Biological and Water Quality Study of the Maumee River and Auglaize River 2012-2013

Paulding, Defiance, Henry, Lucas, Wood, and Putnam Counties
Maumee River LRAUs: 041000059001, 041000099001, 041000099002
Auglaize River LRAU: 041000079001

OHIO EPA Technical Report EAS/2014-05-03

Division of Surface Water
December 8, 2014

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12/8/2014
OhioEPA Report DSW/EAS 2014-05-03

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Executive Summary

Rivers and streams in Ohio sustain aquatic life populations and support a variety of beneficial uses such as recreation and water supply (public, industrial and agricultural). The Ohio EPA evaluates each stream to determine the appropriate beneficial use designations and to also determine if the uses are meeting the goals of the federal Clean Water Act. In 2012 and 2013, twenty-three sampling locations within three Maumee River Large River Assessment Units (LRAUs) and five sampling locations within the Auglaize River LRAU, located in Paulding, Defiance, Henry, Lucas, Wood, and Putnam counties were evaluated for aquatic life and recreation use potential (see Figure 2 and Table 2 in the report).

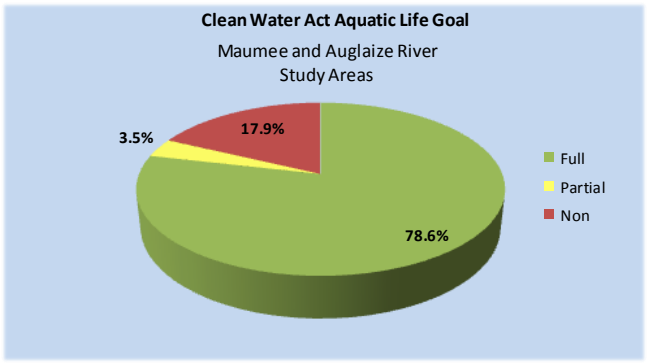

Figure 1. 78% of the sites sampled in the Maumee and Auglaize River study areas met their designated aquatic life use biocriteria.

Of the 28 biological samples collected, 22 sites (78.6%) were fully meeting the designated Warmwater Habitat (WWH) or designated or recommended Modified Warmwater Habitat – Impounded (MWH-I) aquatic life use, one (3.5%) was in partial attainment, and five were in non-attainment (17.9%) (Figure 1). The Maumee River at RM 31.64 was in partial attainment due to nutrient enrichment from upstream agricultural activities and flow alterations from the Grand Rapids dam. The freshwater estuary portion of the Maumee River, the lower 15.0 miles, did not achieve freshwater estuary biological targets for the WWH aquatic life use at five sampling locations due to a variety of causes and sources. Compiled causes and sources of aquatic life use impairment for the four LRAUs are provided in Table 1.

Twenty-seven locations on the Maumee River and Auglaize River mainstems were tested for bacteria indicators (*Escherichia coli*) to determine recreation use attainment status. Evaluation of *E. coli* results revealed that 24 of 27 locations attained the applicable geometric mean criterion, and, thus, were in full attainment of the designated Primary Contact Recreation Class A or Class B use. Three sites were impaired for their designated recreation use: Maumee River RMs 76.1 and 31.6, and Auglaize River RM 28.5. Sources of *E. coli* contamination include pasture and cropland runoff, urban storm water, and waterfowl accumulations (Table 19 in the report).

Table 1. The causes and sources of aquatic life use impairment in the Maumee and Auglaize River study area.

LRAU	Cause	Source
	Maumee River	
IN Border to Tiffin River (04100005 90 01)	No aqutic life use impairment	
Tiffin River to Beaver Creek (04100009 90 01)	Nutrient/eutrophication biological indicators	Agriculture
	Other flow regime alterations	Dam or impoundment
Beaver Creek to Maumee Bay (04100009 90 02)	Nutrient/eutrophication biological indicators	Agriculture
		Dam or impoundment
	Other flow regime alterations	Combined sewer overflows
	Sedimentation/siltation	Sanitary sewer overflows (collection system failures)
	Direct habitat alterations	Discharges from municipal separate storm sewer systems (MS4)
	Other flow regime alterations	On-site treatment systems (septic systems and similar decentralized systems)
		Municipal point source discharges
		Dredging
	Auglaize River	
Ottawa River to mouth (04100007 90 01)	No aqutic life use impairment	

Physical water quality parameters measured throughout the two mainstems indicated a risk for aquatic life use impairment. The average and maximum water temperature exceedances observed during the 2012 field monitoring season were attributed to an unseasonably warm winter, and a hot and dry spring. It is unlikely that point source discharges caused the exceedances due to the elevated temperatures occurring at all but two locations in the Maumee River and Auglaize River, and not just near point source discharges. In addition, there were pH excursions of 6.33 (water temperature 4.06^{o}C) at Antwerp City Park (RM 99.0), 9.16 (water temperature 29^{o}C) at State Route

578 (RM 31.64), and 9.11 (water temperature 26.7^{o}C) at Otsego Park (RM 26.7). Dissolved oxygen criteria violations were found during all three sonde surveys of the Maumee River mainstem. In July 2012, during the lowest, warmest flows associated with a sonde deployment, 12 sites out of the 21 monitored had dissolved oxygen violations. During that survey, most of the sites with dissolved oxygen criteria violations showed a 24-hour range greater than 7.0 mg/l, which is a strong indication of nutrient enrichment. Five of the mainstem Maumee River sites had a 24-hour range greater than 10 mg/L, evidence of extreme algal primary production stimulated by the excess of nutrients in the ecosystem.

The comparison of 1997 and 2012 levels of nitrate-nitrite noted little difference in concentrations at sites located within the most upstream reach of the Maumee River from RM 107 to RM 76; however, at downstream sites, the nitrate-nitrite levels in 2012 were much lower than the 1997 levels. Total phosphorus concentrations were lower in 2012 as compared to the 1997 data across the entire Maumee River mainstem. These results suggest that point source permitting, CSO reductions, and conservation practices are having a positive impact in the Maumee River watershed in Ohio and Indiana although nutrient levels still appear to be higher than desired and contributing to excessive algal primary production and its attendant effects (e.g., excursions of dissolved oxygen and pH measurements as noted above).

The city of Defiance, city of Napoleon, Campbell Soup Company, and the village of McClure all had historic (2002-2007) finished water nitrate concentrations that exceeded the 10.0 mg/L water quality criterion and led to impairments for the Public Drinking Water Supply (PDWS) beneficial use. Defiance and Napoleon now have upground reservoirs and can selectively pump to avoid periods of high nitrate concentrations in their source water. Only Campbell Soup Company has had a nitrate violation since 2008. They exceeded the water quality criterion in finished water and received a violation for nitrate in December, 2012. Since the water quality criterion was exceeded, the Maumee River mainstem from the Tiffin River to Beaver Creek will remain impaired for the PDWS beneficial use. This segment will also remain on the pesticide watch list due to raw water concentrations of atrazine in excess of 12.0 µg/L.

Bowling Green has an upground reservoir and, therefore, finished water data is not indicative of source water quality. However, sampling from the source water intake on the Maumee River, conducted by Bowling Green in 2011 and 2012, resulted in three exceedances of the nitrate water quality criterion. More frequent source water sampling conducted by Heidelberg University at the PDWS intake resulted in 15 exceedances of the nitrate water quality criterion from 2008 to 2012. Therefore, the Maumee River mainstem from Beaver Creek to Maumee Bay will be listed as impaired for the PDWS beneficial use. This segment will also remain on the pesticide watch list, due to raw water concentrations of atrazine in excess of 14.0 µg/L, and on the algae watch list due to raw water microcystin detections.

Fish tissue samples were collected from the Maumee River six times between 1974 and 2012. No PCBs were detected in fish prior to 1990. Over time, large piscivorous trophic level 4 fish, such as the walleye, smallmouth bass, and largemouth bass, have had PCB levels that appear stable, while mercury levels have fluctuated with no specific increasing or decreasing trend evident. Trophic level 3 fish, such as the common carp, smallmouth buffalo, white crappie, and channel catfish, had steady levels of mercury, while PCB levels have fluctuated through time. Since the contamination levels have remained unchanged, there are still tissue consumption advisories in place for PCBs and mercury in the Maumee and Auglaize rivers.

The physical habitat quality in the Maumee River and Auglaize River was generally sufficient to support fish and other aquatic assemblages consistent with the assigned aquatic life uses. The near and instream habitat of the free-flowing WWH sections of the Maumee River, as measured by the Qualitative Habitat Evaluation Index (QHEI), was classified as good ($\bar{x}$ = 74.7), the impounded MWH-I sections were classified as fair ($\bar{x}$ =

52.2), and the freshwater estuary section (also WWH), as evaluated by the freshwater estuary QHEI, was fair ($\bar{x}$ = 45.7). Similarly, the Auglaize River had physical habitat suitable to support WWH fish communities in free-flowing reaches while impounded reaches were rated as fair. Generally, the habitat throughout the two rivers was dominated by sand and gravel substrates from limestone and glacial tills. Silt and embeddedness were typically at normal to moderately high levels.

The riverine Maumee River mainstem sites sampled during 2012 and 2013 achieved the WWH fish biocriteria for the Index of Biotic Integrity (IBI) and Modified Index of well-being (MIwb) at all free-flowing sites (n = 12), and the MWH-I biocriteria at the dam impounded sections (n = 6). Roughly the lower 15 miles of the Maumee River are impounded by the water level in Lake Erie, but are still designated WWH. This freshwater estuary reach of the Maumee River failed to attain the fish IBI and MIwb targets at all sites sampled (n = 5). The Auglaize River sites sampled in 2012 achieved the WWH fish biocriteria at both free-flowing sites (n = 2), and the MWH-I biocriteria at the sites within the dam impounded section where this use is recommended (n = 3).

The Maumee River has been extensively surveyed by the Ohio EPA in 1984 - 1986, 1997, and 2012 - 2013. During this time the fish community has significantly improved. The average IBI score for Maumee River fish assemblages increased from fair (IBI = 29.0) to marginally good (IBI = 38.2) between 1984 and 2012, and from an average fair MIwb score (7.65) to a very good MIwb score (9.50).

Eleven of 12 Maumee River and both Auglaize River free-flowing sites, sampled for macroinvertebrates during 2012, achieved the applicable Invertebrate Community Index (ICI) biocriterion. However, elevated nutrients were indicated by inordinately high numbers of pollution tolerant flatworms and/or aquatic worms at 12 of 14 sites. ICI scores ranged from 46 at RM 85.26 (Co. Rd. 105) to 24 at RM 31.64 (St. Rt. 578). The Maumee River at St. Rt. 578/Bridge St. (RM 31.6), the only site that failed to achieve the WWH biocriterion, yielded an ICI score of 24 which is narratively considered in the fair range. Freshwater estuary macroinvertebrate communities at five Maumee River sites beginning at RM 13.3 were reflective of poor resource conditions. The combination of sedimentation, nutrient enrichment and habitat alterations limited taxa diversity and promoted the predominance of a few select facultative and tolerant taxa throughout the lake-influenced reach.

The Maumee River macroinvertebrate sampling results from 2012-13 demonstrated a significant decline in community condition when compared to similar monitoring conducted in 1997. Twelve free-flowing locations sampled between the Indiana-Ohio state line (RM 107.10) and Buttonwood Recreation Area (RM 16.50) in 1997 produced an average ICI score of 52.2. In 2012, the average of ten similar sites was 37.1 and the decline was persistent along the entire reach. The dissolved oxygen swings, high temperatures, and low flow conditions most negatively affected macroinvertebrate community structure and function at RM 31.64, the only mainstem location where the WWH use was not attained. The decline, observed along the entire mainstem, is a unique situation because it is not reflected in the fish community; the fish assemblages have significantly improved since 1997. Fish are generally able to tolerate, for a short time, dissolved oxygen concentrations below ideal levels (USEPA 1976, pp 123-127). Pollution sensitive Ephemeroptera (mayfly), Plecoptera (stonefly), and Trichoptera (caddisfly) macroinvertebrate taxa (referred to as EPT taxa) adversely respond to these lower dissolved oxygen levels (Dourdoroff and Shumway 1970). At the same time, less sensitive macroinvertebrate taxa become more dominant in low dissolved oxygen environments and these taxa are readily available as fish food. While there is considerable uncertainty as to why declines are being observed in Maumee River macroinvertebrate communities, structure and function changes due to stressful dissolved oxygen and temperature levels are possibly occurring; however, further investigation is needed to

substantiate and document this scenario. If low dissolved oxygen conditions, exacerbated by higher river temperature, do play a significant role in the observed biotic condition and become a "*chronic occurrence, it could have a detrimental effect on long-term survival*" of fish (Canadian Council of Ministers of the Environment 1999) and reverse the positive trend in fish populations observed between the current and previous studies.

Increased annual discharge of the Maumee River since the mid-1990s has led to large increases in the loading of dissolved reactive phosphorus (DRP) to the lower Maumee River, Maumee Bay and the western basin (Ohio EPA 2010). While total phosphorus loadings from the Maumee River basin have declined in this time frame (likely due to nonpoint source conservation practices reducing sediment and particulate phosphorus inputs from Maumee subwatersheds), the DRP fraction of the total has increased. Free-flowing water bodies like the Maumee and Auglaize rivers have a greater capacity to assimilate and sequester nutrients than lake systems and this is likely why these large rivers are supporting diverse and abundant aquatic biotas and meeting aquatic life use expectations. However, the Maumee River serves as a direct conduit of excess, non-assimilated nutrients to Lake Erie. These excess loadings are contributing to aquatic life use impairment in the freshwater estuary reach of the Maumee River, as well as exacerbating harmful algal blooms in Maumee Bay and the western basin of Lake Erie. In order to reduce the increasing nutrient load (primarily DRP) to Lake Erie, it will be necessary to reduce nutrient loadings from the Maumee River basin as well as other adjacent Lake Erie watersheds.

To this end, eleven TMDL projects have been completed or are in progress in Maumee River watersheds, as well as six others for other western basin watersheds. These can be found at http://epa.ohio.gov/dsw/tmdl/index.aspx. Eleven of these TMDL projects recommended or will recommend phosphorus load reductions as a corrective action to restore aquatic life use impairments in the respective watershed. Improvement in water quality already observed in many streams and rivers in Lake Erie watersheds are in large part due to reductions of sediment and particulate phosphorus loadings attributed to increased use of agricultural conservation practices designed to reduce these parameters. Additional positive improvements in resource condition should continue as additional management practices are implemented in these watersheds based on TMDL recommendations. These actions should have a positive effect on the western basin of Lake Erie although more nutrient load reductions (especially for DRP) will likely be necessary to reverse the current trend in Lake Erie water quality. The increased loading of DRP to Lake Erie, coupled with trophic disruptions caused by invasive species such as dreissenid mussels (*Dreissena polymorpha* and *Dreissena rostriformis bugensis*), is an area of intensive research which is ongoing in response to the issue of western basin algal blooms, algal toxins, and deteriorating water quality.

Table 2. Maumee River and Auglaize River sampling locations from the Ohio EPA 2012-13 survey.

Site Number[1]	Stream Name /Location	River Mile	Drainage Area (mi^2)	Latitude	Longitude
1	Maumee River 0.9 mile downstream Ohio/Indiana state line	107.10	2119	41.168600	-84.794400
2	Maumee River at Antwerp, at Antwerp City Park	99.00	2129	41.183900	-84.732500
3	Maumee River 4 miles Northeast of Antwerp, at Eater Rd.	91.48	2168	41.221900	-84.669700
4	Maumee River North of Cecil at Co. Rd. 105	85.26	2203	41.237800	-84.602200
5	Maumee River South of Sherwood at mouth of Platter Creek	80.10	2275	41.262500	-84.561100
6	Maumee River S of the bend at Bend Rd.	76.15	2292	41.275300	-84.515000
7	Maumee River West of Defiance, downstream intersection Switzer Rd/Dowe Rd.	69.20	2311	41.284200	-84.434400
8[2]	Maumee River Near Defiance at St. Rt. 281 (north bank)	62.30	5540	41.292368	-84.322838
9[2]	Maumee River Upstream Independence dam (mid river)	60.00	5543	41.291400	-84.281900
10	Maumee River East of Defiance, upstream Snyder Rd./Weichman Rd.	58.50	5551	41.290600	-84.244400
11[2]	Maumee River E of Florida, downstream Wade Creek	52.10	5578	41.327624	-84.152554
12[2]	Maumee River At Napoleon at water works intake	47.10	5649	41.383769	-84.130089
13[2]	Maumee River Southwest of Liberty Center at RR bridge, upstream St. Rt. 109	41.24	5693	41.411400	-84.032800
14[2]	Maumee River Upstream Grand Rapids dam	32.60	6054	41.415000	-83.877200
15	Maumee River At Grand Rapids, at St. Rt. 578 (Bridge St.)	31.64	6058	41.413600	-83.860300
16	Maumee River Near Otsego at confluence of Sugar Creek	26.70	6264	41.448100	-83.785800
17	Maumee River At Waterville, at St. Rt. 64	20.68	6330	41.500375	-83.713946
18	Maumee River At Buttonwood recreation area	16.52	6340	41.548522	-83.674922
19[3]	Maumee River Downstream Ewing Island	13.30	6367	41.570356	-83.624492
20[3]	Maumee River Near Eagle Point Colony	9.40	6389	41.608900	-83.579400
21[3]	Maumee River At Toledo, at Anthony Wayne bridge	5.80	6397	41.638900	-83.534400
22[3]	Maumee River At Toledo, downstream I-280	3.60	6602	41.661843	-83.509405
23[3]	Maumee River At Toledo, near mouth	0.50	6606	41.694200	-83.466700
24	Auglaize River At Cloverdale, at St. Rt. 114	28.50	719	41.020800	-84.288900
25[2]	Auglaize River At Oakwood, at St. Rt. 613	19.30	1509	41.092470	-84.381970
26[2]	Auglaize River At Charloe, at Co. Rd. 138	14.94	2041	41.128600	-84.431900
27[2]	Auglaize River Upstream Beetree Run at Package WWTP	6.59	2315	41.232321	-84.413296
28	Auglaize River Near Defiance, downstream Powell Creek	3.2	2428	41.261400	-84.385600

1 - 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).

2 - HELP ecoregion Modified Warmwater Habitat – Impounded: Color is based on only fish metrics.

3 - Lacustuary Targets

Figure 2. Maumee River and Auglaize River sampling locations and biological community performance, 2012-13. Site numbers correspond to Table 2.

