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Ohio Environmental Protection Agency
Division of Surface Water

2009 Biological and Water Quality Study of the Lower Sandusky River Watershed

Including Wolf Creek, Muskellunge Creek, and Muddy Creek

Sandusky and Seneca Counties

John R. Kasich, Governor
Mary Taylor, Lt. Governor
Scott J. Nally, Director

EAS/2011-6-9

Biological and Water Quality Study
Of the
Lower Sandusky River Watershed

2009

Sandusky, and
Seneca Counties, Ohio
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OEPA Report DSW/EAS 2011-6-9

prepared by

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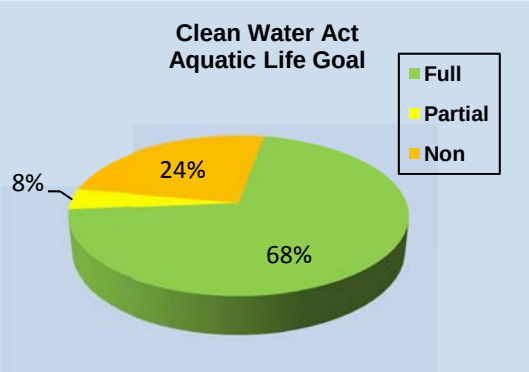
EXECUTIVE SUMMARY

Rivers and streams in Ohio support a variety of uses such as recreation, water supply, and 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. In 2009, nineteen streams in the lower Sandusky River study area, located in Sandusky and Seneca counties, were evaluated for aquatic life and recreation use potential (see Figure 1 and Table 1 for sampling locations). The study area included the mainstem and selected tributaries of the Sandusky River and Muddy Creek.



Of the 53 biological sites assessed, 36 sites (68%) were fully attaining the designated or recommended aquatic life use, four (8%) were in partial attainment and thirteen (24%) were in non-attainment (Table 2). Elevated nutrients and sedimentation related to agricultural practices within the watershed were two principle causes of impairment at impacted sampling locations. Free flowing reaches of the Sandusky River generally had good habitat that in turn supported well balanced aquatic communities. Completion of the planned Ballville Dam removal in the city of Fremont will improve the condition of fish and macroinvertebrate assemblages upstream from the dam site. .

Seventeen locations in the survey area were tested for bacteria indicators (*Escherichia coli*) to determine recreation use attainment status. Evaluation of *E. coli* results revealed that 13 of 17 locations failed to attain the applicable geometric mean criterion, and thus were in non-attainment of the designated recreation use. Suggested sources of contamination include Fremont CSOs, unsewered communities, and livestock. One stream reach where bacteria, chemical and biological sampling results identified impairment of both recreational and aquatic life impairment related to the release of inadequately treated sewage was downstream from the village of Bascom on the East Branch of Wolf Creek.

Water quality, particularly nutrients, varied significantly from site to site. Relative to regional reference conditions, the Sandusky River mainstem was less affected by nutrient enrichment than smaller streams in the study area. Nitrate-nitrite and/or total phosphorus values were elevated at one of eight mainstem sites and at 20 of 34 of the remaining sites. The application of fertilizers for row crop production and subsequent runoff has led to enrichment in many waterways and, subsequently, has contributed to eutrophication of Sandusky Bay and Lake Erie.

Water column inorganic parameters and sediment sampling results were, with few exceptions, within acceptable ecological levels and protective of biological integrity.

Table 1. Lower Sandusky River watershed sampling locations from the Ohio EPA 2009 survey.
The color of the site number corresponds to the narrative biological score (blue is exceptional to very good (meets EWH goals), green is good to marginally good (meets WWH goals) yellow is fair, orange is poor and red is very poor (fair, poor and very poor do not meet the goals of WWH).

Site Number*	Stream Name /Location	River Mile	Drainage Area	Longitude	Longitude
1	Sandusky R. at Co. Rd. 16	65.01	655	40.964756	-83.268721
2	Sandusky R at Walnut Grove Campground	52.58	770	41.015456	-83.200119
3	Sandusky R. at Co. Rd. 90	47.75	774	41.044255	-83.194919
4	Sandusky R. at U.S. Rt. 224	42.92	956	41.095655	-83.198820
5	Sandusky R. at Ella St.	41.84	964	41.103955	-83.186619
6	Sandusky R. adj. Water St.	38.90	1002	41.135655	-83.163219
7	Sandusky R adj. Center Rd.	38.50	1045	41.140655	-83.159919
8	Sandusky R. at Twp. Rd. 143	31.95	1046	41.206954	-83.164319
9	Sandusky R. Co. Rd. 51	26.94	1067	41.239254	-83.145519
10	Sandusky R. ust. Wolf Cr.	23.00	1073	41.277958	-83.164731
11	Sandusky R. adj S. River Rd.	21.30	1238	41.298353	-83.163220
12	Sandusky R. adj S. River Rd	19.00	1255	41.325422	-83.152561
13	Sandusky R. ust. Ballville Dam	18.05	1255	41.326053	-83.136619
14	Sandusky R at Tiffin Rd.	17.70	1255	41.326953	-83.130219
15	Sandusky R. at State St.	15.40	1260	41.346853	-83.111819
16	Sandusky R. at Twp. Rd. 549	12.96	1264	41.370403	-83.098475
17	Sandusky R. ust. Wightmans Grove	4.70	1330	41.429961	-83.061258
18	Sandusky R. ust. Yellow Swale	1.00	1335	41.451952	-83.023517
19	Bark Cr. At Kelley Rd. (Co. Rd. 245)	3.20	10	41.381420	-83.070424
20	Muskellunge Cr. at TR 84	24.44	2.3	41.196123	-83.367730
21	Muskellunge Cr. at St. Rt. 635	16.70	17.7	41.273916	-83.283272
22	Muskellunge Cr. at Spieldenner Rd.	5.40	37	41.356952	-83.159620
23	Muskellunge Cr. at Fangboner Rd.	1.23	44	41.390652	-83.121619
24	Indian Cr. at Hurdick Rd.	0.62	11.2	41.291453	-83.158220
25	Wolf Cr. 0.2 Mi ust Cr 592	13.60	27	41.178954	-83.330724
26	Wolf Cr. at St. Rt. 12	5.15	66	41.249753	-83.229622
27	Wolf Cr. at Township Line Rd.	1.58	71.8	41.270100	-83.188000
28	Wolf Cr. at St. Rt. 53	0.04	158	41.280072	-83.168840
29	Plum Run at St. Rt. 635	0.79	10.1	41.208100	-83.284500
30	Harrison Cr. at Co. Rd. 592	0.38	13.2	41.181500	-83.323500
31	E. Br. Wolf Cr. at Meadowbrook Park	19.65	21.4	41.130722	-83.274458
32	E. Br. Wolf Cr. at Twp. Rd. 132	13.63	33	41.152700	-83.206400
33	E. Br. Wolf Cr. at Twp. Rd. 150	9.00	68	41.196754	-83.183820
34	E. Br. Wolf Cr. at Gilmore Rd.	0.86	84.2	41.261153	-83.184320

Site Number*	Stream Name /Location	River Mile	Drainage Area	Longitude	Longitude
35	Trib. To E. Br. Wolf Cr. at W. Twp. Rd. 112	0.04	8.1	41.123371	-83.259547
36	Snuff Cr. at Twp. Rd. 71	0.33	4.7	41.190800	-83.197000
37	E. Br. Of East Branch Wolf Cr. at Co. Rd. 26	3.52	6.8	41.117800	-83.217800
38	E. Br. Of East Branch Wolf Cr. at Co. Rd. 48 (Twp. Rd. 118)	1.48	19.7	41.138268	-83.211215
39	M. Br. Of East Branch Wolf Cr. at Co. Rd. 26	0.46	11.5	41.118543	-83.221431
40	Sugar Cr. at Twp. Rd. 76	3.11	9.4	41.193367	-83.093178
41	Sugar Cr. at Twp. Rd. 148	1.05	13	41.195854	-83.123818
42	Spicer Cr. at Co. Rd. 33	0.80	12.4	41.183154	-83.144119
43	Muddy Cr. ust. Millersville at Co. Rd. 58	29.36	35	41.290353	-83.310724
44	Muddy Cr.,dst. Twp. Rd. 55	21.10	44	41.364452	-83.244123
45	Muddy Cr. ust. Lindsey at Co. Rd. 90	18.68	63	41.390352	-83.245223
46	Muddy Cr. dst. Lindsey at Co. Rd. 153	9.79	74	41.450051	-83.153521
47	Muddy Cr. at St. Rt. 53	1.23	110	41.452086	-83.053717
48	L. Muddy Cr. at Booktown Rd.	7.55	12.4	41.400315	-83.157824
49	L. Muddy Cr. At Kline Rd	2.50	25	41.438572	-83.086945
50	Fishing Cr. at Weickert Rd.	0.20	7	41.437432	-83.096667
51	S. Br. Muddy Cr. at Anderson Rd.	1.54	22	41.257593	-83.361042
52	Gries Ditch at U.S. Rt. 6	4.72	9.3	41.341242	-83.309402
53	Gries Ditch at Staff Rd.	0.90	16.3	41.363152	-83.257423

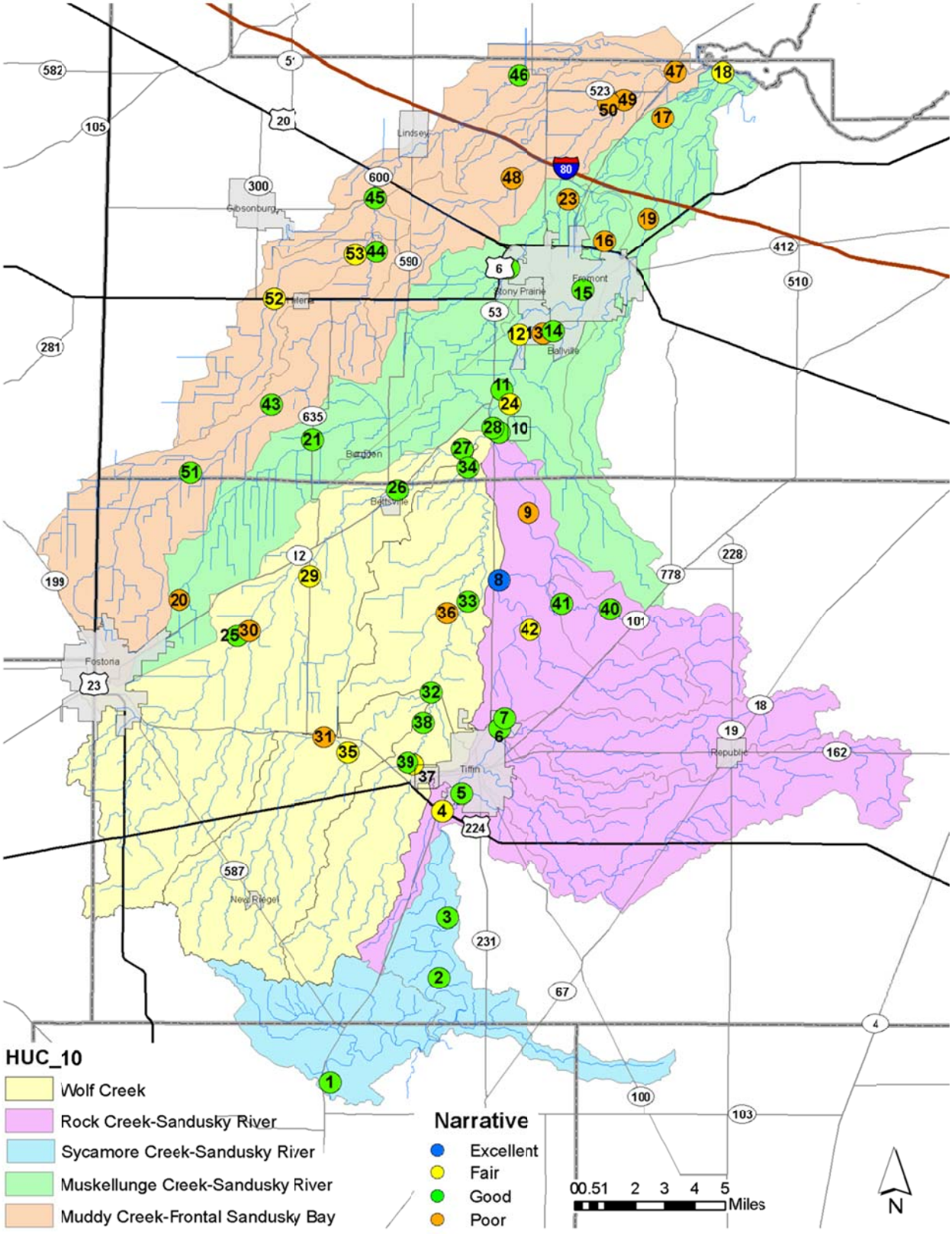


Figure 1. Lower Sandusky River study area and sampling locations including narrative biological community condition, 2009.

Table 2 Aquatic life use attainment status for sampling locations in the Lower Sandusky River watershed, 2009. The Index of Biotic Integrity (IBI), Modified Index of Well-being (MIwb), and Invertebrate Community Index (ICI) scores are based on the performance of the biological community. Stream habitat reflects the ability to support a biological community. The Lower Sandusky River watershed is located in the Eastern Corn Belt Plan and Huron-Erie Lake Plain ecoregions. If biological impairment has occurred, the cause(s) and source(s) of the impairment are noted. NA = not applicable. For the Aquatic Life Use Designation, R denotes a new recommendation that differs from the current use designation.

