Kinsman-Nickerson Road	0.70[H]	0.05	0.78	0.03	0.6
Sugar Creek St. Rt. 88	5.72[H]	0.09	1.2	0.06	0.9
Sugar Creek, Burnett Rd.	0.92[W]	0.06	2.0	0.06	1.0
Yankee Creek Watershed					
Yankee Creek, SR 305	11.34[H]	0.1	0.7	0.08	0.8
Yankee Creek, Co. Rd. 361A	6.50[H]	0.05	0.3	0.03	0.5
Yankee Creek, Ust Brookfield WWTP @ Addison Rd	1.23[W]	0.06	0.3	0.04	0.4
Yankee Creek, Brookfield WWTP Effluent	0.42	0.056	8.39	0.67	0.9
Yankee Creek, Dst. Brookfield WWTP, US 62	0.3[W]	0.07	2.4	0.2	0.7
South Branch Yankee Creek @ Warner Road	1.54[H]	0.05	0.31	0.04	0.7
Little Yankee Creek Watershed					
Little Yankee Creek, Albright-McKay Rd.	10.99[H]	0.08	0.61	0.1	0.68
Little Yankee Creek, Stewart-Sharon Rd.	9.56[H]	0.07	0.47	0.06	0.5
Little Yankee Creek, Chestnut Ridge Rd. (ust Hubbard)	7.95[H]	0.05	0.9	0.3	0.6

		Ammonia—N mg/L	Nitrate+Nitrite-N mg/L	Phosphorus-T mg/L	Total KJEL Nitrogen mg/L
Reference Value (Headwater/ Wading)		**0.19/0.125**	**2.701/1.817**	**0.214/0.200**	**1.080/0.900**
Stream	**River Mile***	**Mean**	**Mean**	**Mean**	**Mean**
Little Yankee Creek, Adj. Valley Mould	5.0[W]	0.10	0.36	0.07	0.66
Little Yankee Creek, Ust Hubbard WWTP @ Mill St.	4.70[W]	0.07	0.3	0.05	0.6
Little Yankee Creek, Hubbard WWTP Effluent	4.59	0.05	4.60	2.37	0.94
Little Yankee Creek, Dst. Hubbard WWTP	4.4[W]	0.07	1.44	0.7	0.7
Little Yankee Creek, Chestnut Ridge Rd. (near Masury)	1.58[W]	0.09	0.34	0.06	0.8
Little Deer Creek, St. Rt. 304	0.40[H]	0.06	0.29	0.05	0.48
Mud Run, North Main St.	0.07[H]	0.05	0.37	0.03	0.45

* - [H] = Headwater; [W] = Wading

Chemical Water Quality Trends, 1994-2008

Most of the streams in the Ohio Tributaries to the Shenango River survey were sampled for the first time in 2008. However, five streams that were sampled during Ohio EPA's last survey of the watershed in 1994 were reassessed for trends purposes in 2008. Those streams are listed and discussed below. Due to resounding watershed influences (habitat, septic systems, and agriculture), dissolved oxygen and nutrient parameters were chosen for comparison.

Pymatuning Creek

Figure 9 shows the longitudinal trend of the mean concentrations of dissolved oxygen, ammonia, nitrate+nitrite, phosphorus, and TKN. As evident from the figure, low dissolved oxygen continues to be problematic in both years in the lower portion of Pymatuning Creek where low gradient wetland conditions persist. The closing of the Kraft Dairy WWTP after the 1994 survey led to reductions in ammonia, phosphorus, and TKN in the 2008 survey downstream from the plant's discharge at RM 17.3. The elimination of this discharge, however, has exposed the effect of several private septic outfalls that are located at about RM 15.7. Ammonia jumps markedly downstream of the outfalls at RM 15.2 before returning to background levels at RM 8.4. Nitrate+nitrite continues to be elevated in the headwaters where agricultural land use is heavy.

Sugar Creek

Sugar Creek, a tributary to Pymatuning Creek at RM 16.65, was sampled at RM 0.92 in both 1994 and 2008. Chemical water quality was consistent in both years, showing a slight decline in concentrations of nutrients in 2008

Yankee Creek

Concentrations of ammonia-N, nitrate+nitrite-N, total phosphorus, and TKN show an increase downstream from the Brookfield WWTP in both 1994 and 2008 (Figure 10); however, the overall concentration of these parameters declined in 2008. This may reflect improvements to the Brookfield WWTP treatment system. Dissolved oxygen concentrations were consistent with instream habitat in both years; wetland habitat in the headwaters and impounded conditions in the lower reach allowed for lower dissolved oxygen values at RMs 11.34 and 0.3 as compared to that at RM 1.23. TKN was markedly higher at RM 11.34 in 2008 and may indicate higher loadings of organic waste into the headwaters of Yankee Creek via septic system failures, agricultural runoff, and/or manure from livestock.

Little Yankee Creek

Concentrations of ammonia-N, nitrate+nitrite-N, total phosphorus, and TKN show an increase downstream from the Hubbard WWTP in both 1994 and 2008 (Figure 11); however, the overall concentrations of these parameters declined in 2008, as seen at RM 4.4. This may reflect improvements to the Hubbard WWTP treatment system. However, concentrations of ammonia-N and TKN increased at RM 1.58 in 2008, which may indicate higher loadings of organic waste via septic system failures, agricultural runoff and/or manure from livestock.

Little Deer Creek

Little Deer Creek, a tributary to Little Yankee Creek at RM 4.08, flows through a rural-residential area of Hubbard Township. Chemical water quality in 2008 was, for the most part, similar to that of 1994, with dissolved oxygen values being slightly higher in 2008.

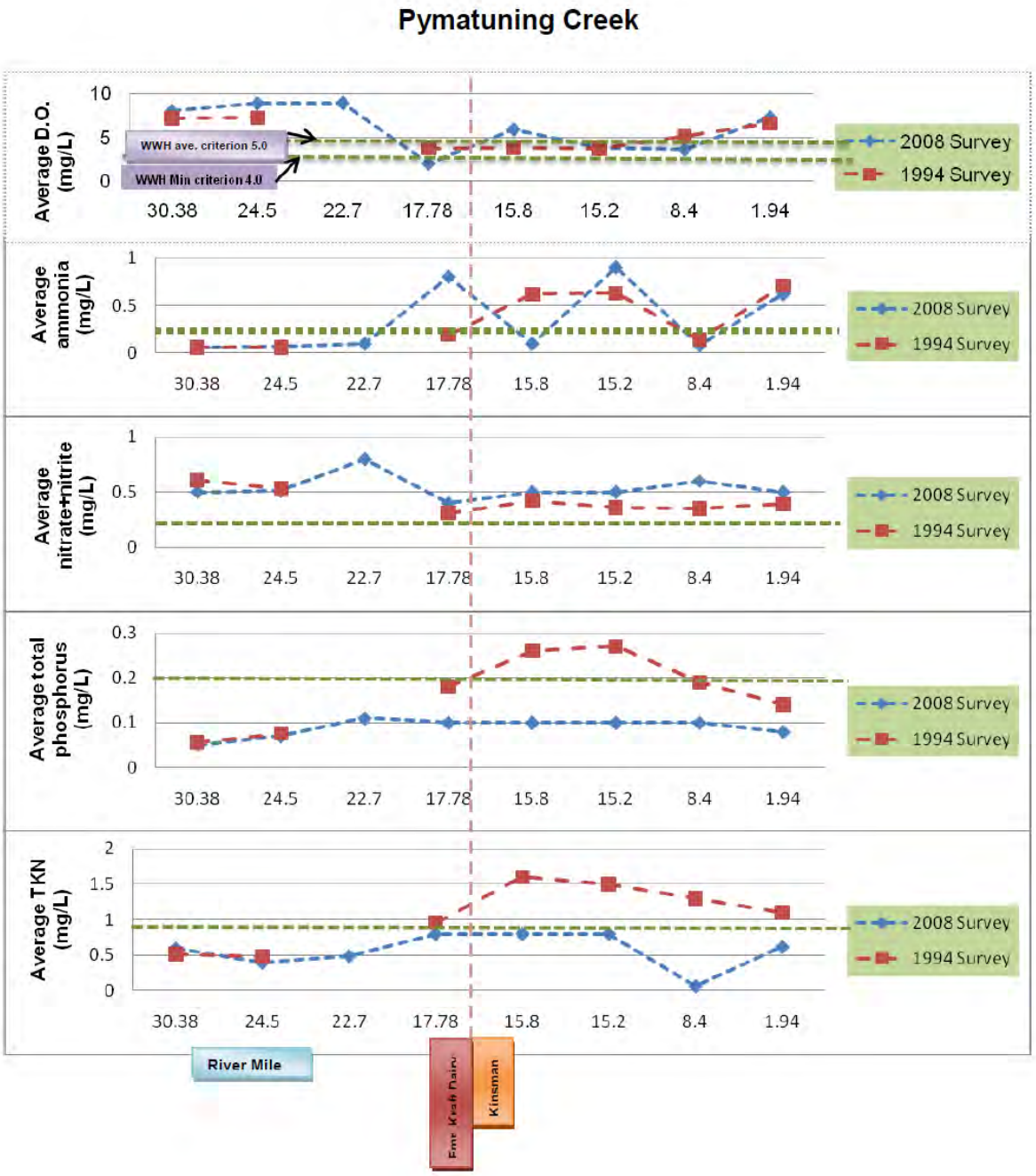


Figure 9. Longitudinal plots of mean concentrations of dissolved oxygen (D.O.), ammonia-N, nitrate+nitrite-N, total phosphorus, and total kjeldahl nitrogen (TKN) for Pymatuning Creek, 1994 and 2008. Dashed horizontal lines represent minimum water quality standards criteria for D.O. and the 90th percentile reference values for the Erie-Ontario Lake Plain (EOLP) ecoregion for the other parameters.

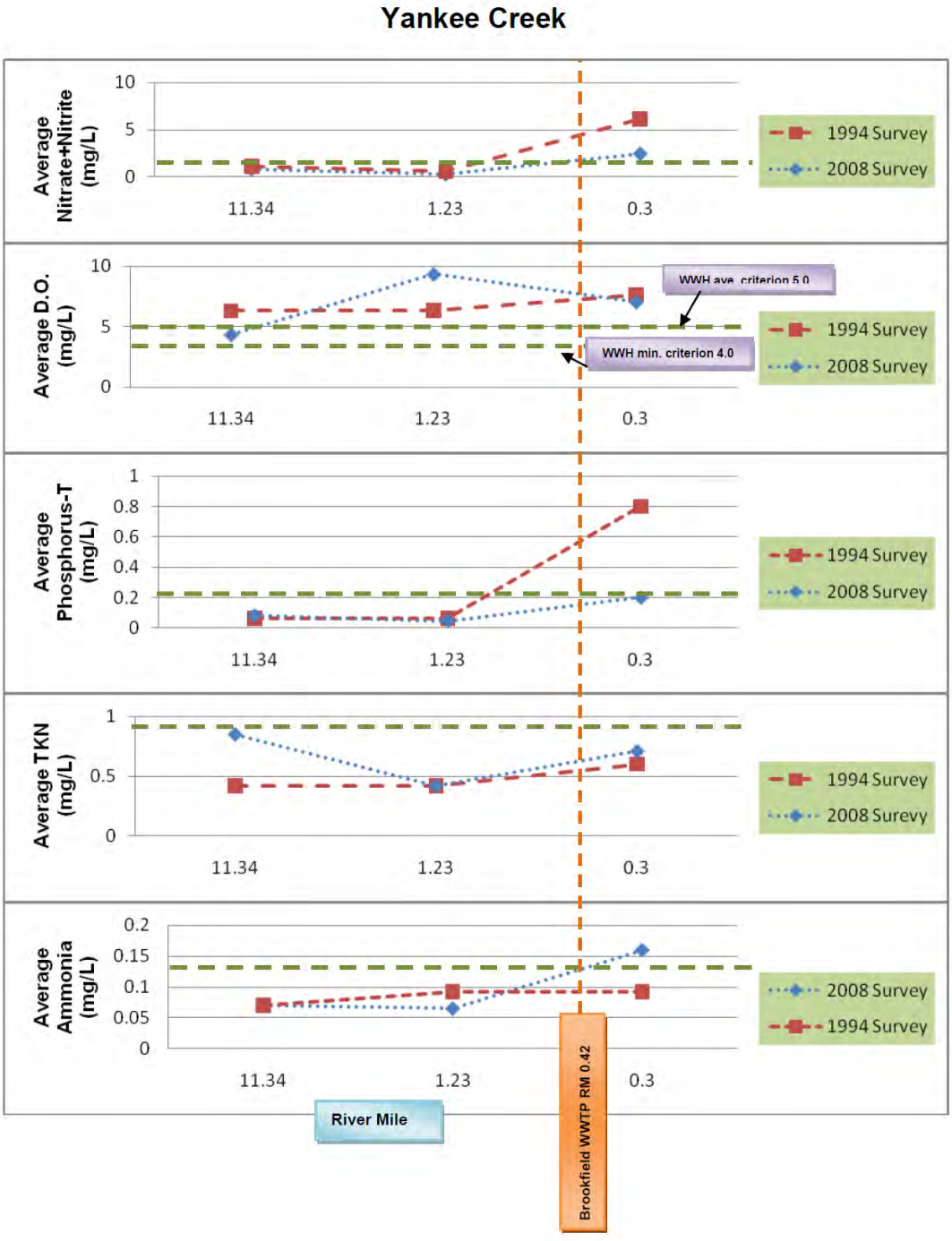


Figure 10. Longitudinal plots of mean concentrations of dissolved oxygen (D.O.), ammonia-N, nitrate+nitrite-N, total phosphorus, and total kjeldahl nitrogen (TKN) for Yankee Creek, 1994 and 2008. Dashed horizontal lines represent minimum water quality standards criteria for D.O. and the 90th percentile reference values for the Erie-Ontario Lake Plain (EOLP) ecoregion for the other parameters.

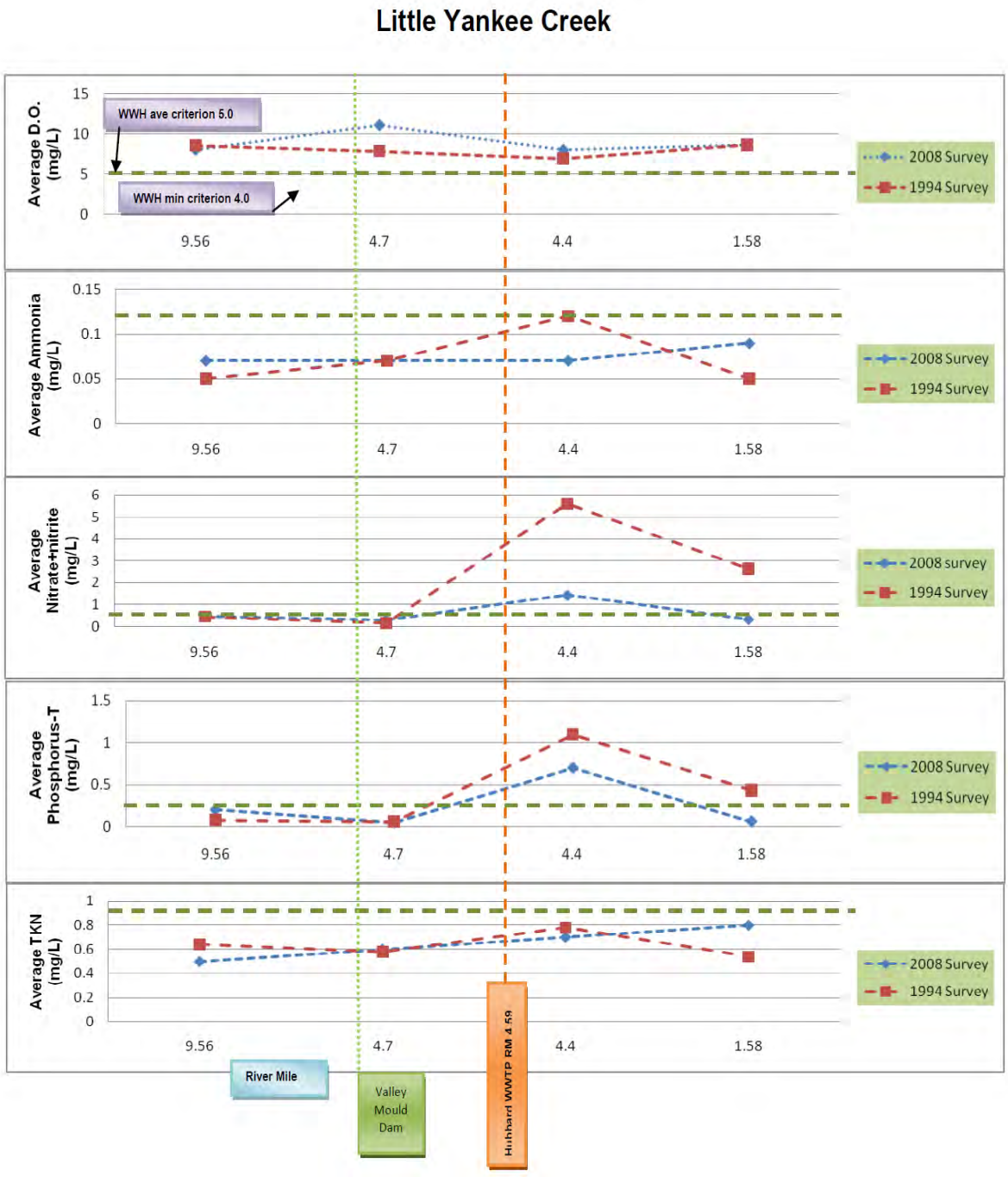


Figure 11. Longitudinal plots of mean concentrations of dissolved oxygen (D.O.), ammonia-N, nitrate+nitrite-N, total phosphorus, and total kjeldahl nitrogen (TKN) for Little Yankee Creek, 1994 and 2008. Dashed horizontal lines represent minimum water quality standards criteria for D.O. and the 90th percentile reference values for the Erie-Ontario Lake Plain (EOLP) ecoregion for the other parameters.

Sediment Chemistry

A sediment sample was collected from Little Yankee Creek behind the Valley Mould Dam at RM 5.0 on October 9, 2008. The sample was analyzed for metals, semivolatile organic compounds, nutrients and particle size. Specific chemical parameters tested with results are listed in Tables 8 and 9. Sediment data were evaluated using guidelines established in *Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems* (MacDonald *et.al*. 2000), and *Ohio Specific Sediment Reference Values (SRVs)* for metals (Ohio EPA 2003). The consensus-based sediment guidelines define two levels of ecotoxic effects. A *Threshold Effect Concentration* (TEC) is a level of sediment chemical quality below which harmful effects are unlikely to be observed, and is comparable to background conditions. A *Probable Effect Concentration* (PEC) indicates a level above which harmful effects are likely to be observed.

The sediment was conservatively sampled by focusing on depositional areas of fine grain material (silts and clays). These areas typically are represented by higher contaminant levels, compared to sands and gravels. All sediment sampling occurred along the stream bank or directly behind the Valley Mould Dam. These areas comprised only a small fraction of the bottom substrate of the streams surveyed.

Bottom substrate at this site was dominated by deep and heavy muck. Organic chemical parameters were tested at this site and are noted in Table 9. All but four organic chemicals (chrysene, ethylbenzene, phenanthrene, and pyrene) were reported as not detected and were within acceptable ecological levels. Several metals, including cadmium, chromium, copper, lead, iron and manganese were above the SRVs for the Erie-Ontario Lake Plain ecoregion. Arsenic, nickel, lead, copper and cadmium were all above the TEC benchmarks. The presence and concentration of these metals are likely related to historical steel operations adjacent to the stream, which included landfilling baghouse dust and foundry sand on-site. Impounded conditions and profound sedimentation (sediment contained behind the dam is at least 10 feet deep caused by the dam contributed to impaired benthic communities in the 2008 study. The high metal concentrations in the sediment were probably a secondary cause of impairment to the benthos.

Table 8. Metal parameters measured above screening levels in sediment samples collected from Little Yankee Creek, (behind the Valley Mould Dam), RM 5.0. Results are reported in mg/kg dry weight. Contamination levels were determined for parameters using consensus-based sediment quality guidelines (MacDonald et.al. 2000). Sediment reference values are listed in the Ohio EPA Ecological Risk Assessment Guidance (2003). Shaded numbers indicate values above the following: Probable Effect Concentration – PEC (red), Threshold Effect Concentration -TEC (yellow), and Sediment Reference Value (orange).