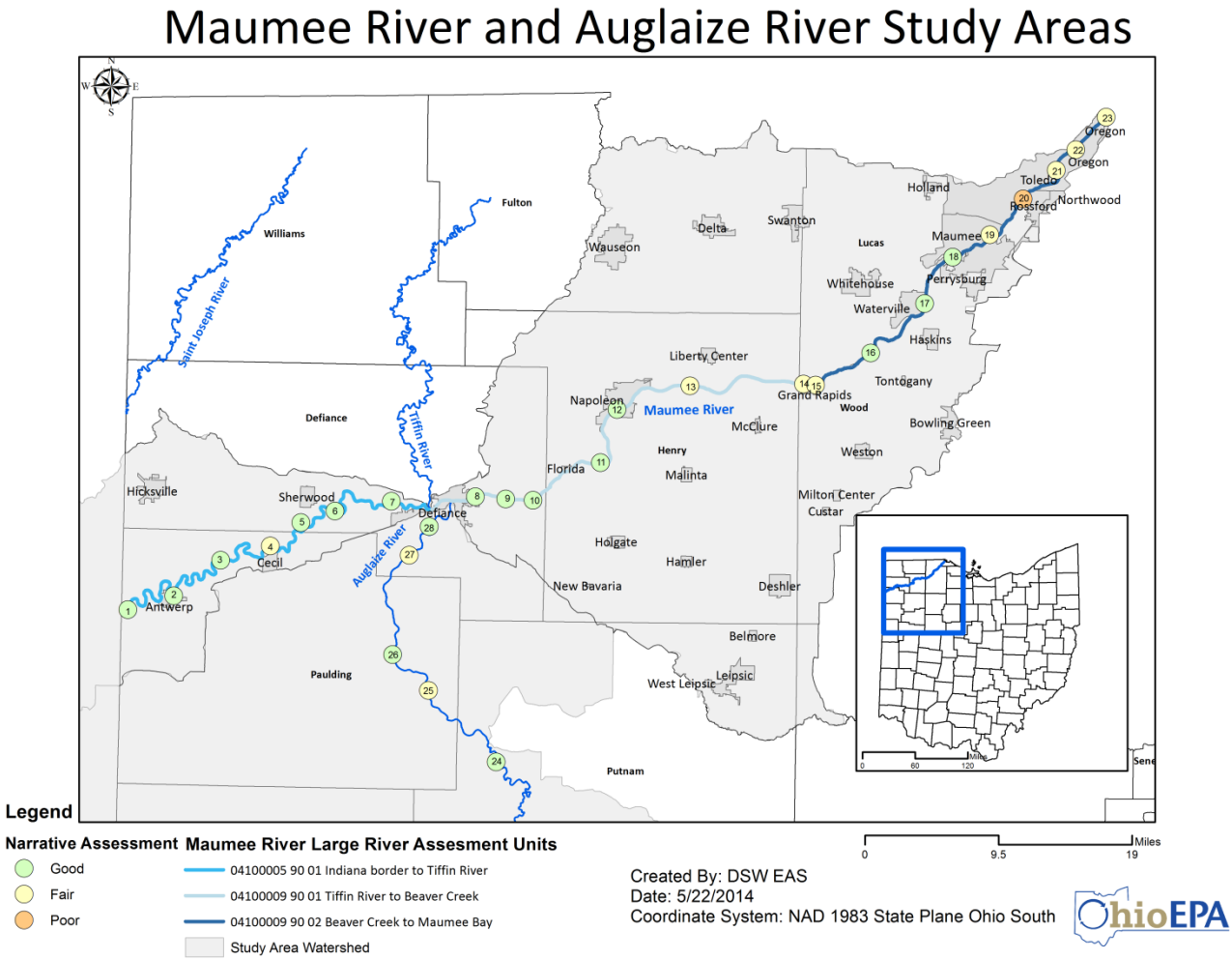

Table 3. Aquatic life use attainment status for stations sampled in the Maumee River and Auglaize River study area based on data collected July-September 2012, and August - October 2013. The Index of Biotic Integrity (IBI), Modified Index of well-being (MIwb), and Invertebrate Community Index (ICI) are scores based on the performance of the biotic community. The Qualitative Habitat Evaluation Index (QHEI) is a measure of the ability of the physical habitat of the stream to support a biotic community. The Maumee and Auglaize rivers are located in the Huron-Erie Lake Plain (HELP) ecoregion. Yellow fill indicates sites assessed with lacustuary targets and breakpoints; biocriteria are not applicable so attainment status is based on a narrative determination of the designated use. If biological impairment has occurred, the cause(s) and source(s) of the impairment are noted.

LRAU	Location	STORET (RM)[a]	DRAIN. (mi^2)	IBI (2012/2013)	MIwb (2012/2013)	ICI (2012/2013)	QHEI (2012/2013)	Status[b]	Cause(s)	Source(s)
04100005 90 01	**Maumee River (04-001-00) WWH Existing**									
	0.9 mile downstream Ohio/Indiana state line	P06K10 (107.10)	2119.0[B]	34	8.18[ns]	38	74.3	FULL		
	At Antwerp, at Antwerp city park	201868 (99.00)	2129.0[B]	34	9.19	38	80.8	FULL		
	4 miles Northeast of Antwerp, at Eater Rd.	P06S08 (91.48)	2168.0[B]	37	9.08	38	69.3	FULL		
	North of Cecil at Co. Rd. 105	P06K06 (85.26)	2203.0[B]	32[ns]	8.72	46	73.8	FULL		
	South of Sherwood at mouth of Platter Creek	P06K05 (80.10)	2275.0[B]	36	9.17	42	83.8	FULL		
	South of the bend at Bend Rd.	P06S07 (76.15)	2292.0[B]	38/33[ns]	9.1/8.7	40/46	65.5/61.0	FULL		
	West of Defiance, downstream intersection Switzer Rd/Dowe Rd.	P06K03 (69.20)	2311.0[B]	40	9.47	42	70.5	FULL		
04100009 90 01	**Maumee River (04-001-00) MWH-I Existing**									
	Near Defiance at St. Rt. 281 (north bank)	P09W32 (62.30)	5540.0[B]	36	9.22	22[c]	46.0	FULL		
	Upstream Independence dam (mid river)	P09W19 (60.00)	5543.0[B]	35	9.04	10[c]	49.0	FULL		
	Maumee River (04-001-00) WWH Existing									
	East of Defiance, upstream Snyder Rd./Weichman Rd.	201858 (58.50)	5551.0[B]	34/45	9.6/10.4	36/38	85.8/71.0	FULL		
	Maumee River (04-001-00) MWH-I Existing									
	East of Florida, downstream Wade Creek	201856 (52.10)	5578.0[B]	37	8.60	14[c]	62.5	FULL		
	At Napoleon at water works intake	500200 (47.10)	5649.0[B]	39	9.39	10[c]	51.5	FULL		
	Southwest of Liberty Center at railroad bridge, upstream St. Rt. 109	P09W37 (41.24)	5693.0[B]	30	7.74	4[c]	47.5	FULL		

LRAU	Location	STORET (RM)[a]	DRAIN. (mi^2)	IBI (2012/2013)	MIwb (2012/2013)	ICI (2012/2013)	QHEI (2012/2013)	Status[b]	Cause(s)	Source(s)
	Upstream Grand Rapids dam	P11S42 (32.60)	6054.0[B]	33	7.88	10[c]	56.5	FULL		
	Maumee River (04-001-00) WWH Existing									
	At Grand Rapids, at St. Rt. 578 (Bridge St.)	P11K33 (31.64)	6058.0[B]	34/44	10.65/10.35	24*/30[ns]	71.5/77.0	PARTIAL	-Nutrient/Eutrophication Biological Indicators -Other Flow Regime Alterations	-Agriculture -Dam or Impoundment
04100009 90 02	Near Otsego at confluence of Sugar Creek	P11K31 (26.70)	6264.0[B]	38	10.03	30	72.0	FULL		
	At Waterville, at St. Rt. 64	500080 (20.68)	6330.0[B]	34	9.78	38/34	72.0	FULL		
	At Buttonwood recreation area	301740 (16.52)	6340.0[B]	41	10.33	34	84.3	FULL		
	Downstream Ewing Island	301644 (13.30)	6367.0[B]	33	8.77	12	45	NON	-Nutrient/Eutrophication Biological Indicators -Other Flow Regime Alterations	-Agriculture -Dam or Impoundment -Combined Sewer Overflows -Sanitary Sewer Overflows (collection system failures) -Discharges from Municipal Separate Storm Sewer Systems (MS4) -On-site Treatment Systems (septic systems and similar decentralized systems) -Municipal Point Source Discharges
	Near Eagle Point Colony	P11S39 (9.40)	6389.0[B]	27	7.32	6	35	NON	-Nutrient/Eutrophication Biological Indicators -Sedimentation/Siltation -Direct Habitat Alterations -Other Flow Regime Alterations	-Agriculture -Dam or Impoundment -Combined Sewer Overflows -Sanitary Sewer Overflows (collection system failures) -Discharges from Municipal Separate Storm Sewer Systems (MS4) -On-site Treatment Systems (septic systems and similar decentralized systems) -Municipal Point Source Discharges

LRAU	Location	STORET (RM)[a]	DRAIN. (mi^2)	IBI (2012/2013)	MIwb (2012/2013)	ICI (2012/2013)	QHEI (2012/2013)	Status[b]	Cause(s)	Source(s)
04100009 90 02	**Maumee River (04-001-00) WWH Existing**									
	At Toledo, at Anthony Wayne bridge	201838 (5.80)	6397.0[B]	36	8.6	14	51	NON	-Nutrient/Eutrophication Biological Indicators -Sedimentation/Siltation -Direct Habitat Alterations -Other Flow Regime Alterations	-Agriculture -Dam or Impoundment -Combined Sewer Overflows -Sanitary Sewer Overflows (collection system failures) -Discharges from Municipal Separate Storm Sewer Systems (MS4) -On-site Treatment Systems (septic systems and similar decentralized systems) -Municipal Point Source Discharges -Dredging
	At Toledo, downstream I-280	301641 (3.60)	6602.0[B]	39	8.88	14	45	NON	-Nutrient/Eutrophication Biological Indicators -Sedimentation/Siltation -Direct Habitat Alterations -Other Flow Regime Alterations	-Agriculture -Dam or Impoundment -Combined Sewer Overflows -Sanitary Sewer Overflows (collection system failures) -Discharges from Municipal Separate Storm Sewer Systems (MS4) -On-site Treatment Systems (septic systems and similar decentralized systems) -Municipal Point Source Discharges -Dredging

LRAU	Location	STORET (RM)[a]	DRAIN. (mi^2)	IBI (2012/2013)	MIwb (2012/2013)	ICI (2012/2013)	QHEI (2012/2013)	Status[b]	Cause(s)	Source(s)
	At Toledo, near mouth	P11S32 (0.50)	6606.0[B]	36	7.92	18	52.5	NON	-Nutrient/Eutrophication Biological Indicators -Sedimentation/Siltation -Direct Habitat Alterations -Other Flow Regime Alterations	-Agriculture -Dam or Impoundment -Combined Sewer Overflows -Sanitary Sewer Overflows (collection system failures) -Discharges from Municipal Separate Storm Sewer Systems (MS4) -On-site Treatment Systems (septic systems and similar decentralized systems) -Municipal Point Source Discharges -Dredging
04100007 90 01	**Auglaize River (04-100-000) WWH Existing**									
	At Cloverdale, at St. Rt. 114	500110 (28.50)	719.0[B]	45	9.79	36	80.5	FULL		
	Auglaize River (04-100-000) MWH-I Recommended									
	At Oakwood, at St. Rt. 613	500130 (19.30)	1509.0[B]	31	8.67	12[c]	48.8	FULL		
	At Charloe, at Co. Rd. 138	P06S10 (14.94)	2041.0[B]	37	8.66	6[c]	46.5	FULL		
	Upstream Beetree Run at Package WWTP	P06P10 (6.59)	2315.0[B]	33	8.22	6[c]	43.5	FULL		
	Auglaize River (04-100-000) WWH Existing									
	Near Defiance, downstream Powell Creek	204260 (3.2)	2428.0[B]	35	8.87	36	65.0	FULL		

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 - Impounded site designated or recommended Modified Warmwater Habitat - Impounded (MWH-I). Attainment status is based exclusively on fish assemblage results (IBI and MIwb); no MWH-I biocriterion has been promulgated based on the ICI.

ns - Nonsignificant departure from biocriteria (≤4 IBI or ICI units, or ≤0.5 MIwb units).

* - Indicates significant departure from applicable biocriteria (>4 IBI or ICI units, or >0.5 MIwb units). Underlined scores are in the Poor or Very Poor range.

B - Boat site.

Biological Criteria							
	Huron-Erie Lake Plain		Lacustuary[1]				
Index - Site Type	WWH	MWH	Exceptional	Good	Fair	Poor	Very Poor
IBI - Boat	34	22	50	42	31	17	<17
MIwb - Boat	8.6	5.7	>9.5	8.6	6.76	5.1	<5.1
ICI	34	-	52	42	25	12	<12

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

Recommendations

The Maumee and Auglaize rivers currently listed in the Ohio Water Quality Standards (WQS) are assigned one or more of the following aquatic life use designations: WWH and MWH-I. The aquatic life use designations of the streams in this survey have been previously verified using biological data. This study used biological data to re-evaluate aquatic life uses for the Maumee and Auglaize rivers.

Twenty-three sites on the Maumee River and five on the Auglaize River were evaluated for aquatic life and recreational use potential in 2012-13 (Table 4). Significant findings include the following:

- Three reaches on the Maumee River with an existing WWH use designation should be maintained. These reaches are:
  - Indiana border to RM 65.8
  - RM 60.0 to RM 54.0
  - RM 32.3 to Maumee Bay
- Two reaches associated with two dam pools on the Maumee River with an existing MWH-I use designation should be maintained. These reaches are:
  - Independence dam pool RMs 65.8 – 60.0
  - Grand Rapids dam pool RMs 54.0 – 32.3
- Two reaches on the Auglaize River with an existing WWH use designation should be maintained. These reaches are:
  - RM 28.5 to RM 26.2
  - RM 5.8 to mouth
- Previous monitoring in the Auglaize River assessment unit focused on free-flowing reaches as the Defiance Power Dam impoundment was considered a reservoir and assessed as part of the Ohio inland lakes and reservoirs program. However, due to renewed power generation at the electric generating station (EGS), which modified reservoir retention time considerably, the recommendation is being made based on the findings of this report to assign the MWH-I aquatic life use to the riverine impounded reach (RMs 26.2 - 5.8).

All LRAUs in this study should retain the Primary Contact Recreation use: Class A for the Maumee River below RM 79.7 and all of the Auglaize LRAU, and Class B above RM 79.7 to the state line on the Maumee River. The Public Water Supply, Agricultural Water Supply, and Industrial Water Supply uses should also be retained as they are currently designated.

Table 4. Waterbody use designation recommendations for the Maumee River and Auglaize River. Designations based on the 1978 and 1985 water quality standards appear as asterisks (*). A plus sign (+) indicates a confirmation of an existing use, a (°) designates use based on justification other than the results of a biological field assessment performed by the OEPA, 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	
Maumee River														
- I-75 (RM 7.1) to confluence with Maumee Bay		°							+	+		+		
- at RM 23.16		+						°	+	+		+		PWS intake – Bowling Green
- RM 54.0 (downstream of Florida) to Grand Rapids dam (RM 32.3)				+					+	+		+		HELP ecoregion – impounded
- at RMs 35.91, 45.88, and 47.13				+				°	+	+		+		PWS intakes - McClure (RM 35.91), Campbell soup (RM 45.88), and Napoleon (RM 47.13)
- Tiffin river (RM 65.8) to Independence dam (RM 60.0)				+					+	+		+		HELP ecoregion – impounded
- at RM 65.84		+						°	+	+		+		PWS intake – Defiance
- all other segments		*							*	*		*		
Auglaize River														
- headwaters to Blanchard river (RM 26.2)		+							+	+		+		
- at Agerter Rd. (RM 64.58)		+						+	+	+		+		PWS intake – Lima
- RM 26.2 to RM 5.8				▲					+	+		+		HELP ecoregion - impounded
-all other segments		+							+	+		+		

Introduction

Twenty-three stream sampling locations were evaluated in the three Maumee River Large River Assessment Units (LRAUs), and five stream sampling locations in the Auglaize River LRAU in Paulding, Defiance, Henry, Lucas, Wood, and Putnam Counties in 2012-2013 (Figure 3). A total of 21 major National Pollutant Discharge Elimination System (NPDES) permitted facilities discharge sanitary wastewater, industrial process water, and/or industrial storm water into the lower Maumee River, upper Maumee River, and the Auglaize River.

Figure 3. The Maumee River and Auglaize River mainstem study areas, 2012-2013.

During 2012-13, Ohio EPA conducted a water resource assessment for the Maumee River and Auglaize River mainstems using standard Ohio EPA protocols as described in Appendix A. Included in this study were assessments of the biological, surface water, and recreation (bacterial) condition. A total of 23 biological, 26 water chemistry, 14 fish tissue, and 22 bacterial stations were sampled in the Maumee River. A total of five biological, six water chemistry, and five bacterial stations were sampled in the Auglaize River.

Specific objectives of the evaluation were to:

- ascertain the present biological conditions in the Maumee River and Auglaize River mainstems 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 the attainment status of assessed beneficial uses and recommend changes if appropriate.

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).

Study Area Description

Location and Scope

The Maumee River begins in Fort Wayne, Indiana, at the confluence of the St. Marys and the St. Joseph rivers and flows east/northeast through northeastern Indiana and northwestern Ohio. In Ohio, the Maumee River flows through portions of Paulding, Defiance, Henry, Wood, and Lucas counties (Figure 4). Larger cities that the Maumee River flows through include Fort Wayne in Indiana and Napoleon, Defiance, Waterville, Maumee, Perrysburg, Rossford, and Toledo in Ohio. After traveling approximately 140 river miles (107.87 river miles in Ohio) the Maumee River discharges to Lake Erie through Maumee Bay. The Maumee River drains the largest area of any river in the Great Lakes region.

The LRAU of the Auglaize River was also monitored as part of this study. The Auglaize River includes approximately 2,430 mi^2 of drainage to the Maumee River. The confluence of the Auglaize River is at approximately RM 64.04 of the Maumee River. The Auglaize River LRAU flows through portions of Putnam, Paulding, and Defiance counties. The Auglaize River flows through the Village of Cloverdale, the Village of Oakwood, and the southern end of Defiance before entering the Maumee River. The Auglaize River consists of LRAU 04100007 90 01 including 12.86 miles (RM 33.26 to RM 0, excluding the Power Dam Impoundment) from the confluence with the Ottawa River (just west of Kalida) to the mouth. The Power Dam at RM 5.8 impounds the Auglaize River to RM 26.2 at the confluence with the Blanchard River just north of Cloverdale.

The Maumee River watershed covers approximately 6,600 mi^2 (approximately 4,850 mi^2in Ohio). The entire Maumee River watershed includes seven 8-digit HUCs: 04100003 (St. Joseph River), 04100004 (St. Marys River), 04100005 (Upper Maumee River), 04100006 (Tiffin River), 04100007 (Auglaize River), 04100008 (Blanchard River), and 04100009 (Lower Maumee River). The four largest tributaries entering the Maumee River are the St. Joseph River and the St. Marys River forming the headwaters and the Tiffin River and Auglaize River entering in Defiance, Ohio. For this study, only the mainstems of the Maumee and Auglaize rivers were sampled and assessed.

For purposes of reporting aquatic life use status in the biennial Integrated Water Quality Monitoring and Assessment Report, the Maumee River mainstem is considered a Large River Assessment Unit (LRAU). Large Rivers are defined as those that have a drainage area greater than 500 mi^2. The LRAU for the Maumee River is further divided into the following three segments; LRAU 04100005 90 01 includes 42.11 miles (RM 107.87 to RM 65.76) from the Indiana-Ohio state line to the confluence of the Tiffin River, LRAU 04100009 90 01 includes 34.44 miles (RM 65.76 to RM 31.32) from the Tiffin River to Beaver Creek, and LRAU 04100009 90 02 includes 31.32 miles (RM 31.32 to RM 0) from Beaver Creek to Maumee Bay.