Stream	River Mile[a]	Sampling Type	Aquatic Life Use Designation	Aquatic Life Attainment Status[b]	IBI	MIwb[c]	ICI[d]	Stream Habitat	Cause of Impairment	Source of Impairment
Sandusky R.	65.01	Boat	WWH	FULL	53	9.4	52	81.5		
Sandusky R.	52.58	Boat	WWH	FULL	44	8.7	48	60.5		
Sandusky R.	47.75	Boat	WWH	FULL	52	10.0	48	86.5		
Sandusky R.	42.92	Boat	MWH	FULL	43	7.7	8	45.5		
Sandusky R.	41.84	Boat	WWH	FULL	53	9.9	38	83.0		
Sandusky R.	38.90	Boat	WWH	FULL	52	10.7	42	82.5		
Sandusky R.	38.50	Boat	WWH	(FULL)			36			
Sandusky R.	31.95	Boat	WWH	FULL	51	9.6	E	69.0		
Sandusky R.	26.94	Boat	WWH	NON	39[ns]	9.0	10*	65.0	Sedimentation/Siltation	Crop Production with Subsurface Drainage
Sandusky R.	23.00	Boat	WWH	FULL	55	10.2	52	83.5		
Sandusky R.	21.30	Boat	WWH	FULL	54	9.7	58	76.0		
Sandusky R.	19.00	Boat	WWH	PARTIAL	44	8.0*		59.0	Sedimentation/Siltation Direct Habitat Alterations	Dam or Impoundment
Sandusky R.	18.05	Boat	WWH	NON	35[ns]	7.2*	P*	52.0	Sedimentation/Siltation Direct Habitat Alterations	Dam or Impoundment
Sandusky R.	17.70	Boat	WWH	FULL	41	9.9	34	93.0		
Sandusky R.	15.40	Boat	WWH	FULL	38	9.7	G	67.0		
Sandusky R.	12.96	Boat	WWH	NON	26	9.2		67.0	Sedimentation/Siltation Nutrient/Eutrophication Biological Indicators	Municipal Point Source Discharges Crop Production with Subsurface Drainage
Sandusky R.	4.70	Boat	WWH	NON	32	8.7	14	60.0	Nutrient/Eutrophication Biological Indicators Sedimentation/Siltation Particle distribution (Embeddedness)	Crop Production with Subsurface Drainage

Stream	River Mile[a]	Sampling Type	Aquatic Life Use Designation	Aquatic Life Attainment Status[b]	IBI	MIwb[c]	ICI[d]	Stream Habitat	Cause of Impairment	Source of Impairment
Sandusky R.	1.00	Boat	WWH	NON	31	7.5		64.5	Sedimentation/Siltation Particle distribution (Embeddedness)	Crop Production with Subsurface Drainage
Bark Cr.	3.20	Headwaters	WWH	NON	20*		F	32.0	Direct Habitat Alterations Phosphorus (Total) Organic Enrichment (Sewage) Biological Indicators Nutrient/Eutrophication Biological Indicators Sedimentation/Siltation Particle distribution (Embeddedness)	Crop Production with Subsurface Drainage Channelization Sewage Discharges in Unsewered Areas
Muskellunge Cr.	24.44	Headwaters	WWH	NA			P*			
Muskellunge Cr.	16.70	Headwaters	WWH	FULL	44		G	38.5		
Muskellunge Cr.	5.40	Wading	WWH	FULL	37	6.9[ns]	G	58.5		
Muskellunge Cr.	1.23	Wading	WWH	NON	37[ns]	9.1	10	69.0	Nutrient/Eutrophication Biological Indicators Sedimentation/Siltation Phosphorus (Total)	Crop Production with Subsurface Drainage
Indian Cr.	0.62	Headwaters	WWH	FULL	30		MG	42.0		
Wolf Cr.	13.60	Wading	WWH	FULL	36	7.5	MG	40.0		
Wolf Cr.	5.15	Wading	WWH	FULL	40	8.1	G	60.5		
Wolf Cr.	1.58	Headwaters	WWH	FULL	36	7.1[ns]		53.0		
Wolf Cr.	0.04	Wading	WWH	FULL	46	10.0	Very G	84.0		
Plum Run	0.79	Wading	WWH-R	PARTIAL	42		F*	37.5	Direct Habitat Alteration	Channelization
Harrison Cr.	0.38	Headwaters	WWH-R	NON	32		P*	64.5	Nutrient/Eutrophication Biological Indicators Nitrogen, Nitrate (Total)	Crop Production with Subsurface Drainage
E. Br. Wolf Cr.	19.65	Headwaters	WWH	NON	26*	6.0*	P*	51.5	Nutrient/Eutrophication Biological Indicators Nitrogen, Nitrate (Total) Phosphorus (Total)	Package Plant or Other Permitted Small Flows Discharges Sewage Discharges in Unsewered Areas
E. Br. Wolf Cr.	13.63	Wading	WWH	FULL	36	7.2[ns]	E	59.5		
E. Br. Wolf Cr.	9.00	Wading	WWH	FULL	37	7.4	G	52.5		
E. Br. Wolf Cr.	0.86	Headwaters	WWH	FULL	51	9.6	38	84.0		

Stream	River Mile[a]	Sampling Type	Aquatic Life Use Designation	Aquatic Life Attainment Status[b]	IBI	MIwb[c]	ICI[d]	Stream Habitat	Cause of Impairment	Source of Impairment
Trib. To E. Br. Wolf Cr. (18.60)	0.04	Headwaters	WWH-R	FULL	32		MG	29.0		
Snuff Cr.	0.33	Headwaters	WWH	FULL	26[ns]		MG	39.5		
E. Br. Of East Branch Wolf Cr.	3.52	Headwaters	WWH	PARTIAL	30*		MG	42.5	Nutrient/Eutrophication Biological Indicators Nitrogen, Nitrate (Total) Phosphorus (Total) Direct Habitat Alteration	Crop Production with Subsurface Drainage Unspecified Urban Storm Water
E. Br. Of East Branch Wolf Cr.	1.48		WWH	FULL	48		G	71.5		
M. Br. Of East Branch Wolf Cr.	0.46	Headwaters	WWH	FULL	38[ns]		G	80.0		
Sugar Cr.	3.11	Wading	WWH	FULL	42		G	47.0		
Sugar Cr.	1.05	Boat	WWH	FULL	44		G	71.0		
Spicer Cr.	0.80	Headwaters	WWH	PARTIAL	34*		E	67.5	Nutrient/Eutrophication Biological Indicators Organic Enrichment (Sewage) Biological Indicators	Manure Runoff Crop Production with Subsurface Drainage
Muddy Cr.	29.36	Headwaters	WWH	FULL	28[ns]	7.1[ns]	G	29.0		
Muddy Cr.	21.10	Headwaters	WWH	FULL	37	7.0[ns]	G	71.0		
Muddy Cr.	18.68	Wading	WWH	FULL	33	7.5[ns]	36	76.0		
Muddy Cr.	9.79	Wading	WWH	FULL	42	7.4[ns]	36	62.0		
Muddy Cr.	1.23	Wading	WWH	NON	21	6.7	12	50.5	Direct Habitat Alterations Phosphorus (Total) Other flow regime alterations	Channelization
L. Muddy Cr.	7.55	Headwaters	WWH	NON	26[ns]		P*	39.0	Nutrient/Eutrophication Biological Indicators Nitrogen, Nitrate (Total) Sedimentation/Siltation	Crop Production with Subsurface Drainage Channelization
L. Muddy Cr.	2.50	Wading	WWH	NON	20	6.9	20	47.5	Nutrient/Eutrophication Biological Indicators Phosphorus (Total) Sedimentation/Siltation	Crop Production with Subsurface Drainage
Fishing Cr.	0.20	Headwaters	WWH-R	NON	32		P*	21.5	Nutrient/Eutrophication Biological Indicators Phosphorus (Total) Sedimentation/Siltation	Crop Production with Subsurface Drainage
S. Br. Muddy Cr.	1.54	Wading	WWH	FULL	34	8.5	42	28.0		

Stream	River Mile[a]	Sampling Type	Aquatic Life Use Designation	Aquatic Life Attainment Status[b]	IBI	MIwb[c]	ICI[d]	Stream Habitat	Cause of Impairment	Source of Impairment
Gries Ditch	4.72	Wading	MWH-R	FULL	30		F	24.5		
Gries Ditch	0.90	Wading	WWH	FULL	28		G	55.0		

a - River Mile (RM) represents the Point of Record (POR) for the station, not the actual sampling RM.

b - Attainment is given for the proposed status when a change is recommended

c - MIwb is not applicable to headwater streams with drainage areas $\leq$ 20 mi^2.

d - 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

ns - Nonsignificant departure from biocriteria ($\leq$4 IBI or ICI units, or $\leq$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.

Index – Site Type	Biological Criteria						Lacustuary Benchmarks[1]				
	Huron Erie Lake Plain			Eastern Corn Belt Plain							
	EWH	WWH	MWH (Channelized)	EWH	WWH	MWH (Channelized)	Exceptional	Good	Fair	Poor	Very Poor
IBI – Headwaters	50	28	20	50	40	24	-	-	-	-	-
IBI – Wading	50	32	22	50	40	24	-	-	-	-	-
IBI – Boat	48	34	20	48	42	24	50	42	31	17	<17
MIwb – Wading	9.4	7.3	5.6	9.4	8.3	6.2	-	-	-	-	-
MIwb – Boat	9.6	8.6	5.7	9.6	8.5	5.8	10	8.6	5.6	2.8	<2.8
ICI	46	34	22	46	36	22	52	42	25	12	<12

1- Proposed Lacustuary scoring breakpoints. These have not yet been adopted into rule.

RECOMMENDATIONS

The streams in the lower Sandusky River study area currently listed in the Ohio Water Quality Standards (WQS) are assigned one or more of the following aquatic life use (ALU) designations: Warmwater Habitat (WWH) and Modified Warmwater Habitat (MWH). The aquatic life use designation of the streams in this survey has been previously verified using biological data with the exception of Plum Run, Harrison Creek, the unnamed tributary to East Br. Wolf Creek (18.60) and Fishing Creek. These streams were originally designated for aquatic life use in the 1978 Ohio WQS but 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.

Nineteen streams in the lower Sandusky River study area were evaluated for aquatic life and recreational use potential in 2009 (Table 3). Significant findings include the following:

- Fourteen streams with an existing WWH use designation should be maintained. These streams include the Sandusky River, Bark Creek, Muskellunge Creek, Indian Creek, Wolf Creek, East Branch Wolf Creek, East Branch to East Branch Wolf Creek, Middle Branch to East Branch to East Branch Wolf Creek, Snuff Creek, Muddy Creek, Little Muddy Creek, South Branch Muddy Creek, Sugar Creek and Spicer Creek. Additionally, the 2009 survey demonstrated the WWH use designation was appropriate for four undesignated streams: Plum Run, Harrison Creek, the unnamed tributary to East Branch Wolf Creek and Fishing Creek.

- Gries Ditch is listed as a WWH stream based on sampling conducted in 1984~~,~~ and 1995. The waterway is listed by the Sandusky County Engineer as a maintained ditch and the habitat condition at RM 4.8 was poor. The original ALU designation did not take habitat conditions of the upper reach into account and instead was based on conditions nearer the confluence with Muddy Creek. Biological sampling results met the MWH use at RM 4.8. Improvement in habitat and biological condition was noted at RM 1.0. It is therefore recommended that the use designation be changed in Gries Ditch upstream from Quinshan Rd. (RM 3.7) from WWH to MWH.

- Gries Ditch should retain the Secondary Contact Recreation use and the Agricultural Water Supply and Industrial Water Supply uses. The remaining eighteen streams in this study should retain the Primary Contact Recreation use (Class A for the Sandusky River and Class B for all other streams), along with the Agricultural Water Supply and Industrial Water Supply uses.

The Sandusky River is designated as a Public Water Supply (PWS) for the cities of Tiffin (RM 41.08) and Fremont (18.02) and should retain this use designation.

The Sandusky River from U.S. route 30 (RM 82.1) to Roger Young Memorial park in Fremont (RM 16.6) is listed as an Outstanding State Water (OSW) based on exceptional ecological values in the Antidegradation Rule (OAC 3745-1-05)of the Ohio Water Quality Standards. The river was designated based on a high level of biological integrity. Included in evaluating exceptional biological value was a determination of declining fish species, high quality habitat to support declining and threatened fish species, and a display of biological integrity equivalent to the Exceptional Warmwater Habitat Index of Biotic Integrity and /or Invertebrate Community Index criteria listed in rule 3745-1-07 of the Ohio Administrative Code.

Crop production with subsurface drainage was the most common nonpoint source of impairment throughout the study area. Increased siltation/sedimentation, nutrient enrichment and channel erosion/incision from crop production contributed to impairment in Muskellunge Creek, Bark Creek, Little Muddy Creek, Harrison Creek, Bark Creek, East Branch Wolf Creek and Fishing Creek. Outreach efforts to the local farming community with SWCDs should be undertaken to encourage best management practices (BMPs) aimed at addressing the effects of agricultural activities on water quality.

Table 3. Waterbody use designation recommendations for the Lower Sandusky River study area. Designations based on the 1978 and 1985 water quality standards appear as asterisks (*). A plus sign (+) indicates a confirmation of an existing use and a triangle (▲) denotes a new recommended use based on the findings of this report.

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	
Muddy Creek		+							+	+		+		
L. Muddy Creek		+							+	+		+		
Fishing Creek		▲							▲	▲		▲		
S. Br. Muddy Creek														
Gries Ditch - headwaters to RM 3.7				▲					▲	▲		▲	▲	ECBP ecoregion – channelized”
- all other segments		+							+	+			+	
Sandusky River - at RMs 18.02, 41.08, 82.9, 83.15 and 115.45		+						o	+	+		+		PWS intakes-Fremont (18.02), Tiffin (41.08), Upper Sandusky (82.9 and 83.15) and Bucyrus (115.45)
- upstream Roger Young memorial park (RM 16.8) to Muskellunge creek (RM 9.37)		+							+	+		+		
- Ella st. dam (RM 42.1) to RM 19.0 (upstream from Fremont)				+					+	+		+		ECBP ecoregion - impounded
- headwaters to RM 45.0		+							+	+		+		
- all other segments		*+							*+	*+		*+		
Bark Creek		+							+	+		+		
Muskellunge Creek		+							+	+		+		
Indian Creek		*+							*+	*+		*+		
Wolf Creek		*+							*+	*+		*+		
E. Br. Wolf Creek		*+							*+	*+		*+		
Snuff Creek		*+							*+	*+		*+		
E. Br. Of East Branch Wolf Creek		*+							*+	*+		*+		
M. Br. Of E. Br. Of East Branch Wolf Creek		*+							*+	*+		*+		
Trib. To Wolf Creek (18.60)		▲							▲	▲		▲		
Plum Run		▲							▲	▲		▲		
Harrison Creek		▲							▲	▲		▲		
Sugar Creek		*+							*+	*+		*+		
Spicer Creek		*+							*+	*+		*+		

INTRODUCTION

Fifty-three stream sampling locations were evaluated in the Lower Sandusky River watershed in Seneca and Sandusky counties in 2009. Eighteen sites on the mainstem of the Sandusky River were sampled along with 24 locations on tributaries including Wolf Creek and Muskellunge Creek. The Muddy Creek watershed, a direct Sandusky Bay tributary, was also sampled at eleven locations. A total of 24 National Pollutant Discharge Elimination System (NPDES) permitted facilities discharge sanitary wastewater, industrial process water, and/or industrial storm water into the Lower Sandusky River and Muddy Creek watersheds.