Parameter	Units	Result	SRV	PEC	TEC
% Solids	%	40.2	--	--	--
Arsenic	mg/kg	17.7	25.1	33.0	9.79
Cadmium	mg/kg	1.01	0.79	5.00	0.99
Chromium	mg/kg	29.9	29.0	111	43.4
Copper	mg/kg	65.3	32.0	--	32.0
Lead	mg/kg	150	47	128	36.0
Nickel	mg/kg	24.2	33	49.0	23.0
Selenium	mg/kg	Below detection	1.7	--	--
Aluminum	mg/kg	9180	29000	--	--
Barium	mg/kg	95.6	190	--	--
Calcium	mg/kg	12100	21000	--	--
Iron	mg/kg	70200	41000	--	--
Magnesium	mg/kg	3140	7100	--	--
Manganese	mg/kg	1760	1500	--	--
Potassium	mg/kg	Below detection	6800	--	--
Strontium	mg/kg	38	62.0	--	--
Zinc	mg/kg	280	160	459	121
Mercury	mg/kg	0.06	0.12	1.06	0.18

Table 9. Organic parameters measured (mg/kg) above screening levels in sediment samples collected from Little Yankee Creek (behind the Valley Mould Dam), RM 5.0. The Ecological Screening Levels for sediment are based on MacDonald et al. 2000). Shaded numbers indicate values above the Probable Effect Concentration – PEC.

Parameter	Units	Result	Ecological Screening Levels
% Solids	%	42.3	--
2,4-Dimethylphenol	mg/kg	Below detection	0.304
2-Methylnaphthalene	mg/kg	Below detection	0.0202
2-Methylphenol	mg/kg	Below detection	--
3&4-Methylphenol	mg/kg	Below detection	--
Acenaphthene	mg/kg	Below detection	0.00671
bis(2-Ethylhexyl)phthalate	mg/kg	Below detection	--
Chrysene	mg/kg	1.49	0.166
Dibenzofuran	mg/kg	Below detection	0.449
Ethylbenzene	mg/kg	2.27	0.175
Fluoranthene	mg/kg	Below detection	0.423
Fluorene	mg/kg	Below detection	0.0774
Naphthalene	mg/kg	Below detection	0.176
Phenanthrene	mg/kg	1.51	0.204
Pyrene	mg/kg	1.92	0.195

Stream Physical Habitat

All or portions of the Shenango River tributaries contained within the State of Ohio were surveyed and assessed in 2008. These waters included the mainstem and principal tributaries of the Pymatuning Creek, Yankee Creek, and Little Yankee Creek watersheds and four direct tributaries to the Pymatuning Reservoir, a large impoundment on the upper Shenango River, straddling the boundary between Ohio and Pennsylvania.

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 in-stream 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 Qualitative Evaluation Index (QHEI) score which generally ranges from 20 to less than 100. Mean QHEI values from rivers or river segments equal to or greater than 60.0 generally indicate a level of macrohabitat quality sufficient to support an assemblage of aquatic organisms fully consistent with the Warmwater Habitat (WWH) aquatic life use designation. Average reach values at greater than 75.0 are generally considered adequate to support fully Exceptional Warmwater Habitat (EWH) communities (Rankin 1989 and Rankin 1995). Values between 55 and 45 indicate limiting components of physical habitat are present and may exert a negative influence upon ambient biological performance. However, due to the potential for compensatory stream features (e.g., strong ground water influence) or other watershed variables, QHEI scores within this range do not necessarily exclude WWH or even EWH assemblages. Values below 45 indicate a higher probability of habitat derived aquatic life use impairment.

Pymatuning Reservoir Tributaries

The northern limits of the of the 2008 study area were defined by a suite of four small direct tributaries to the impounded headwaters of the Shenango River (i.e., Pymatuning Reservoir). From north to south, these streams included, Gravel Run, Wade Creek, Black Creek, and McMichael Creek. The quality of near and instream macrohabitat was assessed at one location on each waterbody.

Taken together, QHEI scores for these upper Shenango tributaries ranged between 65.0 and 70.5, with an average of 68.7 (Table 10). Without the aid of direct field observation these scores would seem to indicate a relatively high biological potential for all four of the tributaries. However, the range of conditions, both local and subregional, require further discussion to fully articulate ambient biological potential as it relates to macrohabitat quality.

The uppermost tributary, Gravel Run, was sampled at RM 1.2 (Lake Rd), and yielded a QHEI score of 65.0. Despite a relatively high gradient (18.52 ft./mile, derived from 7.5' USGS quadrangle), the reach showed a locale or functional gradient very near zero, and possessed all of the negative or otherwise naturally limiting features common to a rheopalustrine stream. This apparent contradiction between calculated gradient and observed condition appeared primarily a result of a local impoundment achieved by a beaver dam situated at the downstream limit of the sampling reach. This natural structure effectively impounded the entire 150 meter sampling zone. A second and equally important observation is the station's close proximity to the Pymatuning Reservoir. A field investigation of stream conditions downstream from the beaver dam and outside of the sampling zone indicated slack flow and other low energy channel features. Even in the absence of the beaver dam, lower Gravel Run appeared to function as a backwater of the reservoir, and as such, lower Gravel Run is very likely inhibited by the duel impoundments from supporting an assemblage of aquatic organisms fully consistent with the prescribed biocriteria.

As measured purely by the QHEI, both Wade and Black creeks were found to contain high quality macrohabitat, achieving a score of 69.0 and 70.5, respectively. Both were free from the ponding influence of beavers or the Pymatuning Reservoir, and contained a full complement of high quality channel and substrate features typical of the ecoregion. However, there were visual indicators that these waters may be interstitial or even intermittent. Although adequate flow was observed at the time of the habitat evaluation, riffle areas were shallow and poorly developed. Furthermore, a cursory investigation

of the associated substrates of riffle, runs, and glides appeared lacking biofilms, encrusting algae, and other indicators of perennial flow. As the spring and early summer of 2008 received anomalously high precipitation (Ohio DNR 2008), perhaps the flows observed in both Wade and Black creeks were higher than typical, giving the impression of perennial flow, when in fact all or portions of these streams may run dry or at a minimum de-water to the point of interstitial flow over the course of the summer. Although not conclusive, the combination of these observations suggested that both Wade and Black Creeks may be biologically limited, or the ambient biological potential may be overstated by current measures due to ephemerality.

The remaining upper Shenango River tributary, McMichael Creek, appeared fully capable of supporting WWH aquatic communities. The waterbody yielded a QHEI score of 70.5, and possessed a full suite of positive riparian, channel and substrate features. Furthermore, riffles runs and glides were well developed and appeared fully functional.

Pymatuning Creek

As part of the 2008 sampling effort, the quality of near and in-steam macrohabitats of the Pymatuning Creek mainstem were evaluated at seven sampling locations, assessing approximately 28 miles of the mainstem, between RM 30.4 (US 6) and RM 1.9 (state line at Orangeville). QHEI values ranged between 46.0 and 65.5, with a mean score of 56.9 ($\pm$8.117 SD). Longitudinal performance of the QHEI and a matrix of macrohabitat features, by station, are presented in Table 10 and Figure 12.

Positive microhabitat features common to most Pymatuning mainstem stations included the presence of well developed pools, an abundance of instream cover (in the form of fallen timber, log jams, root wads, and both emergent and submergent aquatic macrophytes), a persistent wooded riparian corridor, and to a lesser extent, adequate levels of sinuosity. Furthermore, obvious evidence of direct channel manipulation was apparent at only one station (RM 24.5, SR 322), and here only half of the reach sampled appeared modified. It is impossible to say with certainly that other segments were not at some time ditched, channelized or otherwise physically manipulated; however, based upon field observations, it was difficult to discern channel forms native to the subregion from segments that may have been modified in the past but have now recovered.

Although the positive attributes identified above represent important functional components of macrohabitat, all of the Pymatuning mainstem sites consistently lacked critical categories of macrohabitat commonly associated with WWH streams in Ohio. The first and most significant of these is the absence of coarse bed material. The dominant substrate types were sand, silt, detritus, hardpan and muck. An equally important deficiency was the lack of mixed current velocity and associated channel features (e.g., riffles, runs, swift glides, and developed lateral scour pools). Taken together theses substrate and channel deficits are primarily of natural origin and related directly to the low gradient, rheopalustrine conditions that typify the Pymatuning mainstem. With a gradient ranging between 0.67 and 3.68 ft. /mile (Figure 13), and an average of 1.96 ft/mile, the Pymatuning mainstem simply lacks the stream power to form and maintain a diverse and complex channel and to erode, transport, sort and deposit a range of coarser substrates from ready sources within the catchment.

An additional and obvious form of modification not yet identified included an impoundment resulting from a lowhead dam placed on the Pymatuning at the Ohio/Pennsylvania state line. The affected reach represented the lower limits of the 2008 study area, evaluated at RM 1.94 (Orange Rd). As with linear channel modifications observed upstream, the impoundment created by this dam appeared to have little discernable effect upon overall macrohabitat quality, as the form and function of this reach appeared almost indistinguishable from unimpounded, free flowing segments upstream. Given the prevailing low gradient conditions of the Pymatuning, most of the deleterious effects commonly associated with impoundments were of little consequence to local habitat quality, given the dominance of the pre-existing slack water habitat.

Despite the QHEI scores at or near the WWH threshold (QHEI=60.0) and a mainstem average (56.9) well within the limits consistent with WWH, the natural channel and substrate deficits represent a nearly insurmountable obstacle to WWH attainment. It is important to consider that the initial derivation of the

various biometrics (IBI, MIwb, and QHEI) employed by Ohio EPA were calibrated to typical conditions found throughout Ohio's five ecoregions (Omernik and Gallant 1988 and Whittier et al. 1987). As relatively intact, low gradient, wetland-type streams are uncommon in Ohio's modern landscape, the unique features, limits, and other intrinsic attributes of these waters were not adequately accounted for in biocriteria development. As such, the QHEI as presently constituted is undersensitve to the physical limits of rheopalustrine waters, and therefore failed to serve as a reliable predictor of ambient biological performance for streams so classified.

Given the natural limitations of wetland streams in general, the quaternary geologic antecedences of Pymatuning Creek, and the absence of properly calibrated biometrics for rheopalustrine streams, deviation from the prescribed biocriteria were considered likely. Furthermore, in the absence of significant and readily identifiable anthropogenic stress, failure of the Pymatuning to support an assemblage of aquatic organisms consistent WWH biocriteria is likely due to natural or structural (physical and hydrologic) causes.

Sugar Creek and Stratton Creek

Two direct Pymatuning Creek tributaries were surveyed and assessed as part of the 2008 field sampling effort, Sugar and Stratton creeks. Four sampling stations were deployed to these waters, two for each stream. Six linear miles of Sugar Creek were evaluated at RMs 5.7 (SR 88) and 0.9 (Burnett Rd.), and five linear miles of Stratton Creek were evaluated at RMs 4.5 (Weber Rd) and 0.7 (Kinsman-Nickerson Rd.).

Both of these waterbodies drain a mix of dissected ground moraine and end moraine (linear and nonlinear), but unlike the Pymatuning mainstem, the drainage network is geologically young, or rejuvenated through glacial action. As a result, the average gradients of Sugar and Stratton creeks were an order of magnitude greater than that observed for the Pymatuning (Figure 13) and possessed a full suite of positive channel and substrate features typical of the region. Correspondingly, these attributes were reflected in site-specific and average QHEI values consistent with WWH aquatic communities. Although, visual evidence of historic channel modification was present at three of the four stations, only upper Sugar Creek (RM 5.7) showed a delayed recovery from past manipulation. Here the stream was well entrenched with less lateral development and generally finer substrates, and thus yielded a QHEI score of 54.0. Although not profoundly degraded, this result suggests the possibility of habitat-related aquatic life use impairment, particularly if compounded by additional anthropogenic stress.

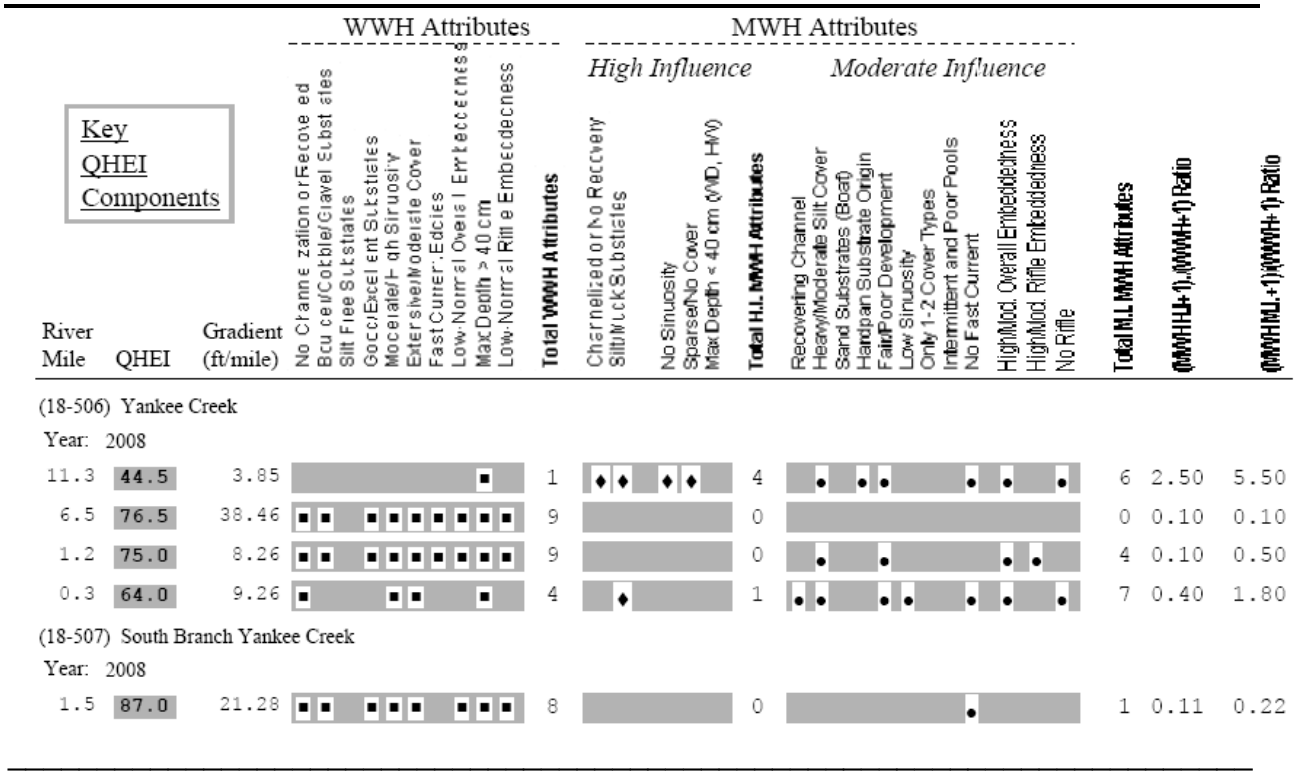
Table 10. A matrix of macrohabitat features and QHEI scores for the Ohio Tributaries to the Shenango River study area, 2008.

River Mile	QHEI	Gradient (ft/mile)	WWH Attributes: No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Substrates	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low-Normal Overall Embeddedness	Max Depth > 40 cm	Low-Normal Riffle Embeddedness	Total WWH Attributes	MWH Attributes — High Influence: Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD, HW)	Total H.I. MWH Attributes	MWH Attributes — Moderate Influence: Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Handpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1-2 Cover Types	Intermittent and Poor Pools	No Fast Current	High/Mod. Overall Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	Total M.I. MWH Attributes	(MWHI+1)/(WWH+1) Ratio	(MWHM+1)/(WWH+1) Ratio
(18-550) Pymatuning Creek																																	
Year: 2008																																	
30.4	55.0	3.68	■					■			■		3	♦		♦	♦		3	•		•			•		•	•		•		5	1.00	2.25
29.1	65.5	3.68	■		■	■	■	■			■	■	6						0	•	•		•		•		•					5	0.14	0.86
24.5	46.0	3.05	■					■			■		3	♦	♦			♦	3		•		•	•	•		•		•		•	7	1.00	2.75
22.7	46.0	3.05				■					■		2		♦			♦	2	•	•		•	•	•		•		•		•	8	1.00	3.67
6.1	64.0	0.67	■			■	■			■	■		5		♦				1		•		•				•				•	4	0.33	1.00
1.9	60.5	0.67	■			■	■			■	■		5		♦				1		•		•				•		•	•	•	5	0.33	1.17
1.5	61.0	1.27	■			■	■			■	■		5		♦				1	•	•		•				•		•	•	•	6	0.33	1.33
(18-554) Stratton Creek																																	
Year: 2008																																	
4.2	61.5	47.62	■	■		■	■	■			■		6	♦		♦	♦		3			•			•		•	•		•		4	0.57	1.14
0.7	68.5	8.47		■			■				■	■	4			♦			1	•	•		•		•		•					5	0.40	1.40
(18-556) Sugar Creek																																	
Year: 2008																																	
5.7	54.0	13.33		■			■	■			■	■	5			♦	♦		2	•	•		•		•		•	•		•		6	0.50	1.50
0.9	77.0	7.83	■			■	■	■			■	■	7						0			•			•							2	0.13	0.38
(18-570) McMichael Creek																																	
Year: 2008																																	
1.3	70.5	34.48	■	■		■	■	■			■	■	8				♦		1						•							1	0.22	0.33
(18-571) Black Creek																																	
Year: 2008																																	
1.4	70.5	37.04	■			■	■	■			■	■	7						0			•			•							2	0.13	0.38
(18-572) Gravel Run																																	
Year: 2008																																	
1.2	65.0	18.52	■			■	■				■		4				♦		1	•		•			•		•	•		•		5	0.40	1.40

Table 10. continued.

River Mile	QHEI	Gradient (ft/mile)	WWH Attributes: No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Substrates	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low-Normal Overall Embeddedness	Max Depth > 40 cm	Low-Normal Riffle Embeddedness	Total WWH Attributes	MWH Attributes: High Influence: Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD, HW)	Total H.I. MWH Attributes	Moderate Influence: Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1-2 Cover Types	Intermittent and Poor Pools	No Fast Current	High/Mod. Overall Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	Total M.I. MWH Attributes	(MWH H.I.+0)/(MWH+1) Ratio	(MWH H.I.+1)/(MWH+1) Ratio
(18-504) Little Yankee Creek																																	
Year: 2008																																	
10.9	75.0	18.87	■	■		■	■	■		■	■	■	8			♦			1			•			•			•	•	•	4	0.22	0.67
9.6	66.0	17.86	■							■	■	■	4			♦	♦		2	•	•	•			•			•	•	•	6	0.60	1.80
8.0	76.0	12.99	■	■	■			■	■	■	■	■	8			♦	♦		2			•									1	0.33	0.44
4.7	79.0	13.45	■	■		■		■	■			■	6						0				•						•	•	3	0.14	0.57
4.4	75.5	11.90	■	■		■		■	■			■	6						0			•	•						•	•	4	0.14	0.71
1.4	74.5	12.20		■		■		■	■	■	■	■	7						0	•		•	•									3	0.13	0.50
(18-505) Little Deer Creek																																	
Year: 2008																																	
0.5	67.5	15.38	■	■		■	■	■		■	■	■	8						0			•						•	•	•	3	0.11	0.44
(18-506) Yankee Creek																																	
Year: 2008																																	
11.3	44.5	3.85									■		1	♦	♦		♦	♦	4	•		•	•					•	•	•	6	2.50	5.50
6.5	76.5	38.46	■	■		■	■	■	■	■	■	■	9						0												0	0.10	0.10
1.2	75.0	8.26	■	■		■	■	■	■	■	■	■	9						0		•		•						•	•	4	0.10	0.50
0.3	64.0	9.26	■				■	■			■		4		♦				1	•	•	•	•					•	•	•	7	0.40	1.80
(18-528) Mud Run																																	
Year: 2008																																	
0.7	57.0	25.00	■	■		■	■				■		5			♦	♦		2									•	•	•	3	0.50	1.00
0.1	35.5	0.10		■				■			■		3	♦	♦		♦		3	•		•						•	•	•	5	1.00	2.25
(18-575) Wade Creek																																	
Year: 2008																																	
1.8	69.0	22.22	■	■		■	■	■		■		■	7				♦	♦	2									•			1	0.38	0.50

Table 10. continued.



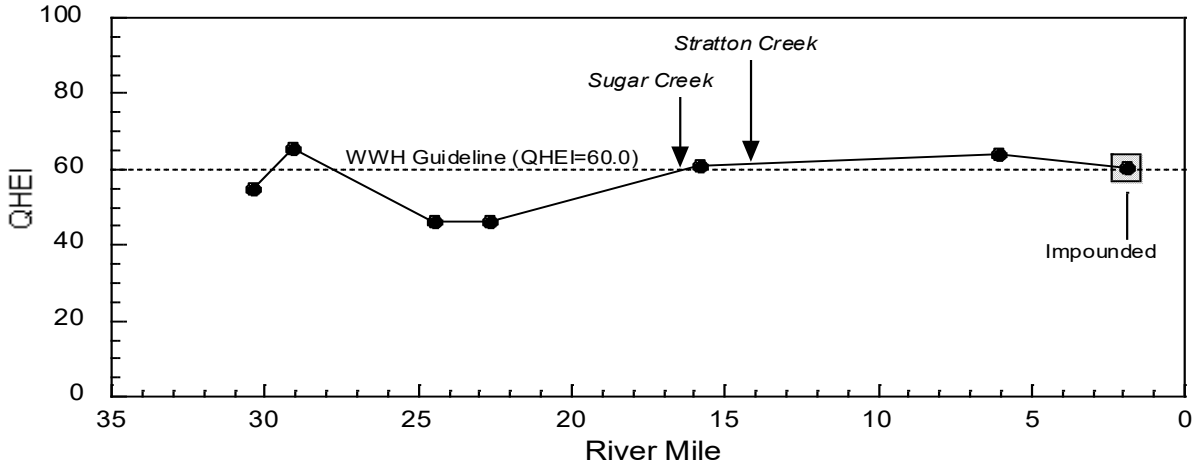


Figure 12. Longitudinal performance of the Qualitative Habitat Evaluation Index (QHEI) for Pymatuning Creek (mainstem), 2008. Dashed lines represent QHEI values associated with, WWH communities. Arrows and lines identify points of discharge for significant NPDES permitted entities, potential pollution sources, important tributaries, or other relevant points of interest.