In Ohio, there are two impoundments located on the Maumee River; the Independence Dam is located at RM 60.0 east of Defiance and the Providence Dam at RM 32.2 at Grand Rapids. The Independence dam impoundment extends from RM 60.0 upstream to RM 65.8 and the Providence Dam impoundment extends from RM 32.3 upstream to RM 54.0.

Sampling locations for the 2012 – 2013 stream survey for the Maumee River and Auglaize River LRAUs are depicted in Figure 4 and Table 2.

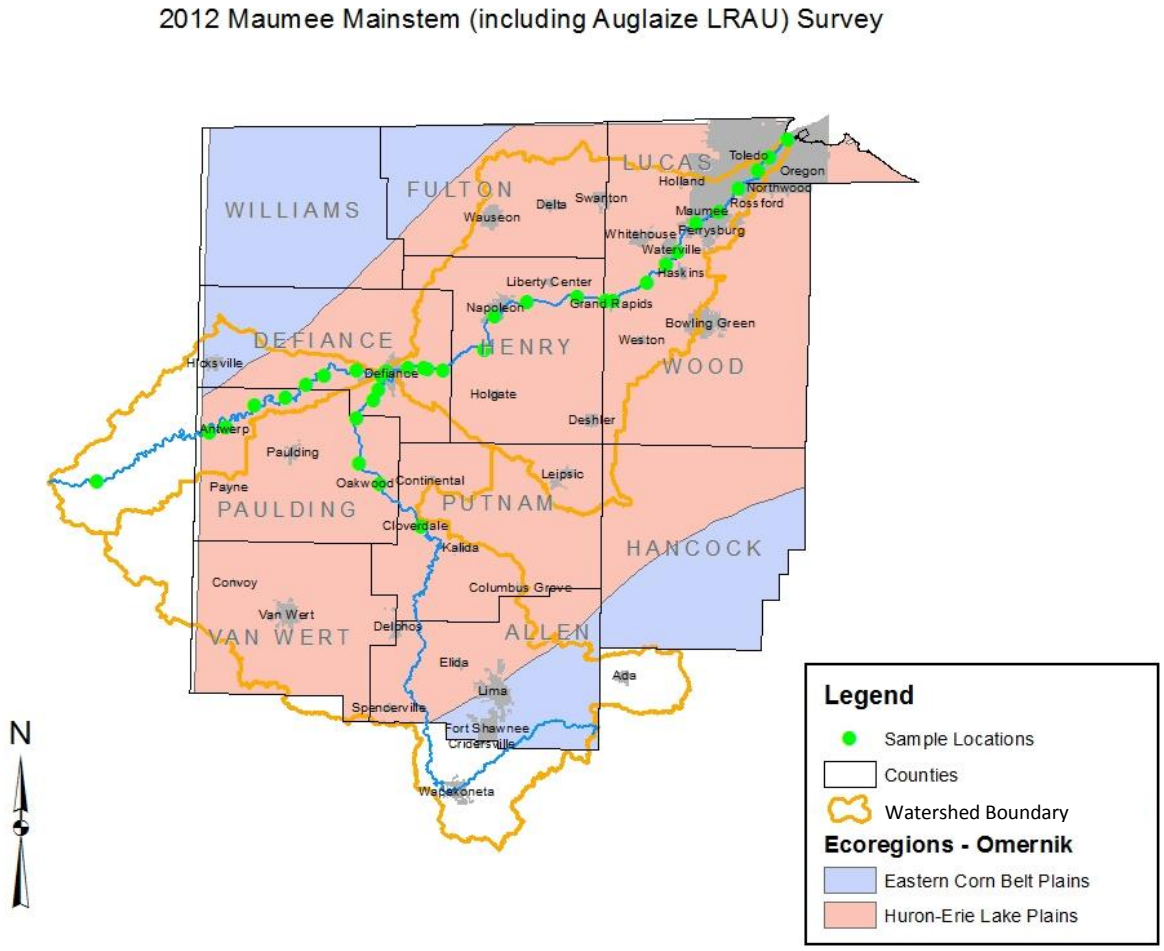

Figure 4. Maumee River and Auglaize River sampling locations with 8-digit HUC boundaries and ecoregion limits, 2012 – 2013.

Table 5. Maumee River and Auglaize River sampling locations, 2012 – 2013.

River Mile	EA3 Station	Sample Type	Location	Latitude	Longitude
Maumee River (04-001)					
129.10	301929	C,D,N	New Haven USGS gage - IN	41.084710	-85.021960
107.10	P06K10	M,F	0.9 mile dst. Ohio/Indiana Line	41.168600	-84.794400
104.7	P06K09	C,D,B	1.0 mile west of Antwerp	41.173900	-84.771700
99.00	201868	M,F,C,FT,D,N,B	Antwerp@ Antwerp City Park	41.183900	-84.732500
91.48	P06S08	M,F,C,D,B	NE of Antwerp – Eater Rd.	41.221900	-84.669700
85.26	P06K06	M,F,C,FT,D,B	N of Cecil @ CR 105	41.237800	-84.602200
80.10	P06K05	M,F,C,FT,D,B	South of Sherwood at mouth of Platter Creek	41.261900	-84.556400
76.15	P06S07	M,F,C,D,N,B	The Bend Road	41.275300	-84.515000
69.20	P06K03	M,F,C,FT,D,B	Dst Intersection Switzer/Dowe Rds.	41.284200	-84.434400
65.84	500180	W,FT	Defiance WTP Intake	41.278600	-84.385300
62.30	P09W32	M,F,FT,D,B,C	SR 281 – south bank	41.291100	-84.323600
60.00	P09W19	M,F,C,B	Upst. Independence Dam	41.291400	-84.281900
59.90`	201859	C,D,N,B	Directly dst. Independence dam	41.291000	-84.278800
58.50	201858	M,F	Upstream Snyder Rd., Weichman Rd.	41.290600	-84.244400
52.10	201856	M,F,FT,D,C,B	East of Florida, downstream Wade Creek	41.330600	-84.153300
47.10	500200	M,F,FT,C,D,SE,N,B	Napoleon WTP Intake	41.385800	-84.131900
46.05	P09S24	C,B	Napoleon WWTP 001 Outfall	41.395000	-84.113100
42.5	201851	C,D,B,N	St. Rt. 6	41.409700	-84.058600
41.24	P09W37	M,F,FT	Southwest of Liberty Center at railroad bridge, upstream St. Rt. 109	41.411400	-84.032800
35.91	301857	W	McClure WTP Intake	41.418420	-83.941690
32.60	P11S42	M,F,C,D,B,S,N	Upstream Grand Rapids dam	41.415000	-83.877200
31.64	P11K33	M,F,C,FT,D,N,B	SR 578	41.413600	-83.860300
26.70	P11K31	M,F,FT,D,C,N,B	Near Ostego at confluence of Sugar Creek	41.448100	-83.785800
23.16	500170	W	Bowling Green WTP Intake	41.476100	-83.738900
20.68	500080	M,F,FT,C,D,N,B	Waterville, SR 64	41.500000	-83.712800
18.22	P11W08	C,B	Lucas Co. Maumee River WWTP 001 Outfall	41.534285	-83.700711
16.52	301740	M,F,C,FT,D,B	Buttonwood Recreation Area	41.548040	-83.674940
13.30	301644	M,F,C,D,B	Downstream Ewing Island	41.571700	-83.624700
9.40	P11S39	M,F,C,FT,D,N,B	Near Eagle Point Colony	41.608900	-83.579400
5.80	201838	M,F,C,D,N,B	Anthony Wayne bridge	41.638900	-83.534400
3.60	301641	M,F,C,B	Downstream I-280	41.660300	-83.507800
0.50	P11S32	M,F,C,D,B	At mouth	41.694200	-83.466700

River Mile	EA3 Station	Sample Type	Location	Latitude	Longitude
Auglaize River (04-100)					
28.50	500110	M,F,C,D,B	Cloverdale @SR 114/Cascade Park	41.020800	-84.288900
19.30	500130	M,F,C,D,B	Oakwood @ SR 613	41.092470	-84.381970
14.94	P06S10	M,F,C,D,N,B	Charloe @ CR 138	41.128600	-84.431900
6.59	P06P10	M,F	Upst. Beetree Run, at package WWTP	41.231400	-84.412200
5.90	204258	C,D,B,S	Defiance Power Dam Reservoir-L1	41.2372	-84.4019
4.14	500290	C,D,B,N	Harding Road	41.253800	-84.389600
3.20	204260	M,F,	Downstream Powell Creek	41.253600	-84.392500

C – Chemistry
B – Bacteria
F – Fish
FT – Fish Tissue
M – Macroinvertebrate
S – Sediment
SE – Sentinel Site
D – Datasonde© Site
N – Chlorophyll a / Nutrient
W – Public Water Supply Intake

Beneficial Uses

Beneficial use designations assigned to the Maumee River mainstem include those for aquatic life, recreation and public water supply. The current use designations for the Maumee River mainstem include WWH, MWH-I, Primary Contact Recreation (PCR) Class A and B, Public Water Supply (PWS), Agricultural Water Supply (AWS) and Industrial Water Supply (IWS). The MWH-I designated use is bounded by the two impounded areas described in the Location and Scope section above. The mainstem of the Maumee River is a Class A recreation water body from RM 76.22 to the mouth and also a PWS at RM 23.16 (city of Bowling Green), RM 45.88 (Campbell Soup), RM 47.13 (city of Napoleon), and RM 65.84 (city of Defiance). The Maumee River is considered to be an Outstanding State Water based on exceptional recreational values from the Indiana-Ohio state line to U.S. Route 20 (RM 15.05) in Perrysburg.

The current use designations for the Auglaize River mainstem segment assessed in this study include WWH, PCR (Class A), AWS and IWS.

Ecoregions, Geology, and Soils

The Maumee River watershed spans two distinct ecoregions; the Eastern Corn Belt Plains (ECBP) and the Huron-Erie Lake Plain (HELP) (Omernik 1987). The entire mainstem of the Maumee River in Ohio and the sampling locations on the Auglaize River are located within the HELP ecoregion (Figure 4).

Soils in the Maumee River watershed can be classified by ecoregion location with the ECBP till plain soils being derived from glacial till material and the HELP soils being formed of lacustrine sediments (USDA 2013). A majority of the HELP ecoregion is the Maumee Lake Plains ecoregion subdivision that is poorly-drained and contains clayey lake deposits, water-worked glacial till, and fertile soils. The LRAU of the Auglaize River is entirely located in the HELP ecoregion, Paulding Plains subdivision as described below.

The HELP also includes the Oak Openings ecoregion and the Paulding Plains ecoregion subdivisions. The Oak Openings subdivision includes a belt of low, often wooded, sand dunes and paleo beach ridges that are situated among the broad, nearly flat, agricultural plains. Well-drained, sandy soils are common and originally supported mixed oak forests and oak savanna; poorly-drained depressions with wet prairies were also found. The Paulding Plains subdivision is characterized by clayey lacustrine sediment and extensive, very poorly-drained, illitic soils such as the Paulding and Roselms (Omernik 1987).

The dominant soil types within the Maumee River and Auglaize River drainage area within a 10 mile buffer of the LRAU for each stream are depicted in Figure 5. The Nappanee-Hoytville, Roselms-Paulding, Latty-Fulton, Tedrow-Ottokee-Granby, Millgrove-Mermill, and Toledo soil types compose 91.6% of the dominant soil types for this buffer area (Figure 5). All of the soils above are considered very poorly draining or poorly draining soils. The poor draining soils in this area were a major contributor to the existence of the Great Black Swamp and the reason artificial drainage was installed and is still maintained today in order to utilize the highly productive agricultural land that exists in the watershed.

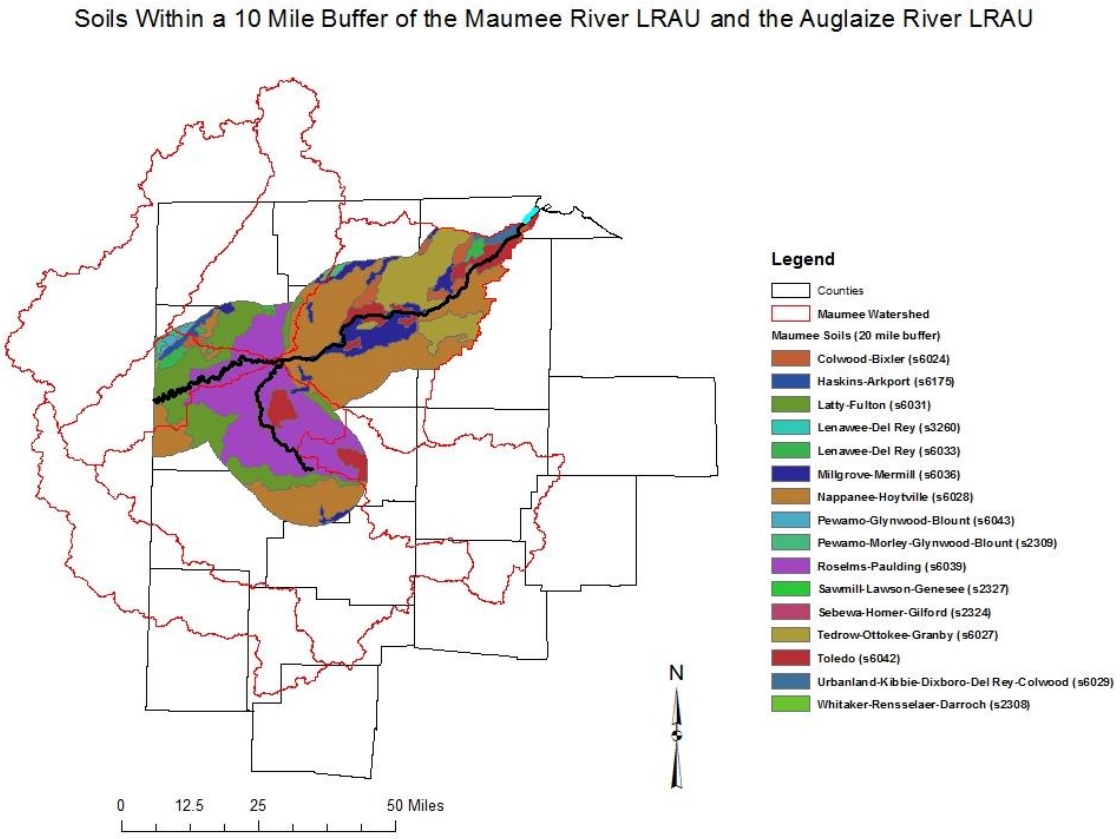

Figure 5. STATSGO general soil groups for the Maumee River and Auglaize River LRAUs (US Geological Survey, 1995).

Land Use

Figure 6 - 8 are individual maps showing land use in the three 8-digit HUCs; Upper Maumee Watershed, Lower Maumee watershed, and Auglaize River watershed, used to determine LRAU land use information (Fry et al. 2011).

In all three watersheds, agriculture is the predominant land use and since most soils are poorly drained, an extensive artificial drainage system must be maintained to make row crop farming possible. Many small streams have been extensively channelized to support the tile and drainage ditch systems throughout the watersheds (ODNR 2008).

The largest urban areas on the Maumee River mainstem include (population in parentheses) Antwerp (1,736), Napoleon (8,749), Defiance (16,494), Waterville (5,523), Perrysburg (20,623), Maumee (14,286), and Toledo (287,208) (US Department of Commerce et. al, 2010). Aggregated land use across the Upper Maumee River watershed is approximately 85.51% agricultural and 7.66% developed for urban or residential use. Other land uses include 5.48% forest, 1.32% open water, 0.34% grassland, 1.66% wetland, and 0.22% other (United States Department of Agriculture, 2012). The 2010 census data including census blocks wholly or partially in the watershed specifies that the Upper Maumee River watershed in Ohio supports a resident population of approximately 20,690 (US Department of Commerce, et. al, 2010). Aggregated land use across the Lower Maumee River watershed is

approximately 75.82% agricultural and 14.64% developed for urban or residential use. Other land uses include 6.61% forest, 1.36% open water, 0.94% grassland, 0.50% wetland, and 0.13% other (United States Department of Agriculture, 2012). The 2010 census data including census blocks wholly or partially in the watershed specifies that the Lower Maumee River watershed in Ohio supports a resident population of approximately 343,024 (US Department of Commerce, et. al, 2010).

The largest urban areas on the Auglaize River mainstem include (population in parentheses) Cloverdale (168), Oakwood (608), and Defiance (16,494) (US Department of Commerce, et. al, 2010). Aggregated land use across the Auglaize River watershed is approximately 81.63% agricultural and 10.94% developed for urban or residential use. Other land uses include 5.29% forest, 0.57% open water, 1.14% grassland, 0.33% wetland, and 0.11% other (United States Department of Agriculture, 2012). The 2010 census data including census blocks wholly or partially in the watershed specifies that the Auglaize River watershed in Ohio supports a resident population of approximately 228,787 (US Department of Commerce, et. al, 2010).

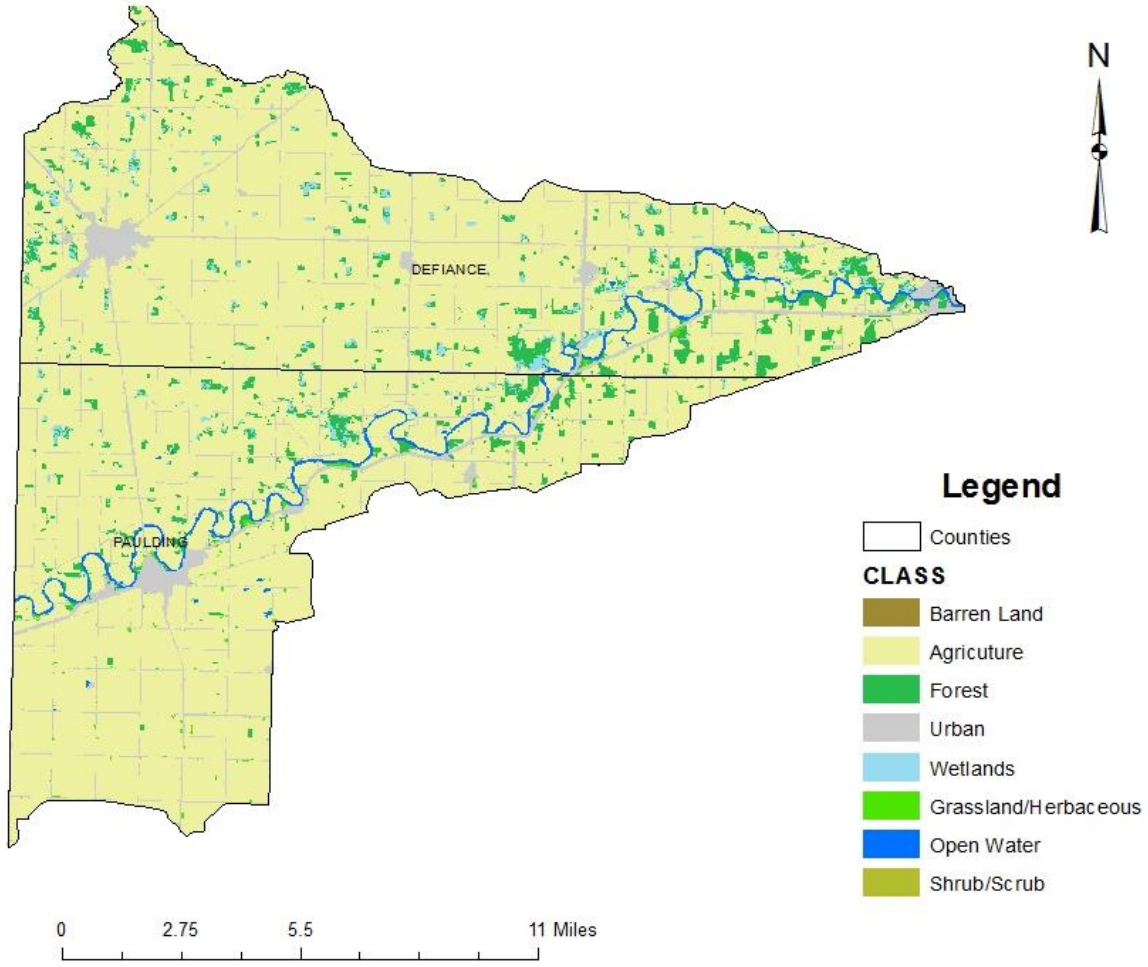

Figure 6. Land Use for the Upper Maumee HUC-8 watershed.