During 2009, Ohio EPA conducted a water resource assessment of 19 streams in the lower Sandusky River study area using standard Ohio EPA protocols as described in 2008 updates to Biological Criteria for the Protection of Aquatic Life: Volume II and Volume II Addendum. Included in this study were assessments of the biological, surface water and recreation (bacterial) condition. A total of 53 biological, 17 water chemistry, and 17 bacterial stations were sampled in the lower Sandusky River study area. All of the biological, chemical and bacteria results can be downloaded from the Ohio EPA GIS interactive maps at the following link: http://www.epa.state.oh.us/dsw/gis/index.aspx.

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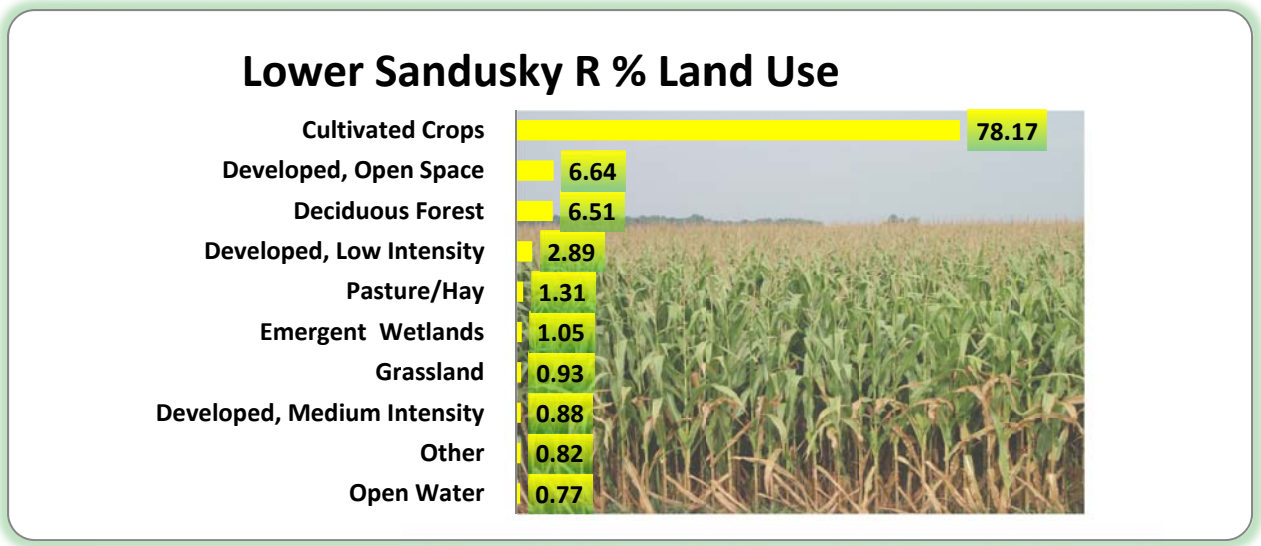
Specific objectives of the evaluation were to:

- ascertain the present biological conditions in the lower Sandusky River study area 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 outfall 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 study area lies within two ecoregions; the southern half is in the Eastern Corn Belt Plain (ECBP) and, to the north, in the Huron-Erie Lake Plain (HELP). Cultivated cropland is the predominant land use (78%) (Figure 3). The cities of Tiffin and Fremont are the largest developed areas in the study area. The monitored reach of the mainstem Sandusky River is 65.01 miles long and drains 1420 mi^2 (ODNR, 2001). The Sandusky River from U.S. route 30 (RM 82.1) to Roger Young Memorial park in Fremont (RM 16.6) is listed as an Outstanding State Water (OSW) based on exceptional ecological values (OAC 3745-1-05).



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).

RESULTS

Water Chemistry

The lower Sandusky River study area consisted of four 10-digit Hydrologic Unit Codes (HUC10s) Each HUC10 may be further divided into HUC12s which are the Watershed Assessment Units (WAUs) as defined by Ohio EPA Integrated Water Quality Monitoring and Assessment reports. Surface water samples were analyzed for metals, nutrients, polychlorinated biphenyls (PCBs), semi-volatile organic compounds, organochlorinated pesticides, bacteria, pH, temperature, conductivity, dissolved oxygen (D.O.), percent D.O.saturation, and suspended and dissolved solids (Appendix Tables 1 and 2).

At most sites, five water quality sampling events were conducted during June - August, 2009. Results for select water quality constituents that exceed Ohio Water Quality Standards (WQS) criteria or targets are summarized in Table 4. The ecoregional criterion (minimum/maximum, average) or target used to evaluate each constituent is included in the table. Results above these levels are considered degraded and are highlighted in bold. In some cases, the geometric mean of sample results is computed and presented for comparison to the criterion or target. Results of all inorganic and organic water quality samples collected in the survey areas during 2009 are presented in Appendices Tables 1 and 2.

Table 4 Results for select water quality constituents tested in grab samples from the Lower Sandusky study area. The standard (min/max, avg.) or target used to evaluate the constituent is included. Concentrations that exceeded these levels and are considered degraded are highlighted in bold.

HUC10 (04100011 11) Rock Creek – Sandusky River				
Stream Use Designations	River Mile/ (Drainage)	Use	Constituent	Values
HUC12 (04100011 11 05) Spicer Creek – Sandusky River				
Sandusky River WWH, PCR, AWS, IWS (1978 WQS)	31.95 (1046 mi^2) Large River	WWH	NO_3-NO_2 (mg/L) Target = 2.0	0.10, 1.20, **3.26, 9.82** (Geo. Mean = 1.50)
	26.94 (1067 mi^2) Large River	WWH	NO_3-NO_2 (mg/L) Target = 2.0	0.10, 0.10, **2.17, 3.21, 9.82** ((Geo. Mean = 0.93)
	23.00 (1073 mi^2) Large River	WWH	NO_3-NO_2 (mg/L) Target = 2.0	0.10, 0.10, **2.98, 3.13, 9.73** (Geo. Mean = 0.98)
Spicer Creek WWH, PCR, AWS, IWS (1978 WQS)	0.80 12.3 mi^2) Headwaters	WWH	NO_3-NO_2 (mg/L) Target = 1.0	0.15, 0.10, **6.24,** 0.54, **7.64** (Geo. Mean = 0.83)
			Total, P (mg/L) Target = 0.08	**0.180**, 0.010, 0.019, 0.032. **0.083** (Geo. Mean = 0.039)
HUC12 (04100011 11 04) Sugar Creek – Sandusky River				
Sugar Creek WWH, PCR, AWS, IWS (1978 WQS)	3.11 (9.4 mi^2) Headwaters	WWH	NO_3-NO_2 (mg/L) Target = 1.0	0.12, 0.10, **1.76**, 0.82, **2.22** (Geo. Mean = 0.52)
HUC10 (04100011 13) Muskellunge Creek – Sandusky River				
Stream Use Designations	River Mile/ (Drainage)	Use	Constituent	Values
HUC12 (04100011 13 01) Muskellunge Creek				
Muskellunge Creek WWH, PCR, AWS, IWS (1978 WQS)	24.44 (2.3 mi^2) Headwaters	WWH	NO_3-NO_2 (mg/L) Target = 1.0	0.15, 0.10, **6.04, 1.60**, (Geo. Mean = 0.62)
			Total, P (mg/L) Target = 0.08	**0.999, 1.110, 0.350, 0.884, (Geo. Mean = 0.765)**
			Iron (µg/L) Ag Use OMZA = 5000	**5090,** 784, 479, 318
	16.70 (17.7 mi^2) Headwaters	WWH	NO_3-NO_2 (mg/L) Target = 1.0	0.11, 0.13, 0.77, **8.16, 2.32** (Geo. Mean = 0.73)
			Total, P (mg/L) Target = 0.08	**0.097**, 0.064, 0.053, **0.089,** 0.064 (Geo. Mean = 0.067)
			D.O. (mg/L) Aquatic Life > 4	6.24, 7.67, 7.91, 6.01**, 3.97**
	5.40 (37.0 mi^2) Wadeable	WWH	NO_3-NO_2 (mg/L) Target = 1.0	0.10, 0.13, 0.13, 0.24, **5.19, 9.17, 4.18** (Geo. Mean = 0.70)
			Strontium (µg/L) Aquatic Life OMZA = 21,000	**35000,** 4870
	1.23 (44.0 mi^2) Wadeable	WWH	NO_3-NO_2 (mg/L) Target = 1.0	0.13, 0.11, 0.23, **9.66, 3.47** (Geo. Mean = 0.64)
			Total, P (mg/L) Target = 0.10	**0.105**, 0.080, 0.063, **0.171**, 0.048 (Geo. Mean = 0.085)

Table 4. continued

Stream Use Designations	River Mile/ (Drainage)	Use	Constituent	Values
HUC12 (04100011 13 01) Muskellunge Creek				
Muskellunge Creek WWH, PCR, AWS, IWS (1978 WQS)	24.44 (2.3 mi^2) Headwaters	WWH	NO_3-NO_2 (mg/L) Target = 1.0	0.15, 0.10, **6.04, 1.60**, (Geo. Mean = 0.62)
			Total, P (mg/L) Target = 0.08	**0.999, 1.110, 0.350, 0.884, (Geo. Mean = 0.765)**
			Iron (µg/L) Ag Use OMZA = 5000	**5090,** 784, 479, 318
	16.70 (17.7 mi^2) Headwaters	WWH	NO_3-NO_2 (mg/L) Target = 1.0	0.11, 0.13, 0.77, **8.16, 2.32** (Geo. Mean = 0.73)
			Total, P (mg/L) Target = 0.08	**0.097**, 0.064, 0.053, **0.089,** 0.064 (Geo. Mean = 0.067)
			D.O. (mg/L) Aquatic Life > 4	6.24, 7.67, 7.91, 6.01**, 3.97**
	5.40 (37.0 mi^2) Wadeable	WWH	NO_3-NO_2 (mg/L) Target = 1.0	0.10, 0.13, 0.13, 0.24, **5.19, 9.17, 4.18** (Geo. Mean = 0.70)
			Strontium (µg/L) Aquatic Life OMZA = 21,000	**35000,** 4870
	1.23 (44.0 mi^2) Wadeable	WWH	NO_3-NO_2 (mg/L) Target = 1.0	0.13, 0.11, 0.23, **9.66, 3.47** (Geo. Mean = 0.64)
			Total, P (mg/L) Target = 0.10	**0.105**, 0.080, 0.063, **0.171**, 0.048 (Geo. Mean = 0.085)
HUC12 (04100011 13 02) Indian Creek – Sandusky River				
Sandusky River WWH, PCR, AWS, IWS (1978 WQS)	20.25 (1251 mi^2) Large River	WWH	NO_3-NO_2 (mg/L) Target = 2.0	**2.70**, 0.30, 0.10, 0.11, **6.23, 9.49, 3.19, 9.19** (Geo. Mean = 1.41)
			Aluminum (µg/L) Human Health Non-Drinking OMZA = 4500	592, 754, 624, 661, 2200, **8040**, 1240, **5910**
			Atrazine (µg/L) MCL = 3.0	2.69, **22.0**
			Copper (µg/L) Aquatic Life OMZA = 15.9 (Hardness = 196)	4.6, 2.4, 2.2, 3.9, 4.4, **21.4**, 2.7, 6.6
			Iron (µg/L) Ag. Use = 5000	820, 1280, 965, 1030, 3380, **12200**, 1810, **8930**
PWS (RM 18.02)	18.05 (1255 mi^2) Large River	WWH PWS	NO_3-NO_2 (mg/L) Target = 2.0	0.10, 0.10, **3.18, 3.41, 8.39** (Geo. Mean = 0.98)
			Aluminum (µg/L) Human Health Drinking OMZA = 970	**1120, 1090**, 272, **1050, 4080**
			Iron (µg/L) Ag. Use = 5000	1930, 1690, 404, 1570, **6010**
Sandusky River	17.70 (1255 mi^2) Large River	WWH	NO3-NO2 (mg/L) Target = 2.0	0.10, 0.10, 3.87, 3.57, 8.36 (Geo. Mean = 1.03)
			Iron (µg/L) Ag. Use = 5000	849, 2390, 559, 1150, 6490
	15.40 (1260 mi^2) Large River	WWH	NO3-NO2 (mg/L) Target = 2.0	0.10, 0.13, 3.98, 3.69, 8.93 (Geo. Mean = 1.11)
			Iron (µg/L) Ag. Use = 5000	883, 1140, 576, 1220, 6220
Indian Creek WWH, PCR, AWS, IWS (1978 WQS)	0.62 (11.2 mi^2) Headwaters	WWH	NO3-NO2 (mg/L) Target = 1.0	0.35, 0.47, 3.21, 4.61, 7.81 (Geo. Mean = 1.80)

Table 4. continued

Stream Use Designations	River Mile/ (Drainage)	Use	Constituent	Values
HUC12 (04100011 13 02) Indian Creek – Sandusky River				
Sandusky River WWH, PCR, AWS, IWS (1978 WQS)	20.25 (1251 mi^2) Large River	WWH	NO_3-NO_2 (mg/L) Target = 2.0	**2.70**, 0.30, 0.10, 0.11, **6.23, 9.49, 3.19, 9.19** (Geo. Mean = 1.41)
			Aluminum (µg/L) Human Health Non-Drinking OMZA = 4500	592, 754, 624, 661, 2200, **8040**, 1240, **5910**
			Atrazine (µg/L) MCL = 3.0	2.69, **22.0**
			Copper (µg/L) Aquatic Life OMZA = 15.9 (Hardness = 196)	4.6, 2.4, 2.2, 3.9, 4.4, **21.4**, 2.7, 6.6
			Iron (µg/L) Ag. Use = 5000	820, 1280, 965, 1030, 3380, **12200**, 1810, **8930**
PWS (RM 18.02)	18.05 (1255 mi^2) Large River	WWH PWS	NO_3-NO_2 (mg/L) Target = 2.0	0.10, 0.10, **3.18, 3.41, 8.39** (Geo. Mean = 0.98)
			Aluminum (µg/L) Human Health Drinking OMZA = 970	**1120, 1090**, 272, **1050, 4080**
			Iron (µg/L) Ag. Use = 5000	1930, 1690, 404, 1570, **6010**
Sandusky River	17.70 (1255 mi^2) Large River	WWH	NO3-NO2 (mg/L) Target = 2.0	0.10, 0.10, 3.87, 3.57, 8.36 (Geo. Mean = 1.03)
			Iron (µg/L) Ag. Use = 5000	849, 2390, 559, 1150, 6490
	15.40 (1260 mi^2) Large River	WWH	NO3-NO2 (mg/L) Target = 2.0	0.10, 0.13, 3.98, 3.69, 8.93 (Geo. Mean = 1.11)
			Iron (µg/L) Ag. Use = 5000	883, 1140, 576, 1220, 6220
Indian Creek WWH, PCR, AWS, IWS (1978 WQS)	0.62 (11.2 mi^2) Headwaters	WWH	NO3-NO2 (mg/L) Target = 1.0	0.35, 0.47, 3.21, 4.61, 7.81 (Geo. Mean = 1.80)
HUC12 (04100011 13 03) Mouth Sandusky River				
Sandusky River WWH, PCR, AWS, IWS (1978 WQS)	4.70 (1330 mi^2) Large River	WWH	NO_3-NO_2 (mg/L) Target = 2.0	0.39, 2.14, 6.56, 6.84, 9.75 (Geo. Mean = 3.25)
Bark Greek	3.20 (10.0 mi^2) Headwaters	WWH	NO_3-NO_2 (mg/L) Target = 1.0	0.14, 0.32, 1.70, 1.75, 6.20 (Geo. Mean = 0.96)
			Total, P (mg/L) Target = 0.08	0.027, **0.175**, 0.028, **0.096**, 0.020 (Geo. Mean = 0.048)