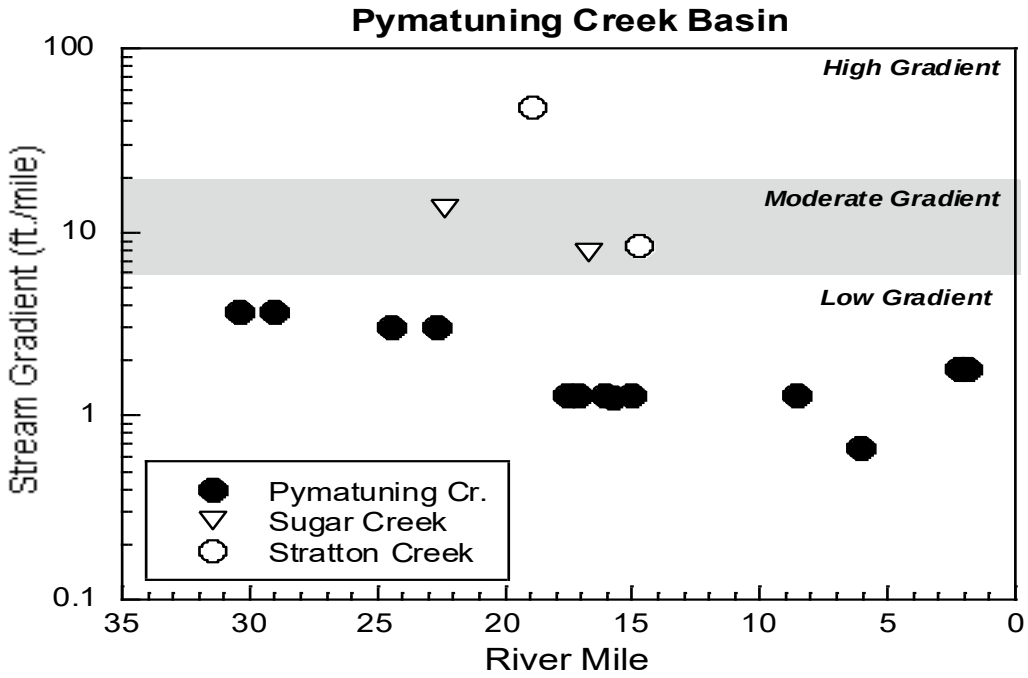


Figure 13. Longitudinal stream gradients for the Pymatuning Creek (mainstem) and principal tributaries. Note: very low gradients of the mainstem.

Yankee Creek
The quality of the near and instream macrohabitats of Yankee Creek were evaluated at four sampling locations, assessing approximately 12 miles of the mainstem, between RM 11.3 (SR 305) and RM 0.3 (US 62). QHEI values ranged between 44.5 and 76.5, with a mean score of 65.0 (±8.117 SD). Longitudinal performance of the QHEI and a matrix of macrohabitat features, by station, are presented in Table 10 and Figure 14.

As measured by the QHEI, significantly deficit macrohabitat on Yankee Creek was limited to the uppermost station at RM 11.3, which yielded a QHEI score in the poor range (44.5). This steam reach was unique among the southern Shenango tributaries (Yankee and Little Yankee basins) evaluated in 2008, as it is contained within and drains a remnant uneroded, high glacial terrace and thus possessed a low gradient (Figure 15). This "high flat" originally supported wetlands or swamp forests perched well above the valley floor (Shanks 1937). As a result, upper Yankee Creek shared many of biologically limiting features with the sluggish and low gradient Pymatuning mainstem. The poorly drained nature of area necessitated artificial drainage and this, coupled with the low energy of rheopalustrine stream types, resulted in the habitat deficit observed at RM 11.3. These deleterious features included low gradient, an absence of coarse substrates, limited channel development and low sinuosity, resulting in a dominance of high and moderate influence modified habitat attributes. The combination of naturally low biological potential and the direct effects of pervious drainage improvements were reflected in a very low QHEI score and indicated a high probability of habitat-related impairment.

Despite a QHEI score well within the WWH range, a moderate habitat deficit was also observed on lower Yankee Creek, at RM 0.3 (US 62, downstream Brookfield WWTP). Specifically, this reach is affected by a lowhead dam on the Shenango River that is located just downstream from where Yankee Creek meets the Shenango. The ponding or backwater effects were not so severe as to render lower Yankee Creek lacustrine, but appeared to retard flow enough to affect channel development and substrate composition. Although by no means profoundly degraded, reduced current velocities associated with the backwater effect on lower Yankee Creek may serve to limit ambient biological performance.

The intervening Yankee Creek stations were found to contain a suite of near and instream habitat features that appeared capable of supporting an assemblage of aquatic communities fully consistent with the existing WWH biocriteria.

South Branch Yankee Creek
South Branch Yankee Creek is the principal tributary to Yankee Creek proper. The quality of near and instream macrohabitat of this waterbody was appraised at one sampling location at RM 1.5 (Warner Rd). As indicated by the QHEI, the South Branch was found to contain a full suite of positive near and instream habitat features, yielding a QHEI score of 87.0. The channel configuration of the mainstem appeared in a natural state, displaying a high degree of sinuosity and good development. Dominant substrates were a mixture of coarse tills (gravel, cobble, and boulders) and native sandstone, both being generally unencumbered with extensive deposits of clayey silts. Riparian areas were well vegetated to fully wooded, attenuating sunlight and providing instream structure in the form of woody debris and rootwad formations. Aquatic life use impairment derived from deficient or otherwise substandard macrohabitat quality did not appear likely through lower South Branch Yankee Creek

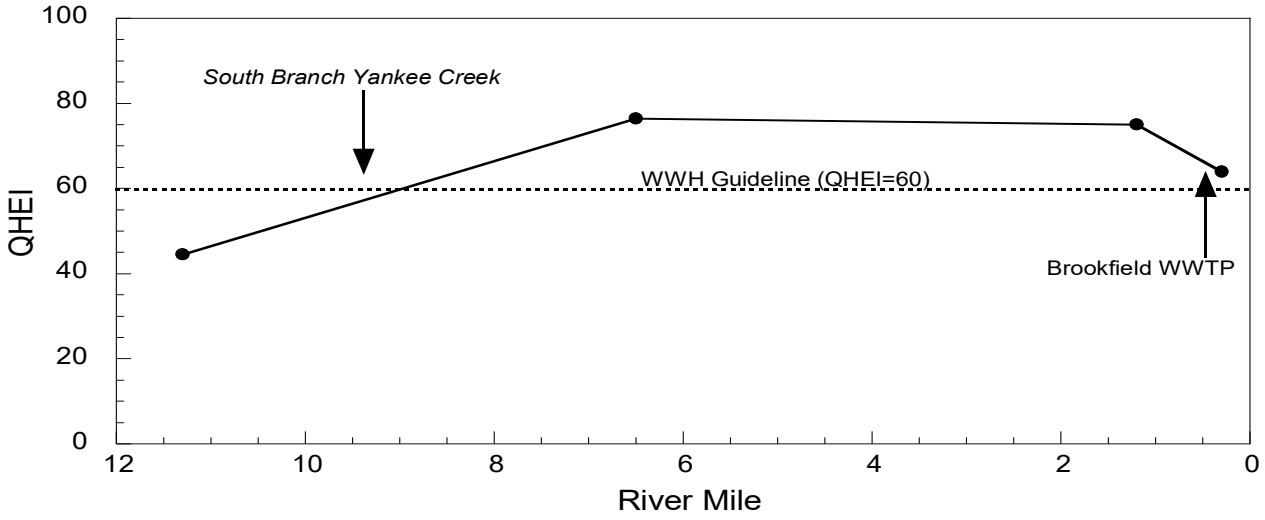


Figure 14. Longitudinal performance of the Qualitative Habitat Evaluation Index (QHEI) for Yankee Creek, 2008. Dashed lines represent QHEI values associated with, WWH communities. Arrows identify points of discharge for significant NPDES permitted entities, potential pollution sources, important tributaries, or other relevant points of interest.

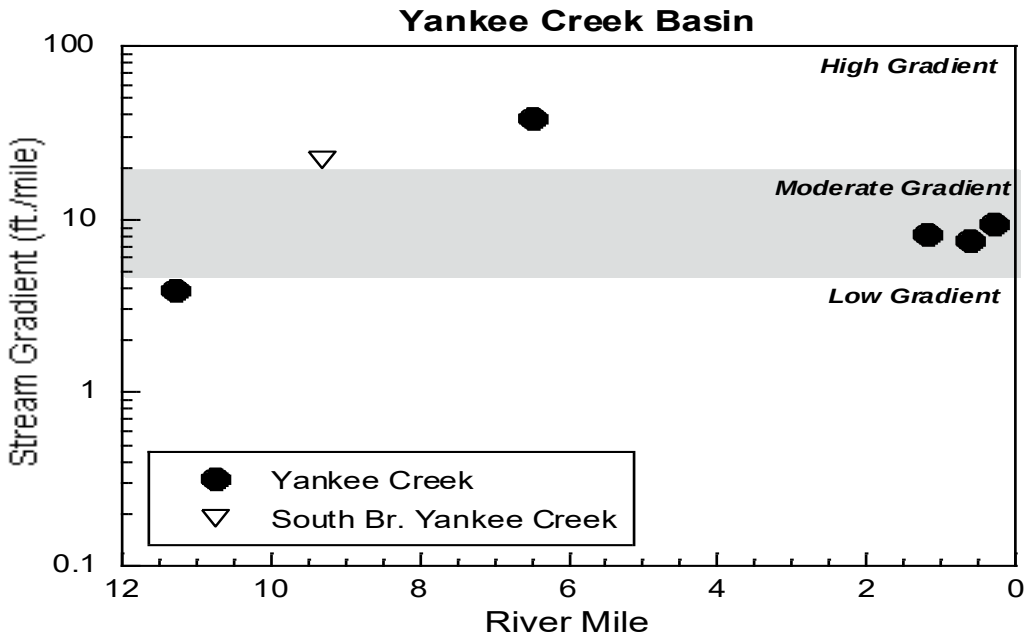


Figure 15. Longitudinal stream gradients for Yankee Creek and its principal tributary South Branch Yankee Creek. Note: low gradient of the uppermost Yankee Creek station.

Little Yankee Creek
The quality of near and in-steam macrohabitats of Little Yankee Creek were evaluated at six sampling locations, assessing approximately 11.0 miles of the mainstem, between RM 10.9 (Albright-McHay Rd.) and RM 1.4 (Chestnut Ridge Rd.). QHEI values ranged between 66.0 and 79.0, with a mean score of 74.5 (±4.405 SD). Longitudinal performance of the QHEI and a matrix of macrohabitat features, by station, are presented in Table 10 and Figure 16.

Owing to moderate to high gradient and subregional topography, deficient or otherwise degraded macrohabitat was not observed on Little Yankee Creek (Figure 17). Positive habitat attributes (channel, substrate, and riparian) were overwhelmingly dominant at most sites as the mainstem reflected a QHEI average within the exceptional range. Based upon QHEI scores and related field observations, Little Yankee Creek appeared fully capable of supporting an assemblage of aquatic organisms fully consistent with the prescribed WWH biocriteria.

Mud Run and Little Deer Creek
Mud Run and Little Deer Creek constitute the principal tributaries of Little Yankee Creek. Three stations were allocated to evaluate these waters: two on Mud Run at RMs 0.7 (adj. Main St./US 62, Hubbard) and 0.1 (at Main St./US 62, Hubbard), and one on Little Deer Creek at RM 0.5 (SR 304).

The lower Mud Run sampling effort was entirely within the urbanized municipal limits of Hubbard. QHEI values were 57.0 and 35.5, at RM 0.7 and 0.1, respectively, and indicated fair to poor macrohabitat quality. The upper station was largely in a natural state, with moderate sinuosity, good development, and coarser and less embedded substrates, than observed downstream. The lower station was physically and hydrologically modified by the combined effects of impoundment and past channelization. Here the stream is monotonous in form and function, showing limited sinuosity, poor channel development, and a dominance of fine substrates. Both stations labored under the combined effects of diffuse pollution sources and the artificial hydrology associated with an urban landscape. Based upon the QHEI scores and related observations, macrohabitat may serve to limit ambient biological performance through lower Mud Run.

Arising near the Ohio/Pennsylvania state line and draining a largely rural landscape, Little Deer Creek offered vastly improved habitat in comparison with Mud Run. Sampled half a mile from its confluence with Little Yankee Creek (RM 0.5), Little Deer Creek yielded a QHEI score of 67.5, well within the range of values associated with WWH aquatic communities. The lower stream reach possessed a full complement of positive channel and substrate features. As such, habitat-derived aquatic life use impairment did not appear probable.

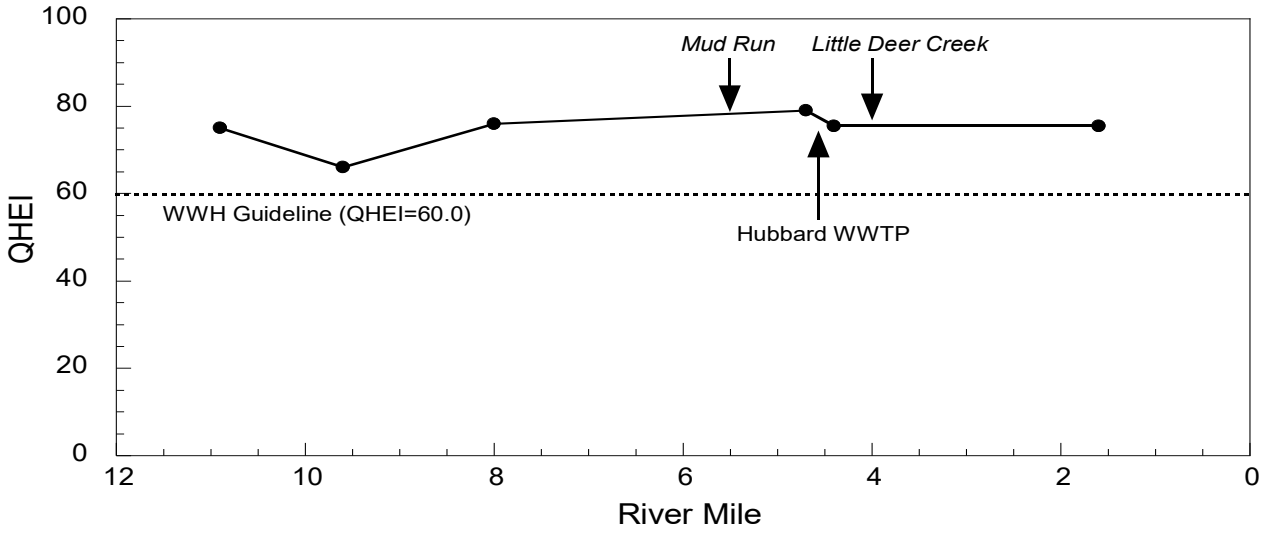


Figure 16. Longitudinal performance of the Qualitative Habitat Evaluation Index (QHEI) for Little Yankee Creek, 2008. Dashed lines represent QHEI values associated with, WWH communities. Arrows identify points of discharge for significant NPDES permitted entities, potential pollution sources, important tributaries, or other relevant points of interest.

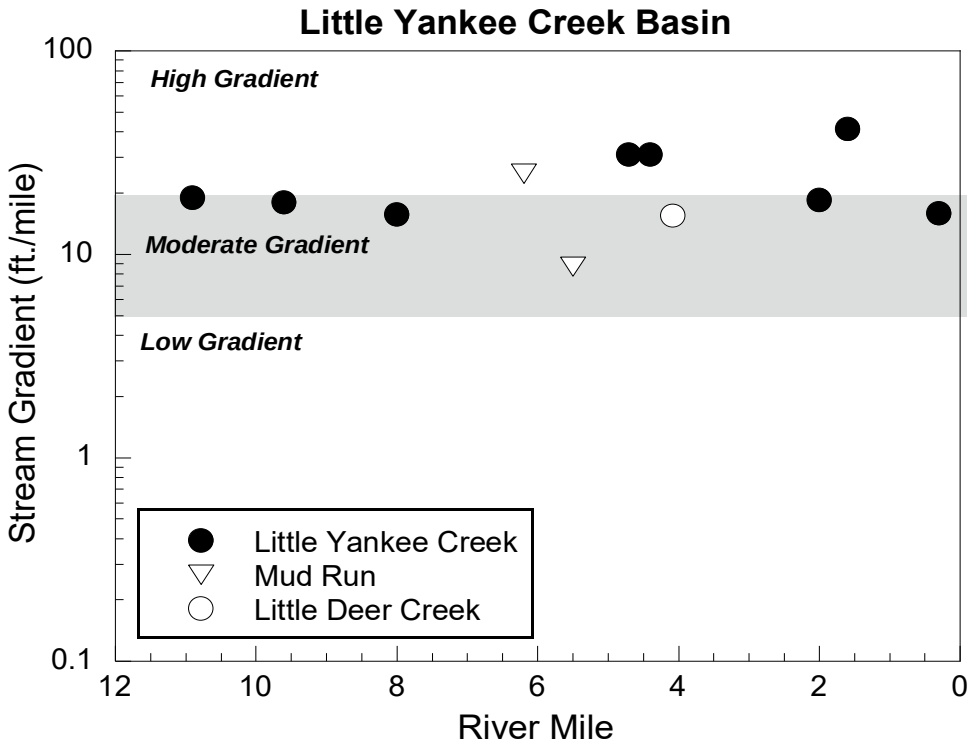


Figure 17. Longitudinal stream gradients for the Little Yankee Creek and its principal tributary South Branch Yankee Creek. Note: high to moderate gradients throughout the sub-basin.

Fish Community

Pymatuning Reservoir Tributaries

The fish assemblages of four direct headwater tributaries of the Pymatuning Reservoir were surveyed and assessed. These waters included Gravel Run, Wade Creek, Black Creek, and McMichael Creek. One fish sampling station was allocated on each waterbody.

Community indices and accompanying biological narratives ranged between fair (IBI=28) and marginally good (IBI=38). Summarized index scores and community statistics by stream and stations are presented in Table 11.

Both the northernmost and southernmost streams, Gravel Run and McMichael Creek respectively, were found to support fish assemblages consistent with the WWH biocriterion. Despite the ponding effects of both a local beaver dam and the Pymatuning Reservoir, community performance of Gravel Run remained within the area of non-significant departure from the prescribed WWH biocriterion. However, the composition of the fish assemblage itself clearly indicated the influence of the reservoir through the abundance of lacustrine or plaustrine taxa: common carp, pumpkinseed, golden shiner, yellow perch, gizzard shad, and brook silverside. Although these species are found in selected lotic environments, their large numbers in a small headwater stream is highly anomalous and thus demonstrated that lower Gravel Run serves as a backwater to the Pymatuning Reservoir. McMichael Creek, in contrast, supported a fairly typical lotic headwater community that appeared to comport with macrohabitat quality and subregional potential.

The intervening streams, Wade and Black creeks, were both found to be impaired. Based upon multiple lines of evidence, departure from the WWH biocriterion was attributed to possible ephemeral stream discharge. Although adequate flow was observed at the time the fish samples were collected, riffle areas were shallow and poorly developed. Furthermore, a cursory investigation of shallow water substrates found them lacking biofilms, encrusting algae, etc., commonly associated with perennial flowing waters. The composition of the fish communities also suggested intermittence, as they were dominated by highly tolerant, pioneering species (taxa adapted to ephemeral waters). As the spring and early summer of 2008 was noted for anomalously high precipitation (Ohio DNR 2008), perhaps the flows observed in both Wade and Black Creek were higher than typical, giving the impression of perennial flow, when in fact all or portions of these streams may run dry or at a minimum de-water to the point of interstitial flow over the course of the summer. Although not conclusive, the combination of these observations suggested that both Wade and Black Creek are biologically limited, or the ambient biological potential may be overstated by current measures, due to intermittent or interstitial discharge. However, the influence of urban runoff and treated wastewater from the City of Andover on Wade Creek could not be excluded as another possible contributing factor for the impairment.

Pymatuning Creek

A total of 4,099 fish comprising 31 species and four hybrids was collected from Pymatuning Creek between July and August, 2008. The fish sampling effort included seven sampling locations, assessing approximately 28 miles of the mainstem, between RM 30.4 (US 6)) and RM 1.9 (State line, at Orangeville).