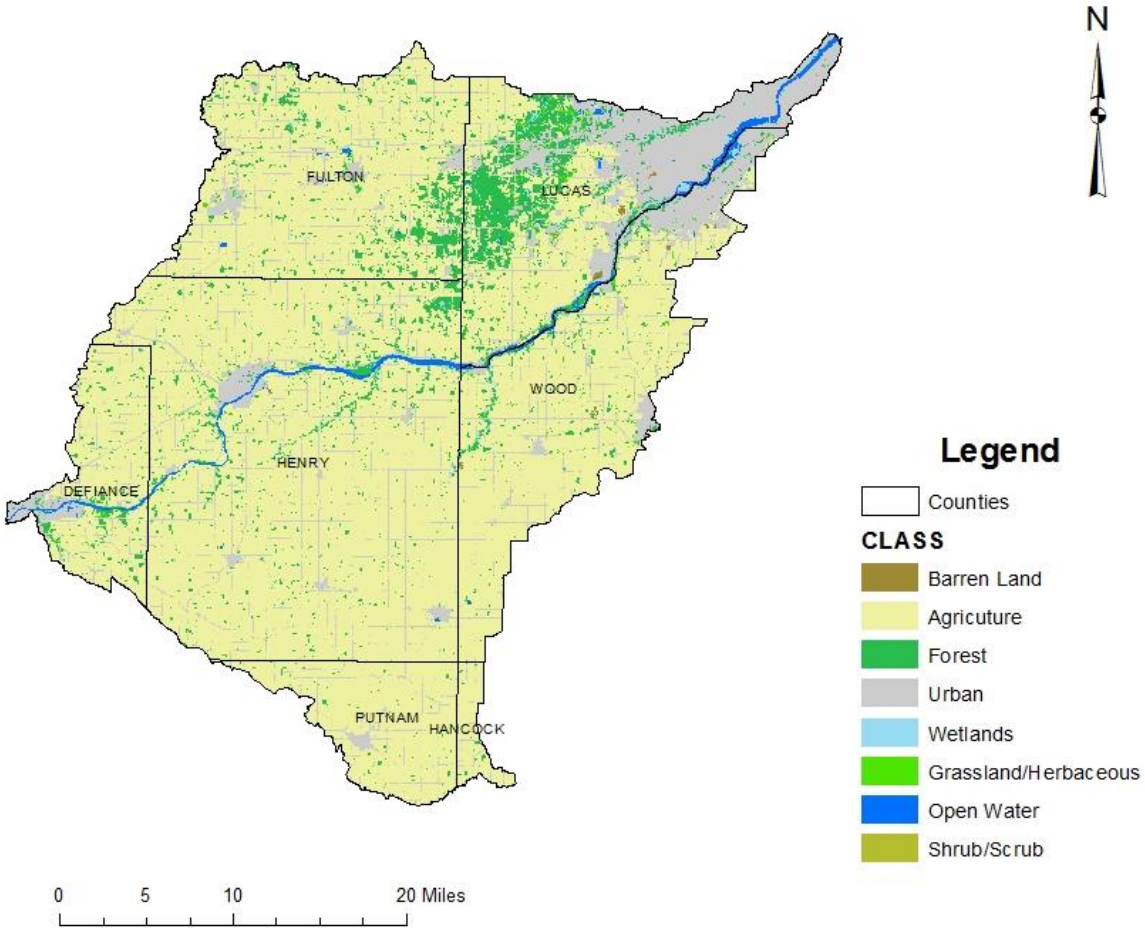

Figure 7. Land Use for the Lower Maumee HUC-8 watershed.

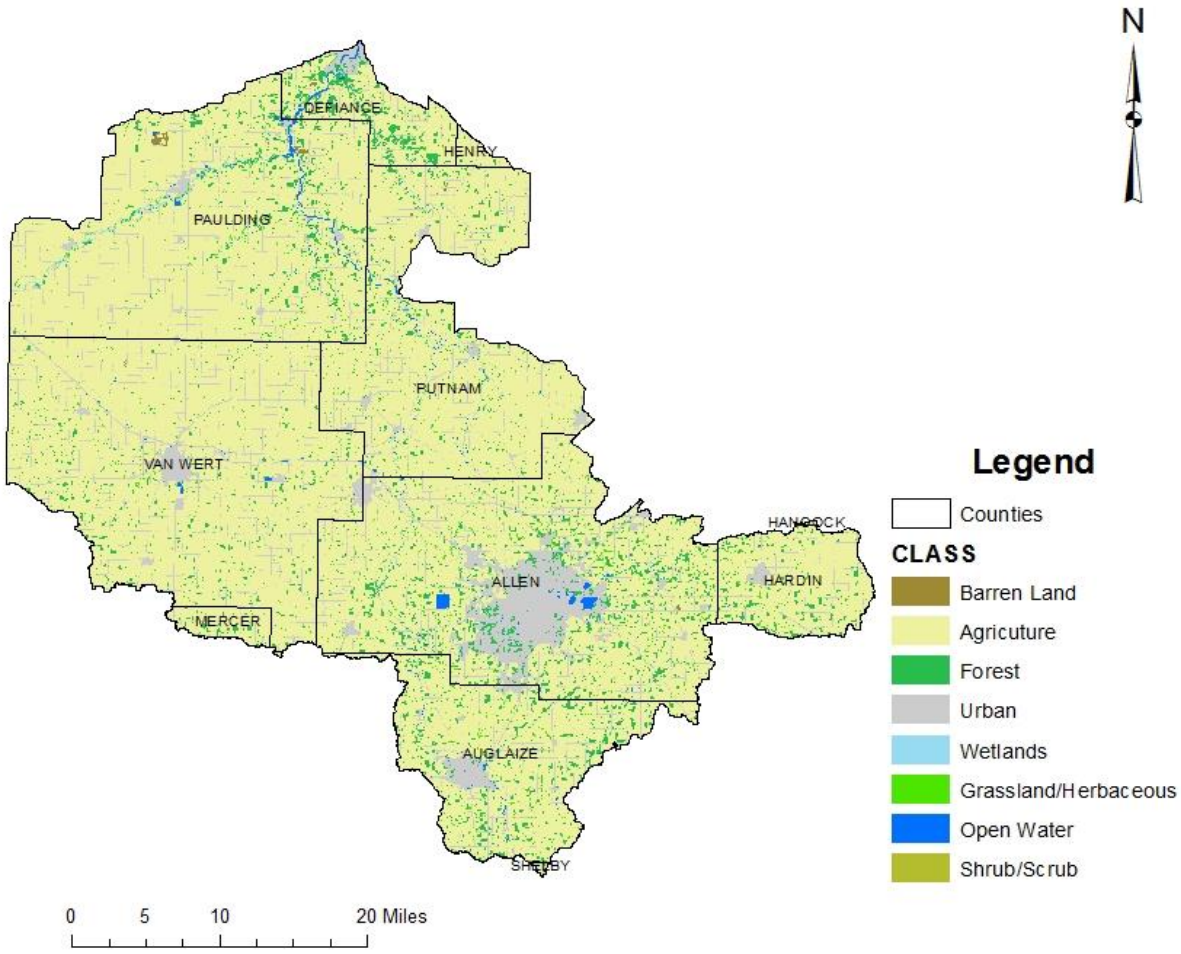

Figure 8. Land Use for the Auglaize River HUC-8 watershed.

Protected Lands

The Maumee River watershed includes approximately 23,090 acres of protected lands. These lands are divided into two main categories, recreation land and conservation land. Recreation land includes parks, fairgrounds, and lands owned by non-governmental organizations (e.g., Boy Scout campgrounds). Conservation lands include parks, wildlife areas, nature preserves, natural areas, forest management areas, fish hatcheries, and conservation clubs. Of the 22,735 acres of protected lands approximately 14,877 acres (64.4%) are in the conservation land categories and are the most protected from development and human impact. The other approximately 8,214 acres (35.6%) are recreation lands (Metroparks of Toledo Area, 2014).

Out of the 280 total protected land areas, the top 24 areas by size comprise 70% of the total areas (Table 6). Out of the top 70%, 77.6% of the area is conservation land. The top four protected land areas by acreage size are 62.4% of the top 24 sites. The top four sites are Oak Openings Preserve Metropark, Maumee State Forest, Lake La Su An Wildlife Area, and Kitty Todd Nature Preserve.

The Metroparks of the Toledo Area was created in 1928 with a mission to enhance quality of life and inspire preservation efforts in this and future generations by providing a regional system of premier natural, historical and cultural parklands maintained and operated to the highest professional standards. The Oak Opening Preserve Metropark owned by the Metroparks of the Toledo Area is a 3,664 acre portion of the Oak Opening Region that has been preserved by this group. The Oak Openings Region is a 130 mi^2 (83,200 acres) area that borders the former Great Black Swamp and supports globally rare oak savanna and wet prairie habitats. Its trees, plants, sandy soils, wet prairies, and floodplains benefit the region by acting as natural filters for air and water. It is home to more rare species of plants and animals than any other area of Ohio. The number of rare plants and animals are higher in northwest Ohio than any other place in Ohio primarily because of the Oak Openings Region. This area is home to approximately 180 rare plant and animal species whose survival depends upon the region's unique combination of wet and dry, sand and clay, forest and prairie (Metroparks of the Toledo Area, 2014).

The Ohio Department of Natural Resources, Division of Forestry manages the Maumee State Forest with a mission to promote and apply management for the sustainable use of Ohio's private and public forest lands. Maumee State Forest is an approximately 3,100 acre area that includes forested land with trails and camping opportunities for the general public (ODNR Department of Forestry, 2014).

Purchase of land for the Lake La Su An Wildlife Area began in 1981. Additional land is being acquired as funds become available. Originally, the area was a beech-maple hardwood forest containing beech, white ash, white oak, red oak, and sugar maple. This combination of hardwood species still dominates the area. There are also several lowland areas that are poorly drained, forming wooded wetlands. Approximately two-thirds of the wildlife area is in woods and brush land. The other one-third is divided between cropland and meadow. The water areas include 14 lakes and ponds ranging from 1/4 acre to 82 acres, and over 30 wooded wetlands and restored wetlands from two to 18 acres (ODNR, 2014).

The Kitty Todd Nature Preserve is a 1,000 acre centerpiece of the Oak Openings Region and is a model of land management practices for the region; it is owned by The Nature Conservancy. Residential and industrial development in the area is accelerating, resulting in habitat loss and fragmentation. The region also has suffered from cessation of natural disturbances such as fire and changes in hydrology caused by drainage ditches and filled wetlands. The Nature Conservancy has been working to combat

these threats through land acquisition, education, and restoration efforts (The Nature Conservancy, 2014).

Table 6. Largest 24 protected land areas (70%) in the Maumee River watershed.

Protected Lands in the Maumee River Watershed (70%)						
Site Name	**Owner**	**Managed By**	**County**	**Description**	**Type**	**Acres**
Oak Openings Preserve Metropark	Local	Toledo Metro Park District	Lucas	Nature Preserve	Conservatio	3664.19
Maumee SF	State	Ohio DNR	Fulton, Henry, Lucas	Forest Management	Conservatio	3068.83
Lake La Su An WA	State	Ohio DNR	Williams	Wildlife Area	Conservatio	2446.82
Kitty Todd	NGO	The Nature Conservancy	Lucas	Nature Preserve	Conservatio	1000
North Turkeyfoot SP	State	Ohio DNR	Henry	Park	Recreation	478.8
Camp Lakota	NGO	Boy Scouts of America	Defiance	Campgrounds	Recreation	474.38
Providence, Bend View, Farnsworth Metroparks	County	Toledo Metro Park District	Wood	Park	Recreation	451.66
Swan Creek Preserve Metropark	Local	Toledo Metro Park District	Lucas	Metropark	Conservatio	416.09
Oxbow Lake WA	State	Ohio DNR	Defiance	Wildlife Area	Conservatio	411.47
Wabash-Cannonball Trail	NGO	NW Ohio Rails to Trails	Williams, Fulton, Henry, Lucas	Trails	Recreation	396.22
Tiffin River WA	State	Ohio DNR	Fulton	Wildlife Area	Conservatio	351.27
Camp Libbey	NGO	Girl Scouts of America	Defiance	Campgrounds	Recreation	321.4
Side Cut Metropark	County	Toledo Metro Park District	Lucas	Park	Recreation	315.68
Goll Woods SNP	State	Ohio DNR	Fulton	Nature Preserve	Conservatio	307.7
Missionary Island WA	State	Ohio DNR	Lucas	Wildlife Area	Conservatio	297.24
Camp Berry	NGO	Boy Scouts of America	Hancock	Campgrounds	Recreation	268.37
Blue Creek Conservation Area	County	Toledo Metro Park District	Lucas	Park	Recreation	245.52
Harrison Lake SP	State	Ohio DNR	Fulton	Park	Recreation	238.38
Kendrick Woods NP	State	Ohio DNR	Allen	Nature Preserve	Conservatio	217.09
Springville Marsh NP	State	Ohio DNR	Seneca	Nature Preserve	Conservatio	204.71
Fallen Timbers Battlefield NHS	County	Toledo Metro Park District	Lucas	Park	Recreation	192.02
Audubon Islands NP	Local	Toledo Metro Park District	Lucas	Nature Preserve	Conservatio	191.66
Independence Dam SP	State	Ohio DNR	Defiance	Park	Recreation	188.01
Campbell SNP	State	Ohio DNR	Lucas	Nature Preserve	Conservatio	172.49

- NGOs = Non-governmental Organizations.
- SF = State Forest
- WA = Wildlife Area
- SP = State Park
- NP = Natural Preserve

Ground Water Supply

Many rural residents in Ohio depend on ground water wells as their source of drinking water. Outside of the service area of municipal public water systems, residents and businesses rely on wells for potable water. Many municipalities in the watershed use ground water for the source of their public drinking water supply as documented in Table 7.

Table 7. Water treatment plants in the Maumee River and Auglaize River watersheds.

Municipal Ground Water Treatment Plants

WTP NAME	PWSID	COUNTY
Ada Village	OH3300012	Hardin
Antwerp WTP[a]	OH6300012	Paulding
Arlington WTP	OH3200012	Hancock
Beaverdam Water Department	OH0200012	Allen
Bryan Municipal Light And Water Utility	OH8600012	Williams
Columbus Grove Village	OH6900112	Putnam
Continental Village	OH6900212	Putnam
Convoy Village	OH8100112	Van Wert
Cridersville Village	OH0600212	Auglaize
Deshler Village	OH3500112	Henry
Dunkirk WTP	OH3300212	Hardin
Edgerton WTP	OH8600312	Williams
Edon Village WTP	OH8600512	Williams
Fayette Village	OH2600412	Fulton
Forest Village	OH3300312	Hardin
Hamler Village	OH3500312	Henry
Hicksville Village	OH2000212	Defiance
Holgate WTP	OH3500512	Henry
Kalida WTP	OH6900512	Putnam
Leipsic Village	OH6900612	Putnam
Mendon WTP	OH5400612	Mercer
Middle Point WTP	OH8100312	Van Wert
Montpelier Village	OH8600912	Williams
Mt Blanchard, Village	OH3200512	Hancock
New Bremen Village WTP	OH0600512	Auglaize
New Knoxville Village	OH0601012	Auglaize
Ney WTP	OH2000512	Defiance
Oakwood WTP[b]	OH6300312	Paulding
Ohio City	OH8100412	Van Wert
Ottoville Village	OH6900812	Putnam
Pandora Village	OH6900912	Putnam
Payne Village	OH6300712	Paulding
Pioneer, Village Of	OH8601312	Williams
Rawson Village	OH3200612	Hancock
Rockford WTP	OH5401112	Mercer
Saint Marys City	OH0600612	Auglaize
Sherwood Village[a]	OH2000712	Defiance
Spencerville WTP	OH0201312	Allen
Stryker Village	OH8601712	Williams
Vanlue Village	OH3248312	Hancock
Wapakoneta, City	OH0600712	Auglaize
West Unity WTP	OH8601812	Williams
Willshire WTP	OH8100911	Van Wert

a – Maumee River mainstem community
b – Auglaize River mainstem community

Surface Water Supply and Drinking Water Quality

The status of the public drinking water supply use is summarized in the Ohio 2012 Integrated Water Quality Monitoring and Assessment Report. The five surface water intakes located on the mainstem of the Maumee River are the city of Defiance WTP, the city of Napoleon WTP, Campbell Soup WTP, the village of McClure (no longer active) and the city of Bowling Green WTP. Due to the proximity of the city of Napoleon intake and the Campbell Soup intake, one set of samples was taken in that location to cover the use designation for both sites. Sampling conducted in 2012 and 2013 at the four aforementioned water intake locations is discussed in detail in the Public Drinking Water Supply section of this report. Additional information on drinking water sources can be found in the Drinking Water - Source Water Assessments for the municipalities located in the watershed at the following website http://epa.ohio.gov/ddagw/swap.aspx.

Nonpoint Source Issues

The most common nonpoint sources negatively affecting water quality throughout the study area included fertilizer runoff, failing home sewage treatment systems, sedimentation from agricultural crop production and urban storm water runoff. Agricultural practices including channelization and routine maintenance of streams and ditches and the drainage of farm fields through subsurface tiles cause habitat and flow alteration impairments in headwater and small tributary streams.

Drainage alterations were also found where floodplains and wetlands were crossed by numerous highways and railroads, as well as in urban areas where development has encroached or filled in natural wetlands and floodplains. All of the counties in the study area have programs for drainage maintenance (ODNR, 2008). Unsewered communities that exist in the watershed contribute to recreational use impairment due to the lack of centralized wastewater collection and treatment.

Watershed Groups

The Conservation Action Project (CAP) of Ohio is a water quality effort aimed at improving the water quality of Lake Erie by increasing the number of acres of conservation tillage on the farms in seven counties bordering or draining into the Maumee River. The CAP program is planned and conducted by a Board of Trustees made up of an agricultural chemical, equipment, or seed dealer; one agency person; and one farmer from each of the seven counties (Conservation Action Project, 2014).