Table 4. continued

HUC10 (04100011 10) Wolf Creek				
Stream Use Designations	River Mile/ (Drainage)	Use	Constituent	Values
HUC12 (04100011 10 01) East Branch East Branch Wolf Creek				
East Br. East Br. Wolf Creek WWH, PCR, AWS, IWS (1978 WQS)	3.52 (6.8 mi^2) Headwaters	WWH	NO_3-NO_2 (mg/L) Target = 1.0	0.64, 0.58, 0.56, **9.83, 4.88** (Geo. Mean = 1.58)
			Total, P (mg/L) Target = 0.08	0.118, 0.110, 0.152, 0.108, 0.085 (Geo. Mean = 0.113)
	1.48 (19.7 mi^2) Headwaters	WWH	NO_3-NO_2 (mg/L) Target = 1.0	0.17, 0.44, 0.55, **12.6, 7.02** (Geo. Mean = 1.29)
			Total, P (mg/L) Target = 0.08	0.098, 0.084, 0.077, 0.120, 0.093 (Geo. Mean = 0.093)
Middle E. Br. E. Br. Wolf Creek WWH, PCR, AWS, IWS (1978 WQS)	0.46 (11.3 mi^2) Headwaters	WWH	NO_3-NO_2 (mg/L) Target = 1.0	3.21, 1.61, 1.85, 12.2, 7.49 (Geo. Mean = 3.87)
			Total, P (mg/L) Target = 0.08	0.072, 0.188, 0.168, 0.122, 0.089 (Geo. Mean = 0.120)
HUC12 (04100011 10 02) Town of New Riegal – East Branch Wolf Creek				
East Branch Wolf Creek WWH, PCR, AWS, IWS (1978 WQS)	19.65 (19.0 mi^2) Headwaters	WWH	NO_3-NO_2 (mg/L) Target = 1.0	**1.29**, 0.72, 0.49, **14.3, 7.20** (Geo. Mean = 2.16)
			Total, P (mg/L) Target = 0.08	4.540, 3.830, 0.254, 0.148, 0.133 (Geo. Mean = 0.613)
	13.63 (33.0 mi^2) Wadeable	WWH	NO_3-NO_2 (mg/L) Target = 1.0	0.54, 0.48, 0.27, **15.1, 5.96** (Geo. Mean = 1.44)
			Total, P (mg/L) Target = 0.10	0.396, 0.144, 0.085, 0.160, 0.106 (Geo. Mean = 0.145)
Trib. to East Branch Wolf Creek	0.04 (8.2 mi^2) Headwaters	WWH	NO_3-NO_2 (mg/L) Target = 1.0	0.21, 0.51, **12.7, 8.35** (Geo. Mean = 1.83)
			Total, P (mg/L) Target = 0.08	0.301, 0.209, 0.105, 0.092 (Geo. Mean = 0.157)
HUC12 (04100011 10 03) Snuff Creek – East Branch Wolf Creek				
East Branch Wolf Creek WWH, PCR, AWS, IWS (1978 WQS)	9.00 (68 mi^2) Wadeable	WWH	NO_3-NO_2 (mg/L) Target = 1.0	0.30, 0.27, 0.40, 1.20, 4, 65, 15.0, 7.16 (Geo. Mean = 1.53)
			Total, P (mg/L) Target = 0.10	0.117, 0.130, 0.170, 0.236, 0.116, 0.163, 0.117 (Geo. Mean = 0.145)
	0.86 (83 mi^2) Wadeable	WWH	NO_3-NO_2 (mg/L) Target = 1.0	0.30, 0.10, 0.17, **15.3, 7.87** (Geo. Mean = 0.767)
			Total, P (mg/L) Target = 0.10	0.113, 0.077, 0.051, 0.155, 0.104 (Geo. Mean = 0.093)
Snuff Creek WWH, PCR, AWS, IWS (1978 WQS)	0.33 (4.7 mi^2) Headwaters	WWH	NO_3-NO_2 (mg/L) Target = 1.0	2.44, 0.53, 2.04, 10.6, 7.26 (Geo. Mean = 2.89)
			Total, P (mg/L) Target = 0.08	0.102, 0.102, 0.117, 0.061, 0.052 (Geo. Mean = 0.083)

Table 4. continued

Stream Use Designations	River Mile/ (Drainage)	Use	Constituent	Values
HUC12 (04100011 10 04) Wolf Creek				
Wolf Creek WWH, PCR, AWS, IWS (1978 WQS)	13.60 (27.0 mi^2) Headwaters	WWH	Total, P (mg/L) Target = 0.08	0.051, 0.087, 0.054, **0.106, 0.086** (Geo. Mean =0.074)
			NO_3-NO_2 (mg/L) Target = 1.0	0.76, 0.49, 1.70, 11.9, 5.45 (Geo. Mean = 2.10)
	5.15 (66.5 mi^2) Wadeable	WWH	Total, P (mg/L) Target = 0.10	1.67, 0.202, 0.671, 0.108, 0.095 (Geo. Mean =0.297)
			NO_3-NO_2 (mg/L) Target = 1.0	0.10, 0.12, 0.10, **3.73, 11.5, 5.87** (Geo. Mean = 0.82)
	1.58 (71.8 mi^2) Wadeable	WWH	Total, P (mg/L) Target = 0.10	0.162, 0.155, 1.119, 0.098, 0.103, 0.074 (Geo. Mean = 0.114)
			NO_3-NO_2 (mg/L) Target = 1.0	0.15, 0.10, 0.10, **14.3, 6.83** (Geo. Mean = 0.68)
	0.04 (158.0 mi^2) Wadeable	WWH	Total, P (mg/L) Target = 0.10	0.119, 0.10, 0.039, 0.134, 0.107 (Geo. Mean = 0.092)
			NO_3-NO_2 (mg/L) Target = 1.0	0.95, 0.13, 0.10, **13.1, 6.59** (Geo. Mean = 1.01)
Harrison Creek	0.38 (13.1 mi^2) Headwaters	WWH	Total, P (mg/L) Target = 0.08	0.024, **0.284**, 0.016, 0.073, 0.033 (Geo Mean = 0.048)
			NO_3-NO_2 (mg/L) Target = 1.0	0.10, 0.10, 0.25, **9.30, 4.91** (Geo. Mean = 0.648)
Plum Run	0.79 (10.1 mi^2) Headwaters	WWH	NO_3-NO_2 (mg/L) Target = 1.0	0.10, 0.10, 0.25, **9.30, 4.91** (Geo. Mean = 0.648)
HUC10 (04100011 14) Muddy Creek – Frontal Sandusky Bay				
HUC12 (04100011 14 01) Gries Ditch				
Gries Ditch WWH, SCR, AWS, IWS (Biological Assessment)	4.72 (9.3 mi^2) Headwaters	WWH	D.O. (mg/L) Aquatic Life > 4	7.12, 8.05, 8.77, 6.79, **2.98**
			NO_3-NO_2 (mg/L) Target = 1.0	0.10, 0.61, 1.08, **9.65, 4.87** (Geo. Mean = 1.25)
	0.99 (21.9 mi^2) Wadeable	WWH	NO_3-NO_2 (mg/L) Target = 1.0	0.10, 0.61, 1.08, **9.65, 4.87** (Geo. Mean = 1.25)
HUC12 (04100011 14 02) Town of Helena – Muddy Creek				
Muddy Creek WWH, PCR, AWS, IWS (Biological Assessment)	29.36 (33 mi^2) Wadeable	WWH	NO_3-NO_2 (mg/L) Target = 1.0	0.23, 0.23, 1.06, 8.01, 2.85 (Geo. Mean = 1.05)
	21.10 (44 mi^2) Wadeable	WWH	NO_3-NO_2 (mg/L) Target = 1.0	0.12, 0.46, 0.36, **8.16, 2.25** (Geo. Mean = 0.82)
South Br. Muddy Creek WWH, PCR, AWS, IWS (Biological Assessment)	0.99 (21.9 mi^2) Wadeable	WWH	D.O. (mg/L) Aquatic Life > 4	6.85, 7.99, 8.98, 7.58, **3.56**
			D.O. (mg/L) Aquatic Life > 4	6.85, 7.99, 8.98, 7.58, **3.56**

Table 4. continued

Stream Use Designations	River Mile/ (Drainage)	Use	Constituent	Values
HUC12 (04100011 14 03) Little Muddy Creek				
Little Muddy Creek WWH, PCR, AWS, IWS (1978 WQS)	7.55 (12.4 mi^2) Headwaters	WWH	NO_3-NO_2 (mg/L) Target = 1.0	0.10, 0.10, 3.50, 8.72, 5.36 (Geo. Mean = 1.10)
	2.5 (25 mi^2) Wadeable	WWH	Total, P (mg/L) Target = 0.10	**0.204, 0.172**, 0.099, 0.082, 0.070 (Geo. Mean = 0.115)
			NO_3-NO_2 (mg/L) Target = 1.0	0.10, 0.10, 1.96, 8.00, 2.52 (Geo. Mean = 0.83)
Fishing Creek	0.2 (7.0 mi^2) Headwaters	WWH	Total, P (mg/L) Target = 0.08	0.229, 0.150, 0.121, 0.069, 0.084 (Geo. Mean = 0.119)
			D.O. (mg/L) Aquatic Life > 4	6.04, 5.95, 7.71, 4.48**, 3.67**
			D.O. (mg/L) Aquatic Life > 4	6.04, 5.95, 7.71, 4.48**, 3.67**
HUC12 (04100011 14 04) Town of Lindsey – Muddy Creek				
Muddy Creek WWH, PCR, AWS, IWS (Biological Assessment)	18.68 (63 mi^2) Wadeable	WWH	Total, P (mg/L) Target = 0.10	0.026, 0.029, **0.126**, 0.028, 0.032 (Geo. Mean = 0.038)
			NO_3-NO_2 (mg/L) Target = 1.0	0.57, 0.26, 0.35, 1.61, 4.42, 8.85, 3.36 (Geo. Mean = 1.41)
	9.79 (74 mi^2) Wadeable	WWH	NO_3-NO_2 (mg/L) Target = 1.0	0.10, 0.10, 0.16, 0.61, **5.71** (Geo. Mean = 0.35)
	1.23 (110 mi^2) Wadeable	WWH	Total, P (mg/L) Target = 0.10	0.399, 0.273, 0.106, 0.138, 0.075 (Geo. Mean = 0.164)

Bacteriological samples were collected from seventeen locations, and the results are reported in the Recreation Use section.

Metals were measured at forty-two locations with eighteen parameters tested (Appendix Table 1). A few exceedances of chemical water quality standards were recorded over the course of the sampling season (Table 5). Iron, aluminum and strontium exceedances were likely a reflection of groundwater contributed flow and the surrounding geology. A source of the copper exceedence from the Sandusky River at Rice Road (RM 20.25) was undetermined but may have been the result of runoff following rain in the days prior to the sampling event.

Table 5. Results for metals exceedances tested in grab samples from the Lower Sandusky Study Area.

Site	Cu ug/L	Al ug/L	Fe mg/L	Sr ug/L
MUSKELLUNGE CREEK AT TR 84 RM 24.44 (300675)				
			5090	
MUSKELLUNGE CREEK AT SPIELDENNER RD RM 5.40 (201332)				
				35000
SANDUSKY RIVER AT RICE RD RM 20.25 (500820)				
		5910	8930	
	21.4	8040	12200	
SANDUSKY RIVER JUST UPST BALLVILLE DAM RM 18.05 (U04T02)				
		4080	6010	

Nutrient levels were a concern throughout the study area. Each water sampling location was analyzed for ammonia-N, nitrate+nitrite-N, total phosphorus, and total Kjeldahl nitrogen (TKN). Fourteen of the 42 locations yielded geometric means that exceeded regional reference conditions for nitrate and/or phosphorus. Forty-two percent of phosphorus and 51% of nitrate values of 210 samples were elevated. Summary statistics for nutrients measured in the Lower Sandusky River watershed are detailed in Table 6. Nutrient enrichment was primarily a consequence of the crop production within the study area. One notable exception was linked to inadequately treated sewage from residential septic systems in the village of Bascom.

Datasonde™ water quality recorders were placed at six locations from July 7, 2009 to July 9, 2009 to monitor hourly levels of dissolved oxygen, pH, temperature, and conductivity (Appendix 3). Datasonde™ hourly monitoring results for dissolved oxygen are listed in Table 7. Dissolved oxygen measurements were indicative of good water quality, with all values above the average WWH water quality criteria (5.0 mg/l).