Based on aggregated catch statistics, numerically predominant species (No./km) included bluntnose minnow (24.8%), white sucker (10.6%), bluegill (10.0%), johnny darter (9.9%), pumpkinseed (9.9%), and golden shiner (6.8%). In terms of relative biomass (kg/km), dominant species were common carp (46.7%), white sucker (19.6%), northern pike (6.1%), and spotted sucker (5.1%). The majority of the numerically dominant species included wetland or rheopalustrine stream associates, most of which are classified as environmentally tolerant (Ohio EPA 1987b). Fish biomass was overwhelmingly concentrated in common carp, a highly tolerant and adaptable, naturalized exotic species. Although the common carp can inhabit a wide range of habitats and environmental conditions, it is particularly well-adapted to low gradient waters (Cooper 1987), and thus thrives in the Pymatuning mainstem. The remaining dominant species, in terms of biomass, were primarily native wetland associates. The overall dominance of the taxa identified above (numerical abundance and biomass) was in perfect accord with the low gradient, rheopalustrine nature of the Pymatuning mainstem.

No fish species classified as rare, threatened, endangered, or otherwise recognized for special conservation status by the Ohio DNR (2003), were collected. Highly intolerant, declining or otherwise ecologically significant species (Ohio EPA 1987 and 1996) included only one taxon, banded darter. This species, however, was not evenly distributed throughout the mainstem, and, along with most other darter species observed, was limited in distribution to the uppermost sampling stations.

Presently, the entire length of Pymatuning Creek is designated WWH. Community indices and accompanying narrative evaluations for Pymatuning Creek ranged between fair (IBI=28/MIwb=6.4) and marginally good/good (IBI=38/MIwb=8.7). Overall, the fish assemblage was characterized as *fair*, as most stations failed to support an assemblage of fish fully consistent with the prescribed biocriteria. Longitudinal performance of the IBI, MIwb, and other relevant indicators are presented in Figure 19. Summarized index scores and community statistics by station are presented in Table 11.

As measured by the IBI and MIwb (the latter where applicable), community performance was more consistent with WWH through the upper four stations between RMs 30.4 (US 6) and 22.7 (Underwood Rd.). Although low, stream gradients through this reach were consistently higher than observed for the remaining downstream sites. Species richness estimates were correspondingly higher through the upper segment (Figure 18). This pattern is particularly noteworthy, as species richness of riverine environments typically *increases* longitudinally with increasing drainage area through the process of addition and replacement of taxa. For the Pymatuning, the relationship between drainage area and species richness was inverted, with the highest species richness occurring in the upper and middle segments.

Both the fish community measures (MIwb and IBI) demarked the lowest level of biological performance at RM 15.2 (SR 7 at Kinsman). The decline of the IBI at this location was specifically attributed to an increased proportion of omnivorous species, a decline in the proportion of specialist insectivores, and a significant increase in the incidence of gross external anomalies, the latter is being a consistent and reliable indicator of chronic sublethal stress (Figure 18). This overall decline in ambient biological performance did not correlate with a significant change in gradient, macrohabitat quality, or other structural attributes; rather, it appeared indicative of local phenomenon. Direct field observations from this location indicated that the Pymatuning receives a significant quantity of runoff from failing septic systems. Over the course of the summer sampling season, a very strong septic odor was consistently noted at this station, along with discrete deposits of black, septic sediments. The aggregate BOD load may have been adequate to depress D.O. concentrations, and thus engendered higher anomaly rates among the fish. Additionally, low D.O. stress would serve to suppress sensitive taxa through mortality or avoidance, while also making conditions more favorable to tolerant, generalist species. Although community performance around Kinsman was the lowest observed in 2008, when viewed within the context of overall depressed levels of performance that characterized the mainstem, the level of degradation was not strongly divergent from adjacent sites. Furthermore, the apparent effects of Kinsman's septic drainage are very likely exacerbated by the natural stresses and lower assimilative capacity associated with the rheopalustrine habitats. Under riverine conditions typical of the ecoregion (nonpalustrine), the modest waste load associated with Kinsman would have likely been safely assimilated with little or no deleterious effects to water quality.

The condition of the fish assemblage at all remaining stations appeared primarily controlled by natural limiting features. The numbers, kinds, and relative proportion of fish species at these stations comported with exiting habitat conditions. As such, the failure of nearly all resulting community indices to meet the prescribed WWH biocriteria was attributed to natural or otherwise structural causes. Even in the case of Kinsman, the effects of failing septic systems appeared secondary to the limited habitat of the mainstem.

Sugar Creek and Stratton Creek

The fish assemblages of two direct Pymatuning Creek tributaries were surveyed and assessed as part of the 2008 field sampling effort, Sugar and Stratton creeks. Four sampling stations were deployed to these waters, two for each stream. Six linear miles of Sugar Creek were evaluated at RMs 5.7 (SR 88) and 0.9 (Burrett Rd.), and five linear miles of Stratton Creek were evaluated at RMs 4.5 (Weber Rd) and 0.7 (Kinsman-Nickerson Rd.).

Community indices and accompanying narrative evaluations from these waters ranged between poor (IBI=24) and exceptional (IBI=52). Taken together, the fish assemblages of the tributaries can be characterized narratively as *good*. Summarized index scores and community statistics by stream and by station are presented in Table 11.

As indicated by the IBI, departure from the WWH biocriterion was limited to the uppermost station (RM 5.7) on Sugar Creek. Nearly every community metric was diminished, as the assemblage was dominated by highly tolerant, generalist, and omnivorous species. The resulting IBI did not exceed the poor range (IBI=24). Undoubtedly, marginal macrohabitat quality originating from past channel modification served to limit community performance, but these effects should have suppressed the structure and form of the fish assemblage to a point no lower than the fair range. Upper Sugar Creek at RM 5.7 courses through wet pasturage, but a persistent, narrow and dense riparian corridor served to naturally limit direct livestock access to the wetted channel. However, conditions may be less restrictive further upstream, and the influence of cattle access may have been exported downstream to the reach evaluated in 2008. Alternatively, the high percentage of pioneering species (nearly 70%) suggests that upper Sugar Creek may have been subjected to pulsed or temporal stress (desiccation, spill event, fish kill etc.), and the fish assemblage as observed in 2008 was in the process of recovery. Regardless of the ultimate cause(s), these results indicate environmental factors beyond macrohabitat complexity or quality to be responsible for the present poor condition of the fish assemblage.

The remaining monitoring station on lower Sugar Creek (RM 0.9) was found to support fish assemblages fully consistent with the WWH biocriterion. Similarly, both the upper and lower sampling stations on Stratton Creek (RMs 4.5 and 0.7) were populated by WWH fish communities.

Table 11. Fish community and descriptive statistics from the Shenango River Tributaries study area, 2008.

River Mile	Mean Species	Total Species	Mean Rel. No. (No./km)[a]	Mean Rel. Wt. (Wt./km)[a]	Mean IBI	Mean MIwb	QHEI	Narrative[b]
Pymatuning Creek [18-550]								
30.4[H]	15.0	15	187.5	9.53	34*	NA	55.0	Fair
29.1[H]	20.0	20	616.5	5.97	38[ns]	NA	65.5	Marginally Good
24.5[W]	18.5	22	759.8	4.41	37[ns]	7.2*	46.0	Marginally Good/Fair
22.7[W]	21.5	24	1004.3	21.84	36[ns]	7.6[ns]	46.0	Marginally Good
15.8[B]	16.0	17	346.0	83.86	27*	6.4*	61.0	Fair
6.1[B]	16.5	17	456.0	39.24	34*	8.1*	64.0	Fair/Good
1.9[B]	15.5	17	409.0	45.95	31*	8.1*	60.5	Fair/Marginally Good
Sugar Creek [18-556]								
5.7[H]	13	13	898.50	39.22	24*	NA	54.0	Poor
0.9[H]	20	20	397.50	6.66	44	NA	77.0	Good
Stratton Creek [18-554]								
4.2[H]	18	18	618.0	11.56	44	NA	61.5	Good
0.7[H]	21	21	499.50	3.84	52	NA	68.5	Exceptional
Gravel Run [18-572]								
1.3[H]	18	18	382.0	75.64	38[ns]	NA	65.0	Marginally Good
Wade Creek [18-575]								
1.8[H]	9	9	1446.0	8.84	28*	NA	69.0	Fair
Black Creek [18-571]								
1.4[H]	12	12	278.0	8.86	28*	NA	70.5	Fair
McMichael Creek [18-570]								
1.3[H]	13	13	850.0	8.08	38[ns]	NA	70.5	Marginally Good
Yankee Creek [18-506]								
11.3[H]	11	11	175.0	3.62	34*	NA	44.5	Fair
6.5[W]	20.5	24	900.0	8.22	48	8.6	76.5	Very Good/Good
1.2[W]	24	28	1214.3	18.82	41	8.9	75.0	Good/Very Good
0.3[B]	24	30	402.0	60.70	39[ns]	8.6[ns]	64.0	Marginally Good/Good
South Branch Yankee Creek [18-507]								
1.5[H]	22	22	951.0	4.70	46	NA	87.0	Very Good
Little Yankee Creek [18-504]								
10.9[H]	14	14	774.38	-	38[ns]	NA	75.0	Marginally Good
9.6[H]	9	9	186.0	-	36[ns]	NA	66.0	Marginally Good
8.0[H]	11	11	232.0	6.94	40	NA	76.0	Good
4.7[W]	21.5	24	1897.50	28.99	40	8.6	79.0	Good
Little Yankee Creek [18-504]								
4.4[W]	23	26	1625.25	32.79	37[ns]	8.6	75.5	Marginally Good
1.6[W]	19.5	22	1008.00	20.12	44	8.1	74.5	Good/Marginally Good
Mud Run [18-528]								
0.7[H]	11	11	2358.0	-	40	NA	43.5	Good
0.1[H]	10	10	105.0	-	38[ns]	NA	53.0	Marginally Good
Little Deer Creek [18-505]								
0.4[H]	18	20	1446.00	13.95	40	NA	67.5	Good

a - Relative abundance and relative weight estimates are normalized to 0.3km for headwaters/wading sites and to 1.0km for boat sites.
b - Biological narratives.

H - Headwaters: sites draining areas ≤ 20 miles^2.
W - Wadable Streams: sites draining areas > 20 miles^2.
ns- Nonsignificant departure from the biocriteria (≤4 IBI units or ≤0.5 MIwb units).
* - Significant departure from the biocriteria (>4 IBI units or >0.5 MIwb units). Poor or very poor results are underlined.

Ecoregional Criteria (ORC 3745-1-07, Table 7-14)
Erie-Ontario Lake Plain (ELOP)

Index Site Type	EWH	WWH	MWH[d]
IBI-Headwaters	50	40	24
IBI-Wading	50	38	24
MIwb-Wading	9.4	7.9	6.2
IBI-Boat	48	40	24
MIwb-Boat	9.6	8.7	5.8

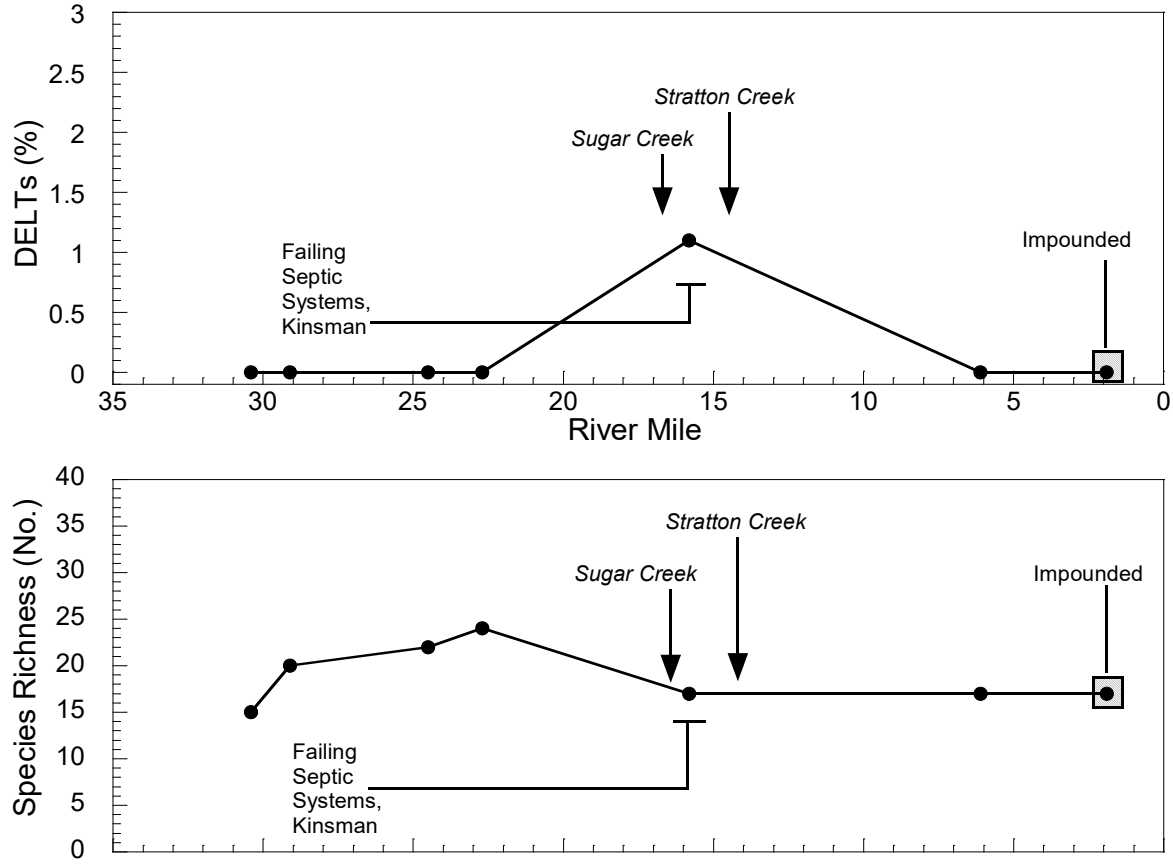


Figure 18. Longitudinal species richness (lower) and the incidence of DELT anomalies (upper) from Pymatuning Creek, 2008. Arrows identify points of discharge for significant NPDES permitted entities, potential pollution sources, or other relevant points of interest.

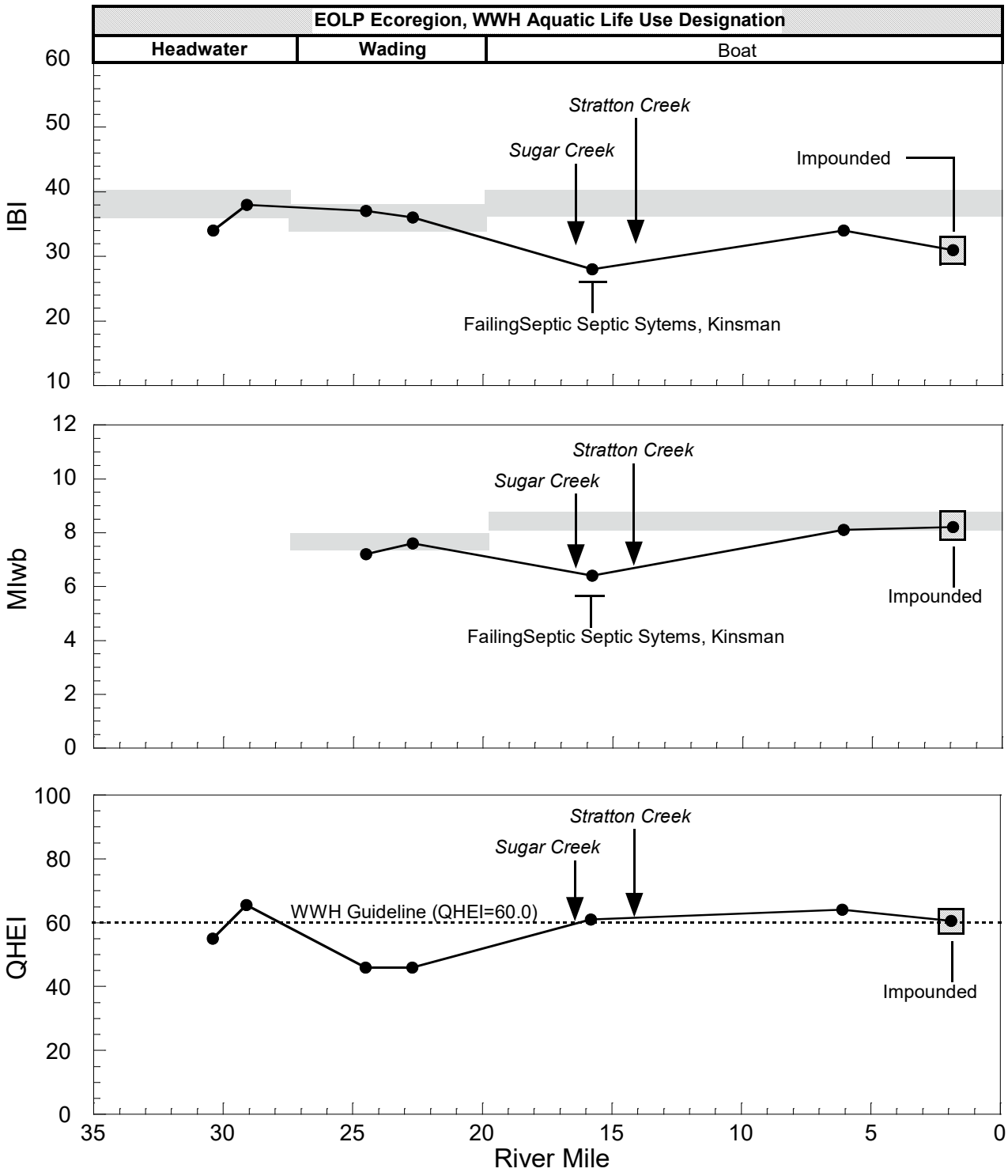


Figure 19. Longitudinal performance of the Index of Biological Integrity (IBI), Modified Index of well-being (MIwb), and Qualitative Habitat Evaluation Index (QHEI) for Pymatuning Creek (mainstem), 2008. Shaded areas represent biocriteria and areas of nonsignificant departure for the WWH aquatic life use. Dashed lines represent QHEI values associated with WWH communities. Arrows identify points of discharge for significant NPDES permitted entities, potential pollution sources, or other relevant points of interest.

Yankee Creek

A total of 3,326 fish comprising 41 species and two hybrids was collected from Yankee Creek between July and August, 2008. The fish sampling effort included four sampling locations, assessing approximately 12 miles of the mainstem, between RM 11.3 (SR 305) and RM 0.3 (US 62).

Community indices and accompanying narrative evaluations for Yankee Creek ranged between fair/marginally good (IBI=34/MIwb=8.7) and very good (IBI=48/MIwb=8.9). Overall, the fish assemblage of Yankee Creek was characterized as *good.* Longitudinal performance of the IBI, MIwb, and other relevant indicators are presented in Figure 20. Summarized index scores and community statistics by station are presented in Table 11.

Based on aggregated catch statistics, numerically predominant species (No./0.3km) included bluntnose minnow (16.0%), central stoneroller (15.8%), mottled sculpin (9.6%), sand shiner (9.1%), white sucker (4.8%), pumpkinseed (4.4%), and greenside darter (4.1%). In terms of relative biomass (kg/km), dominant species were white sucker (27.7%), common carp (18.4%), northern pike (10.8%), golden redhorse (7.7%), channel catfish (4.4%), and largemouth bass (4.2%). In contrast to the rheopalustrine habitat of Pymatuning Creek, numerically dominant fish taxa on Yankee Creek were primarily lotic or riverine associates. Furthermore, despite its smaller drainage area, Yankee Creek supported a greater number of species. Both of these basic features of the fish assemblage were a direct result of significantly higher gradient and associated higher macrohabitat quality of Yankee Creek.

No fish species classified as rare, threatened, endangered, or otherwise recognized for special conservation status by the Ohio DNR (2003), were collected. Highly intolerant, declining or otherwise ecologically significant species included rosyface shiner, silver shiner, banded darter, and black redhorse (Ohio EPA 1987 and 1996). Although not presently imperiled, species so defined have experienced a significant reduction in their historical distributions statewide or have been found to be sensitive to a wide range of environmental disturbance, and therefore are considered associates of the high quality riverine habitats in Ohio.

Presently, the entire length of Yankee Creek is designated WWH. As measured by the IBI and MIwb (where applicable), departure from the WWH biocriterion was limited to the uppermost station at RM 11.3 (SR 305). Here community performance was in the fair range and appeared directly related to an isolated reach of poor macrohabitat quality. Upper Yankee Creek drains a remnant high glacial terrace that originally supported wetlands or swamp forests perched well above the valley floor (Shanks 1937). The poorly drained nature of this area necessitated artificial drainage. The combined effects of natural limitations of rheopalustrine streams and further habitat simplification through channelization structurally precluded the development a rich and diverse fish fauna. As such, the failure of upper Yankee Creek to support a WWH assemblage was attributed primarily to natural or pre-existing conditions, with the effects of anthropogenic channel modification serving as a secondary or tertiary stressor.