The Maumee River Basin Partnership of Local Governments (MRBPLG) is a consortium of cities, towns, villages, townships, counties, watershed management groups, and the regional community, which was founded in March 2001 by the City of Fort Wayne, Indiana and the City of Toledo, Ohio. This Partnership stretches across three state boundaries and focuses on a watershed-based approach to water quality management in the Maumee River basin (Maumee River Basin Partnership of Local Governments, 2014).

Partners for Clean Streams (PCS) works directly with businesses, governmental agencies, non-profit organizations, partners and volunteers to make waterways clean, clear, and safe. PCS connects organizational and individual partners through educational opportunities, conservation programs, events and outreach programs for the benefit of local and regional water in northwest Ohio. PCS is the local umbrella organization for the Maumee Remedial Action Plan Advisory Committee, or RAC for short. The RAC is a diverse group of interested citizens, government agencies, businesses, and other non-profit organizations that collaborate and plan together to meet the broader goals set up for the Maumee RAP (Remedial Action Plan) by the International Joint Commission (Partners for Clean Streams, 2014).

The Toledo Metropolitan Area Council of Governments (TMACOG) is a voluntary organization of dues-paying members. TMACOG members include governmental and non-governmental organizations in northwest Ohio and southeast Michigan: cities, counties, villages, and townships, as well as schools and colleges, park districts, businesses, and other groups concerned with quality of life in the region. TMACOG is both a Regional Council and a Metropolitan Planning Organization. Members work together on common problems that cross jurisdictional borders, specifically transportation, and air and water issues. Members coordinate plans for roadways, highways, railways, and bikeways that serve the entire region. Joining together, members can take better care of rivers and watersheds that drain several jurisdictions (Toledo Metropolitan Area Council of Governments, 2014).

The Upper Maumee Watershed Partnership is a locally-led group of concerned citizens and organizations whose primary goal is the improvement of water quality throughout the upper Maumee River watershed and ultimately throughout the western Lake Erie basin. Their focus is the development of a watershed management plan and implementation of best management practices. Additionally, events and other public outreach programs are held to further community awareness of water quality (Upper Maumee Watershed Partnership, 2014).

Results

Water Chemistry

Surface water chemistry samples were collected from the Maumee and Auglaize Rivers study area from March through November 2012 and 2013 at 31 locations (Appendix G). Stations were established in free-flowing sections of the streams and were collected directly from the stream or from bridge crossings. Surface water samples were collected directly into appropriate containers, preserved and delivered to Ohio EPA's Environmental Services laboratory. Collected water was preserved using appropriate methods, as outlined in the Ohio EPA Surface Water Field Sampling Manual (Ohio EPA 2013a).

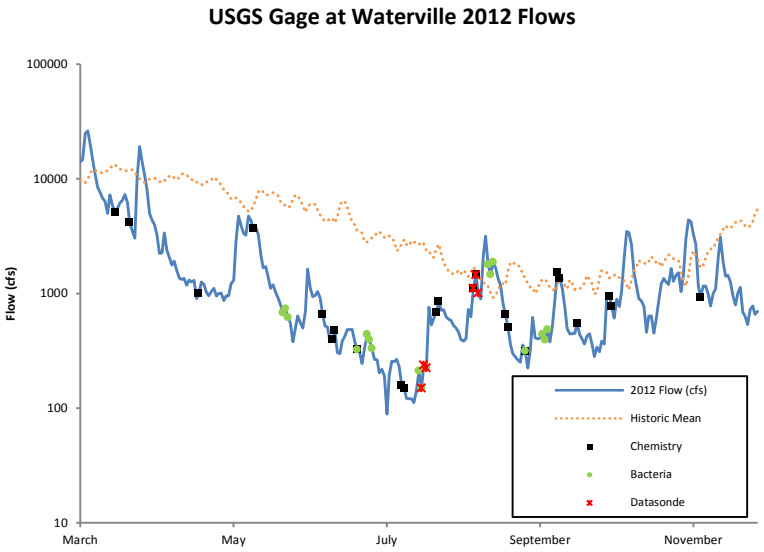

Figure 9. Mean flow conditions in the Maumee River at Waterville during the 2012 sampling season.

USGS gage data from the Maumee River at Waterville near SR 64 were used to show flow trends in the large river assessment units during the 2012 to 2013 survey (Figure 9 and Figure 10). Dates when water chemistry samples, bacteria samples, and Datasonde® deployments were completed in the study area are noted on the graphs. Flow conditions during the 2012 field season were typically lower than the historic median (April through July). Low flow conditions were observed from April through July with limited rain events occurring. Water samples captured a variety of flow conditions in the study area during the field season. Bacteria was collected during the Recreation Use season (May 1 through October 31) and was typically collected during low flows.

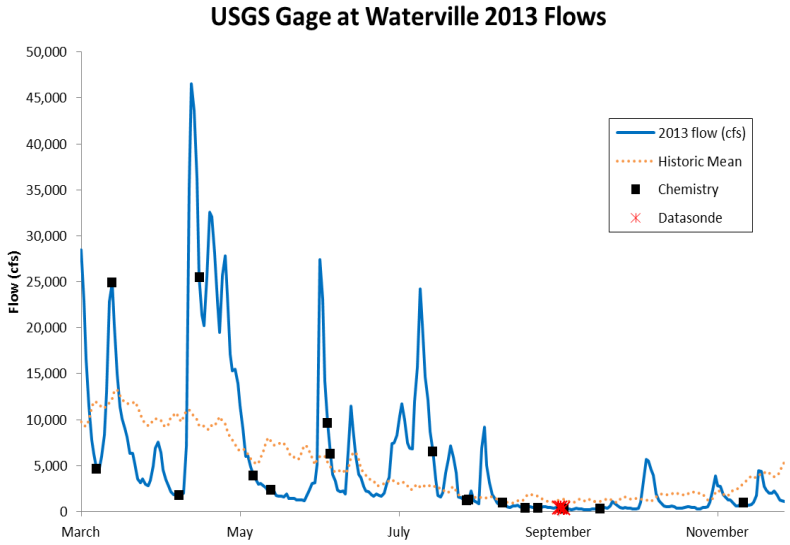

Figure 10. Mean flow conditions in the Maumee River at Waterville during the 2013 sampling season.

Surface water samples were analyzed for metals, nutrients, semi-volatile organic compounds, bacteria, pH, temperature, conductivity, dissolved oxygen (D.O.), percent D.O. saturation, and suspended and dissolved solids (Appendix G). Parameters which were in exceedance of the Ohio WQS criteria are reported in Table 8. Bacteriological samples were collected from 30 locations, and the results are reported in the Recreation Use section. Datasonde® water quality recorders were placed at 26 locations to monitor hourly levels of temperature, pH, specific conductivity, and dissolved oxygen (Appendix J). For the purposes of this assessment, Ohio water quality criteria and nutrient targets were used to evaluate the data that was collected at the sampling location in New Haven, Indiana.

Metals were measured at all 31 chemistry locations with seventeen parameters tested (Appendix G). Copper exceeded the water quality standard at the City of Napoleon water intake on the Maumee River at RM 47.1 on two occasions (Table 8). Both dates the copper exceedances were observed the samples were collected from the copper sampling tap in the water intake building instead of directly from the stream. The exceedances potentially occurred due to inadequate flushing of the sample tap prior to taking the sample. In addition, an iron result above the agricultural use criteria was found at Harding Road on the Auglaize River (RM 4.14) (Table 8). The elevated iron observed on this date may have been caused by a higher flow event from the prior day causing discharge from the Power Dam impoundment located approximately 1.7 miles upstream and additional agricultural run-off and / or ground water recharge to the stream. Other iron exceedances of the agricultural use criteria on the Maumee River mainstem occurred during the March 13, 2013 sampling event and are potentially a result of high flows with high sediment loads from run-off and resuspension of sediments.

Table 8. Exceedances of Ohio Water Quality Standards criteria (OAC 3745-1) for chemical and physical parameters measured in the Maumee and Auglaize Rivers study area, 2012-2013. Data sorted by Large River Assessment Unit (LRAU). 2013 exceedances are underlined. Bacteria exceedances are presented in the Recreational Use section.

LRAU	*Stream/RM*	Station ID	Location	Parameter (value – mg/l unless noted)
04100005 90 01	*Maumee River*		*Undesignated / WWH Recommended*	
	129.10	301929	New Haven, IN Gage	Dissolved oxygen – 4.24[a], 4.67[a], 3.88[b]
	Maumee River		*WWH Existing*	
	104.70	P06K09	1.0 Mile West of Antwerp	Temperature – 24.35° C[c]
	99.00	201868	Antwerp City Park	Temperature – 16.68 ° C[d]; Iron – 10,000 µg/l[e]; pH – 6.33
	91.48	P06S08	Eater Road / County Road 73	Temperature - 24.54° C[c]
	85.26	P06K06	County Road 105	Temperature – 24.36° C[c], Dissolved Oxygen – 4.19[a]
	80.10	P06K05	State Route 127 (Platter Creek)	Temperature – 25.27° C[c]
	76.15	P06S07	Bend Road	Temperature – 25.09° C[c], 17.19° C[d]; Iron – 9,530 µg/l[e]; Dissolved Oxygen-4.91[a]
	69.20	P06K03	Intersection Switzer Road & Dowe Road	Temperature – 25.14° C[c]
04100009 90 01	*Maumee River*		*MWH Existing*	
	62.30	P09W31	State Route 281	Temperature - 25.22° C[c], 31.74° C[d]
	Maumee River		*WWH Existing*	
	60.00	201895	Downstream Independence Dam	Temperature – 23.99° C[c], 30.05° C[c], 12.69° C[d], 17.41° C[d]; Iron – 10,700 µg/l[e]
	Maumee River		*MWH Existing*	
	52.10	201856	Wade Creek / Girty Island	Temperature – 24.54° C[c]
	47.10	500200	Napoleon WTP Intake	Temperature – 24.96° C[c], Copper – 23.9 µg/l[e], 36.9 µg/l[e]
	41.24	201851	State Route 6	Temperature – 16.45° C[c], 24.24° C[c], 18.11° C[d]; Iron – 15,500 µg/l[e]
	32.60	P11S42	Upstream Grand Rapids Dam	Temperature – 23.94° C[c]
	Maumee River		*WWH Existing*	
	31.64	P11K33	State Route 578	Temperature – 17.31° C[c], 24.06° C[c], 18.88° C[d]; Iron – 14,300 µg/l[e]; pH-9.16
04100009 90 02	26.70	P11K31	Otsego Park	Temperature – 24.93° C[c]; pH-9.11
	20.70	500080	State Route 64 / Waterville	Temperature – 25.39° C[c], 24.29° C[c], 11.24° C[d], 21.17° C[d], 19.8º C[c], 30.1º C[c]; Dissolved Oxygen – 4.35[a]; pH – 6.07, 9.01, 9.32, 9.26, 9.33, 9.07; Iron – 15,000 µg/l[e], 10,100 µg/l[e]
	16.52	301740	Buttonwood Recreation Area	Temperature - 17.24° C[c], 24.03° C[c], 18.88° C[d]; Iron – 13,700 µg/l[e]
	13.30	301644	Ewing Island / Maple Street	Temperature – 28.54° C[c], 28.96° C[c], 25.63° C[d]
	9.40	P11S39	Eagle Point Colony	Temperature – 22.53° C[c]
	5.80	201838	Anthony Wayne Bridge	Temperature – 22.03° C[c], Dissolved Oxygen – 4.1[a]
	3.60	301641	Interstate 280	Dissolved Oxygen – 4.14[a], 2.81[b]
	0.50	P11S32	Near Mouth	Dissolved Oxygen – 4.30[a]
	Auglaize River		*WWH Existing*	

LRAU	*Stream/RM*	Station ID	Location	Parameter (value – mg/l unless noted)
	28.5	500110	Cloverdale at State Route 114	None
	Auglaize River		*MWH-I Recommended*	
	19.3	500130	Oakwood at State Route 613	Temperature – 22.92° C[c], Dissolved Oxygen – 4.9[a], 4.66[a], 4.86[a]
	15.0	P06S10	Charloe at County Road 138	Temperature – 22.32° C[c], 27.98° C[c]
	5.90	204258	Upstream Defiance Power Dam	Temperature – 23.81° C[c], Dissolved Oxygen – 4.75[a], 3.2[b]
	Auglaize River		*WWH Existing*	
	4.14	500290	Harding Road	Temperature – 17.64° C[d], Iron – 6180 µg/l[e], 14,800 µg/l[e]

a- Exceedance of the aquatic life Outside Mixing Zone Minimum 24 hour Average water quality criterion. Exceedance of the aquatic life Outside Mixing Zone Minimum water quality criterion. Exceedance of the average temperature criterion. Exceedance of the daily maximum temperature criterion.

e- Exceedance of the statewide water quality criteria for the protection of agricultural uses.

Multiple iron exceedances of the public drinking water supply human health criteria were found within 500 yards of the City of Napoleon water treatment plant intake (RM 47.1) and one time at the City of Bowling Green water intake (RM 23.15) (Table 9). Iron exceedances of the drinking water human health criteria occurred in multiple samples collected at all other sampling locations greater than 500 yards from a water intake. Iron only has a secondary drinking water standard that was set based on the aesthetics of the water and the potential to need additional water treatment equipment to remove excess iron from the system. Iron is abundant in the soils and rock in the area and elevated levels exist in many ground water and surface water sources in northwest Ohio.

Table 9. Exceedances (µg/l) of the Lake Erie drainage basin water quality criteria for the protection of human health for drinking water in the Maumee River, 2012-2013.

River Mile	Location	Parameter - Value
47.1	Napoleon WTP Intake	Iron – 482, 429, 761, 900, 403, 425
23.15	Bowling Green WTP Intake	Iron - 390

Average and maximum temperature exceedances observed from field samples can be attributed to an unseasonably warm winter and a hot and dry spring. It is unlikely that point source discharges caused the exceedances due to the elevated temperatures occurring at every sampling location but two in the Maumee and Auglaize Rivers. The impounded areas on both rivers can also contribute to elevated water temperatures, especially in hot, dry summers preceded by a warmer than normal winter. All temperature exceedances occurred between March 15 and July 24, 2012 on the Maumee and Auglaize Rivers.

A seasonal pH range was observed in the 2013 field data at the State Route 64 sampling location near Waterville (RM 20.6). In addition, there was a pH of 6.33 (water temperature - 4.06^{o} C) at Antwerp City Park (RM 99.0), 9.16 (water temperature – 29^{o} C) at State Route 578 (RM 31.64), and 9.11 (water temperature – 26.7) at Otsego Park (RM 26.7). The Waterville pH results compliment the results at the three upstream sites above in that low pH occurs at lower temperatures and higher pH occurs at higher temperatures. The pH results for the 2013 field data at the Waterville sampling location ranged from 6.56 (water temperature – 2.08) in March to 9.33 (water temperature – 30.1) in August.

The greatest natural cause for change in pH in a stream is the seasonal and daily variation in photosynthesis. Photosynthesis consumes carbon dioxide which reacts with water to form carbonic acid. The result of lowering carbon dioxide is a decrease in hydrogen ion concentration which raises the pH of the stream (Wurts and Durborow, 1992). The higher pH levels during longer, warmer days in the summer reflect high levels of photosynthetic activity.

Datasonde® Monitoring Results

Multi-parameter Datasondes® are deployed in each study area to collect physical parameter data. The Datasondes® have four electrical sensors that record water column dissolved oxygen, pH, electrical conductivity, and temperature. All parameters, excluding electrical conductivity, are exposed to daily (diel) mechanisms that result in general trends in the parameter. Temperature shows strong diel fluctuations that reflect air temperature and solar radiation on the global scale, with local factors such as base flow (groundwater), stream flow, and shading. In general, diel fluctuations in temperature increase as base flow, stream flow, and shading decrease. The inverse is also true. Dissolved oxygen

responds in a similar diel pattern to temperature, as they are affected strongest by similar factors. However, dissolved oxygen trends are directly dependent on temperature, with high temperatures decreasing the solubility of oxygen in water and increasing the reactions driving diel fluctuations. The inverse relationship, without the influence of other environmental conditions, would cause the two parameters to naturally follow opposite trends. The dissolved oxygen response to photosynthesis is strong enough in most instances to overwhelm the inverse relationship causing the trends to follow similar trajectories. The photosynthetic effect on dissolved oxygen is particularly useful for describing the trophic condition of a stream. Increased diel fluctuation relates to an increase in productivity as equilibrium dissolved oxygen concentrations are pushed to super saturation by photosynthesis and depleted by respiration. The result is a diel trend that typically reaches a maximum concentration of dissolved oxygen in the early evening and a minimum near sunrise. Diel trends in pH are reflective of this productivity because carbon dioxide, which dissolves in water to form carbonic acid, is consumed during photosynthesis, thus raising the pH of the stream.

The data collected with the Datasonde® is evaluated with the values established in the WQS for each parameter. Datasonde® sites on the Maumee and Auglaize Rivers are designated WWH and MWH-I, and therefore the aquatic life use (ALU) standards are used to evaluate the data (OAC 3745-1-07, Tables 10 - 13). Note that the Maumee River mainstem temperature criteria (Table 11) are less stringent than the rest of Lake Erie drainage streams (Table 13).

Table 10. Water quality standards for dissolved oxygen, pH and dissolved solids (OAC 3745-1-07).

Chemical (ALU)	Units	OMZM[1]	OMZA[1]
Dissolved Oxygen (WWH)	mg/l	4.0	5.0
Dissolved Oxygen (MWH)	mg/l	3.0	4.0
pH (WWH, MWH)	s.u.	--	6.5-9.0
Dissolved Solids	mg/l	--	1500[2]

[1] *OMZM = outside mixing zone minimum; OMZA = outside mixing zone average.*
[2] *Equivalent 25°C specific conductance value is 2400 micromhos/cm.*

Table 11. Water temperature for the Maumee River from the Ohio-Indiana state line to the Maumee River estuary criteria (OAC 3745-1-07, Table 7-14).

	Units	June 16-30	July 1-31	Aug. 1-31	Sept. 1-15	Sept. 16-30
Average:	°F	85	85	85	85	80
	°C	29.4	29.4	29.4	29.4	26.7
Daily	°F	89	89	89	89	85
Maximum:	°C	31.7	31.7	31.7	31.7	29.4

Table 12. Water temperature for the Maumee Bay including the Maumee River estuary criteria (OAC 3745-1-07, Table 7-14).

	Units	June 16-30	July 1-31	Aug. 1-31	Sept. 1-15	Sept. 16-30
Average:	°F	83	83	83	83	75
	°C	28.3	28.3	28.3	28.3	23.9
Daily	°F	87	87	87	87	80
Maximum:	°C	30.6	30.6	30.6	30.6	26.7

Table 13. Water temperature for general Lake Erie surface waters criteria (OAC 3745-1-07, Table 7-14).