Table 6 Summary statistics for select nutrient water quality parameters sampled in the Lower Sandusky Study Area, 2009. Values above statewide reference conditions are shaded yellow

Stream	River Mile	Ammonia—N	Nitrate+Nitrite-N	Phosphorus-T
		Geometric Mean	Geometric Mean	Geometric Mean
SANDUSKY R	31.95	0.035	1.15	0.075
SANDUSKY R	26.94	0.036	0.70	0.104
SANDUSKY R	23.00	0.034	0.74	0.084
SANDUSKY R	20.25	0.087	2.05	0.072
SANDUSKY R	18.05	0.046	0.74	0.087
SANDUSKY R	17.70	0.048	0.78	0.074
SANDUSKY R	15.40	0.032	0.97	0.073
SANDUSKY R	4.70	0.079	3.25	0.093
BARK CREEK	3.20	0.042	0.96	0.050
MUSKELLUNGE CREEK	24.44	0.052	0.52	0.765
MUSKELLUNGE CREEK	16.70	0.076	0.73	0.067
MUSKELLUNGE CREEK	5.40	0.053	0.96	0.052
MUSKELLUNGE CREEK	1.23	0.025	0.64	0.085
INDIAN CREEK	0.62	0.040	1.80	0.022
WOLF CREEK	13.40	0.040	0.55	0.074
WOLF CREEK	5.15	0.029	2.07	0.298
WOLF CREEK	1.58	0.029	0.54	0.118
WOLF CREEK	0.04	0.038	0.52	0.092
PLUM RUN	0.79	0.025	0.49	0.028
HARRISON CREEK	0.38	0.025	0.88	0.048
E. BR. WOLF CREEK	19.65	0.947	2.16	0.614
E. BR. WOLF CREEK	13.63	0.036	1.44	0.145
E. BR. WOLF CREEK	9.00	0.043	1.69	0.158
E. BR. WOLF CREEK	0.86	0.044	0.67	0.094
TRIB. TO E. BR. WOLF CREEK (18.60)	0.04	0.113	1.84	0.157
SNUFF CREEK	0.33	0.034	2.89	0.083
E. BR. OF EAST BRANCH WOLF CREEK	3.52	0.041	1.58	0.113
E. BR. OF EAST BRANCH WOLF CREEK	1.48	0.025	1.29	0.093
M. BR. TO E. BR.EAST BRANCH WOLF CREEK	0.46	0.025	3.87	0.120
SUGAR CREEK	3.11	0.041	0.45	0.033
SPICER CREEK	0.80	0.039	0.72	0.034
MUDDY CREEK	29.36	0.025	0.30	0.015
MUDDY CREEK	21.88	0.025	1.05	0.032
MUDDY CREEK	18.68	0.025	0.88	0.039
MUDDY CREEK	9.79	0.029	1.36	0.068
MUDDY CREEK	1.23	0.070	0.27	0.164
L. MUDDY CREEK	7.55	0.025	3.89	0.047

Stream	River Mile	Ammonia—N Geometric Mean	Nitrate+Nitrite-N Geometric Mean	Phosphorus-T Geometric Mean
L. MUDDY CREEK	2.50	0.045	0.84	0.115
FISHING CREEK	0.20	0.075	0.63	0.119
S. BR. MUDDY CREEK	0.99	0.040	0.82	0.014
GRIES DITCH	4.72	0.050	1.06	0.012
GRIES DITCH	0.90	0.025	1.25	0.020
		Reference Value		
	Headwater Wading Large River	>90% of Reference Site Values	>0.8 >1.0 >2.0	>0.08 >0.10 >0.30

Table 7. Summary of hourly dissolved oxygen measurements (mg/L) recorded by automatic meters deployed in the Lower Sandusky Study Area, 7/7/2009 to 7/9/2009.

River Mile	Hours	Mean	Median	Minimum	Maximum	Flux
Sandusky River						
20.25	45	10.05	9.67	7.53	13.5	6.32
13.7	45	15.28	15.94	7.82	19.51	11.69
East Branch Wolf Creek						
9.0	45	6.2	6.2	5.54	6.9	1.36
Wolf Creek						
1.58	46	9.41	8.32	6.67	15.56	8.89
Muskellunge Creek						
5.4	46	8.11	7.72	6.84	10.09	3.25
Muddy Creek						
9.79	5	7.62	7.56	6.69	8.72	2.03

Rock Creek – Sandusky River HUC10 (04100011 11)

The Rock Creek-Sandusky River HUC10 consists of two HUC12s, which were sampled at five locations. The Spicer Creek-Sandusky River HUC12 (04100011 11 05) included one sample location on Spicer Creek and three on the Sandusky River mainstem. None of the physical or chemical constituents tested in grab samples exceeded their respective WQS criteria. Nitrate concentrations were elevated in several grab samples; however calculation of the geometric mean indicated a level below the target values of 2.0 mg/L for large rivers and 1.0 mg/L for headwater streams. One site was sampled within the Sugar Creek-Sandusky River (HUC12-04100011-11-04). Sample results revealed no parameters which exceeded their respective WQS criteria. Nitrate concentrations were elevated in several grab samples; however calculation of the geometric mean indicated a level below the target values of 1.0 mg/L for headwater streams.

Muskellunge Creek – Sandusky River HUC10 (04100011 13)

The Muskellunge Creek–Sandusky River HUC10 consists of three HUC12s which were sampled and evaluated at 11 locations. Within the Muskellunge Creek HUC12 (0410001 13 01) results from several grab samples collected at four locations contained elevated nitrate concentrations; however calculation of the geometric mean indicated a level below the target value. Phosphorous concentrations were evaluated in numerous grab samples; calculations of the geometric mean indicated a level above the target values of 0.08 mg/L for headwater streams at RM 24.44. Iron concentrations were above the WQS criterion of 5000 µg/L for the protection of the Agricultural Water Supply use in one grab sample at RM 24.44. Strontium was present in one grab sample at RM 5.40, exceeding the Outside Mixing Zone Average (OMZA) criterion of 21,000 (µg/L).

Within the Indian Creek-Sandusky River HUC12 (04100011 13 02) three locations were sampled on the Sandusky River and one on Indian Creek. Evaluation of grab samples yielded elevated nitrate concentrations at all sampling locations, though only the Indian Creek site produced a geometric mean calculation above the target nitrate value of 1.0 (mg/L). Atrazine, a water soluble herbicide used to maximize corn yields, was detected in samples collected at RM 20.25, exceeding the drink water Maximum Contaminate Level (MCL). Aluminum concentrations exceeded the Human Health (Drinking) Outside Mixing Zone Average (OMAZ) of 970 (µg/L) in samples collected from the Sandusky River at RM 20.25 and 18.05. Copper concentrations exceeded the OMZA for the Protection of Aquatic Life in one sample collected from the Sandusky River at RM 20.25. A source of the copper was undetermined but may have been the result of runoff following rain in the days prior to the sampling event. Iron concentrations in numerous samples were above the WQS criterion of 5000 µg/L for the protection of the Agricultural Water Supply.

The mouth Sandusky River HUC12 (04100011 13 03) was sampled at two locations. At RM 4.70 on the Sandusky River nitrate concentrations were elevated in several grab samples; calculation of the geometric mean indicated a level well above the target values of 2.0 (mg/L). Grab samples were collected from Bark Creek at RM 3.20. Evaluation of sample results indicated elevated nutrient levels; however geometric mean calculations were below the respective target values.

Iron, aluminum and strontium exceedances in the Muskellunge Creek – Sandusky River HUC10 were likely a reflection of groundwater contributed flow and the surrounding geology. Elevated nutrient concentrations were a consequence of agricultural production within the watershed.

Wolf Creek HUC10 (04100011 10)

The Wolf Creek HUC10 consists of four HUC12s which were sampled and evaluated at 15 locations. Three locations were sampled within the East Branch East Branch Wolf Creek HUC12 (04100011 10 01). Evaluation of sample results indicated elevated nutrient levels; geometric mean calculations were above the target values for both nitrate and phosphorous at all locations. Three locations were sampled within the Town of New Riegal-East Branch Wolf Creek HUC12 (04100011 10 02). Evaluation of sample results indicated elevated nutrient levels; geometric mean calculations were above the target values for both nitrate and phosphorous at all locations. Three locations were samples within the Snuff Creek-East Branch Wolf Creek HUC12 (04100011 10 03). At RM 0.86 on the East Branch Wolf Creek nutrients were elevated in several grab sample; geometric mean calculations were below the respective target values. At RM 9.00 on the East Branch Wolf Creek and RM 0.33 on Snuff Creek sample results indicated elevated nutrient levels; geometric mean calculations were above the target values for both nitrate and phosphorous. Six locations were sampled and evaluated within the Wolf Creek HUC12 (04100011 10 04).

Evaluation of sample results collected from four locations on Wolf Creek indicated elevated nutrient concentrations in numerous grab samples; geometric mean calculations exceeded the respective target values at RM 5.15. Results of nitrate geometric mean calculations from sample collected at RM 0.38 on Harrison Creek were above the target value.

Nutrient enrichment was noted throughout the Wolf Creek HUC10 due largely to agricultural production; however, the highest nitrate and phosphorus in this portion of the watershed were downstream from the village of Bascom on the East Branch of Wolf Creek resulting from the release of inadequately treated sewage.

Muddy Creek- Frontal Sandusky Bay HUC 10 (04100011 14)

The Muddy Creek-Frontal Sandusky Bay HUC10 consists of four HUC12s which were sampled and evaluated at 11 locations. Nutrient enrichment related to agricultural production was noted throughout the watershed. Two locations were sampled within the Gries Ditch HUC12 (04100011 14 01). Nitrate concentrations were elevated above the target nutrient target value at both sampling locations. During one site visit to Gries Ditch at RM 4.72 the dissolved oxygen (DO) level as recorded from a field meter was below the WQS DO minimum criterion of 4.0 mg/L for the protection of aquatic life. Within the Town of Helena-Muddy Creek HUC12 (04100011 14 02), Muddy Creek and South Branch geometric mean calculations yielded nitrate concentrations above the respective target values. South Branch Muddy Creek at RM 0.99 the dissolved oxygen (DO) level was recorded below the WQS DO minimum criterion on one occasion. Little Muddy Creek HUC12 (04100011 14 03) was assessed at three locations. Sample results indicated elevated nutrient levels; geometric mean calculations were above the target values for both nitrate and phosphorous at two locations on Little Muddy Creek. Nutrient levels were found to be elevated on Fishing Creek at RM 0.2; geometric mean calculations were above the target value for phosphorous. During one site visit the dissolved oxygen (DO) level as recorded from a field meter was below the WQS DO minimum criterion of 4.0 mg/L for the protection of aquatic life. Within the Town of Lindsey-Muddy Creek HUC12 (04100011 14 04) three locations were sampled and evaluated. Nutrient concentrations were elevated in grab samples at all sites on occasions. Nutrient geometric mean calculations for Muddy Creek were above the target values for nitrate at RM 18.68 and phosphorus at RM 1.23.

Public Water Supplies

The public water supply beneficial use in the WQS (OAC 3745-1-33) currently applies within 500 yards of drinking water intakes and for all publicly owned lakes. Ohio EPA has developed an assessment methodology for this beneficial use which focuses on source water contaminants not effectively removed through conventional treatment methods. The 2010 Integrated Water Quality Report describes this methodology and is available on OEPA's website: http://www.epa.state.oh.us/dsw/tmdl/OhioIntegratedReport.aspx.

Impaired source waters may contribute to increased human health risk or treatment costs. For the case when stream water is pumped to a reservoir, the stream and reservoir will be evaluated separately. These assessments are designed to determine if the quality of source water meets the standards and criteria of the Clean Water Act. Monitoring of the safety and quality of treated finished drinking water is regulated under the Safe Drinking Water Act and evaluated separately from this assessment. For those cases when the treatment plant processes do not specifically remove a source water contaminant, the finished water quality data may be considered representative of the raw source water directly feeding into the treatment plant.

City of Fremont

The city of Fremont operates a community public water system that serves a population of approximately 19,500 people through 7,400 service connections. The water treatment system obtains its water from a surface water intake on the Sandusky River at the Ballville Dam (RM 18.02). The system's treatment capacity is approximately 10.5 million gallons per day, but current average production is approximately four million gallons per day. Fremont's water treatment system consists of coagulation, lime softening, sedimentation, filtration, adsorption, stabilization, fluoridation, and disinfection.

The city of Fremont exceeded the nitrate WQS criterion in finished water and was in violation of the Safe Drinking Water Act five times during the past five years. Most recently, Fremont posted water quality advisories due to elevated nitrate in January and February of 2010. Due to high nitrate levels in the Sandusky River, Fremont began construction of a large upground reservoir to allow for selective pumping of the river water during periods of poor water quality. Once the upground reservoir is completed, a new surface water intake will be constructed on the Sandusky River mainstem upstream of the current location at the Ballville Dam. The new intake location will be moved approximately one mile upstream of the Ballville Dam to a site near the Portage Trail Canoe Livery.

Ohio EPA collected two samples in 2008 and seven more in 2009 to assess nitrate levels at the Fremont intake (Table 8). Nitrate levels ranged from below detection limit (BDL) to 11.4 mg/L for this sample set. OEPA also reviewed nitrate levels in the finished water since the city of Fremont does not remove nitrate during the treatment process. During the period 2004-2008, nitrate levels were greater than 10 mg/L in 17 of 128 samples with a maximum of 20.70 mg/L in finished water. Nitrate levels in the finished water triggered the impairment listings in the 2008 and 2010 Integrated Water Quality Reports.

A total of four samples were collected in 2008 and 2009 at the intake and analyzed for pesticides. Atrazine ranged from 0.88 to 16.5 ug/L with two samples exceeding the WQS criterion of 3.0 ug/L. However, additional samples are needed in order to complete the assessment for pesticides since the criteria are evaluated as an annual average. At a minimum, the Sandusky River at the Fremont intake will be identified on the watch list for pesticides since at least one sample was greater than 4 times the WQS criterion.

Fremont's raw and finished water were also included in the additional June 2009 pesticide sampling described above. The highest concentration of pesticides was found in Fremont's Sandusky River raw water intake, with 2,4-D (4.1 ppb), acetochlor (0.72 ppb), atrazine (6.27ppb), deethylatarzine (0.48 ppb), and simazine (0.24 ppb). Fremont's treated drinking water sample had significantly lower concentrations of pesticides with atrazine at 0.25 ppb and acetochlor and deethylatarzine at concentrations below the Limit Of Quantification (LOQ).

Table 8. Summary of available water quality data for parameters of interest at sampling sites near/at PWS intakes.

Location(s)	PDWS Parameters of Interest			
	Nitrate-Nitrite WQC = 10 mg/L[1]		Atrazine WQC = 3.0 ug/L[2]	
	Average/ (sample count)	Maximum (#samples >WQC)	Average / (sample count)	Maximum
Sandusky R. Just Upstream Ballville Dam	5.0 mg/L (N=9)	11.4 mg/L (1)	7.07 ug/L[3] (N=4)	16.5 ug/L

1- Nitrate Water Quality Criteria (WQC) evaluated as maximum value not to be exceeded, impaired waters defined as having two or more excursions about the criteria.

2- Atrazine WQC evaluated as annual average.

3- Insufficient data available to assess the annual average for the PDWS beneficial use. Only four spring samples available, additional data required to more accurately characterize the annual average.

Recreation Use

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

Escherichia coli (*E. coli*) bacteria are microscopic organisms that are 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 of human feces (Dufour, 1977), but 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 practicable. 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 them directly. 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 source or another. Swimming or other recreational-based contact with water having a high fecal coliform or *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.