All remaining downstream stations consistently supported diverse and well-organized fish communities, fully consistent with the WWH biocriteria. As indicated by the fish assemblage, wasteloads delivered to Yankee Creek by the Brookfield WWTP (evaluated at RM 0.3), appeared safely assimilated.

South Branch Yankee Creek

South Branch Yankee Creek is the primary tributary in the Yankee Creek watershed. The fish assemblage of the South Branch was surveyed and assessed at one sampling station located at RM 1.5 (Warner Rd). Summarized index scores and community statistics by station are presented in Table 11. As indicated by the IBI and MIwb, performance of the fish assemblage fully comported with macrohabitat potential and thus easily met the prescribed WWH biocriteria.

No fish species classified as rare, threatened, endangered, or otherwise recognized for special conservation status by the Ohio DNR (2003), were collected. Highly intolerant, declining or otherwise ecologically significant species included only black redhorse (Ohio EPA 1987 and 1996).

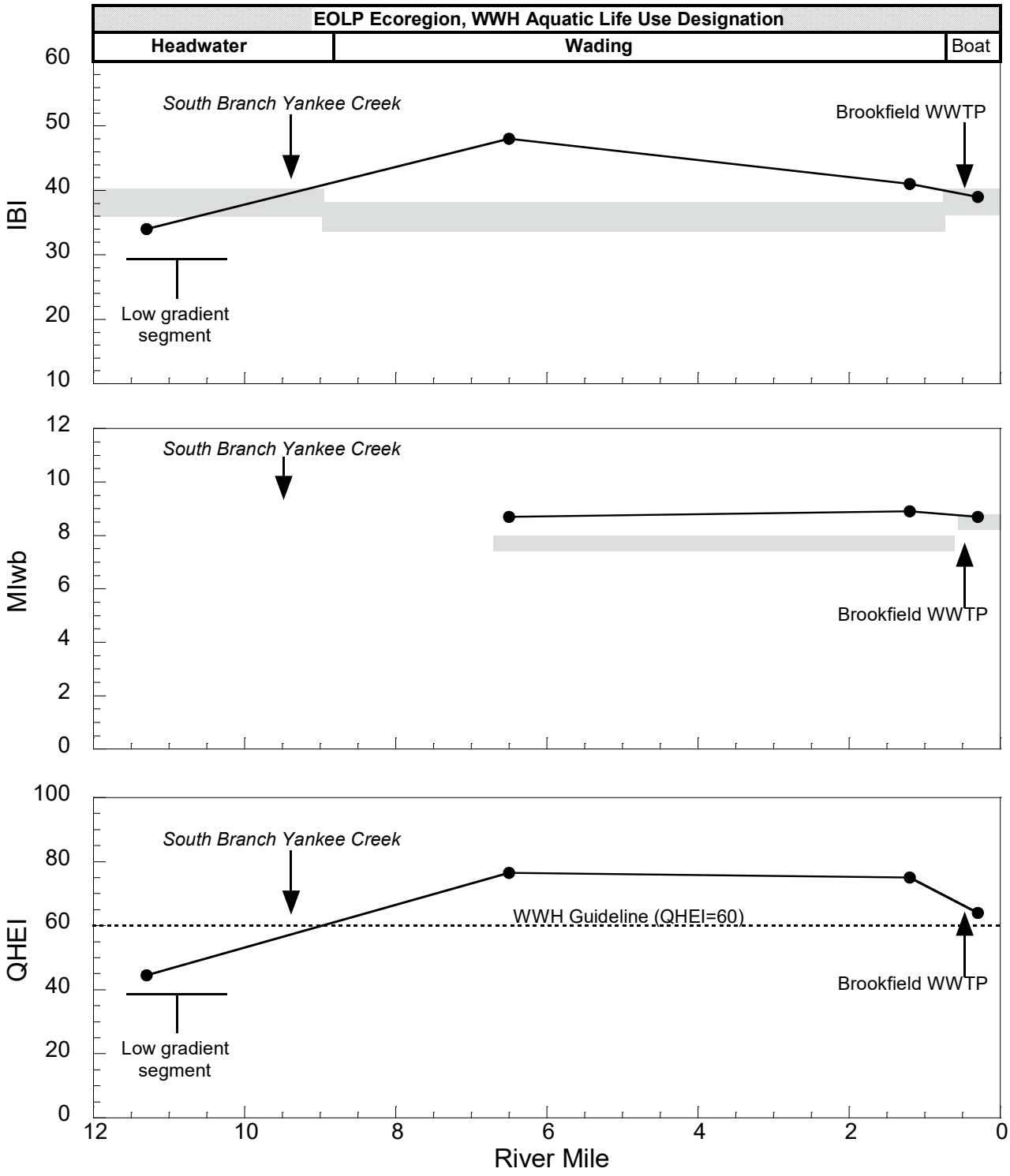


Figure 20. Longitudinal performance of the Index of Biological Integrity (IBI), Modified Index of well-being (MIwb), and Qualitative Habitat Evaluation Index (QHEI) for Yankee Creek (mainstem), 2008. Shaded areas represent biocriteria and areas of no significant departure for the WWH aquatic life use. Dashed lines represent QHEI values associated with WWH communities. Arrows identify points of discharge for significant NPDES permitted entities, potential pollution sources, or other relevant points of interest.

Little Yankee Creek

A total of 6,900 fish comprising 30 species and three hybrids was collected from Little Yankee Creek between July and September, 2008. The fish sampling effort included six sampling locations, assessing approximately 11 miles of the mainstem, between RM 10.9 (Albright-McKay Rd.) and RM 1.4 (Chestnut Ridge Rd.).

Based on aggregated catch statistics, numerically predominant species (No./0.3km) included, bluntnose minnow (24.3%), central stoneroller (18.3%), greenside darter (12.7%), white sucker (9.2%), and banded darter (8.7%). In terms of relative biomass (kg/km), dominant species were white sucker (27.7%), common carp (31.4%), northern hog sucker (18.3%), white sucker (13.5%), central stoneroller (8.7%), and bluntnose minnow (5.8%). Like Yankee Creek, the fish fauna was dominated by lotic or riverine fish taxa, as opposed to the palustrine fish fauna collected in the Pymatuning mainstem.

No fish species classified as rare, threatened, endangered, or otherwise recognized for special conservation status by the Ohio DNR (2003), were collected. Highly intolerant, declining or otherwise ecologically significant species included only banded darter (Ohio EPA 1987 and 1996).

Community indices and accompanying narrative evaluations for Little Yankee Creek ranged between marginally good/good (IBI=36/MIwb=8.1) and good (IBI=44/MIwb=8.7). Overall, the fish assemblage of the Yankee Creek was characterized as *good.* Longitudinal performance of the IBI, MIwb, and other relevant indicators are presented in Figure 21. Summarized index scores and community statistics by station are presented in Table 11.

As measured by the IBI and MIwb (where applicable), community performance through the entire length of Little Yankee Creek was found fully consistent with the WWH biocriteria. Every station was found to support an assemblage of fish possessing the expected structure, functional organization, and species richness, comparable to the reference conditions within the EOLP ecoregion.

Despite a marked decline in the community measures downstream from the Hubbard WWTP, index scores did not fall below the minimum WWH level, indicating that the existing wasteloads from the facility, though not without impact or effect, were safely assimilated.

Mud Run and Little Deer Creek

The fish assemblages of the two principal Little Yankee Creek tributaries were surveyed and assessed as part of the 2008 field sampling effort, Mud Run and Little Deer Creek. Three sampling stations were allocated to this effort, two on Mud Run at RMs 0.7 (adj. Main St./US 62, Hubbard) and 0.1(at Main St./US 62, Hubbard), and one on Little Deer Creek at RM 0.5 (SR 304). Summarized index scores and community statistics by station are presented in Table 11. All monitoring sites on both Mud Run and Little Deer Creek were found to support fish assemblages having species richness and structural and functional organization consistent with the WWH biological criteria.

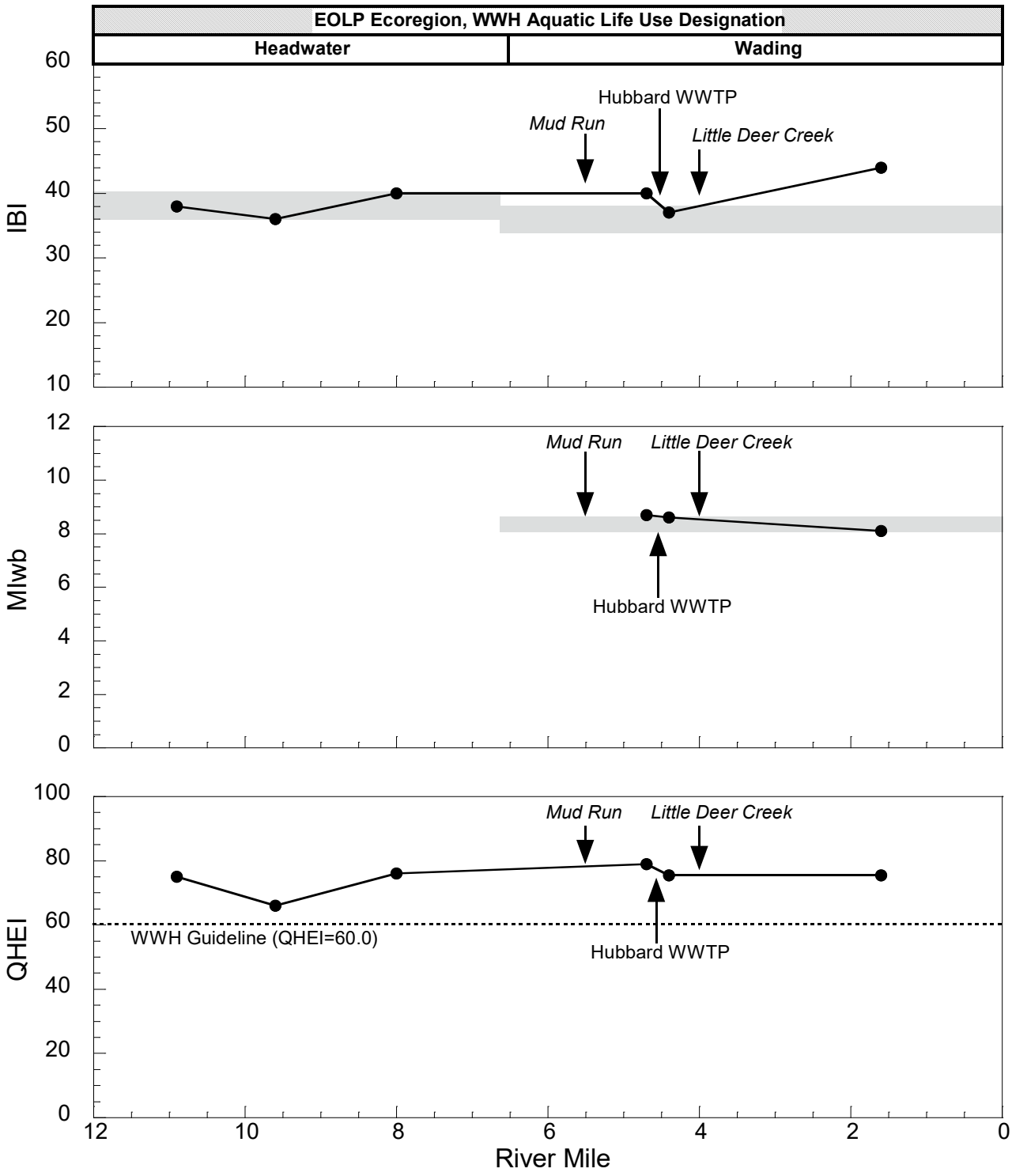


Figure 21. Longitudinal performance of the Index of Biological Integrity (IBI), Modified Index of well-being (MIwb), and Qualitative Habitat Evaluation Index (QHEI) for Little Yankee Creek (mainstem), 2008. Shaded areas represent biocriteria and areas of nonsignificant departure for the WWH aquatic life use. Dashed lines represent QHEI values associated with WWH communities. Arrows identify points of discharge for significant NPDES permitted entities, potential pollution sources, or other relevant points of interest.

Trend Assessment: Fish Community

Through the intensive biosurvey survey process and ancillary sampling efforts, all or portions of the Shenango River tributaries contained within the political boundaries of Ohio have been regularly surveyed and assessed by Ohio EPA since 1984. The most thorough of these historical surveys was done in 1994. Sampling efforts in 1984 included the entire length of Little Yankee Creek, and selected sampling on the other Shenango tributaries.

In order to succinctly summarize and compare survey results between field years, analysis of trends will take two forms: 1) aggregated annual trends, examining cumulative performance from each field year through time, and 2) comparative longitudinal trends, relative to the principal associated stressors, through time. The only significant structural difference between the two main survey years (1994 and 2008) was a slightly greater station density in 1994. Given this, these data provided an excellent opportunity to evaluate meaningful changes, or lack thereof, in the environmental conditions of these Shenango River tributaries over the last 20 plus years.

Pymatuning Creek

Aggregate Community Performance: 1994-2008

Annual cumulative community performance summarized by box and whisker plots of the IBI for Pymatuning Creek are presented in Figure 22. Taken together, median, 75th, and 25th percentiles for the IBI indicated improved aggregate community performance between 1994 and 2008.

Longitudinal Community performance: 1994-2008

Taken together, the longitudinal performance of the IBI and MIwb, through time, indicated a general improving trend in the environmental condition of the Pymatuning Creek mainstem (Figure 23). The IBI portrayed modest improvement in the form and function of the fish assemblage, with specific stations showing either continuity through time or modest improvement. The MIwb, however, revealed vastly improved diversity and structural organization at nearly every station. Although improved in 2008, survey results from both years found impacted or otherwise depressed conditions around Kinsman. The community metrics showing the greatest level of improvement within this area included the incidence of DELT anomalies. In 1994, the mean proportion gross external anomalies approached 20% (Figure 24). By 2008 this measure of chronic sublethal stress as reduced to 1.1%. The positive performance of DELT anomalies is likely reflective of the elimination of pollutant loads from the now closed Kraft Dairy.

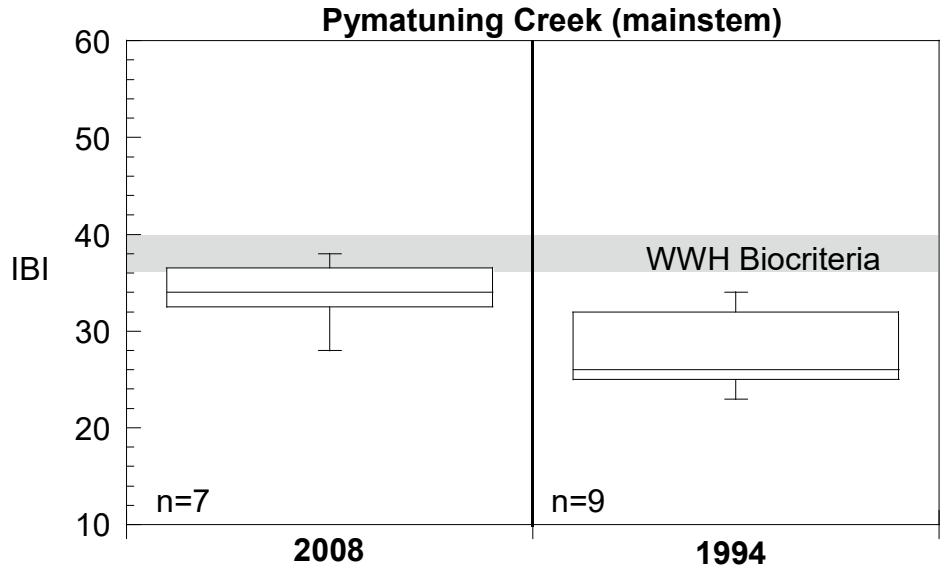


Figure 22. Aggregated Index of Biotic Integrity (IBI) scores from Pymatuning Creek (mainstem), 1994 and 2008. Shaded area represents the WWH biocriteria and area of nonsignificant departure.

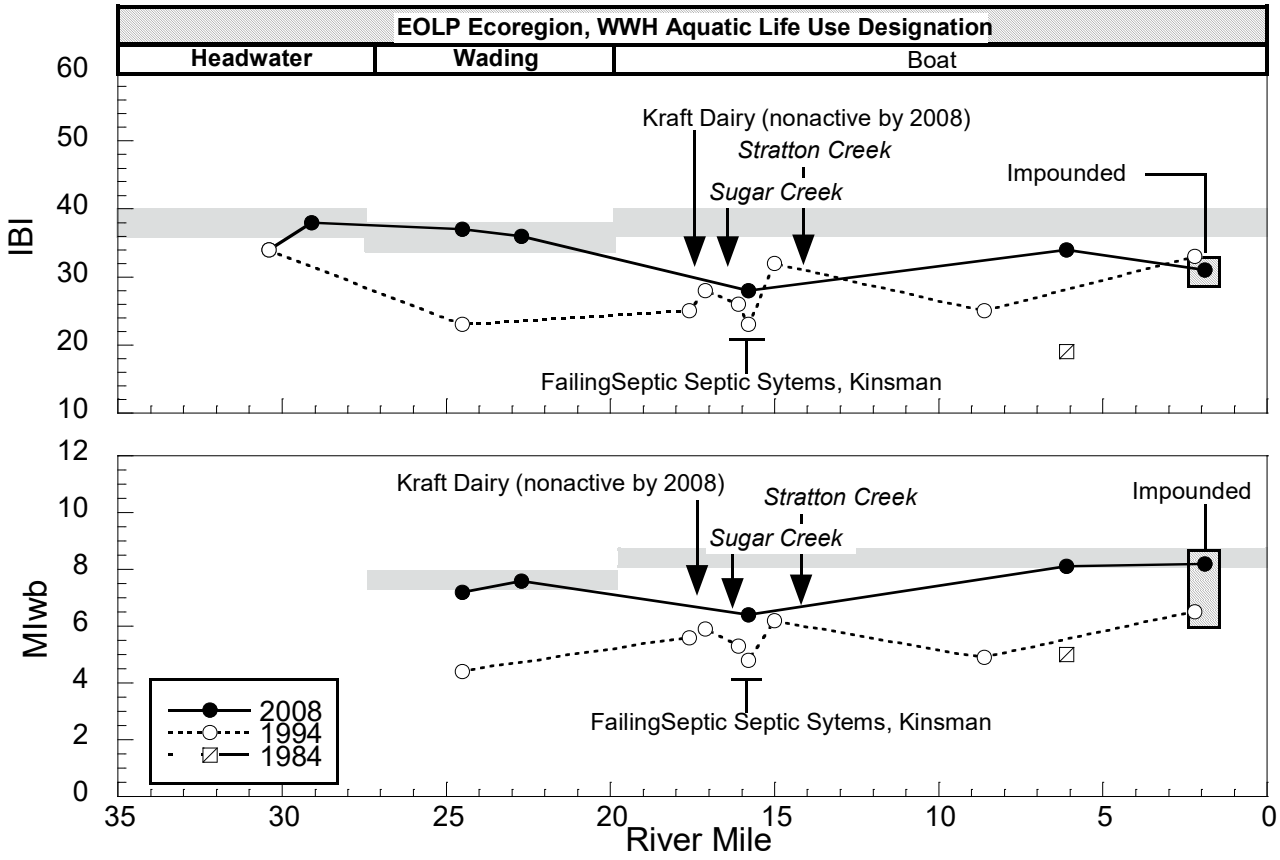


Figure 23. Longitudinal performance of the Index of Biological Integrity (IBI) and Modified Index of well-being (MIwb) Pymatuning Creek (mainstem), 1984, 1994, and 2008. Shaded areas represent biocriteria and areas of nonsignificant departure for the WWH aquatic life use. Arrows identify points of discharge for significant NPDES permitted entities, potential pollution sources, or other relevant points of interest.

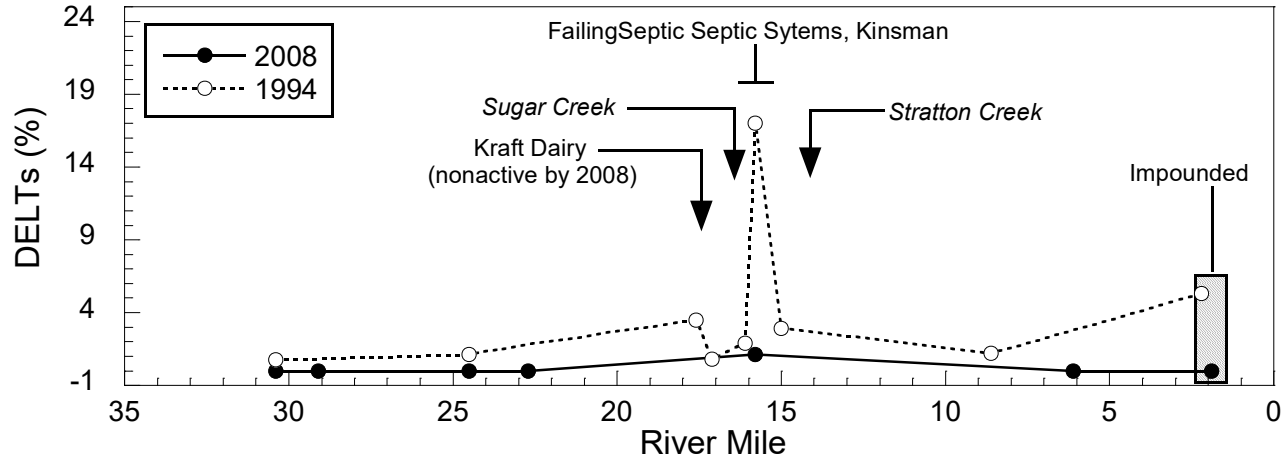


Figure 24. Longitudinal incidence of Deformities, Eroded Fins, Lesions, and Tumors (DELT) anomalies, Pymatuning Creek, 1994 and 2008.