	Units	June 16-30	July 1-31	Aug. 1-31	Sept. 1-15	Sept. 16-30
Average:	°F	82	82	82	82	75
	°C	27.8	27.8	27.8	27.8	23.9
Daily	°F	85	85	85	85	80
Maximum:	°C	29.4	29.4	29.4	29.4	26.7

Twenty-six locations were sampled (Figure 11) within the study area in 2012 to provide a representative sample of the watershed and also target areas of concern (e.g. point sources or historically impaired areas). In order to observe longitudinal trends, Datasondes® were deployed at nearly every assessed site on the mainstem Maumee River in 2012; a total of twenty-one sites. The large river assessment unit portion of the Auglaize River was monitored at five sites. A follow-up 2013 survey included monitoring at eleven sites on the Maumee River (Figure 11).

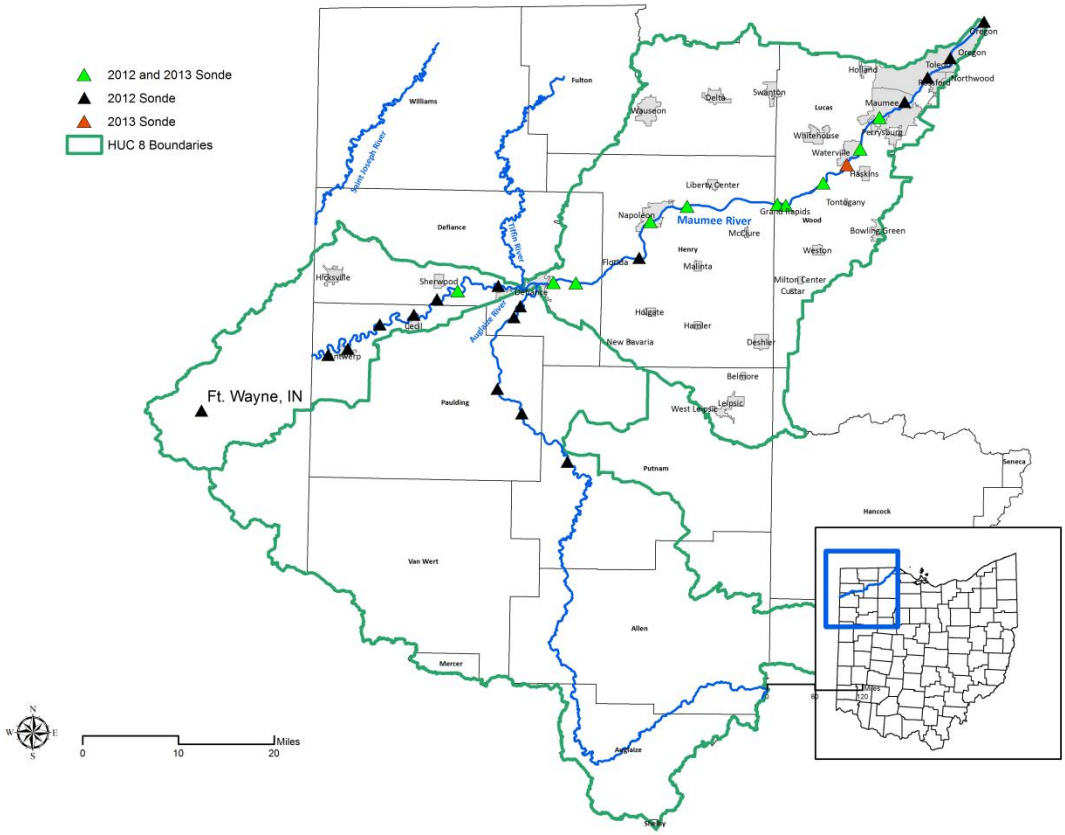

Figure 11. Map of deployment locations for Datasondes® in the Maumee and Auglaize Rivers, 2012 & 2013.

Critical conditions for the parameters (times when impact to a given parameter are most severe) monitored with Datasondes® are times when flows are low and temperatures are high, and daylight is long. As a result, Datasondes® are typically deployed in low flow conditions from June to September representing the time that streams are most sensitive to enrichment by organic matter and nutrients. In 2012, Datasondes® were deployed July 17-19 and August 7-9 in the Maumee River and Auglaize River (Figure 12). The first deployment benefitted from higher temperatures than the second survey and much lower flows resulting in data best representing the previously defined critical condition. The second deployment was affected by thunderstorms and increased cloud cover which resulted in increased stream flows and overall lower primary productivity. A second year deployment occurred from September 3-5 in 2013 near an area suspected of nutrient enrichment on the Maumee River

mainstem around Grand Rapids (Figure 13). The growing season of 2013 was affected by sustained high flows into late August which seemed to affect the structure of the algal communities.

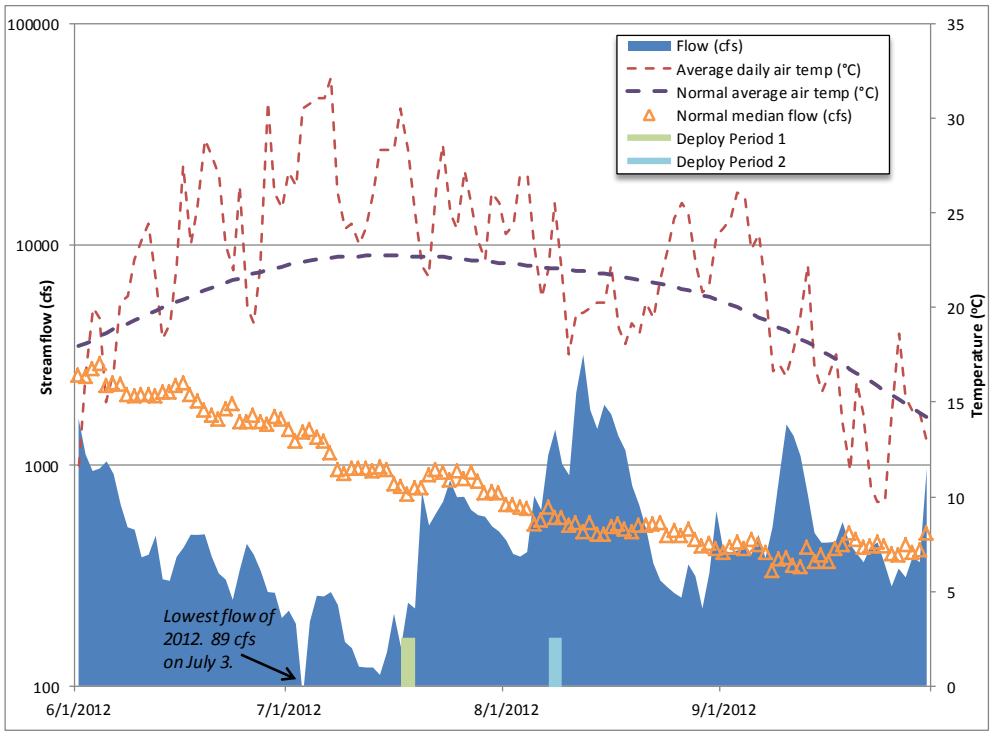

Figure 12. Graph of average daily stream flow relative to the historical (1930 – 2012) daily median stream flow (USGS 04193500 Maumee River at Waterville OH) including the average daily air temperature (NOAA-GHCND: USW00004851) for 2012.

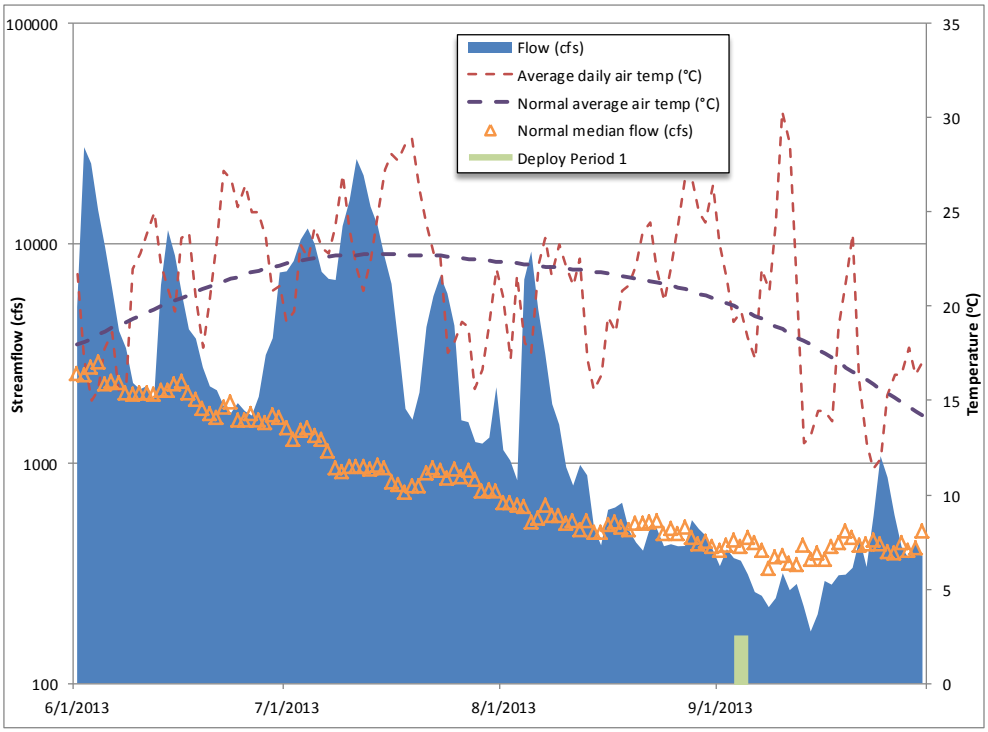

Figure 13. Graph of average daily stream flow relative to the historical (1930 – 2012) daily median stream flow (USGS 04193500 Maumee River at Waterville OH) including the average daily air temperature (NOAA -GHCND: USW00004851) for 2013.

Longitudinal plots help visualize measurements of stream water quality as it changes at sampling points along the stream channel. Longitudinal plots present stream data referenced by RM and only data sampled along the same water course can be accurately presented on the plot. A longitudinal plot of dissolved oxygen data from the July 2012 Datasonde® deployment was developed using 24 hours of data (Figure 14). The data presented for dissolved oxygen is represented by a box-and-whisker plot. Box-and-whisker plots represent the maximum value as the top of the upper whisker, the 75th percentile value as the top of the upper box, the median as the intersection of the two boxes, the 25th percentile value as the bottom of the lower box, and the minimum as the end of the lower whisker; the average value is represented by a diamond. The "best" 24-hour diel cycle for dissolved oxygen data is presented in Figure 14. This "best" 24-hour period from the survey represents the condition nearest the targeted dry/hot weather and low flow critical condition. This occurred from the evening of the first day to the morning of the second day of the survey (July 17-18). Figure 15 shows the longitudinal box-and-whisker plot of the 2013 survey.

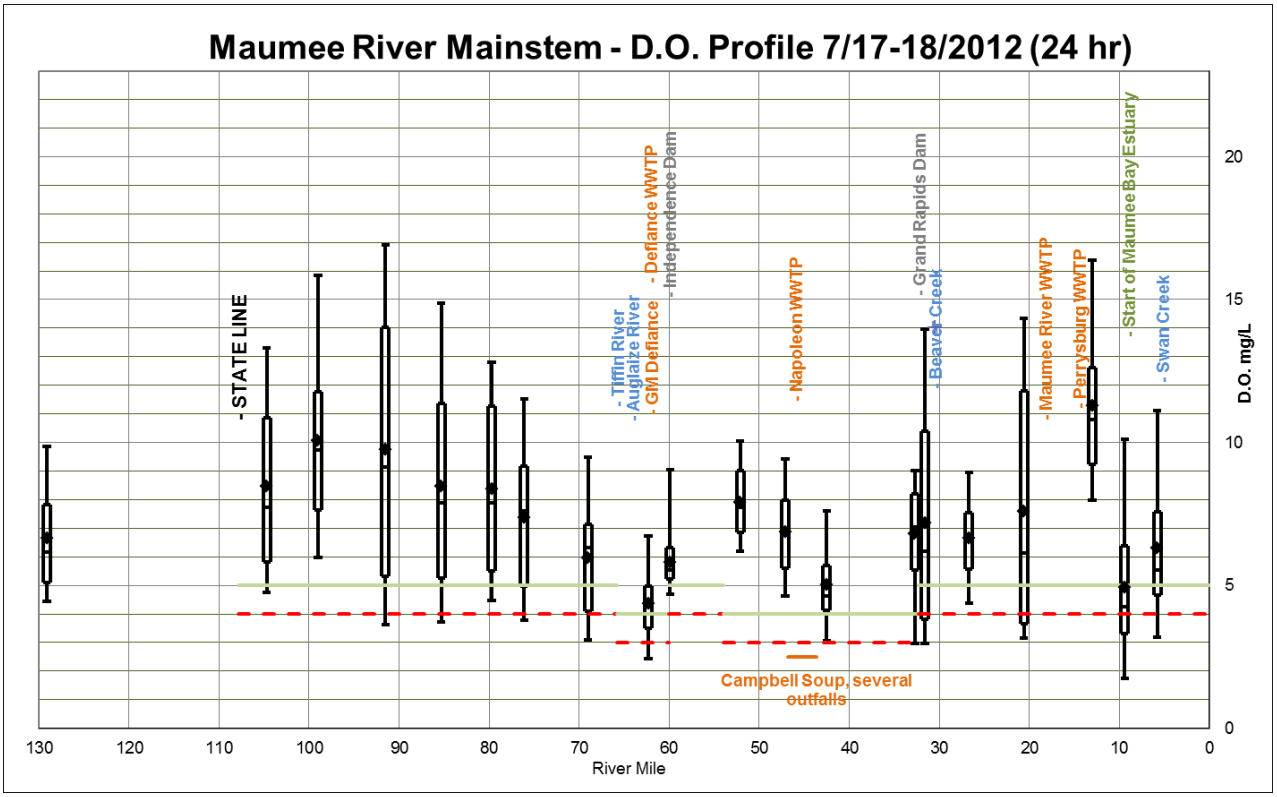

Figure 14. Longitudinal profile for dissolved oxygen on the mainstem of the Maumee River ,2012. The data represented in the box plots is the same data summarized in Table 14. The plot's range is July 17-18 from 1800 to 1700 (24hrs).

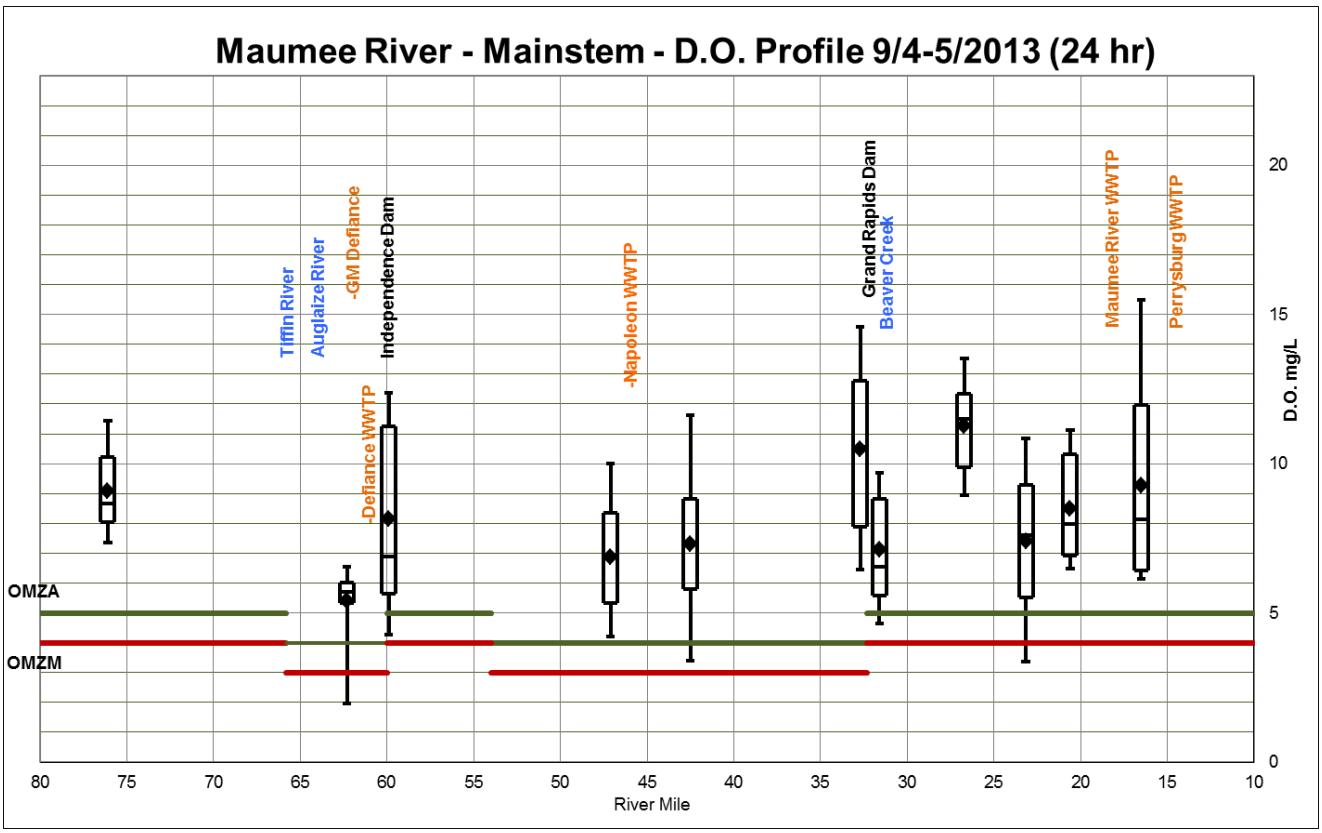

Figure 15. Dissolved oxygen representing 24 hour dissolved oxygen values in the lower Maumee River from September 2013. The data represented in the box plots is the same as the data summary in Table 16, range B (September 4-5 from 0400-0300, 24hrs).

The additional data that was collected is summarized in Table 14, Table 15, and Table 16. Each table includes a summary of temperature, pH, conductivity, and dissolved oxygen data collected by the Datasondes®. Data is summarized by identifying the minimum, average, maximum, and range captured during a 24-hour period. The typical Datasonde® deployment captures three 24-hour time frames that include the needed critical values to perform these calculations. Generally during a deployment the following critical values are recorded: local maximum on day one, a local minimum and maximum on day two, and a local minimum on day three. These four critical values represent three diel swings: A) between the day one maximum and day two minimum, B) between the day two minimum and day two maximum, and C) between the day two maximum and day three minimum. These three ranges are presented as A, B, and C in the tables and capture the full scope of potential water quality violations in a 48 hour Datasonde® deployment. Values that do not meet water quality criteria are flagged (shown in bold with bold cell borders). Additionally, while not a water quality standard, 24-hour DO minimum to maximum ranges that exceed 7 mg/l are strong indications of nutrient enrichment (Miltner 2010). These are also shown in bold with bold cell borders. A narrative summary of water quality standard exceedances for each parameter follows:

Temperature: As evident from Figure 12 above, in 2012 only five days in June and July were below the average air temperature. The mid-July survey caught the stream temperatures responding to this hot, drought period. Fifteen out of twenty-one mainstem Maumee River sites did not meet the temperature criteria during this survey. Additionally, all five of the Auglaize River sites exhibited temperature criteria

violations during the July 2012 survey. The extremely wide channel of the Maumee River precludes riparian vegetation from offering any substantial shading. While the Maumee River mainstem temperature criteria limits are greater than the majority of Lake Erie draining streams, most of the monitoring sites exceed these criteria. Only one Auglaize River site showed a temperature violation during the August, 2012 survey. None of the mainstem Maumee River sites had a violation to the criteria during the August, 2012 survey. Additionally no violations occurred during the 2013 survey.

pH: The geology of the Maumee River watershed results in the river having high alkalinity. The high alkalinity buffers the systems pH resulting in stable pH's that meet Ohio's water quality criteria. However, the system's productivity (more clearly expressed in the dissolved oxygen data) is reflected in pH fluctuations. The range was as high as 1.37 SU/day in July 2012 and represents depletion of carbon dioxide by photosynthesis.