The streams in this survey are designated with the Primary Contact Recreation (PCR) use in OAC Rule 3745-1-07 with exception of Gries Ditch. Water bodies with a designated recreational use of PCR "…are waters that, during the recreation season, 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 typically have identified public access points and support primary contact recreation. Streams designated PCR Class B support, or potentially support, occasional primary contact recreation activities. The surveyed reach of the Sandusky River mainstem is designated Class A PCR waters; all other PCR streams assessed during this survey are designated Class B waters. The *E. coli* criteria that apply to PCR Class A and B streams include a geometric mean of 126 and 161 cfu/100 ml, and a maximum value of 298 and 523 cfu/100 ml, respectively. The geometric mean is based on two or more samples and is used as the basis for determining attainment status when more than one sample is collected.

Gries Ditch is designated as a Secondary Contact Recreation (SCR) use in OAC Rule 3745-1-07. Water bodies with a designated recreational use of SCR "...are waters that result in minimal exposure potential to water borne pathogens because the waters are: rarely used for water based recreation such as, but not limited to, wading; situated in remote, sparsely populated areas; have restricted access points; and have insufficient depth to provide full body immersion, thereby greatly limiting the potential for water based recreation activities." [OAC 3745-1-07 (B)(4)(c)]. The *E. coli* criteria that apply to SCR streams include a geometric mean of 1030 cfu/100 ml, and a maximum value of 2318 cfu/100 ml.

Summarized bacteria results are listed in Table 9, and the complete dataset is reported in Appendix 4. Downloadable bacteria results are also available from the Ohio EPA GIS interactive maps at the following link: http://www.epa.ohio.gov/dsw/gis/index.aspx . Seventeen locations in the lower Sandusky River study area were sampled for *E. coli* five to eight times, from June 4th – October 5th, 2009. Evaluation of *E. coli* results revealed that four of the seventeen locations attained the applicable geometric mean criterion, and thus were in full attainment of the recreation use. One location on the Sandusky River at RM 15.40 exceeded the bacteria criterion, with a geometric mean value of 445 cfu/100 ml. This location is located downstream from several combined sewer overflows (CSOs) that discharge during rain events within the city of Fremont.

The current NPDES permit for Fremont contains a compliance schedule to implement a Long Term Control Plan (LTCP) with the goal of reducing combined sewer overflows (CSOs) to four (4) or less during a typical year. The reduction of CSO releases will take place through improvements to the wastewater collection system by 2028.

Several unsewered communities are located within the lower Sandusky River study area. The 2009 bacteria sampling found widespread recreation use impairment throughout the study area. It is possible that unsanitary conditions exist which may warrant centralized sewage collection and treatment, particularly in the village of Bascom and Bettsville.

Table 9. A summary of E. coli data for locations sampled in the Lower Sandusky River watershed, June 4 – October 5, 2009. Recreation use attainment is based on comparing the geometric mean to the applicable water quality criterion: Primary Contact Recreation (PCR) Classes A or B geometric mean water quality criterion of 126 or 161 cfu/100 ml and (Ohio Administrative Code 3745-1-07). All values are expressed in colony forming units (cfu) per 100 ml of water. Gray shaded values exceed the applicable PCR Class A or B geometric mean criterion.

Location	River Mile	Recreation Use	# of Samples	Geometric Mean	Maximum Value	Recreational Attainment Status	Probable Source(s) of Bacteria
Sandusky River	31.95	PCR Class A	8	282	1200	NON	Unknown
Sandusky River	26.94	PCR Class A	8	128	730	NON	Unknown
Sandusky River	23.00	PCR Class A	8	301	2000	NON	Unknown
Sandusky River	20.25	PCR Class A	9	287	1600	NON	Unknown
Sandusky River	18.05	PCR Class A	5	67	440	FULL	
Sandusky River	17.70	PCR Class A	5	94	790	FULL	
Sandusky River	15.40	PCR Class A	7	445	1800	NON	Fremont CSOs
Sandusky River	4.70	PCR Class A	7	123	580	FULL	
Indian Creek	0.62	PCR Class B	8	1252	3600	NON	Unknown
Muskellunge Creek	5.40	PCR Class B	8	188	460	NON	Unknown
Wolf Creek	1.58	PCR Class B	7	234	2000	NON	Unknown
E. Br. Wolf Creek	13.63	PCR Class B	8	437	1300	NON	Unknown
E. Br. Wolf Creek	9.00	PCR Class B	8	426	980	NON	Unknown
M. Br. E. Br Wolf Ck	0.46	PCR Class B	8	437	1200	NON	Unknown
Muddy Creek	21.10	PCR Class B	8	346	770	NON	Unknown
Muddy Creek	9.79	PCR Class B	8	719	2600	NON	Unknown
Gries Ditch	0.90	PCR Class B	8	179	830	FULL	

Effluent Dischargers

A total of 24 National Pollutant Discharge Elimination System (NPDES) permitted facilities discharge sanitary wastewater, industrial process water, and/or industrial storm water into streams in the lower Sandusky River study area (Table 10). Included in this list are one major municipal discharger with CSOs and a number of small sewage treatment plants and industrial dischargers. Each facility is required to monitor their discharges according to sampling and monitoring conditions specified in their NPDES permit and report results to the Ohio EPA in a Discharge Monitoring Report (DMR). Each permit includes a detailed list of each parameter to be monitored and the specific limits for both concentration and loading rate. They also include monthly average limits and daily or weekly maximum limits, depending on the monitoring requirements. This DMR data can be used to track compliance as well as to evaluate historical trends. Facilities or sites within the study area that are regulated by a general NPDES permit may be found by visiting http://www.epa.ohio.gov/dsw/permits/gpfact.aspx#background.

The Ohio EPA conducts 48-hr acute screening bioassays to evaluate toxicity during the permit compliance and renewal process for Major NPDES permitted facilities [discharge >1.0 Million Gallons per Day (MGD)] and occasionally minor facilities if time permits. Grab and composite samples of the effluents are collected along with samples of the receiving stream upstream and in

the near field mixing zone. The fathead minnow *Pimephales promelas* and daphnid *Ceriodaphnia dubia* are used as test organisms. More detailed information on the one major point source discharger in the lower Sandusky study area is included below.

Fremont WPCF

The city of Fremont Water Pollution Control Facility (WPCF) (2PD00007) is the only major discharger in the survey area. The Fremont WPCF is located at 1019 Sand Road, Fremont and discharges to the Sandusky River at RM 13.85. The existing facility was built in 1949 and the latest major modification occurred in 1988. The system is designed to treat 7.6 MGD and utilizes conventional activated sludge with primary sedimentation and sand filters with chemical disinfection. The collection system is 75% separated sewers with 9 lift stations, the remaining 25% is combined sewers with 11 lift stations and 13 permitted CSOs, of which only four are currently active and includes a primary and secondary bypass. Fremont has developed a Long Term Control Plan (LTCP) to address CSOs from the city wastewater collection system. Final revisions to the plan were approved by the Ohio EPA on April 8, 2010, before completion of final construction is scheduled for 2028

Acute bioassays performed at the Fremont WPCF in 2005 by Ohio EPA staff indicated no toxicity to aquatic test organisms. A review of monthly self-monitoring data revealed one permit limit violation for total residual chlorine in 2009. Annual loadings (kg/day) of total phosphorus and nitrate+nitrite were evaluated using the LEAP system and are presented in Figures 3 and 4.

Some variability in flow rate is indicated by the graphs, due in part to the fact that 25% of the collection system is combined and affected by storm runoff. There are also sources of infiltration and inflow into the collection system estimated at 0.15 MGD. Only the highest flow rates (95^{th} percentile) exceed the plants design capacity of 7.6 MGD and none exceed the hydraulic capacity of 13.75 MGD. Flows generally show an increasing trend since about 2005, possibly due to several sewer extension projects that have been completed in that time frame.

Phosphorus loads are closely tied to flow rate, indicating that effluent concentrations are relatively consistent. The plant adds ferrous chloride to enhance phosphorus removal and has load limits of 28.8 kg/day on a monthly average and 43.2 kg/day on a daily maximum. Even the loads associated with the highest flows do not exceed this monthly average.

Nitrate loads show a bit more variability and can be more influenced by improvements in the treatment process. The graph shows a decreasing trend in the 1995-1997 time period and generally levels off thereafter. Although no major plant modifications have been done since 1988, it is possible that improvements in sludge handling in 1994 and rehabilitation of the tertiary sand filters in 2001 resulted in more efficient removal of nitrogen.

Table 10. Facilities within the Lower Sandusky River study area regulated by an individual permit.

Facility Name Permit Number	Outfall	Receiving Stream	River Mile	Description
Adam's Acres Sub. 2PG00082	001	Muskellunge Ck.	8.88	0.035 MGD, ex-aeration, sand filter, chlorination-dechlorination
Apollo MHP 2PY00062	001	Little Muddy Creek	3.90	0.015 MGD, aeration, clarification, sand filters, chl.-dechl.
Atlas Ind. Inc. 2IS00017	001	Houck Ditch	1.88	0.0046 MGD, storm water
Bettsville WWTP 2PA00072	001	Wolf Creek	5.35	0.175 MGD, activated sludge, ex-aeration, UV
BP Products, Tiffin 2IN00209	001	E.Br. of E. Br. Wolf Creek		0.001 MGD, storm water
Carmeuse Lime, Inc. 2IJ00032	001 005	Muddy Creek Rosa Walby Ditch	25.57 0.48	0.41 MGD, sedimentation 1.4 MGD, sedimentation
Carmeuse Lime, Inc. 2IN00051	001 002	Wander Creek Wander Creek	2.65 1.85	0.10 MGD, sedimentation 0.58 MGD, sedimentation
Church & Dwight Co. 2IE00011	001 002	Sandusky River Indian Creek	26.28 ~5.81	0.0781 MGD, EQ pond, RO, boiler blow down 0.08 MGD, storm water
Culligan Water Cond. 2IN00084	001	Minnow Creek	2.00	0.002 MGD, backwash water
Framland Foods Inc.	001	John Smith Ditch	6.78	0.05 MGD, activated sludge, chl-dechl
Fostoria Ethanol, LLC 2IF00026	001	trib. Muskellunge Ck.	25.0	0.185 MGD, non-contact cooling water
Fremont WPCF 2PD00007	001 002 003 004 005 006 007 008 009 010 011 012 013 015 016 017	Sandusky River Sandusky River Sandusky River Sandusky River Sandusky River Sandusky River Sandusky River Sandusky River Sandusky River Sandusky River Sandusky River Sandusky River Sandusky River Sandusky River Sandusky River Sandusky River Sandusky River	13.85 15.80 15.70 15.32 15.05 14.82 16.00 16.00 14.80 14.82 14.48	7.6 MGD, primary/sedimentation, activated sludge, sand filter, chl.-dechl. bypass secondary bypass combined sewer overflow combined sewer overflow combined sewer overflow combined sewer overflow combined sewer overflow combined sewer overflow combined sewer overflow combined sewer overflow combined sewer overflow combined sewer overflow combined sewer overflow combined sewer overflow combined sewer overflow combined sewer overflow
Hammer-Heinsman 2PG00011	001	Wolf Creek	22.73	0.030 MGD, activated sludge, ex-aeration, chl-dechl.
Heinz Company 2IN00009	001	Sandusky River	14.16	0.68 MGD, cooling water
Helena head Start 2PT00032	001	trib. Muddy Creek		0.004 MGD, package plant w/chlorination-dechlorination
Hopewell Estates MHP 2PY00006	001	Harrison Creek	4.04	0.016 MGD, ex-aeration, chl, tertiary pond
Lindsey WWTP 2PA00024	001 602	Muddy Creek	15.05	0.215 MGD, ex-aeration, sand filter, chl.-dechl. bypass
Meadowbrook Park 2PR00142	001 002	E. Br. Wolf Creek E. Br. Wolf Creek	1.97 1.58	945 GPD, ex-aeration package plant 875 GPD, ex-aeration package plant
New Riegel Café 2IH00032	001	trib. to E. Br. Wolf Ck.	6.18	75 GPD, settling, activated sludge, chl.
New Riegel School 2PT00035	001	trib. to E. Br. Wolf Ck.		0.01 MGD, eq, ex-aeration, activated sludge, sand filter, chl-dechl
Pelton MHP 2PY00032	001	Keckler Ditch	1.41	1875 GPD, package plant

Facility Name Permit Number	Outfall	Receiving Stream	River Mile	Description
Westwood Acres Sub. 2PG00023	001	trib. Muskellunge Ck.	2.95	0.02 MGD,ex-aeration, sand filter, chl.-dechl.bypass
Snakesters 2PR00114	001	E. Br. Wolf Creek		245 GPD, ex-aeration, sand filter, chl-dechl.
ThyssenKrupp Atlas 2IN00211	001	trib. to Wolf Creek	~1.2	0.01 MGD, oil/water separator (contaminated ground)

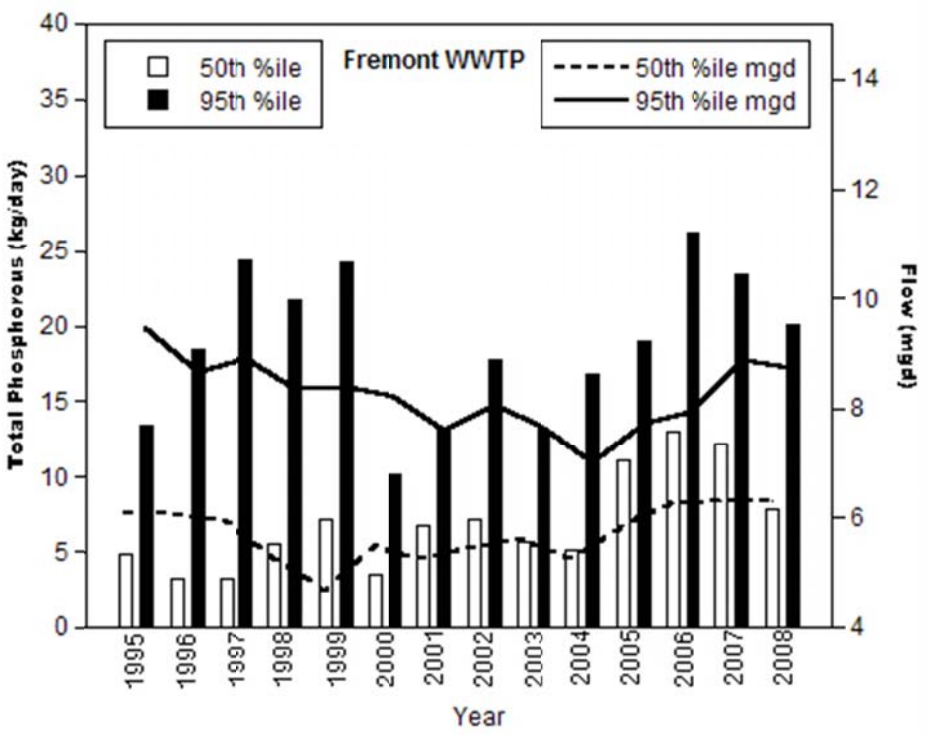


Figure 3. Annual total phosphorus loadings (kg/day) and flow from the Fremont WPCF, 1995 to 2008.