Yankee Creek

Aggregate Community Performance: 1984-2008

Annual cumulative community performance summarized by box and whisker plots of the IBI for the Yankee Creek mainstem are presented in Figure 25. Taken together, median, 75th, and 25th percentiles for the IBI showed steady improvement through time.

Longitudinal Community performance: 1984-2008

Longitudinal performance of the IBI and MIwb, through time indicated significant improvement through the vast majority of Yankee Creek (Figure 26). With the exception of the headwaters, which appear environmentally stable, all remaining downstream stations portrayed a positive trend. The most striking changes observed on Yankee Creek where through the lower reaches affected by the Brookfield WWTP. In 1984, nearly every community metric was diminished, including low species richness, low frequency of sensitive fish taxa, and extremely elevated incidence of DELT anomalies through the affected reach; the latter community attribute reached values over 40%. By 2008, species richness was significantly improved, sensitive taxa were well represented and DELT anomalies returned to background levels (Figure 27). These positive changes in the environmental conditions of lower Yankee Creek were attributable to reduced pollutant loads from the Brookfield WWTP.

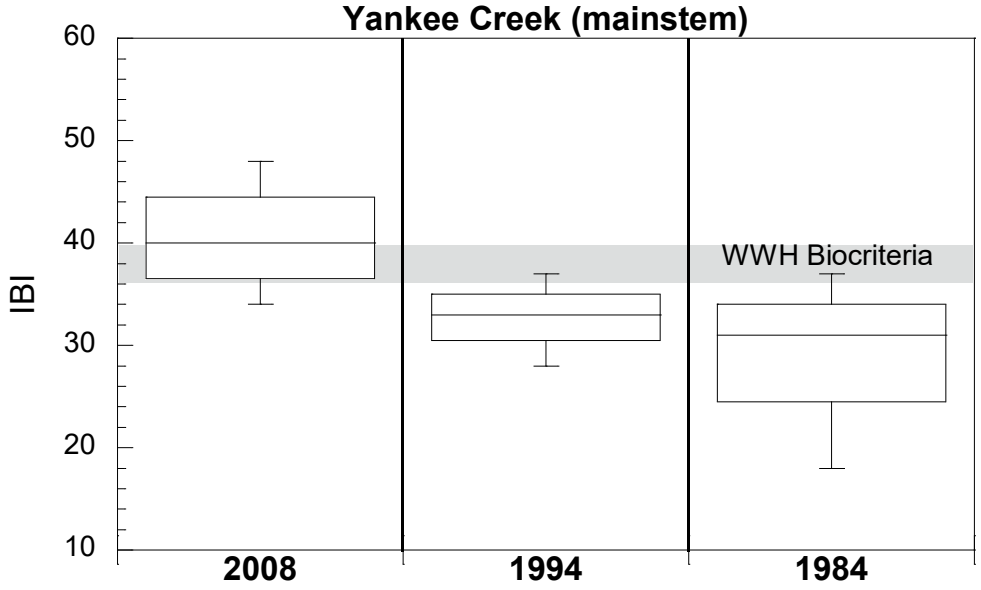


Figure 25. Aggregated Index of Biotic Integrity (IBI) scores from Yankee Creek (mainstem), 1984, 1994, and 2008. Shaded area represents the WWH biocriteria and area of nonsignificant departure.

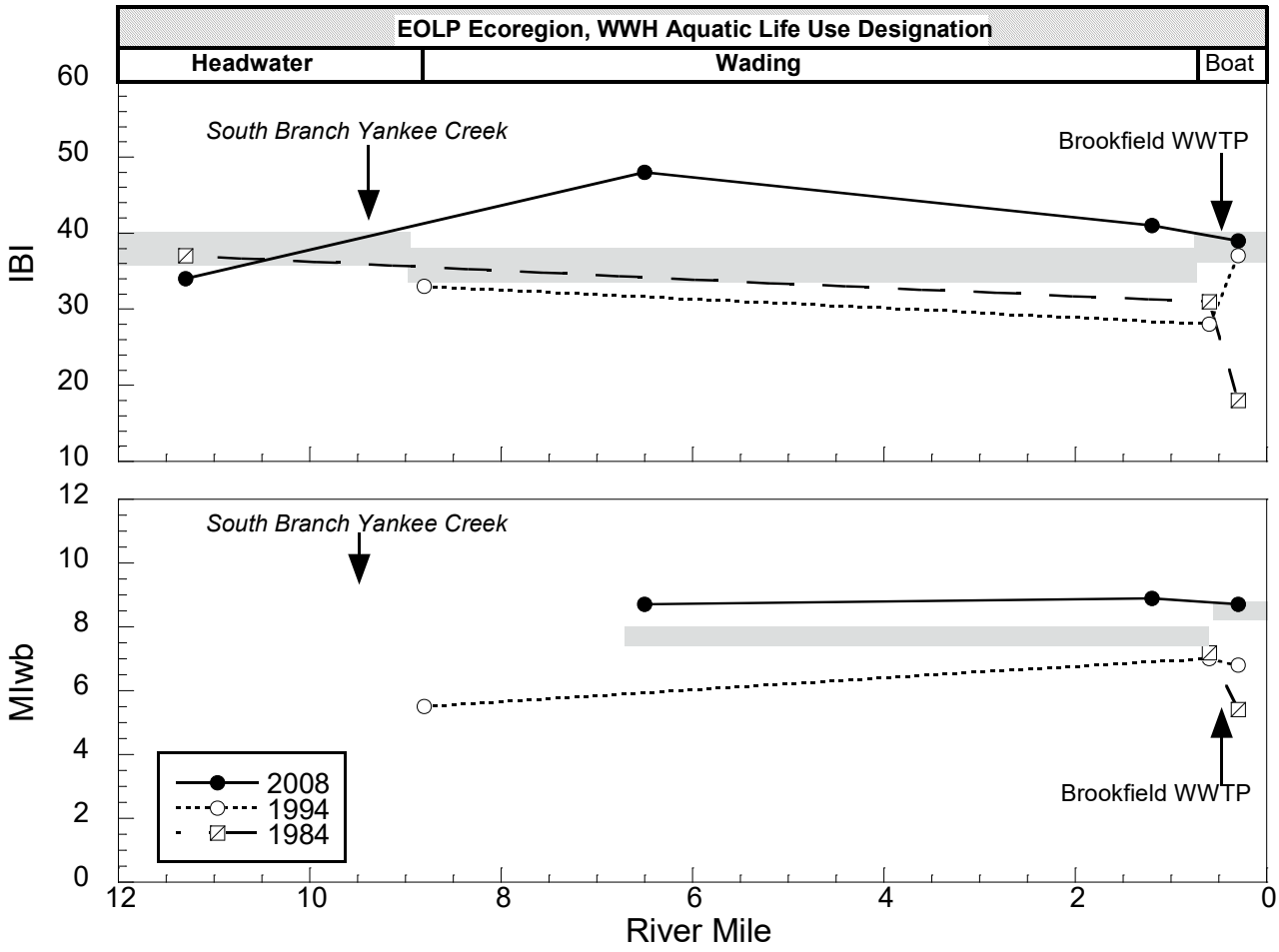


Figure 26. Longitudinal performance of the Index of Biological Integrity (IBI) and Modified Index of well-being (MIwb) Yankee Creek (mainstem), 1984, 1994, and 2008. Shaded areas represent biocriteria and areas of nonsignificant departure for the WWH aquatic life use. Arrows identify points of discharge for significant NPDES permitted entities, potential pollution sources, or other relevant points of interest.

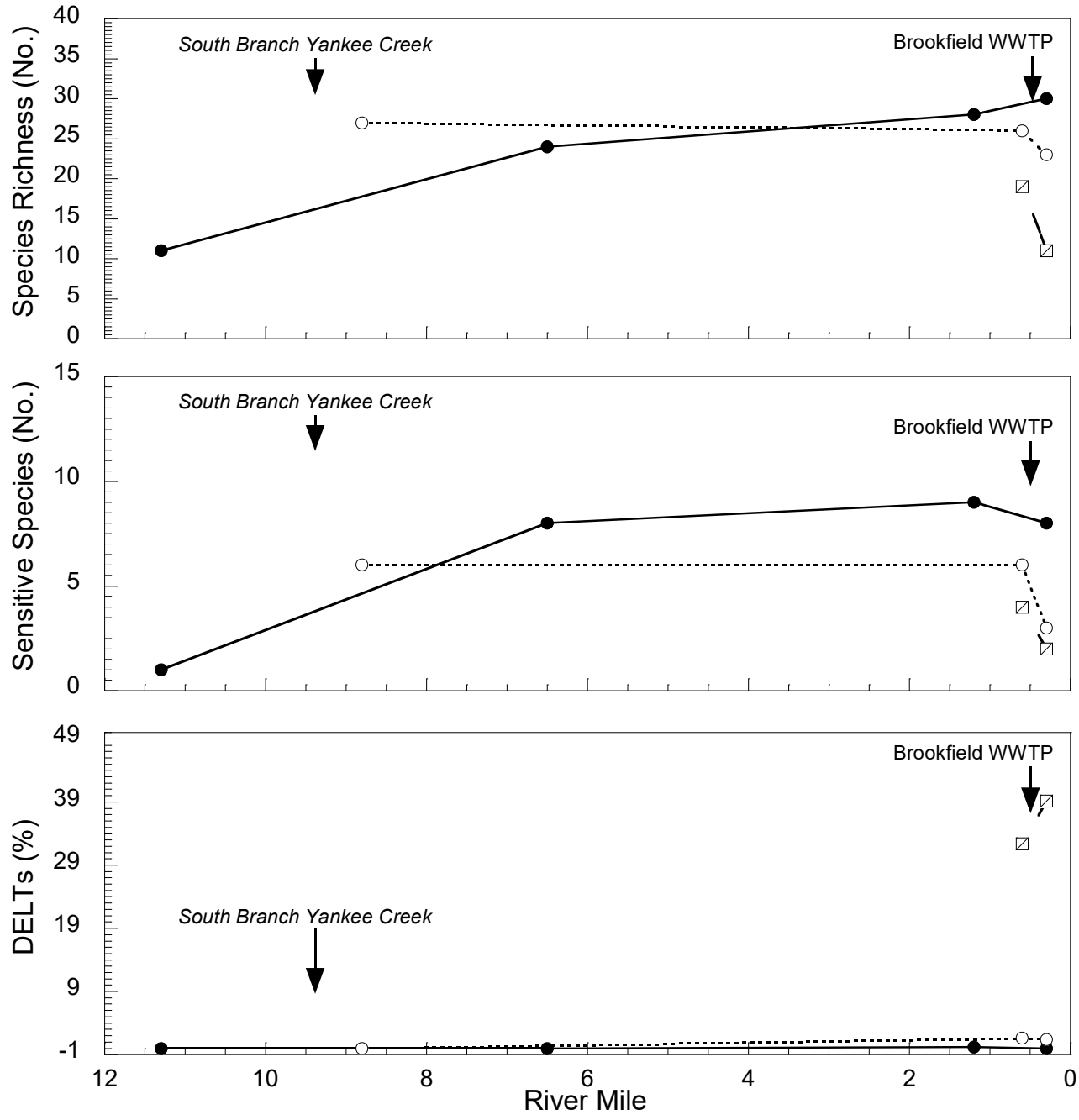


Figure 27. Longitudinal performance of selected fish community metrics: species richness (upper), proportion of sensitive fish taxa (middle), and incidence of DELT anomalies (lower), Yankee Creek, 1984, 1994 and 2008.

Little Yankee Creek

Aggregate Community Performance: 1994-2008

Annual cumulative community performance summarized by box and whisker plots of the IBI for Little Yankee Creek are presented in Figure 28. Aggregate IBI scores clearly portrayed significant and positive changes in community performance between 1984 and 2008.

Longitudinal Community performance: 1984-2008

Among all of the Shenango tributaries, improving trends are nowhere more clearly displayed than on Little Yankee Creek (Figure 29). In 1984, middle and lower Little Yankee Creek were profoundly degraded by the waste load from Hubbard WWTP. At the time, the affected reach of Little Yankee Creek supported a simple assemblage of fish, dominated by a very small number of highly tolerant species. The incidence of DELT anomalies rose dramatically at Hubbard and remained highly elevated throughout the remaining downstream segments. Partial recovery of the affected reach was observed in 1994, and by 2008, full recovery to WWH was indicated (Figure 30). These dramatic results were attributed to improved wastewater treatment and associated reduced pollutant loads to Little Yankee Creek from the Hubbard WWTP.

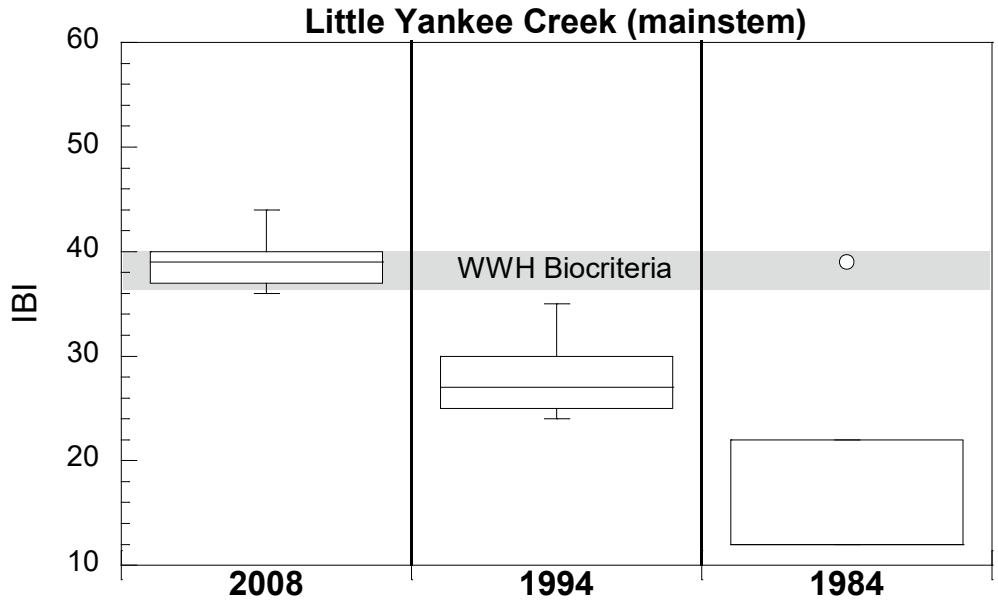


Figure 28. Aggregated Index of Biotic Integrity (IBI) scores from Little Yankee Creek (mainstem), 1984, 1994, and 2008. Shaded area represents the WWH biocriteria and area of nonsignificant departure.

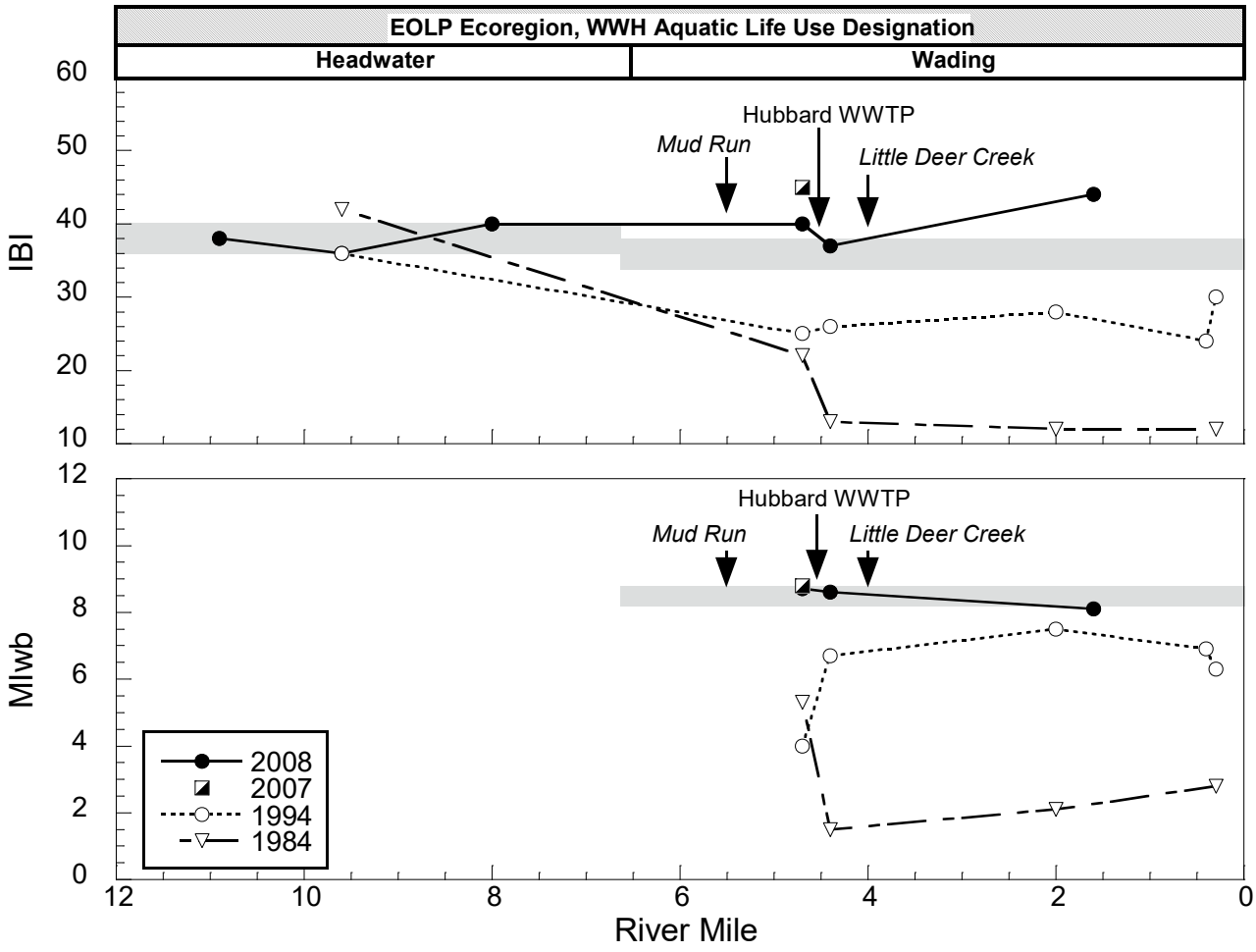


Figure 29. Longitudinal performance of the Index of Biological Integrity (IBI) and Modified Index of well-being (MIwb) Little Yankee Creek (mainstem), 1984, 1994, and 2008. Shaded areas represent biocriteria and areas of nonsignificant departure for the WWH aquatic life use. Arrows identify points of discharge for significant NPDES permitted entities, potential pollution sources, or other relevant points of interest.