Specific Conductivity: No water quality violations were captured during the sonde survey.

Dissolved Oxygen: Dissolved oxygen has a direct impact on aquatic life and is the most useful indicator tracked by Datasonde® sampling. Dissolved oxygen criteria violations were found during all three sonde surveys of the Maumee River mainstem. The lowest, warmest flow during the July 2012 survey found twelve out of twenty-one of the sites monitored had dissolved oxygen violations (one site had a sensor failure). During that survey, most of the sites with dissolved oxygen criteria violations showed a 24-hour range greater than 7.0 mg/l, which is a strong indication of nutrient enrichment. Five of the mainstem Maumee River sites had a 24-hour range greater than 10 mg/l. This is a strong indication of *extreme* primary production stimulated by nutrients in excess of ecosystem needs. Fewer dissolved oxygen violations occurred during the August 2012 survey and ranges, while still high, were dampened from the July survey. This survey was less representative of the biological critical condition as thunder storms resulted in elevated stream flows which rose throughout the 48-hour deployment period (Figure 12). In addition to the rising stream flows, cloud cover further subdued primary productivity.

The 2013 follow-up survey focused on the Maumee River mainstem centered near Grand Rapids. The summer of 2013 was a relatively high stream flow season, however the survey in early September caught a period were the river's stream flow had receded below the long term median flows. Only two out of the eleven sites sampled had minimum dissolved oxygen criteria violations and five had 24-hour ranges greater than 7 mg/l. The higher flows and shorter photoperiod during the 2013 survey dampened the dissolved oxygen violations and ranges relative to the 2012 surveys.

The July 2012 survey also found dissolved oxygen criteria violations for two out of four Auglaize River sites (one site had a dissolved oxygen sensor failure). The most upstream Auglaize River sampling site (RM 28.5) had minimum violations. This site's maximum dissolved oxygen was 8.6 mg/l and the minimum was 3.7 mg/l with a range of about 5.0 mg/l. This indicates some nutrient enrichment, but also likely some organic enrichment from biological oxygen demanding waste. The same applies to the RM 19.3 site; however this site had a lower maximum, under 8.0 mg/l, and thus an average criteria violation as well as a minimum criteria violation. The two lower Auglaize River sites dissolved oxygen data indicate nutrient enrichment evident by the dissolved oxygen range. Note that the RM 5.9 site is in the Auglaize Power Dam pool. The subsequent Datasonde® survey in August of 2012 found similar signatures at the Auglaize River sites, however they were subdued due to the lower temperature and higher stream flows and water quality criteria were not violated.

Table 14. Summary of Datasonde® data from the July 2012 survey as three separate diel cycles (A, B, and C).

				Temperature (°C)				pH (SU)				Sp Conductivity (µS/cm)				Dissolved Oxygen (mg/L)			
Stream (ALU)	River Mile	Storet	Range*	Min	Ave	Max	Range	Min	Ave	Max	Range	Min	Ave	Max	Range	Min	Ave	Max	Range
Dates sampled: July 17 - 19, 2012																			
Maumee R.			A	28.08	28.92	30.29	2.21	7.64	7.79	8.07	0.43	982	1012	1022	40	4.43	6.24	9.87	5.44
WWH	129.1	301929	B	27.91	28.52	29.55	1.64	7.64	7.76	7.94	0.30	982	999	1015	33	4.43	5.69	7.87	3.44
	Indiana Site		C	27.14	28.35	29.55	2.41	7.62	7.75	7.94	0.32	974	992	1009	35	4.12	5.60	7.87	3.75
Maumee R.			A	28.36	**29.90**	**31.78**	3.42	8.03	8.29	8.60	0.57	859	912	933	74	4.74	8.05	13.32	**8.58**
WWH	104.7	P06K09	B	28.02	28.97	30.47	2.45	7.90	8.12	8.27	0.37	843	881	933	90	4.50	6.30	8.16	3.66
			C	26.98	28.66	30.47	3.49	7.82	8.06	8.27	0.45	843	867	907	64	**3.80**	6.01	8.16	4.36
Maumee R.			A	28.84	**30.23**	**32.21**	3.37	8.25	8.54	8.85	0.60	877	900	911	34	5.98	9.52	15.85	**9.87**
WWH	99	201868	B	28.28	29.28	30.54	2.26	8.09	8.32	8.53	0.44	874	894	911	37	5.49	7.10	8.69	3.20
			C	27.17	28.86	30.54	3.37	7.87	8.21	8.41	0.54	871	886	911	40	4.11	6.50	8.69	4.58
Maumee R.			A	28.80	**30.85**	**33.25**	4.45	8.16	8.60	8.95	0.79	834	857	873	39	**3.64**	9.39	16.90	**13.26**
WWH	91.5	P06S08	B	28.71	**29.69**	30.61	1.90	8.16	8.46	8.70	0.54	860	871	876	16	**3.64**	6.69	10.90	**7.26**
			C	27.43	29.38	30.61	3.18	7.91	8.39	8.70	0.79	869	875	883	14	5.00	8.78	10.90	5.90
Maumee R.			A	28.46	**30.41**	**33.71**	5.25	8.15	8.52	8.90	0.75	809	821	828	19	**3.73**	8.28	14.86	**11.13**
WWH	85.3	P06K06	B	28.38	**29.47**	31.18	2.80	8.15	8.41	8.73	0.58	810	821	828	18	**3.73**	7.57	12.58	**8.85**
			C	27.22	29.23	31.18	3.96	7.92	8.35	8.73	0.81	810	820	827	17	**3.97**	7.59	12.58	**8.61**
Maumee R.			A	28.68	**30.82**	**33.45**	4.77	8.59	8.80	8.96	0.37	786	800	815	29	4.46	8.32	12.79	**8.33**
WWH	79.7	P06K05	B	28.68	**29.96**	31.61	2.93	8.59	8.79	8.97	0.38	788	801	815	27	4.46	8.13	11.43	6.97
			C	27.49	**29.71**	31.61	4.12	8.43	8.76	8.97	0.54	788	801	811	23	4.58	8.16	11.43	6.85
Maumee R.			A	28.84	**30.60**	**32.39**	3.55	8.14	8.45	8.75	0.61	803	813	818	15	**3.79**	7.36	11.51	**7.72**
WWH	76.1	P06S07	B	28.84	**30.05**	**31.88**	3.04	8.14	8.37	8.56	0.42	802	809	815	13	**3.79**	6.88	9.70	5.91
			C	27.67	**29.81**	**31.88**	4.21	8.00	8.34	8.56	0.56	802	808	816	14	4.17	6.92	9.70	5.53
Maumee R.			A	28.75	**30.23**	**32.10**	3.35	8.14	8.45	8.72	0.58	813	825	837	24	**3.09**	6.17	9.97	6.88
WWH	69	P06K03	B	28.75	**29.83**	30.93	2.18	8.14	8.34	8.59	0.45	815	820	826	11	**3.09**	5.61	8.87	5.78
			C	27.99	**29.73**	30.93	2.94	8.00	8.31	8.59	0.59	808	819	823	15	**2.96**	5.60	8.87	5.91
Maumee R.			A	28.53	28.67	28.93	0.40	7.76	7.96	8.22	0.46	736	747	757	21	**2.56**	4.57	6.73	4.17
MWH	62.3	P09W32	B	28.57	28.62	28.79	0.22	7.65	7.80	8.04	0.39	749	757	763	14	**1.08**	**2.92**	5.23	4.15
			C	28.54	28.61	28.76	0.22	7.65	7.74	7.93	0.28	751	759	763	12	**1.08**	**2.30**	4.62	3.54
Maumee R.			A	29.08	**29.87**	**31.83**	2.75	8.00	8.33	8.73	0.73	692	709	714	22	4.68	5.80	9.05	4.37
WWH	59.9	201859	B	28.59	29.24	30.18	1.59	7.90	8.10	8.37	0.47	708	715	723	15	4.14	5.11	6.43	2.29
			C	28.25	29.00	30.18	1.93	7.80	8.02	8.37	0.57	708	717	723	15	**3.80**	**4.77**	6.43	2.63

				Temperature (°C)				pH (SU)				Sp Conductivity (µS/cm)				Dissolved Oxygen (mg/L)			
Stream (ALU)	River Mile	Storet	Range*	Min	Ave	Max	Range	Min	Ave	Max	Range	Min	Ave	Max	Range	Min	Ave	Max	Range
Dates sampled: July 17 - 19, 2012																			
Maumee R.			A	29.26	**29.98**	30.99	1.73	8.50	8.63	8.82	0.32	658	662	666	8	6.18	7.73	9.86	3.68
MWH	52.1	201856	B	29.26	**30.04**	30.77	1.51	8.50	8.63	8.75	0.25	664	666	668	4	6.18	8.02	9.69	3.51
			C	29.13	**30.07**	30.77	1.64	8.34	8.62	8.75	0.41	664	667	671	7	5.32	7.98	9.69	4.37
Maumee R.			A	29.12	**29.79**	30.59	1.47	8.18	8.39	8.57	0.39	664	667	670	6	4.62	6.96	9.41	4.79
MWH	47.1	500200	B	29.12	**29.68**	30.13	1.01	8.18	8.38	8.56	0.38	665	668	670	5	4.62	6.45	8.16	3.54
			C	29.12	**29.69**	30.13	1.01	8.24	8.41	8.56	0.32	664	667	670	6	5.04	6.54	8.16	3.12
Maumee R.			A	28.74	29.18	29.79	1.05	8.11	8.36	8.63	0.52	675	680	686	11	3.06	5.18	7.61	4.55
MWH	42.5	201851	B	28.74	29.05	29.38	0.64	8.11	8.23	8.39	0.28	680	684	688	8	3.06	4.54	5.90	2.84
			C	28.74	29.07	29.38	0.64	8.07	8.23	8.39	0.32	683	686	688	5	3.35	4.54	5.90	2.55
Maumee R.			A	28.80	**30.00**	31.36	2.56	7.82	8.27	8.46	0.64	658	680	691	33	**2.98**	6.81	9.01	6.03
MWH	32.7	P11S42	B	28.80	**29.79**	31.22	2.42	7.85	8.20	8.46	0.61	641	668	688	47	3.31	6.20	8.48	5.17
			C	28.38	**29.69**	31.22	2.84	7.80	8.15	8.46	0.66	641	660	679	38	**2.95**	5.78	8.48	5.53
Maumee R.			A	28.37	**30.50**	**33.44**	5.07	7.78	8.20	8.74	0.96	662	696	710	48	**2.98**	7.21	13.95	**10.97**
WWH	31.6	P11K33	B	27.93	**30.04**	**32.82**	4.89	7.74	8.19	8.72	0.98	643	674	710	67	**3.05**	7.23	13.95	**10.90**
			C	27.69	**29.80**	**32.82**	5.13	7.68	8.17	8.72	1.04	643	661	698	55	**2.97**	7.06	13.95	**10.98**
Maumee R.			A	29.49	**30.43**	31.68	2.19	8.08	8.31	8.51	0.43	721	725	729	8	4.38	6.69	8.94	4.56
WWH	26.7	P11K31	B	29.49	**30.10**	30.80	1.31	8.08	8.23	8.36	0.28	627	723	729	102	4.38	6.23	7.51	3.13
			C	28.85	**29.97**	30.80	1.95	7.98	8.21	8.36	0.38	627	723	729	102	4.43	6.20	7.51	3.08
Maumee R.			A	26.52	**30.15**	**34.99**	8.47	7.36	8.05	8.73	1.37	645	681	712	67	**3.16**	7.59	14.33	**11.17**
WWH	20.6	500080	B	26.52	**29.63**	**33.64**	7.12	7.36	8.04	8.73	1.37	656	684	712	56	**3.16**	7.68	14.33	**11.17**
			C	25.67	**29.48**	**33.64**	7.97	7.38	8.05	8.73	1.35	476	674	712	236	**3.28**	7.87	14.33	**11.05**
Maumee R.			A	29.22	**30.12**	31.43	2.21	8.60	8.89	9.19	0.59	595	612	621	26	7.99	11.6	16.39	**8.40**
WWH	13	301644	B	29.22	**29.66**	30.36	1.14	8.60	8.79	8.99	0.39	595	612	621	26	7.89	9.77	12.32	4.43
			C	28.59	**29.52**	30.36	1.77	8.52	8.76	8.99	0.47	602	614	623	21	6.17	9.26	12.32	6.15
Maumee R.			A	28.77	29.28	30.57	1.80	7.82	8.28	8.81	0.99	569	573	577	8	**1.76**	5.15	10.11	**8.35**
WWH	9.4	P11S39	B	28.77	29.02	29.36	0.59	7.82	8.15	8.39	0.57	574	575	577	3	**1.76**	**4.10**	5.71	3.95
			C	28.64	28.97	29.36	0.72	7.84	8.16	8.37	0.53	573	575	577	4	**2.60**	**4.26**	5.71	3.11
Maumee R.			A	28.32	28.87	30.03	1.71	7.51	7.96	8.57	1.06	567	575	581	14	**3.19**	6.26	11.81	**8.62**
WWH	5.8	201838	B	28.27	28.76	30.03	1.76	7.51	7.90	8.61	1.10	571	578	582	11	**3.19**	6.05	12.75	**9.56**
			C	28.21	28.71	30.03	1.82	7.45	7.83	8.61	1.16	571	579	585	14	**2.52**	5.61	12.75	**10.23**

				Temperature (°C)				pH (SU)				Sp Conductivity (µS/cm)				Dissolved Oxygen (mg/L)			
Stream (ALU)	River Mile	Storet	Range*	Min	Ave	Max	Range	Min	Ave	Max	Range	Min	Ave	Max	Range	Min	Ave	Max	Range
Dates sampled: July 17 - 19, 2012																			
Maumee R.			A	28.00	28.64	29.63	1.63	7.90	8.22	8.66	0.76	444	507	547	103	Dissolved Oxygen sensor failure			
WWH	0.5	P11S32	B	28.00	28.32	29.06	1.06	7.87	8.07	8.46	0.59	444	475	511	67				
			C	27.94	28.30	29.06	1.12	7.87	8.05	8.46	0.59	446	466	485	39				
Auglaize R.			A	28.58	**30.16**	**32.28**	3.70	7.68	7.86	8.15	0.47	1220	1269	1285	65	**3.78**	5.60	8.67	4.89
WWH	28.5	500110	B	28.24	**29.32**	**31.58**	3.34	7.66	7.82	8.12	0.46	1212	1247	1285	73	**3.78**	5.26	8.66	4.88
			C	27.26	**29.06**	**31.58**	4.32	7.64	7.80	8.12	0.48	1167	1227	1285	118	**3.67**	5.22	8.66	4.99
Auglaize R.			A	28.30	**28.52**	28.82	0.52	7.77	7.88	8.04	0.27	1080	1087	1095	15	**3.58**	5.18	7.66	4.08
WWH	19.3	500130	B	28.38	**28.65**	28.94	0.56	7.75	7.89	7.99	0.24	1077	1082	1087	10	**3.37**	**4.88**	6.29	2.92
			C	28.09	**28.58**	28.94	0.85	7.75	7.87	7.99	0.24	1070	1080	1086	16	**3.37**	**4.61**	6.29	2.92
Auglaize R.			A	28.64	**29.18**	**29.95**	1.31	7.95	8.13	8.32	0.37	1033	1039	1042	9	Dissolved Oxygen sensor failure			
WWH	15	P06S10	B	28.64	**29.07**	**29.57**	0.93	8.00	8.18	8.37	0.37	1038	1041	1044	6				
			C	28.25	**28.99**	**29.57**	1.32	8.01	8.19	8.37	0.36	1038	1041	1045	7				
Auglaize R.			A	29.28	**29.82**	**30.71**	1.43	8.51	8.76	8.99	0.48	611	622	629	18	7.46	11.1	15.36	**7.90**
WWH	5.9	204258	B	29.03	**29.53**	**29.86**	0.83	8.39	8.62	8.91	0.52	621	626	632	11	6.28	8.97	12.89	6.61
			C	28.50	**29.37**	**29.86**	1.36	8.25	8.53	8.91	0.66	621	629	635	14	5.43	7.99	12.89	**7.46**
Auglaize R.			A	28.24	**29.48**	**31.18**	2.94	7.95	8.37	8.78	0.83	600	611	621	21	4.40	8.48	13.89	**9.49**
WWH	4.1	500290	B	28.24	**29.07**	**30.22**	1.98	7.72	8.12	8.41	0.69	611	622	634	23	**3.80**	6.41	9.34	5.54
			C	27.65	**28.96**	**30.22**	2.57	7.55	8.02	8.41	0.86	619	626	634	15	**2.72**	5.94	9.34	6.62

*Three 24-hour cycles capture unique ranges between critical values during a 48-hour Datasonde® deployment. Range A is from 7/17/12 at 16:00 to 7/18/12 at 15:00. Range B is from 7/18/12 at 16:00 to 7/19/12 at 15:00. Range C is from 7/18/12 at 10:00 to 7/19/12 at 09:00.

Table 15. Summary of Datasonde® data from the August 2012 survey as three separate diel cycles (A, B, & C).