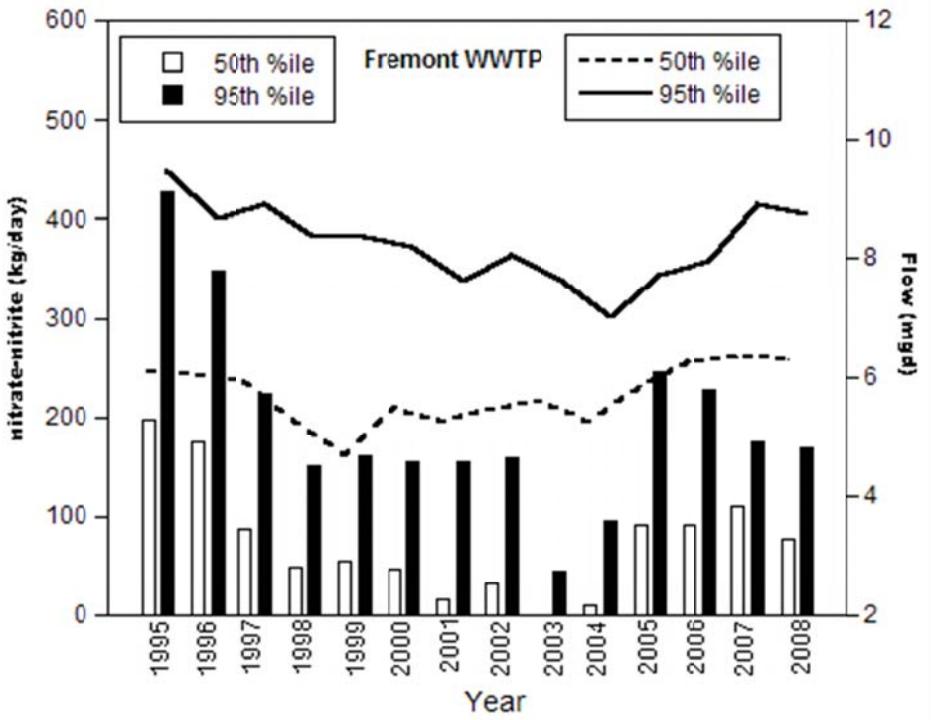


Figure 4. Annual nitrate+nitrite loadings (kg/day) and flow from the Fremont WPCF, 1995 to 2008.

Sediment

Sediment samples were collected from seven locations in the lower Sandusky River study area by the Ohio EPA during 2009. Several locations identified in the study plan were not sampled due to a lack of suitable sediments. Samples were analyzed for metals, semi-volatile organic compounds, nutrients, and particle size. Specific chemical parameters tested and results are listed in Appendix 5. 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 Sediment Reference Values (SRV)* for metals (Ohio EPA 2008c). 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.

Sediment samples were conservatively sampled by focusing on depositional areas of fine grain material (silts and clays). These near bank areas typically are represented by higher contaminant levels, compared to sands and gravels. All sediment sampling occurred in areas along the stream bank, which were represented by sparse deposits of fine grained material. These near bank areas comprised only a small fraction of the bottom substrates of the streams surveyed. Bottom substrates at sediment sites were dominated by gravel, cobble and bedrock material. Organic chemical parameters were tested at nine sampling locations (Appendix Table 5). All organic chemicals were reported as not detected - organic chemical measurements in sediment were within acceptable ecological levels.

Of the metals measured in sediment samples, nickel was detected above the TEC benchmark at one site (Table 11). However, all of the nickel values were below Ohio SRV benchmarks. Two strontium concentrations and one calcium concentration exceeded Ohio sediment reference values. Overall, sediment metals concentrations were within acceptable ecological levels, reflective of natural background conditions, and protective of biological integrity.

Table 11. Chemical parameters measured above screening levels in samples collected by Ohio EPA from surficial sediments in the lower Sandusky River study area, 2009. Shaded numbers indicate values above the following: SRVs (blue),Threshold Effect Concentration –TEC (yellow), Probable Effect Concentration – PEC (red) and Ecological Screening Levels (orange). Sampling locations are indicated by river mile (RM).

Stream	River Mile	Nickel (mg/kg)	Strontium (mg/kg)	Calcium (mg/kg)
Sandusky River	4.7	28.3		
Muddy Creek	1.23		289	
Muddy Creek	21.10		386	
Gries Ditch	0.96			188000

Stream Physical Habitat

Sandusky River

Stream habitat was evaluated at 51 fish sampling locations in the lower Sandusky River study area during 2009 (Table 12, Appendix 6). Seventeen of these stations were located on the Sandusky River, where habitat quality ranged from fair to excellent. The average Qualitative Habitat Evaluation Index (QHEI) score for all Sandusky River sites was 70.3, consistent with good overall habitat quality. Free flowing portions of the Sandusky River are predominated by limestone bedrock and gravel substrates, with lesser amounts of cobble, sand, and boulders. However, moderate to heavy substrate embeddedness occurred at 8 of the 12 lotic sites. Embeddedness is the degree that cobble, gravel, and boulder substrates are surrounded, impacted in, or covered by fine sand and silt. Extensive amounts are detrimental to bottom spawning fish and can impair macroinvertebrate populations. Additionally, the reach of the Sandusky River impounded by the Ballville Dam in Fremont and Lake Erie influenced sites (RMs 4.70 and 1.00) had bottom substrates predominated by muck and silt which negatively affected fish and macroinvertebrate communities.

Figure 5. Sandusky River upstream from Wolf Creek

Other Streams/Tributaries

Varied conditions were encountered among the 34 stations on small streams in the study area. The average QHEI score for all small stream sites was 52.9. QHEI scores below 60 indicate habitat conditions which may not be favorable to support WWH communities. Excellent to good stream habitat was noted at thirteen locations (38%). Fair habitat was noted at 9 locations (26%), poor or very poor habitat was documented at 12 locations (35%) (Table 12). The majority of sites with fair to very poor habitat quality reflect the detrimental effects of excessive siltation and channel modification associated with crop production throughout the study area.

Figure 6. South Branch Muddy Creek at Anderson Rd. QHEI-28. Typical poor quality habitat features include sedimentation and unstable channelized banks.

Table 12. Stream physical habitat (QHEI) summarized results for the Lower Sandusky River study area, 2009.

Stream Name /Location	River Mile	Drainage Area	QHEI	Comment
Sandusky R. at Co. Rd. 16	65.01	655	81.5	
Sandusky R at Walnut Grove Campground	52.58	770	60.5	
Sandusky R. at Co. Rd. 90	47.75	774	86.5	
Sandusky R. at U.S. Rt. 224	42.92	956	45.5	Impounded
Sandusky R. at Ella St.	41.84	964	83	
Sandusky R. adj. Water St.	38.90	1002	82.5	
Sandusky R. at Twp. Rd. 143	31.95	1046	69	
Sandusky R. Co. Rd. 51	26.94	1067	65	
Sandusky R. ust. Wolf Cr.	23.00	1073	83.5	
Sandusky R. adj S. River Rd.	21.30	1238	76	
Sandusky R. adj S. River Rd	19.00	1255	59	
Sandusky R. ust. Ballville Dam	18.05	1255	52	Impounded
Sandusky R. at Tiffin Rd.	17.70	1255	93	
Sandusky R. at State St.	15.40	1260	67	Lacustuary
Sandusky R. at Twp. Rd. 549	12.96	1264	67	Lacustuary
Sandusky R. ust. Wightmans Grove	4.70	1330	60	Lacustuary
Sandusky R. ust. Yellow Swale	1.00	1335	64.5	Lacustuary
Bark Cr. At Kelley Rd. (Co. Rd. 245)	3.20	10	32	Channelized, Silt Substrates
Muskellunge Cr. at St. Rt. 635	16.70	17.7	38.5	Silt Substrates
Muskellunge Cr. at Spieldenner Rd.	5.40	37	58.5	
Muskellunge Cr. at Fangboner Rd.	1.23	44	69	Lacustuary
Indian Cr. at Hurdick Rd.	0.62	11.2	42	Maintained Ditch
Wolf Cr. 0.2 Mi ust Cr 592	13.60	27	40	Channelized
Wolf Cr. at St. Rt. 12	5.15	66	60.5	
Wolf Cr. at Township Line Rd.	1.58	71.8	53	
Wolf Cr. at St. Rt. 53	0.04	158	84	
Plum Run at St. Rt. 635	0.79	10.1	37.5	Shallow, Limited Cover
Harrison Cr. at Co. Rd. 592	0.38	13.2	64.5	
E. Br. Wolf Cr. at Meadowbrook Park	19.65	21.4	51.5	
E. Br. Wolf Cr. at Twp. Rd. 132	13.63	33	59.5	
E. Br. Wolf Cr. at Twp. Rd. 150	9.00	68	52.5	
E. Br. Wolf Cr. at Gilmore Rd.	0.86	84.2	84	
Trib. To E. Br. Wolf Cr. at W. Twp. Rd. 112	0.04	8.1	29	Silt Substrates, Shallow, Limited Cover
Snuff Cr. at Twp. Rd. 71	0.33	4.7	39.5	Shallow, Limited Cover
E. Br. Of East Branch Wolf Cr. at Co. Rd. 26	3.52	6.8	42.5	
E. Br. Of East Branch Wolf Cr. at Co. Rd. 48 (Twp. Rd. 118)	1.48	19.7	71.5	
M. Br. Of East Branch Wolf Cr. at Co. Rd. 26	0.46	11.5	80	

Sugar Cr. at Twp. Rd. 76	3.11	9.4	47	Silt Substrates, Limited Cover
Sugar Cr. at Twp. Rd. 148	1.05	13	71	
Spicer Cr. at Co. Rd. 33	0.80	12.4	67.5	
Muddy Cr. ust. Millersville at Co. Rd. 58	29.36	35	29	Channelized, Limited Cover
Muddy Cr.,dst. Twp. Rd. 55	21.10	44	71	
Muddy Cr. ust. Lindsey at Co. Rd. 90	18.68	63	76	
Muddy Cr. dst. Lindsey at Co. Rd. 153	9.79	74	62	
Muddy Cr. at St. Rt. 53	1.23	110	50.5	Lacustuary
L. Muddy Cr. at Booktown Rd.	7.55	12.4	39	Channelized, Limited Cover
L. Muddy Cr. At Kline Rd	2.50	25	47.5	Lacustuary
Fishing Cr. at Weickert Rd.	0.20	7	21.5	Channelized, Silt Substrates, Limited Cover
S. Br. Muddy Cr. at Anderson Rd.	1.54	22	28	Channelized, Silt Substrates, Limited Cover
Gries Ditch at U.S. Rt. 6	4.72	9.3	24.5	Maintained Ditch
Gries Ditch at Staff Rd.	0.90	16.3	55	Maintained Ditch

General narrative ranges assigned to QHEI scores.			
Narrative Rating		QHEI Range	
		Headwaters (≤20 sq mi)	Rivers and Streams
Excellent		≥70	≥75
Good		55 to 69	60 to 74
Fair		43 to 54	45 to 59
Poor		32 to 42	30 to 44
Very Poor		<30	<30

Aquatic Life

Aquatic life uses and attainment status were assessed for 52 sites within the lower Sandusky River study area. Recommended changes and additions to the applicable aquatic life uses within presented in Table 3 and attainment status is included in Table 2. Additional information is included in the appendices to this report. Appendix 7 contains Index of Biotic Integrity (IBI) scoring. Fish species by site are listed in Appendix 8. Invertebrate Community Index (ICI) scoring and macroinvertebrate community attributes are contained in Appendices 9 and 10, respectively and the macroinvertebrate taxa and densities recorded for each site are listed in Appendix 11.

Sandusky River

The drainage area of the Sandusky River within the study area exceeded 500 mi^2 and for the purpose of this discussion will be considered separately from smaller drainages within the basin. Additionally, the mainstem can be divided into two reaches, upstream and downstream from the confluence of Wolf Creek.

The upper portion of the Sandusky River encompasses the mainstem from downstream Tymochtee Creek (RM 65.73) to Wolf Creek (RM 22.73). This reach is located almost entirely within the ECBP and designated as WWH with the exception of an impounded segment upstream from the Ella Street Dam in Tiffin. The impounded reach is a MWH (RM 45.0 to RM 42.1). Fish and macroinvertebrate community sampling was conducted at ten locations. QHEI habitat scores were consistent with designated aquatic life uses. Eight of nine WWH sites supported good to exceptional fish and macroinvertebrate communities. The one exception was a deep, low gradient reach near the village of Old Fort (RM 26.94) with physical attributes akin to an impounded stream. Silt and sediment were accumulated as a result of agricultural activities higher in the watershed. Fish sampling in this low gradient reach produced an IBI score that marginally met ecoregional expectations (IBI=39). Heavy siltation and the lentic nature of the site severely limited the macroinvertebrate community. Qualitative sampling yielded just one sensitive taxon. Conversely, qualitative sampling produced an average of 17 sensitive taxa from the other WWH designated sites on the Sandusky River.

A previously impounded reach demonstrated full recovery following removal of the St. Johns Dam. The dam at RM 50.2, removed in 2003, had impounded approximately seven miles of the Sandusky River. Both fish and macroinvertebrate communities were negatively affected within the dam pool in 2001 but showed significant improvement in 2009 and mirrored sampling results from 2004 and 2005 by Heidelburg University. Restoration of natural flow conditions yielded good to exceptional biological index scores even though heavy sediment deposits remained within the bank full width of the channel.

Downstream from Wolf Creek (RM 22.73) to the head of Sandusky Bay (RM 0.0), the Sandusky River is located within the Huron-Erie Lake Plain and designated as WWH. Fish and macroinvertebrate community sampling was conducted at eight locations. Upstream from Fremont (RM 21.30), the river habitat was predominantly a wide shallow mostly bedrock run with some coarse substrates and scattered boulders. Both fish and macroinvertebrate indices scored in the exceptional range (IBI=54, MIwb=9.7, ICI=58). The Ballville Dam impounds the river within the city of Fremont. Sampling of the dam pool predictably yielded depressed biological sampling results due to siltation and habitat alteration. Fish community sampling netted MIwb scores in the fair range at both sites where pollution tolerant common carp exceeded 60% by the total weight of fish collected. Additionally, the macroinvertebrate community was in poor condition at RM 18.05.

Downstream from the Ballville Dam, the next two sites, RMs 17.70 and 15.40 were in full attainment of the WWH aquatic life use designation.