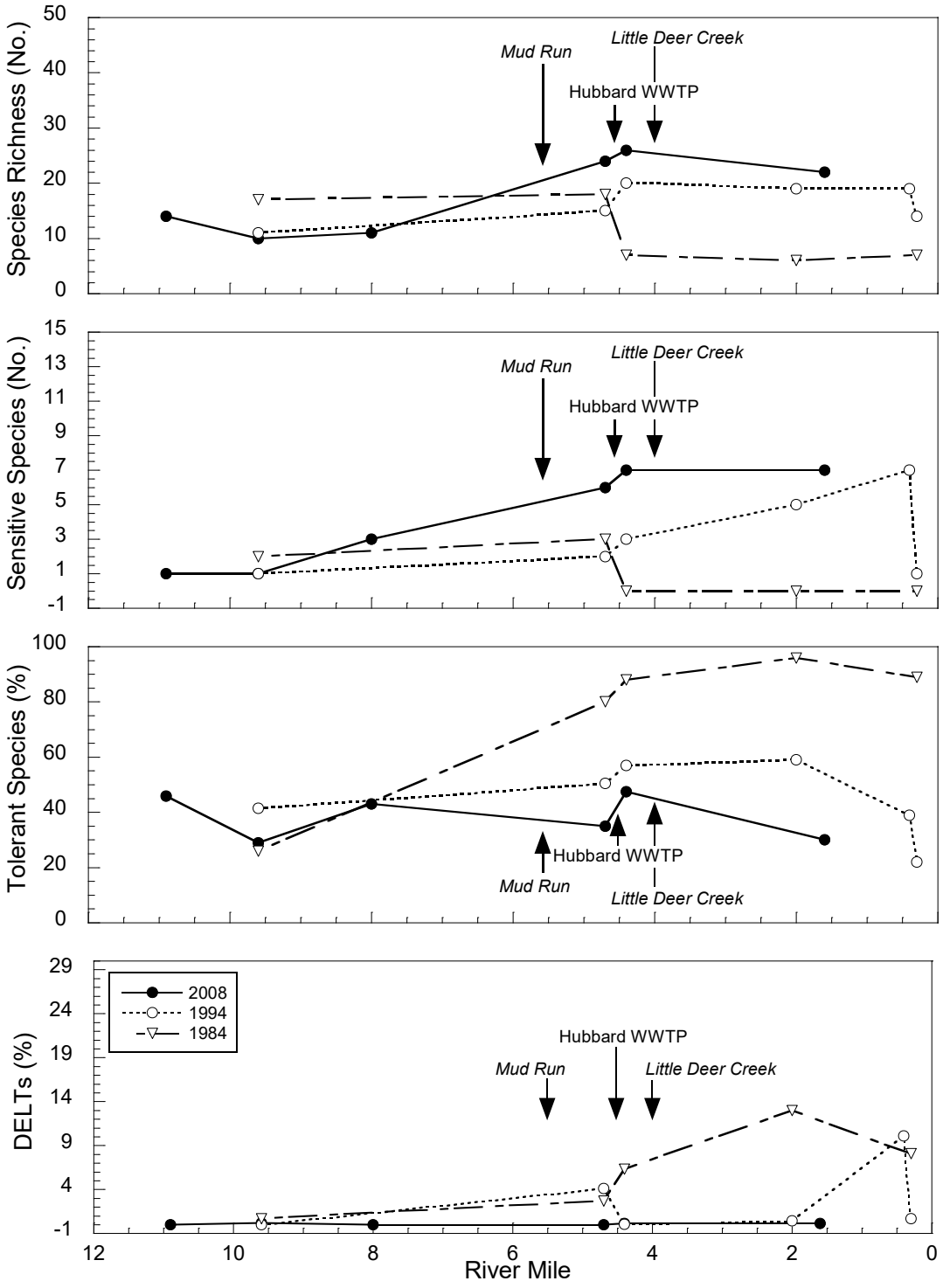


Figure 30. Longitudinal performance of selected fish community metrics: species richness (top), proportion of sensitive fish taxa (upper middle), proportion of tolerant species (lower middle) and incidence of DELT anomalies (lower), Little Yankee Creek, 1984, 1994 and 2008. Arrows identify points of discharge for significant NPDES permitted entities, potential pollution sources, or other relevant points of interest.

Selected Minor Tributaries: 1984-2008

Limited historical fish community data were available for secondary tributaries contained within the 2008 Shenango River basin survey. Past efforts were limited to the lower reaches of three named streams: Little Deer Creek and Mud Run (Little Yankee Creek tributaries) and Sugar Creek (Pymatuning Creek tributary) (Figure 31). In terms of congruency of biological performance with the prescribed WWH biological criteria, stable to improving conditions were indicated for Little Deer Creek and lower Sugar Creek, through the period of record. Significant improvement up to the WWH criterion was observed through lower Mud Run.

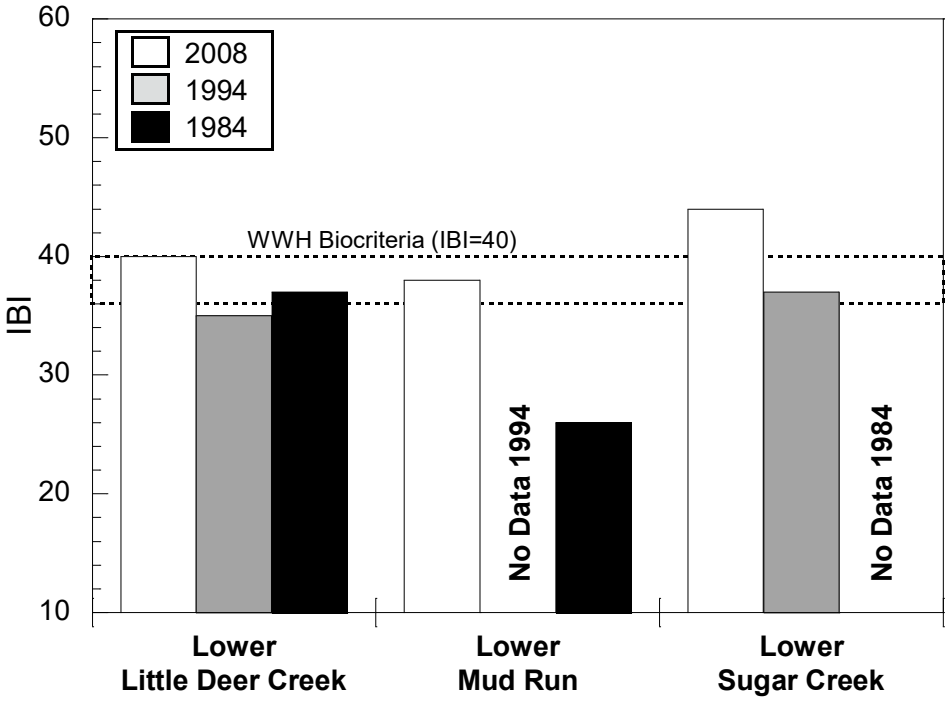


Figure 31. Performance of the Index of Biotic Integrity (IBI) through the lower reaches of selected secondary Shenango River tributaries, 1984, 1994, and 2008.

Macroinvertebrate Community

Pymatuning Reservoir Tributaries

Five stations on four streams were sampled among the Pymatuning Reservoir tributaries (Table 13). The principal factor affecting benthic performance on these streams was habitat quality. Wade Creek, Gravel Run, and Black Creek were located in areas with emergent wetland vegetation or scrub shrub wetland vegetation. As a result, there was little riparian canopy cover and the substrates were comprised mostly of sand and silt. These attributes resulted in low numbers of EPT[1] and sensitive taxa (mean of five for both categories) and resulted in narrative evaluations of fair for their respective communities. None of the sites on these streams met WWH expectations. Wade Creek was additionally impacted by the effects of urbanization, as the stream flows through the city of Andover and is the receiving waters for the city's treated sanitary waste discharge. The effects of nutrient enrichment were apparent downstream from the plant's discharge at RM 1.82, as the abundance of blackflies and filter-feeding midges increased markedly versus the upstream station at RM 2.8.

In contrast to the aforementioned streams, McMichael Creek contained intact habitat, most of which was forested with some pockets of residential and farm land. The site at RM 1.26 was heavily wooded and substrates were comprised of boulder and rubble. There, 14 EPT taxa were collected and pollution-sensitive taxa were predominant. This diverse assemblage received an evaluation of good, which met WWH expectations.

Pymatuning Creek Watershed

Twelve sites on three streams were assessed in the Pymatuning Creek watershed (Table 13), which is characterized by wetland habitat and low stream gradient. With the exception of the impoundments created by a lowhead dam at the Pennsylvania state line (RM 1.94) and a large beaver dam at RM 17.76, Pymatuning Creek is free-flowing with natural channel morphology. In spite of this, riffle development in the stream is sparse and most of the stream has little detectable current. These attributes lend themselves to sluggish waters and sandy/silty substrates, both of which can negatively influence the integrity of the benthic communities. Therefore, with little exception, the macroinvertebrates collected at each sampling station on Pymatuning Creek was a reflection of the ambient habitat conditions.

The upper segment of Pymatuning Creek is strongly influenced by wetland habitat, particularly at RM 30.38 where most of the sampled reach was stagnant with a muck bottom. This favored the proliferation of pouch snails and water boatmen, both of which are extremely pollution-tolerant organisms. This community at this site was evaluated as fair. The next three downstream sites (RMs 29.1, 24.5 and 22.7) were also of wetland origin, but also featured riffle habitat. Even though these riffles were sparsely developed and of poor quality, the aeration provided by their presence had a positive effect on the benthos. A mean of 13 EPT taxa was collected at these sites, with WWH-attaining scores or evaluations that ranged from marginally good to exceptional. The remaining sites (RMs 17.76, 15.8, 8.4 and 1.94) had Invertebrate Community Index (ICI) scores that were reflective of the natural low gradient of lower Pymatuning Creek. None of these sites met the WWH biocriterion except for RM 8.4, where a good ICI of 34 was obtained in spite of an absence of current over the artificial substrates. An analysis of ICI metrics revealed a greater abundance of mayflies and a lower percentage of tolerant organisms at RM 8.4, versus the other lower Pymatuning Creek sites. The scoring from these two metrics alone was the difference between attainment and non-attainment of the WWH biocriterion. No collections of the clubshell mussel (*Pleurobema clava*) were made during the 2008 survey. This federally endangered mussel was previously collected in the headwater region of Pymatuning Creek during an independent study in 1994.

Two tributaries to Pymatuning Creek, Sugar Creek and Stratton Creek, were also sampled in this watershed (Table 13). Sugar Creek drains into Pymatuning Creek at RM 16.65 just upstream from the town of Kinsman. The benthic communities that were collected reflected the local habitat at each of the

[1] EPT stands for Ephemeroptera-Plecoptera-Trichoptera, the orders of invertebrates commonly known as mayflies, caddisflies, and stoneflies, respectively. Their collective presence and abundance in the benthos is generally considered an indicator of high resource quality.

two sites sampled on this stream. The upstream site at RM 5.72 was bordered by farm land and appeared to have been formerly channelized. The substrate was mostly sand and silt and there was no obvious stream flow. As a result, benthic diversity was compromised and the community was evaluated as low fair. By contrast, the habitat at RM 0.92 was more natural than at RM 5.92, including riffle-run-pool complexes, coarse bottom substrates and full riparian canopy. These habitat attributes yielded an exceptional ICI score of 46 at this site.

Stratton Creek enters Pymatuning Creek downstream from the town of Kinsman at RM 14.69. Sampling stations at RM 4.3 and RM 0.7 supported EPT and sensitive taxa numbers that were the highest of any stream sampled in the Shenango River Tributaries survey and resulted in narrative assessments of exceptional and very good, respectively. Included in these numbers were numerous rare or intolerant taxa, including the mayfly *Diphetor hageni* (RM 4.3 only) and the caddisflies *Neophylax*, *Psychomyia flavida and Triaenodes ignitus* (RM 0.7 only).

Yankee Creek and Little Yankee Creek Watersheds
Yankee Creek and Little Yankee Creek are two separate but similar subwatersheds. Yankee Creek drains into the Shenango River at RM 23.82, while Little Yankee Creek enters the Shenango just downstream at RM 23.6. A dam on the Shenango River at RM 23.15 impounds the lower segments of both of these streams. Yankee Creek and Little Yankee Creek both drain approximately 45 square miles and contain the only two major WWTPs in the survey, Brookfield and Hubbard, respectively.

Yankee Creek was sampled at four locations (Table 13). Both the upper and lower sites did not meet the WWH biocriterion due to poor substrate quality (muck) and stagnant flows that favored mostly facultative and pollution-tolerant benthic taxa. The upper site at RM 11.34 was affected by natural wetland conditions, while the lower site at RM 0.3 was impacted by the lowhead dam on the Shenango River. The Brookfield WWTP discharges into Yankee Creek just upstream from RM 0.3, but its effect on the benthos was indiscernible due to the backwater conditions created by the dam. The middle sites of Yankee Creek, RMs 6.50 and 1.23, were free-flowing with coarse substrates and supported benthic communities that were meeting WWH expectations. EPT, sensitive, and total taxa were significantly higher at these sites than at the upper and lower sites. Significant ground water recharge also provided for the presence of five cold water taxa at RM 6.50, including the rare state-threatened cased caddisfly *Psilotreta indecisa*.

One tributary to Yankee Creek, South Branch Yankee Creek, was sampled in 2008. The benthic community at RM 1.54 was evaluated as fair, which was not meeting WWH expectations. Most of the sampled reach was comprised of bedrock, and flows were low enough to expose rootwads, thus limiting margin habitat. As a result, the overall density and diversity of organisms on the natural substrates was low, with the exception of midges of the genus *Rheotanytarsus*, which were highly abundant in the riffles. This may be indicative of nutrient enrichment, with WWTP discharge from an upstream trailer park or storm water from the Youngstown Municipal airport being potential sources.

Little Yankee Creek was sampled at seven stations (Table 13). All but one station were meeting the applicable WWH biocriteria. The station at RM 9.56 was distinguished by having the highest number of both pollution-sensitive and cold water taxa in the Shenango River Tributaries survey. Overall, the upper stations tended to have higher EPT and sensitive taxa than the lower stations, which were impacted to some degree by urbanization and nutrient enrichment from the Hubbard WWTP, but not enough to significantly lower the ICI scores into non-attainment of WWH standards.

The one non-attaining site, RM 5.0, was located within an impounded reach created by an industrial dam at RM 4.96. The combination of deep, heavy muck substrate and non-detectable current limited the benthic community. The artificial substrates were dominated by the pollution-tolerant organisms, including aquatic worms and the midges *Glyptotendipes* and *Dicrotendipes simpsoni*. This dam, once used to provide cooling water for the former Valley Vulcan Mould steel mill, impounds approximately one mile of Little Yankee Creek. Removal of the dam and the consequent restoration of this reach to a natural, free-flowing state would likely bring the stream into full attainment of WWH standards.

Three sites on two tributaries to Little Yankee Creek, Mud Run and Little Deer Creek, were sampled for benthic macroinvertebrates (Table 13). Only Mud Run at RM 0.2 failed to meet WWH expectations. This site was impacted by a combination of both urban runoff from the city of Hubbard and the dam on Little Yankee Creek, which resulted in extensive siltation and stream flashiness. This phenomenon was evident via extreme bank erosion, heavily embedded riffles and numerous logjams. Consequently, only 24 total taxa were collected, most of which were midges or early instars of higher invertebrates. This community composition may indicate a recent "flushing" of benthic invertebrates due to high flow events. The upstream site at RM 2.10, by comparison, is located in a park upstream from the city of Hubbard and was unimpacted by the urban influences observed downstream. Forty-six total taxa were collected, including five cold water taxa. The contrast between RM 2.10 and RM 0.2 indicates that urbanization has a profound negative effect on the biological integrity of Mud Run within the city of Hubbard. Little Deer Creek at RM 0.4 supported the greatest diversity of benthic invertebrates in the entire survey with 79 total taxa. The ICI of 50 garnered at this site was second only to Pymatuning Creek RM 24.5 as being the highest in the Shenango River Tributaries survey. Four coldwater taxa were also collected at this location.

Macroinvertebrate Community Trends, 1994-2008

Most of the streams in the Ohio Tributaries to the Shenango River survey were sampled for the first time in 2008. However, five streams that were sampled during Ohio EPA's last survey of the watershed in 1994 were reassessed for trends purposes in 2008. Those streams are listed and discussed below.

Pymatuning Creek

The underlying low gradient and swamp-like habitat of Pymatuning Creek renders the stream a long, sinuous pool with very little detectable stream flow. Consequently, most of the benthic organisms that inhabit Pymatuning Creek are those organisms which are adapted to slow-moving current and little dissolved oxygen. Resource quality as indicated by the ICI in both 1994 and 2008 were a reflection of the ambient habitat available at a given site. At the sites where riffles provided aeration and habitat for pollution-sensitive filter-feeding organisms, ecoregional expectations were met in both sampling years (Figure 32). Conversely, where riffles were absent and the sampling reach was limited to pool/glide habitat with no detectable current, the applicable biocriterion was not achieved. The lone exception to this rule occurred at RM 8.4.

Table 12. Selected benthic community attributes for Pymatuning Creek RM 8.4, 1994 and 2008.

Year	# Taxa	EPT Taxa	Sensitive Taxa	ICI	Predominant organisms
1994	29 –Qual 41 –Total	1 – Qual 1 - Total	2 – Qual 2 - Total	**4**	Scuds, sowbugs, red midges, and water boatmen.
2008	33 –Qual 57 -Total	3 – Qual 6 - Total	2 – Qual 8- Total	**34**	Scuds, cased caddisflies, flathead mayflies, and alderfly larvae.

The ICI improved substantially at RM 8.4, from a very poor score of 4 in 1994 to a WWH-attaining score of 34 in 2008. Much-reduced percentages of both tolerant and non-insect taxa, coupled with a predominance of mayflies on the artificial substrates accounted for the most of the ICI improvement. Total, EPT, and sensitive taxa were also higher in 2008 (Table 12). A review of the taxa on the artificial substrates from both years revealed a higher abundance of silt-tolerant organisms in 1994, specifically aquatic worms and the midges *Glyptotendipes* and *Dicrotendipes simpsoni* (Appendix Table 14). RM 8.4 physically appeared to be more stagnant in 1994, as a green-grey film coated the water's surface in 1994 that was not observed in 2008. However, the reason for any excess silt or stagnation at RM 8.4 in 1994 could not be ascertained. Whatever was impacting the community in 1994 was obviously absent in 2008.

Sugar Creek

Sugar Creek, a tributary to Pymatuning Creek at RM 16.65, was sampled only at RM 0.92 in both 1994 and 2008. A marginally good qualitative community was collected in 1994, while a very good ICI of 46 was obtained in 2008. A comparison of qualitative attributes from both sampling years showed a slight improvement to the benthic community in 2008. Qualitative EPT taxa increased from 9 to 12, while

sensitive taxa increased from 10 to 15. This may reflect a possible reduction in nutrient loadings in this subwatershed.

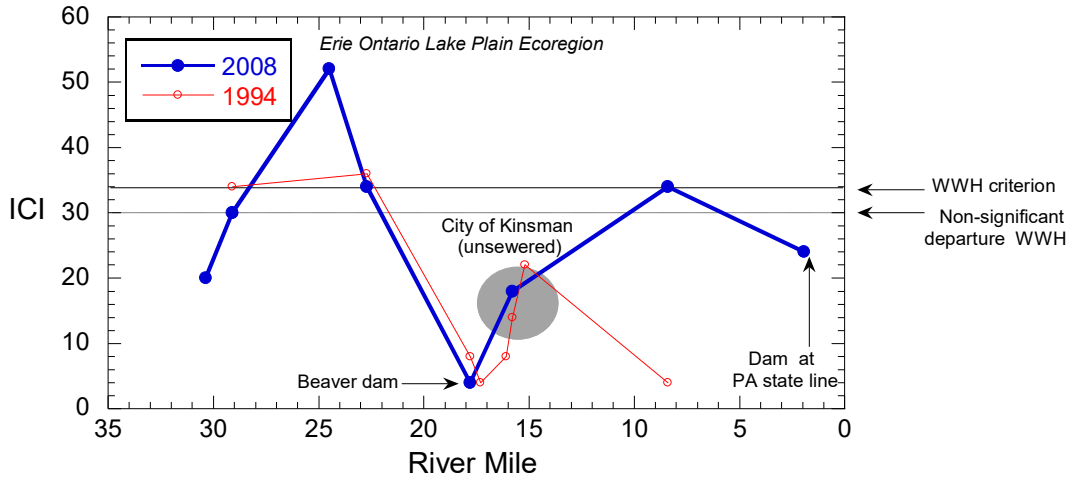


Figure 32. Longitudinal trend of the Invertebrate Community Index (ICI) in Pymatuning Creek, 1994 and 2008. The ICI is estimated where quantitative data are not available.

Yankee Creek

Three Yankee Creek stations that were sampled in the 1994 survey were repeated in the 2008 study. Figure 33 compares the qualitative EPT and sensitive taxa collected at each Yankee Creek station in both 1994 and 2008, and shows very similar benthic communities. In terms of the applicable biocriteria, WWH expectations were met in both years at the stations representing RMs 6.5 and 1.23, while the station at RM 0.3 below the Brookfield WWTP and within the reach impounded by the Shenango River was still in non-attainment. Unless the lowhead dam just downstream from Yankee Creek's confluence with the Shenango River is removed, it is unlikely that the benthos will meet WWH expectations at RM 0.3 in future surveys.

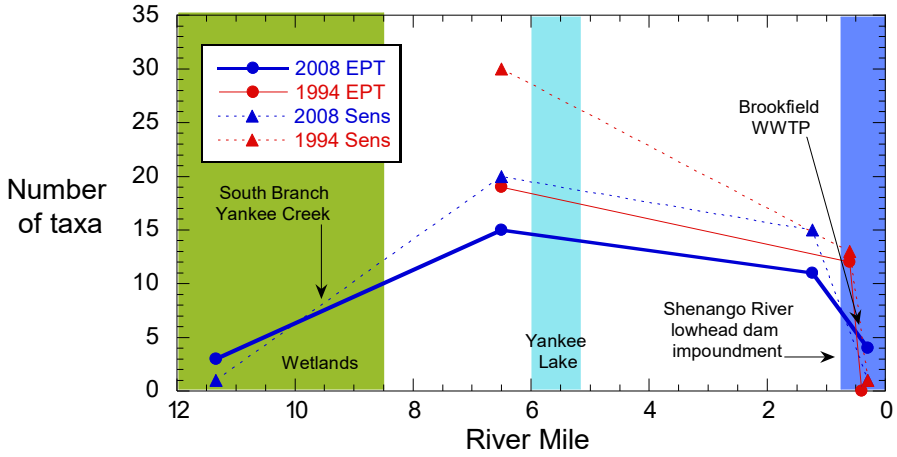


Figure 33. Longitudinal trend of qualitative EPT and sensitive taxa in Yankee Creek, 1994 and 2008.

Little Yankee Creek

Little Yankee Creek displayed a similar longitudinal trend of ICI scores from both 1994 and 2008 (Figure 34). One notable exception was at the station downstream from the Hubbard WWTP discharge. An ICI of 34 was garnered in 2008, an improvement by eight points over the ICI of 26 from 1994. Decreases in both tolerant organisms and non-insect taxa, coupled with an increase in EPT taxa, accounted for the improvement to the ICI. This was a possible reflection of improved wastewater treatment at the Hubbard wastewater facility.

A Brownfield assessment by Ohio EPA's Division of Emergency and Remedial Response was conducted in 2007 on land that was formerly occupied by Valley Vulcan Mould (Ohio EPA 2008). Sampling protocols included a biological assessment of Little Yankee Creek on the segment adjacent to the property. Most of this reach was within the backwaters created by Valley Mould's lowhead dam at RM 4.96. Impaired benthic communities from that sampling event were collected within the dam pool at RM 5.2, which was corroborated by the fair ICI of 14 that was obtained in 2008. Oxygen-deficient waters and muck-laden substrates typify the environment created by lowhead dams such as the one on Little Yankee Creek. The impaired biological communities associated with such conditions are likely to persist as long as the dam remains in place. Removal of dams in the middle Cuyahoga River near Kent, Ohio demonstrated that dam removal is a viable option for the restoration of the biological integrity of water resources (Tuckerman and Zawiski 2007). The impounded reach of Little Yankee Creek would be expected to demonstrate the same restoration should the dam at RM 4.96 be removed. In the tailwaters of the dam, the 2008 ICI showed a slightly improved benthic community over that of 2007. This difference was attributed to the better flow conditions available in 2008.

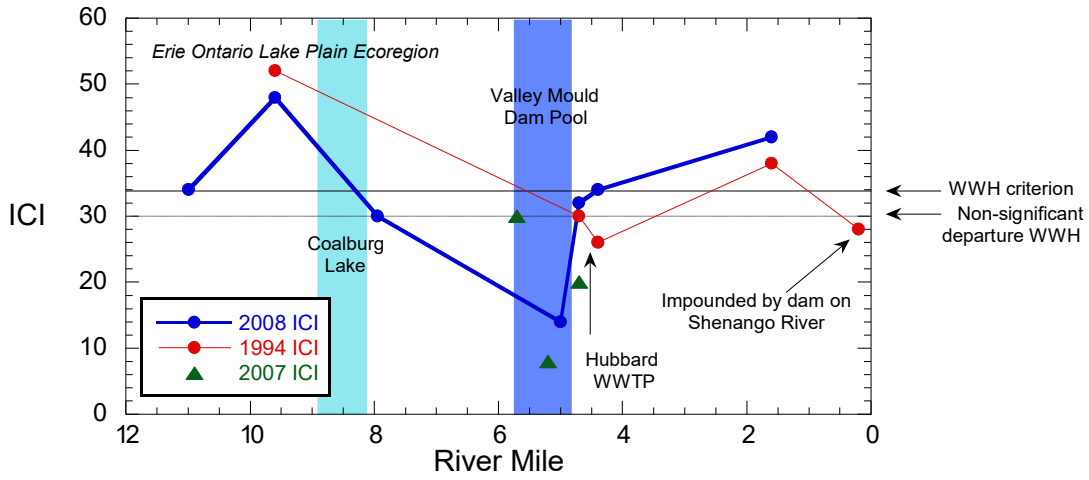


Figure 34. Longitudinal trend of the ICI in Little Yankee Creek, 1994-2008. The ICI is estimated where quantitative data are not available.

Little Deer Creek

Little Deer Creek, a tributary to Little Yankee Creek at RM 4.08, flows through a rural-residential area of Hubbard Township. This stream was sampled at RM 0.4 in both 1994 and 2008 and yielded very different results between sampling years. The ICI scored in the fair range with a 20 in 1994, while an exceptional ICI of 50 was obtained in 2008. The largest variable that affected benthic community performance was stream flow. The conditions at RM 0.4 in 1994 were impounded, perhaps by a logjam downstream. In 2008, the site was free-flowing with numerous coarse substrate riffles, which helped to provide adequate current over the artificial substrates. The heterogeneous habitat available in 2008 allowed for much higher total, sensitive, and EPT taxa than that of 1994, and therefore a much higher ICI.

Table 13. Summary of macroinvertebrate data collected from artificial substrates (quantitative data) and natural substrates (qualitative data) in the Ohio Tributaries to the Shenango River (PA) basin, July-September, 2008.

Location	River Mile	Drain. (mi^2)	Total Taxa	Qual EPT	Total Sens	Total Tol.	CW Taxa	Substrate Density[a]	ICI[b]	Narrative Evaluation	Observations[c]
HUC 0503010201 – Pymatuning Reservoir-Shenango River											
Gravel Run @ Pymatuning Lake Road	1.27	5.3	31	6	5	10	0	Moderate	n/a	Fair	Philopotamid caddisflies (MI), sowbugs (MT), flatworms (F), and riffle beetles (F) predominant. Little riparian cover.
Wade Creek @ US 6; ust Andover WWTP	2.80	2.8	21	4	4	2	0	Low	n/a	Low Fair	Bryozoan (F) and midges (mostly F) predominant. Heavily embedded substrates.
Wade Creek @ US 6; dst Andover WWTP	1.82	3.1	32	3	6	6	1	High	n/a	Low Fair	*Rheotanytarsus sp.* midges (MI) and blackflies (F) predominant. Embedded substrates and abundant algae.
Black Creek @ Pymatuning Lake Road	1.43	5.2	39	9	6	8	0	Low	n/a	Fair	*Stictochironomus sp.* midges (F), baetid mayflies (F) predominant. Mostly sand substrate.
McMichael Creek @ Pymatuning Lake Road	1.26	6.3	37	14	9	3	0	Moderate	n/a	Good	Hydropsychid caddisflies (F), baetid mayflies (F), *Rheotanytarsus sp.* midges (MI), waterpenny beetles (MI), polycentropid caddisflies (MI) predominant.
HUC 0503010203 – Pymatuning Creek											
Pymatuning Creek @ US 6	30.38	11.8	48	7	6	14	0	Moderate	n/a	Fair	Hydropsychid (F) and philopotamid (MI) caddisflies and midges (F-T) predominant. Wetland habitat.
Pymatuning Creek @ Dodgeville Rd	29.1	15.9	47	11	11	11	0	Moderate	n/a	Marginally Good	Hydropsychid (F) and philopotamid (MI) caddisflies predominant. Wetland habitat with a couple fine substrate riffles.
Pymatuning Creek @ US 322	24.5	35.0	73	14	25	10	1	Moderate	52	(Exceptional)	Baetid mayflies (F) predominant. *Pycnopsyche* cased caddisflies (MI) and three-ridge mussels abundant in pools.
Pymatuning Creek @ Underwood Rd	22.7	43.0	55	13	14	11	0	High	n/a	Good	Baetid mayflies (F, I) water boatmen (F) predominant. Three-ridge mussels common. Sparse riparian cover and silt substrates.
Pymatuning Creek @ SR 87	17.76	66.0	28	2	2	14	0	High	4	(Very Poor)	Sowbugs (MT), scuds (F) predominant. Site not free-flowing due to large beaver dam.

Location	River Mile	Drain. (mi^2)	Total Taxa	Qual EPT	Total Sens	Total Tol.	CW Taxa	Substrate Density[a]	ICI[b]	Narrative Evaluation	Observations[c]
Pymatuning Creek @ SR 7 dst storm sewer #2	15.8	96.0	46	4	9	11	0	Low	18	(Fair)	Sowbugs (MT), scuds (F,MT), heptageniid mayflies (F), and sponge (F) predominant. No detectable current in sampling reach.
Pymatuning Creek @ SR 88	8.4	135.0	57	3	8	17	0	Moderate	34	(Good)	Alderfly larva (F) and scuds (F) predominant. Heptageniid mayflies (*Stenacron sp.* – F) and *Pycnopsyche sp.* common in shallows. No detectable current in sampling reach.
Pymatuning Creek @ PA State line at Orangeville	1.94	148.0	64	9	13	14	1	Moderate	24	(Fair)	Sowbugs (MT), scuds (F,MT) predominant. Large spill-over dam impounding reach, with some flow at edge.
Sugar Creek @ SR 88	5.72	9.0	42	5	5	10	0	Moderate	n/a	Low Fair	Damselflies (MT), long-horned cased caddisflies (MI) and microcaddisflies (F) predominant. Formerly channelized with no riffle and mostly sand substrate.
Sugar Creek @ Burnett Rd	0.92	19.9	70	12	15	11	3	Moderate	46	(Exceptional)	Hydropsychid (F), philopotamid (MI), and snail case caddisflies (MI) caddisflies predominant.
Stratton Creek @ Webber Rd	4.21	7.1	53	20	23	5	2	High	n/a	Exceptional	*Rheotanytarsus sp.* midges (MI) and snail cased caddisflies (MI) predominant. Little riparian cover due to removal by golf course.
Stratton Creek @ Kinsman-Nickerson Rd	0.70	17.1	54	19	18	7	1	High	n/a	Very Good	Hydropsychid (F), philopotamid (MI), and snail case caddisflies (MI) caddisflies, and crayfish (F) predominant.
HUC 05030102006 – Yankee Creek-Shenango River											
Yankee Creek @ SR 305	11.34	14.8	28	3	1	7	0	Low	n/a	Low Fair	Scuds (F), water boatmen (F) predominant. Wetland habitat.
Yankee Creek @ SR 361A	6.50	33.0	66	15	29	5	5	Moderate	n/a	Very Good	Hydropsychid and philopotamid caddisflies (F,MI), *Petrophila sp.* moths (MI) and waterpenny beetles (MI) predominant.
Yankee Creek @ Addison Rd.; ust. Brookfield WWTP	1.23	44.0	72	11	23	15	1	Low	40	(Good)	Hydropsychid caddisflies (F, MI) and midges predominant.
Yankee Creek @ US 62; dst Brookfield WWTP	0.30	45.7	42	4	3	12	0	Low	14	(Low Fair)	Water boatmen (F) and squaregill mayflies F) predominant. Impouded due to dam on Shenango River.
South Branch Yankee Creek @ Warner Rd	1.54	9.0	29	7	9	4	0	Low	n/a	Fair	*Rheotanytarsus sp*. midges (MI) predominant. Dense bedrock substrate.

Location	River Mile	Drain. (mi^2)	Total Taxa	Qual EPT	Total Sens	Total Tol.	CW Taxa	Substrate Density[a]	ICI[b]	Narrative Evaluation	Observations[c]
Little Yankee Creek @ Albright-McKay Rd	10.99	8.0	54	13	17	12	0	Moderate	n/a	Good	Hydropsychid (F) and polycentropid (MI) caddisflies and bryozoa (F) predominant. Very silty substrates.
Little Yankee Creek @ Rd. Stewart-Sharon	9.56	11.0	73	19	32	7	6	Moderate	48	(Exceptional)	Hydropsychid and snail case caddisflies (F,MI), heptageniid mayflies (F, MI) and *Neophylax sp.* cased caddisflies predominant.
Little Yankee Creek @ Chestnut Ridge Rd	7.95	15.6	36	9	7	9	0	Moderate	n/a	Marginally Good	Hydropsychid (F) and philopotamid (MI) caddisflies, Squaregill mayflies (F) and midges predominant. Downstream from Coalburg Lake.
Little Yankee Creek @ Valley Mould Dam Pool	5.0	29.8	35	1	6	13	0	Moderate	14	(Low Fair)	Sowbugs (MT), scuds (F,MT) predominant.
Little Yankee Creek @ Mill St. ust Hubbard WWTP	4.7	30.8	56	7	11	10	0	Low	32	(Marginally Good)	Hydropsychid caddisflies (F,MI) and midges predominant. Profound sedimentation - likely from dam.
Little Yankee Creek @ 1st Railroad Bridge dst Hubbard WWTP	4.4	30.9	51	6	15	6	0	Moderate	34	(Good)	Hydropsychid caddisflies (F) and midges predominant. Great habitat but poor diversity. WWTP may have bypassed prior to HD retrieval.
Little Yankee Creek @ Chestnut Ridge Rd	1.58	41.2	50	12	18	7	0	Moderate	42	(Very Good)	Hydropsychid (F) and philopotamid (MI) caddisflies and heptageniid mayflies (F,MI) predominant.
Mud Run @ Harding Park	2.10	2.6	46	6	18	4	5	Moderate	n/a	Marginally Good	Hydropsychid caddisflies (F,MI), *Polycentropus sp.*caddisflies (MI), craneflies (F-MI) and midges predominant.
Mud Run @North Main St.	0.20	5.2	24	2	6	4	2	Low	n/a	Low Fair	Midges predominant. Early instar odonates and crayfish.
Little Deer Creek @ SR 304	0.40	7.6	79	9	29	8	4	Low	50	(Exceptional)	Riffle beetles (*Stenelmis sp.* – F), Caenis sp. mayflies (F) and hydropsychid caddisflies (F) predominant.

a – Observed relative density of benthos on natural substrates. Please refer to Appendix table 12 for relative densities on artificial substrates (where available).
b – Invertebrate Community Index. ICI not available for sampling locations with drainage area <20mi^2 (excluding reference sites), and are indicated by n/a. Dashed lines (--) indicate sites where quantitative data were not available due to vandalism, dessication, or some other disturbance of Hester Dendy artificial substrates (HDs).
c – Predominant taxa are those observed on natural substrates. Please refer to Appendix table 14 for predominant taxa on artificial substrates. Tolerance categories for taxa groups are parenthetically expressed: VT = Very Tolerant, T = Tolerant, MT = Moderately Tolerant, F = Facultative, MI = Moderately Intolerant, I = Intolerant.

Fish Tissue

Ohio has been sampling streams annually for sport fish contamination since 1993. Fish are analyzed for contaminants that bioaccumulate in fish that could pose a threat to human health if consumed in excessive amounts. Contaminants analyzed in Ohio sport fish include mercury, PCBs, DDT, mirex, hexachlorobenzene, lead, selenium, and several other metals and pesticides. Other contaminants are sometimes analyzed if indicated by site-specific current or historic sources. Fish contaminant data are primarily used for three purposes: 1) to determine fish advisories; 2) to determine attainment with the water quality standards; and 3) to examine trends in fish contaminants over time.

For more information about the chemicals analyzed, how fish are collected, or the history of the fish contaminant program, see State Of Ohio Cooperative Fish Tissue Monitoring Program Sport Fish Tissue Consumption Advisory Program, Ohio EPA, January 2010 at http://www.epa.state.oh.us/portals/35/fishadvisory/FishAdvisoryProcedure10.pdf.

Advisories

Fish contaminant data are used to determine a meal frequency that is safe for people to consume (e.g., two meals a week, one meal a month, do not eat), and a fish advisory is issued for applicable species and locations. Because mercury mostly comes from nonpoint sources, Ohio has had a statewide one meal a week advisory for most fish since 2001. Most fish are assumed to be safe to eat once a week unless specified otherwise in the fish advisory, which can be viewed at http://www.epa.state.oh.us/dsw/fishadvisory/index.aspx.

The minimum data requirement for issuing a fish advisory is 3 samples of a single species from within the past 10 years. For Pymatuning Creek, no species met this requirement (Table 14). Therefore, the statewide advisories apply, which are two meals a week for sunfish (e.g., bluegill) and yellow perch, one meal a week for most other fish, and one meal a month for flathead catfish and northern pike 23" and over.

For the Pymatuning Reservoir, advisories were issued for bluegill sunfish, largemouth bass, and common carp. Bluegill sunfish and largemouth bass are both in the two meals a week advisory category, and carp are in the one meal a week advisory category. All other species caught in Pymatuning Reservoir should follow the statewide advice of two meals a week for sunfish and yellow perch, one meal a week for most other fish, and one meal a month for flathead catfish and northern pike 23" and over.

For a listing of fish tissue data collected from Pymatuning Creek and Pymatuning Reservoir in support of the advisory program, and how the data compare to advisory thresholds, see Appendix table 14.

Human health use attainment

In addition to determining safe meal frequencies, fish contaminant data are also used to determine attainment with the human health water quality criteria pursuant to OAC Rules 3745-1-33 and 3745-1-34. The human health water quality criteria are presented in water column concentrations of µg/Liter, and are then translated into fish tissue concentrations in mg/kg. See Ohio's 2010 Integrated Report, Section E (http://www.epa.state.oh.us/portals/35/tmdl/2010IntReport/Section%20E.pdf) for further details of this conversion. In order to be considered in attainment of the water quality standards, the sport fish caught within a HUC-12 assessment unit must have a weighted average concentration of the geometric means for all species below 1.0 mg/kg for mercury, and below 0.054 mg/kg for PCBs.

Fish tissue data were adequate to determine attainment status. At least 2 samples from trophic levels 3 (sunfish, catfish, etc.) and 4 (largemouth bass, northern pike, etc.) are needed, and both Pymatuning Creek and Pymatuning Reservoir met that data requirement. No PCBs were detected in fish (reporting limit of 0.05 mg/kg) from Pymatuning Creek (HUC 12 050301030304). PCBs were detected in only one carp from Pymatuning Reservoir (HUC 12 050301020105), but the average PCB concentration in trophic level three fish was below the 0.054 mg/kg criterion. No fish had mercury levels above the criterion of 1.0 mg/kg (reporting limit of 0.024 mg/kg). Therefore, both HUC-12 assessment units are considered in attainment of the fish tissue use.

Trends

Fish contaminant levels can be used as an indicator of pollution in the water column at levels lower than laboratory reporting limits for water concentrations but high enough to pose a threat to human health from eating fish. Most bioaccumulative contaminant concentrations are decreasing in the environment because of bans on certain types of chemicals like PCBs, and because of stricter permitting limits on dischargers for other chemicals. However, data show that PCBs continue to pose a risk to humans who consume fish, and mercury concentrations have been increasing in some locations because of increases in certain types of industries for which mercury is a byproduct that is released to air and/or surface water.

For this reason, it is useful to compare the results from the survey presented in this TSD with the results of the previous survey(s) done in the study area. Recent data can be compared against historical data to determine whether contaminant concentrations in fish tissue appear to be increasing, decreasing, or staying the same in a water body or watershed.

Fish tissue had previously been collected from Pymatuning Creek in 1994 and 1997. Of the data collected in Pymatuning Creek, only mercury in trophic level 3 fish had enough data to compare between the studies. Both levels were approximately the same, 0.14 mg/kg in 1994-1997 and 0.132 mg/kg in 2008.

Fish tissue had been collected from Pymatuning Reservoir in 1994 and 1998. Only trophic level 3 fish were collected in those years. Mercury in trophic level 3 fish remained approximately the same, 0.084 mg/kg and 0.085 mg/kg, between the earlier collections and the 2008 collection. PCBs in trophic level 3 fish in the reservoir declined, down from 0.131 mg/kg in 1994-98 to 0.031 mg/kg in 2008.

Table 14. Select Fish Tissue Data from 2008 Pymatuning Creek Sampling (mg/kg)

Year Collected	Location	River Mile	Species	Selenium	Lead	Mercury
2008	Pymatuning Creek dst. Milligan Rd. East	5.7	Black Crappie	0.637	<0.039	0.07
2008	Pymatuning Creek upst. Orangeville Rd., State Route 609	2.2	Black Crappie	0.412	<0.039	0.139
Averages →				0.525	--	0.105
2008	Pymatuning Creek dst. Milligan Rd. East	5.7	Bluegill Sunfish	0.578	<0.036	0.138
2008	Pymatuning Creek upst. Orangeville Rd., State Route 609	2.2	Bluegill Sunfish	0.374	<0.039	0.086
Averages →				0.476	--	0.112
2008	Pymatuning Creek upst. Orangeville Rd., State Route 609	2.2	Common Carp	0.791	<0.036	0.143
2008	Pymatuning Creek dst. Milligan Rd. East	5.7	Largemouth Bass	0.504	0.061	0.296
2008	Pymatuning Creek upst. Orangeville Rd., State Route 609	2.2	Northern Pike	0.419	<0.040	0.379
2008	Pymatuning Creek dst. Milligan Rd. East	5.7	Yellow Perch	0.702	<0.039	0.213

All contaminant levels in the table were in the unrestricted consumption range except for the mercury. The shading indicates the advisory category that would apply, though as discussed in the text, the data are not sufficient for issuing additional advisories beyond the statewide advisory. Green = two meals per week, yellow = one meal per week, orange = one meal per month. No PCBs or pesticides were detected in any samples.

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