The lower three sites were influenced by their proximity to Sandusky Bay and Lake Erie. These sites were assessed with lacustuary metrics and breakpoints; biocriteria are not applicable so attainment status is based on a narrative determination of the designated use using IBI, MIwb and ICI scores adapted to lacustuary and other attributes of the fish and macroinvertebrate community samples. Failure to achieve the lacustuary benchmarks of the lacustuary benchmark was noted at RM 12.96 (IBI=26), with siltation and nutrient enrichment from the upstream crop production and Fremont WPCF negatively affecting water quality. Siltation and embedded substrates continued to negatively affect water quality in a downstream direction, as the two most downstream sites, RMs 4.70 and 1.00 did not achieve the lacustuary benchmarks. Improvements addressing nutrient enrichment from upstream WWTPs and agricultural runoff are needed along the Sandusky River mainstem before the fish and macroinvertebrate communities can meet lacustuary WWH expectations in the future.

It is worth restating that free flowing reaches of the Sandusky River generally had good habitat that in turn supported well balanced fish and macroinvertebrate communities. Sensitive macroinvertebrate taxa diversity was greater than for other subwatersheds in the study area. Mimic shiners (*Notropis volucellus*), a species identified as declining in Ohio, were distributed throughout the mainstem; as were river and greater redhorse (*Moxostoma carinatum* and *Moxostoma valenciennesi)*. Maintaining a healthy population of these two sucker species will reflect continued good conditions in the mainstem. Removal of the Ballville Dam will allow a third relatively pollution sensitive sucker species, shorthead redhorse (*Moxostoma macrolepidotum)*, to establish a presence upstream from the dam..

Muddy Creek-Frontal Sandusky Bay HUC10 (04100011 14)

Biological sampling in the Muddy Creek watershed took place on Muddy Creek, Little Muddy Creek, Fishing Creek, South Branch Muddy Creek and Gries Ditch where seven of eleven evaluated sites met expectations of the HELP ecoregion. Biological communities at four sites between RMs 29.36 and 9.79 on Muddy Creek were in marginally good condition. The MIwb scores were in the range of nonsignificant departure (MIwb=7.5 to 7.0) suggesting that any additional stress, be it habitat or water quality related, could lead to impairment of the WWH aquatic life use for the entire reach.

The 2009 sampling of Fishing Creek served as an initial investigation for the designation of the appropriate aquatic life use for the stream. Crop production with subsurface drainage contributed to the excessive siltation and sedimentation. Nutrient enrichment was also in evidence based on the biological sampling. The mean phosphorus concentration exceeded the ecoregion target value of 0.08 mg/l and dissolved oxygen was measured below the 4.0 mg/l on one of five sampling events during the summer sampling period. The stream channel was enveloped by aquatic plants at Weickert Rd. (RM 0.2) resulting in a QHEI score of 21.5. Nevertheless, fish sampling produced an assemblage that met expectations for the HELP ecoregion (IBI=32), but the macroinvertebrate community was in poor condition. Just twenty taxa were collected; half of them are considered

pollution tolerant. The poor habitat conditions will likely continue to negatively influence the macroinvertebrate community; however, WWH is the appropriate aquatic life use designation since attainment was demonstrated in the fish community.

Little Muddy Creek at Booktown Rd. (RM 7.55) was similarly afflicted with excessive siltation, sedimentation and nutrient enrichment. The fish community marginally attained ecoregional expectations (IBI=26) but the macroinvertebrate community was in poor condition.

Both fish and macroinvertebrate communities were in poor condition in the lacustuary portions of Muddy Creek (RM 1.23) and Little Muddy Creek (RM 2.50). Pollution tolerant aquatic worms and midges of the genus *Glyptotendipes* predominated the macroinvertebrate community at both locations. Carp were numerous in Muddy Creek and a large number of goldfish were collected in Little Muddy Creek. An abundance of carp and/or goldfish within a fish community is a clear indication of an imbalanced condition. Crop production with subsurface drainage contributed to the excessive siltation and sedimentation along with nutrient enrichment in the Little Muddy Creek lacustuary. Nutrient enrichment and channelization activities including extensive levees and armored banks limited the biological communities in Muddy Creek at SR 53 (RM.1.23).

Gries Ditch is listed as a WWH stream based on sampling conducted in 1984 and 1995. The waterway is listed by the Sandusky County Engineer as a maintained ditch and the habitat condition at US 6 (RM 4.72) was poor (QHEI = 24.5). The original ALU designation did not take habitat conditions of the upper reach into account and instead was based on conditions nearer the confluence with Muddy Creek. Biological sampling results met the MWH use at RM 4.72 (IBI=30, Fair macroinvertebrate community). Improvement in habitat and biological condition was noted at Staff Rd. (RM 1.0). The QHEI score was 55.0; fish and macroinvertebrate communities were in marginally good (IBI=28) and good condition, respectively. It is recommended that the use designation be changed in Gries Ditch upstream from Quinshan Rd. (RM 3.7) from WWH to MWH.

The South Branch of Muddy Creek and Gries Ditch both supported biological communities that met ecoregional expectations. The South Branch was easily the better of the two streams with an ICI score in the very good range and fish biocriteria scores reflecting marginally good to good communities.

Wolf Creek HUC10 (04100011 10)

Biological sampling in the Wolf Creek watershed took place on Wolf Creek, Plum Run, Harrison Creek, East Branch Wolf Creek, an unnamed tributary to the East Branch confluent at RM 18.60, Snuff Creek, East Branch to the East Branch Wolf Creek and Middle Branch to the East Branch of the East Branch Wolf Creek. The majority of the Wolf Creek drainage is in the HELP ecoregion. East Branch to the East Branch Wolf Creek and Middle Branch to the East Branch of the East Branch Wolf Creek are in the ECBP ecoregion. Eleven of fifteen evaluated sites met ecoregion expectations.

The four sampled locations on Wolf Creek generally supported marginally good to very good macroinvertebrate and fish communities. No macroinvertebrate sample was collected at RM 1.58 because the site went completely dry in late August. Perennial flow resumed downstream from the East Branch Wolf Creek. The biota in Wolf Creek was reflective of generally good water quality; pollution sensitive taxa were present and mimic shiners were recorded near the confluence with the Sandusky River.

The 2009 sampling of Harrison Creek served as an initial investigation for the designation of the appropriate aquatic life use for the stream. Habitat was consistent with a WWH use but there was no apparent flow at CR 592 (RM 0.38) when macroinvertebrate sampling was conducted on 21 July. Silt and a layer of attached green and blue-green algae covered the stream bottom. These conditions were likely the result of excess agricultural nutrients and yielded a limited macroinvertebrate assemblage. The macroinvertebrate community was in poor condition but the fish community met ecoregional expectations. The WWH use is appropriate based upon attainment in the fish community and a QHEI score of 64.5.

Overall poor condition of biota in the East Branch Wolf Creek at Meadowbrook Park and elevated nutrient levels, particularly phosphorus, demonstrated that inadequately treated sewage from residential septic systems in Bascom was impacting the stream. In one grab sample at RM 19.65, the phosphorus concentration was in excess of five hundred times the 0.08 target (4.54 mg/l). White suckers predominated the fish community and biological index scores were in the fair to poor range downstream from Wertz Rd. (RM 18.9). Qualitative macroinvertebrate sampling yielded a relatively low diversity of taxa and just two EPT taxa; one of which was *Callibaetis* sp., a pollution tolerant mayfly. Impact from sewage was likely exacerbated by the nearly intermittent nature of the stream during typical summer low flow conditions downstream from the Meadowbrook Park dam. The biota of the stream demonstrated recovery approximately six miles downstream at TR 132. Bascom has been issued Director's Findings and Orders to address the unsanitary conditions. A Permit to Install (PTI) has been submitted and approved by the Ohio EPA for the construction of a treatment system.

Macroinvertebrates collected from East Branch to East Branch Wolf Creek at CR 26 (RM 3.52) marginally met WWH expectations but fish sampling produced an IBI score in the fair range (IBI= 30). The low diversity fish community was predominated by pollution tolerant creek chubs. Additionally, a relatively high number of central stonerollers were collected. Central stonerollers are herbivores and tend to be most numerous where elevated nutrients promote the growth of attached algae. Nitrogen and phosphorus levels that exceeded ecoregional background target values [(NO3-NO2 (mg/L) Target = 1.0 Total, P (mg/L) Target = 0.08.] and limited habitat (QHEI = 42.5) were the principle causes for the depressed fish community. Degraded chemical and habitat quality at CR 26 was a reflection of land use in the watershed, principally agriculture and urban runoff from the western portion of the city of Tiffin. Mean nutrient values remained elevated at CR 48 (RM 1.48); however, improved habitat ameliorated the enrichment impact. The improved habitat was reflected in a QHEI score of 71.5 and fish and macroinvertebrate communities that were considered in excellent and good condition, respectively.

The 2009 sampling of Plum Run served as an initial investigation for the designation of the appropriate aquatic life use for the stream. Habitat consisted of a straight, shallow channel with limited cover and flow volume. A QHEI score of 37.5 was recorded. Nevertheless, fish sampling yielded a relatively diverse assemblage of species and an IBI score of 42. Qualitative macroinvertebrate sampling produced a fair result. The stream bottom was mostly comprised of hardpan and fine grained material. This combined with essentially no discernible flow during the summer inhibited the diversity of benthic taxa in Plum Run. Nutrients were not as evident a factor as other sites within the Wolf Creek watershed. Nitrate was elevated in two of five samples collected at SR 635 (RM 0.79), but the mean of the five values was lower than the target of 1.0 mg/l. Additionally, algal growth was not excessive. While the manmade habitat alterations will likely continue to negatively influence the macroinvertebrate community, the WWH use is appropriate based on the WWH attainment in the fish community.

The unnamed tributary to East Branch Wolf Creek confluent at RM 18.50, Snuff Creek and Middle Branch to the East Branch of East Branch Wolf Creek supported macroinvertebrate and fish

communities that met ecoregional WWH expectations. However, one or both organism groups were no better than marginally good condition at each of three sampled locations. The 2009 sampling of the unnamed tributary served as an initial investigation for the designation of the appropriate aquatic life use at each of these streams.

Designation of the WWH use was verified based on full attainment of the use at West TR 112 (RM 0.04).

Muskellunge Creek-Sandusky River HUC10 (0410001113)

The study plan for sampling of Muskellunge Creek included biological sampling at TR 84 (RM 24.44). However, the fish community was not evaluated owing to near intermittent conditions at the site. Pooled areas consisted of silty sediments overlain with decaying algae. Phosphorus was present in the water column at nearly an order of magnitude higher than the target concentration of 0.8 mg/l, suggesting that the sediments likely had become anoxic. Qualitative macroinvertebrate sampling produced a limited diversity of taxa of facultative and pollution tolerant taxa.

Downstream, in the free flowing reach of Muskellunge Creek, fish and macroinvertebrate communities met WWH ecoregional expectations. Relatively high taxa diversity was documented in the macroinvertebrate community and a variety of mayfly and caddisfly taxa were present. An IBI in the very good range was recorded at RM 16.70 (SR 635). IBI and MIwb scores at Spieldenner Rd. (RM 5.40) were in the good and marginally good range, respectively. Both locations supported a variety of darter species. The collection of high proportions of these and other insectivorous species likely reflected the presence of relatively un-embedded substrates, benefiting both predator and prey.

Muskellunge Creek at Fangboner Rd. (RM 1.23) was located within a reach with no discernible flow. Heavy siltation and sedimentation resulted, the consequence of which was a severely impaired macroinvertebrate community. The pollution tolerant midge *Dicrotendipes simpsoni* predominated on artificial substrates at RM 1.23. Qualitative sampling produced just two EPT taxa. Commensurate fish sampling conducted at RM 0.80 (SR 53) yielded index scores that reflected a marginally good condition.

Multiple impacts on Bark Creek impaired the fish and macroinvertebrate communities at RM 3.20 (Kelley Rd.). The Sandusky County Engineer maintains the stream to facilitate agricultural drainage. A combination of heavy silt and extensively embedded substrates, habitat alterations and channelization, the result of surrounding agricultural activities, contributed to the non-attainment of the WWH use. It also appeared that failing home sewage treatment systems and unsewered areas contributed to nutrient and organic enrichment. The fish community was comprised to a large extent by pioneering fish species and those able to proliferate in disturbed environments. Two pollution tolerant species, fathead and bluntnose minnows (*Pimephales promelas* and *P. notatus*) predominated the collected assemblage. The fish community produced an IBI score in the poor range (IBI = 20). Blackflies of the genus *Simulium*, which are often abundant under degraded conditions, were also numerous. The macroinvertebrate community sampling was indicative of occasional low dissolved oxygen levels resulting from organic enrichment and reflected a fair condition.

Indian Creek supported biological communities that met the designated WWH aquatic life use. The stream is maintained by the Sandusky County Engineer to promote drainage. Consequently, the stream was channelized with embedded rubble substrates at Hurdick Rd. (RM 0.62). Qualitative macroinvertebrate sampling produced a marginally good assemblage indicative of moderate enrichment. Fish sampling yielded a fair rated IBI score that, nevertheless, met the

expectations for the HELP ecoregion (IBI =30). Nitrate concentrations also reflected a somewhat enriched condition with a geometric mean concentration (1.80 mg/l) that exceeded the target concentration of 1.0 mg/l.

Rock Creek-Sandusky River HUC10 (0410001111)

Spicer Creek and Sugar Creek are two headwater tributaries to the much larger Sandusky River. The streams appeared to be somewhat distinct from the other tributaries in the study area in that both supported populations of mottled sculpins (*Cottus bairdii)*. Their presence is evidence of a greater contribution of groundwater derived flow compared with surveyed streams to the north and west. Macroinvertebrate assemblages in the streams reflected a good to excellent resource condition and pollution sensitive taxa were well represented. Fish sampling results from Sugar Creek at TR 76 (RM 3.11) and TR 148 (RM 1.05) produced eleven and fourteen taxa, respectively, IBI scores were in the good range and biological communities reflected full attainment of the WWH aquatic life use.

Spicer Creek at CR 33 (RM 0.80) was similar to Sugar Creek, but with a more open canopy and evidence of enrichment that promoted algae growth. As a result, Spicer Creek supported a wider variety of fish species; twenty-one taxa were collected, but pollution tolerant fish comprised in excess of 70 percent of the community. Bluntnose minnows were collected in high density. They have been associated with the presence of organic enrichment, possibly the result of manure runoff from surrounding agricultural areas. The net result was an IBI score in the fair range (IBI= 34) and partial attainment of the WWH use.

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*Some of the references not in the report can be found in the appendices which includes Methods, biosurvey background information, and Notice to Users.