				Temperature (°C)				pH (SU)				Sp Conductivity (µS/cm)				Dissolved Oxygen (mg/L)			
Stream (ALU)	**River Mile**	**Storet**	**Range***	**Min**	**Ave**	**Max**	**Range**	**Min**	**Ave**	**Max**	**Range**	**Min**	**Ave**	**Max**	**Range**	**Min**	**Ave**	**Max**	**Range**
Dates sampled: August 7 - 9, 2012																			
Maumee R.			A	25.75	26.71	27.30	1.55	7.39	7.62	7.90	0.51	637	664	690	53	4.59	6.58	8.62	4.03
WWH	129.1	301929	B	25.75	26.84	27.50	1.75	7.39	7.56	7.69	0.30	637	701	849	212	4.59	5.92	6.95	2.36
	Indiana Site		C	26.10	26.97	27.50	1.40	7.46	7.59	7.69	0.23	638	762	870	232	4.28	5.80	6.95	2.67
Maumee R.			A	26.46	27.23	28.73	2.27	7.87	7.99	8.30	0.43	737	756	764	27	6.96	8.00	10.73	3.77
WWH	104.7	P06K09	B	26.46	27.81	29.43	2.97	7.95	8.21	8.42	0.47	685	731	763	78	6.96	9.44	12.53	5.57
			C	26.87	27.98	29.43	2.56	8.08	8.26	8.42	0.34	656	704	751	95	7.30	9.61	12.53	5.23
Maumee R.			A	25.91	27.34	28.55	2.64	7.83	8.10	8.43	0.60	740	769	793	53	5.48	7.59	10.12	4.64
WWH	99.0	201868	B	25.91	27.83	29.50	3.59	7.83	8.23	8.58	0.75	774	787	793	19	5.48	8.71	12.25	6.77
			C	26.32	28.11	29.50	3.18	7.92	8.34	8.58	0.66	749	781	793	44	6.40	9.10	12.25	5.85
Maumee R.			A	26.15	27.48	29.09	2.94	7.92	8.27	8.62	0.70	664	769	805	141	5.45	8.39	12.42	6.97
WWH	91.5	P06S08	B	26.15	27.99	29.88	3.73	7.92	8.20	8.49	0.57	664	754	780	116	5.45	8.13	11.43	5.98
			C	26.62	28.18	29.88	3.26	7.96	8.20	8.49	0.53	679	761	786	107	5.53	8.13	11.43	5.90
Maumee R.			A	26.14	27.62	29.34	3.20	8.08	8.40	8.69	0.61	772	801	823	51	6.20	9.84	14.64	**8.44**
WWH	85.3	P06K06	B	26.14	28.01	29.70	3.56	8.08	8.34	8.61	0.53	635	777	823	188	6.20	9.29	13.15	6.95
			C	26.52	28.18	29.70	3.18	7.91	8.29	8.61	0.70	635	763	803	168	4.96	9.06	13.15	**8.19**
Maumee R.			A	26.40	27.63	28.89	2.49	8.24	8.54	8.92	0.68	761	783	806	45	6.78	10.9	17.41	**10.63**
WWH	79.7	P06K05	B	26.40	27.98	29.48	3.08	8.24	8.46	8.68	0.44	767	792	806	39	6.78	10.1	14.60	**7.82**
			C	26.61	28.14	29.48	2.87	8.01	8.41	8.68	0.67	728	779	806	78	5.94	9.96	14.60	**8.66**
Maumee R.			A	26.57	27.95	29.28	2.71	8.38	8.69	8.97	0.59	755	774	789	34	7.14	13.1	21.29	**14.15**
WWH	76.1	P06S07	B	26.57	28.17	29.52	2.95	8.38	8.65	8.86	0.48	771	790	806	35	7.14	11.4	16.51	**9.37**
			C	27.06	28.33	29.52	2.46	8.30	8.63	8.86	0.56	734	791	806	72	6.38	11.1	16.51	**10.13**
Maumee R.			A	26.50	28.01	29.41	2.91	8.20	8.59	8.90	0.70	719	739	765	46	8.41	12.2	17.19	**8.78**
WWH	69.0	P06K03	B	26.50	28.36	30.02	3.52	8.20	8.53	8.83	0.63	571	692	744	173	8.41	13.4	19.76	**11.35**
			C	26.74	28.49	30.02	3.28	8.32	8.55	8.83	0.51	571	679	724	153	6.90	13.1	19.76	**12.86**
Maumee R.			A	27.08	27.32	27.58	0.50	8.07	8.29	8.48	0.41	783	813	845	62	4.37	6.25	7.97	3.60
MWH	62.3	P09W32	B	27.09	27.34	27.58	0.49	7.83	8.09	8.33	0.50	785	820	845	60	**2.63**	4.78	7.04	4.41
			C	27.06	27.30	27.58	0.52	7.73	7.95	8.24	0.51	792	813	845	53	**1.04**	**3.39**	5.91	4.87
Maumee R.			A	27.00	27.70	29.14	2.14	8.04	8.16	8.41	0.37	731	785	809	78	6.40	7.22	9.51	3.11
WWH	59.9	201859	B	27.00	27.81	29.14	2.14	7.92	8.21	8.48	0.56	487	797	4.78	7.27	4.78	7.27	9.51	4.73
			C	26.41	27.66	29.14	2.73	7.70	8.11	8.48	0.78	487	803	3.91	6.53	**3.91**	6.53	9.51	5.60

				Temperature (°C)				pH (SU)				Sp Conductivity (µS/cm)				Dissolved Oxygen (mg/L)			
Stream (ALU)	**River Mile**	**Storet**	**Range***	**Min**	**Ave**	**Max**	**Range**	**Min**	**Ave**	**Max**	**Range**	**Min**	**Ave**	**Max**	**Range**	**Min**	**Ave**	**Max**	**Range**
Dates sampled: August 7 - 9, 2012																			
Maumee R.			A	26.57	28.21	29.92	3.35	8.16	8.62	9.02	0.86	697	738	780	83	3.79	9.72	17.03	**13.24**
MWH	52.1	201856	B	26.57	28.19	29.88	3.31	8.16	8.48	8.72	0.56	733	775	794	61	3.79	7.43	11.27	**7.48**
			C	26.68	28.67	29.88	3.20	8.21	8.55	8.72	0.51	775	787	808	33	4.78	8.19	11.27	6.49
Maumee R.			A	26.43	27.73	28.89	2.46	8.07	8.47	8.74	0.67	655	683	704	49	7.18	10.7	14.09	6.91
MWH	47.1	500200	B	26.43	28.28	29.70	3.27	8.07	8.46	8.69	0.62	695	710	741	46	6.96	9.96	12.80	5.84
			C	27.25	28.59	29.70	2.45	7.94	8.44	8.69	0.75	701	727	768	67	3.69	8.99	12.80	**9.11**
Maumee R.			A	27.09	27.50	27.84	0.75	7.80	8.07	8.25	0.45	653	715	764	111	3.40	5.34	6.45	3.05
MWH	42.5	201851	B	27.15	27.34	27.73	0.58	8.01	8.11	8.22	0.21	646	667	713	67	3.50	5.29	6.42	2.92
			C	27.14	27.24	27.39	0.25	7.79	8.05	8.22	0.43	646	653	681	35	3.10	4.79	6.42	3.32
Maumee R.			A	27.04	28.05	29.41	2.37	8.37	8.53	8.73	0.36	706	710	720	14	6.78	9.49	13.14	6.36
MWH	32.7	P11S42	B	27.04	28.92	31.41	4.37	8.37	8.55	8.70	0.33	710	719	729	19	6.78	9.65	12.41	5.63
			C	27.34	29.05	31.41	4.07	8.34	8.54	8.70	0.36	715	725	734	19	6.34	9.54	12.41	6.07
Maumee R.			A	26.50	27.69	29.06	2.56	8.22	8.46	8.66	0.44	694	703	713	19	6.10	7.17	8.53	2.43
WWH	31.6	P11K33	B	26.50	28.03	30.04	3.54	8.20	8.45	8.69	0.49	591	695	722	131	5.45	6.89	8.25	2.80
			C	26.51	28.02	30.04	3.53	8.15	8.42	8.69	0.54	514	668	722	208	5.22	6.66	8.25	3.03
Maumee R.			A	27.09	27.60	28.25	1.16	8.28	8.42	8.57	0.29	689	696	705	16	6.28	8.09	10.22	3.94
WWH	26.7	P11K31	B	27.09	27.81	28.57	1.48	8.28	8.40	8.49	0.21	695	703	713	18	6.28	7.93	9.61	3.33
			C	27.29	27.95	28.57	1.28	8.27	8.39	8.49	0.22	699	709	718	19	6.15	7.93	9.61	3.46
Maumee R.			A	26.48	27.90	30.22	3.74	7.73	8.03	8.64	0.91	673	678	681	8	6.29	7.63	10.07	3.78
WWH	20.6	500080	B	26.48	27.87	29.97	3.49	7.69	7.79	7.90	0.21	679	686	696	17	5.49	7.00	9.06	3.57
			C	26.74	27.91	29.97	3.23	7.63	7.74	7.86	0.23	679	690	696	17	5.49	6.81	9.06	3.57
Maumee R.			A	25.32	27.76	31.02	5.70	7.78	8.26	8.97	1.19	684	698	707	23	**1.20**	5.37	11.84	**10.64**
WWH	16.5	301740	B	25.32	27.90	31.19	5.87	7.78	8.02	8.40	0.62	702	710	729	27	**1.20**	**2.98**	5.52	4.32
			C	25.74	28.03	31.19	5.45	7.69	7.99	8.40	0.71	702	717	735	33	**0.75**	**2.72**	5.52	4.77
Maumee R.			A	27.07	27.87	28.85	1.78	8.28	8.70	9.06	0.78	660	678	689	29	5.60	9.88	14.71	**9.11**
WWH	13	301644	B	27.07	28.17	29.00	1.93	8.28	8.59	8.77	0.49	678	686	694	16	5.60	9.03	11.74	6.14
			C	27.07	28.32	29.00	1.93	8.28	8.54	8.71	0.43	684	691	699	15	5.03	8.54	11.74	6.71
Auglaize R.			A	25.63	26.48	28.08	2.45	7.60	7.67	7.85	0.25	635	730	822	187	5.54	6.30	7.49	1.95
WWH	28.5	500110	B	25.63	27.26	28.67	3.04	7.60	7.70	7.88	0.28	737	804	840	103	5.49	6.33	7.69	2.20
			C	26.16	27.62	28.67	2.51	7.58	7.69	7.88	0.30	729	802	840	111	5.40	6.26	7.69	2.29

				Temperature (°C)				pH (SU)				Sp Conductivity (µS/cm)				Dissolved Oxygen (mg/L)			
Stream (ALU)	**River Mile**	**Storet**	**Range***	**Min**	**Ave**	**Max**	**Range**	**Min**	**Ave**	**Max**	**Range**	**Min**	**Ave**	**Max**	**Range**	**Min**	**Ave**	**Max**	**Range**
Dates sampled: August 7 - 9, 2012																			
Auglaize R.			A	25.46	26.05	26.75	1.29	7.42	7.43	7.45	0.03	566	595	609	43	**3.54**	**3.83**	4.14	0.60
WWH	19.3	500130	B	25.46	26.06	26.93	1.47	7.43	7.44	7.45	0.02	598	604	609	11	**3.54**	**3.72**	3.91	0.37
			C	25.46	26.34	26.93	1.47	7.43	7.44	7.45	0.02	598	602	607	9	**3.54**	**3.72**	3.93	0.39
Auglaize R.			A	25.68	26.06	26.64	0.96	7.31	7.35	7.38	0.07	680	740	870	190	**2.44**	**2.80**	3.26	0.82
WWH	15	P06S10	B	25.68	26.62	28.26	2.58	7.33	7.43	7.63	0.30	665	692	723	58	**2.15**	**3.60**	5.72	3.57
			C	25.71	27.09	28.26	2.55	7.33	7.48	7.63	0.30	640	676	723	83	**2.15**	**4.15**	5.72	3.57
Auglaize R.			A	26.99	27.59	28.49	1.50	8.17	8.35	8.64	0.47	929	957	967	38	5.49	8.09	12.56	**7.07**
WWH	5.9	204258	B	26.93	**27.95**	**30.24**	3.31	7.86	8.32	8.82	0.96	953	964	972	19	**3.16**	8.30	16.00	**12.84**
			C	25.95	**27.81**	**30.24**	4.29	7.82	8.23	8.82	1.00	953	968	990	37	**2.98**	7.56	16.00	**13.02**
Auglaize R.			A	26.84	27.58	28.67	1.83	8.04	8.24	8.49	0.45	927	957	972	45	4.86	6.84	9.96	5.10
WWH	4.1	500290	B	26.84	27.73	29.09	2.25	7.80	8.08	8.29	0.49	957	971	984	27	**3.77**	5.88	8.33	4.56
			C	26.50	27.68	29.09	2.59	7.67	7.99	8.29	0.62	968	977	985	17	**1.49**	5.18	8.33	6.84

*Three 24-hour cycles capture unique ranges between critical values during a 48-hour Datasonde® deployment. Range A is from 8/07/12 at 14:00 to 8/08/12 at 13:00. Range B is from 8/08/12 at 16:00 to 8/09/12 at 15:00. Range C is from 8/08/12 at 11:00 to 8/09/12 at 10:00.

Table 16. Summary of Datasonde® data from the September 2013 survey as three separate diel cycles (A, B, & C).

				Temperature (°C)				pH (SU)				Sp Conductivity (µS/cm)				Dissolved Oxygen (mg/L)			
Stream (ALU)	**River Mile**	**Storet**	**Range***	**Min**	**Ave**	**Max**	**Range**	**Min**	**Ave**	**Max**	**Range**	**Min**	**Ave**	**Max**	**Range**	**Min**	**Ave**	**Max**	**Range**
Dates sampled: September 3 - 5, 2013																			
Maumee R.			A	22.28	24.23	26.26	3.98	8.26	8.32	8.39	0.13	857	861	871	14	7.36	9.09	11.54	4.18
WWH	76.1	P06S07	B	22.28	24.18	26.03	3.75	8.26	8.31	8.39	0.13	857	866	875	18	7.36	9.10	11.44	4.08
			C	22.57	24.25	26.03	3.46	8.26	8.32	8.39	0.13	861	868	875	14	7.40	9.16	11.44	4.04
Maumee R.			A	24.69	25.04	25.27	0.58	7.30	7.53	7.79	0.49	692	699	707	15	**1.89**	4.22	6.35	4.46
MWH	62.3	P09W32	B	24.69	24.96	25.19	0.50	7.30	7.65	7.79	0.49	696	701	707	11	**1.97**	5.42	6.54	4.57
			C	24.26	24.81	25.19	0.93	7.58	7.75	7.94	0.36	690	699	707	17	4.98	6.06	7.09	2.11
Maumee R.			A	23.86	25.80	28.35	4.49	7.67	8.09	8.53	0.86	565	622	632	67	5.46	8.30	12.36	6.90
WWH	59.9	201859	B	23.86	25.54	28.00	4.14	7.32	8.03	8.50	1.18	518	624	643	125	4.26	8.14	12.36	**8.10**
			C	23.92	25.52	28.00	4.08	7.32	8.00	8.50	1.18	518	628	644	126	4.26	8.08	12.36	**8.10**
Maumee R.			A	24.21	24.92	25.49	1.28	7.90	8.20	8.59	0.69	566	570	574	8	4.04	5.83	8.00	3.96
MWH	47.1	500200	B	24.21	25.06	25.81	1.60	7.98	8.43	8.76	0.78	569	572	580	11	4.21	6.88	10.02	5.81
			C	24.31	25.11	25.81	1.50	8.07	8.48	8.76	0.69	571	575	580	9	3.02	6.85	10.02	7.00
Maumee R.			A	24.65	25.43	27.28	2.63	8.04	8.48	9.00	0.96	515	521	523	8	3.40	7.90	14.22	**10.82**
MWH	42.5	201851	B	24.65	25.16	26.09	1.44	8.04	8.37	8.77	0.73	521	525	532	11	3.40	7.32	11.64	**8.24**
			C	24.38	25.07	26.09	1.71	8.16	8.37	8.77	0.61	521	526	532	11	5.50	7.80	11.64	6.14
Maumee R.			A	24.05	25.12	26.16	2.11	8.18	8.56	9.06	0.88	412	418	421	9	6.46	9.60	14.59	**8.13**
MWH	32.7	P11S42	B	24.05	24.92	25.92	1.87	8.18	8.69	9.06	0.88	412	416	421	9	6.46	10.4	14.59	**8.13**
			C	23.90	24.87	25.92	2.02	8.40	8.80	9.06	0.66	412	414	419	7	8.14	11.1	14.59	6.45
Maumee R.			A	22.74	24.54	26.89	4.15	7.89	8.36	8.86	0.97	389	395	400	11	5.37	7.11	9.68	4.31
WWH	31.6	P11K33	B	22.74	24.49	26.64	3.90	7.89	8.35	8.88	0.99	392	396	399	7	5.37	7.12	9.68	4.31
			C	23.03	24.53	26.64	3.61	7.78	8.33	8.88	1.10	392	397	402	10	5.17	7.07	9.68	4.51
Maumee R.			A	23.03	24.30	25.59	2.56	8.76	8.92	9.08	0.32	386	388	391	5	8.93	10.8	13.32	4.39
WWH	26.7	P11K31	B	23.03	24.23	25.10	2.07	8.76	8.95	9.09	0.33	387	390	393	6	8.93	11.2	13.54	4.61
			C	23.24	24.30	25.10	1.86	8.84	8.98	9.09	0.25	387	391	395	8	9.72	11.4	13.54	3.82
Maumee R.			A	23.71	25.01	26.51	2.80	8.25	8.66	8.96	0.71	382	386	389	7	**3.36**	7.13	10.50	**7.14**
WWH	23.16	500170	B	23.71	24.74	26.22	2.51	8.25	8.69	9.00	0.75	385	388	391	6	**3.36**	7.39	10.86	**7.50**
			C	23.24	24.60	26.22	2.98	8.26	8.74	9.00	0.74	385	389	391	6	**3.36**	7.78	10.86	**7.50**
Maumee R.			A	21.23	24.32	28.59	7.36	8.08	8.67	9.06	0.98	384	397	410	26	6.47	8.47	11.13	4.66
WWH	20.6	500080	B	21.23	24.50	28.59	7.36	8.08	8.69	9.07	0.99	389	398	410	21	6.47	8.50	11.13	4.66
			C	21.99	24.67	28.59	6.60	8.28	8.73	9.07	0.79	389	396	402	13	6.77	8.56	11.13	4.36

				Temperature (°C)				pH (SU)				Sp Conductivity (µS/cm)				Dissolved Oxygen (mg/L)			
Stream (ALU)	**River Mile**	**Storet**	**Range***	**Min**	**Ave**	**Max**	**Range**	**Min**	**Ave**	**Max**	**Range**	**Min**	**Ave**	**Max**	**Range**	**Min**	**Ave**	**Max**	**Range**
Dates sampled: September 3 - 5, 2013																			
Maumee R.			A	20.38	23.28	25.83	5.45	8.11	8.68	9.06	0.95	375	384	396	21	6.28	9.42	15.49	**9.21**
WWH	16.5	301740	B	20.38	23.89	27.10	6.72	8.11	8.67	9.05	0.94	377	386	396	19	6.13	9.29	15.49	**9.36**
			C	20.38	24.16	27.10	6.72	8.14	8.67	9.05	0.91	284	381	396	112	6.13	9.25	15.49	**9.36**

*Three 24-hour cycles capture unique ranges between critical values during a 48-hour Datasonde® deployment. Range A is from 9/03/13 at 17:00 to 9/04/13 at 16:00. Range B is from 9/04/13 at 16:00 to 9/05/13 at 15:00. Range C is from 9/04/13 at 10:00 to 9/05/13 at 09:00.

Trophic Evaluation

Trophic status was evaluated by considering how the interactions between multiple metrics influence the stream's aquatic life. The biological indices and the submetrics within dictate whether the aquatic life in the Maumee River was being stressed by eutrophic conditions. Macroinvertebrates indicated eutrophic conditions responding to excess organic material produced in the stream. Water quality data was collected to establish the baseline conditions that were causing the biological response. Three water quality conditions were analyzed to describe the trophic status of the Maumee River: nutrients, algae and dissolved oxygen. The water quality conditions were targeted to capture seasonal conditions but the nature of the water quality data does not capture a complete scope of conditions that are represented in macroinvertebrate community health.

The first condition that must exist for eutrophication to occur is nutrient availability. Nutrients were measured at 26 sampling locations, and included ammonia-N, nitrate+nitrite-N, total phosphorus, and total Kjeldahl nitrogen (TKN). In addition, nine sentinel sites were measured for orthophosphate, two sentinel sites were measured for total dissolved phosphorous, and three public water system intakes were monitored for ammonia-N, nitrate+nitrite-N,

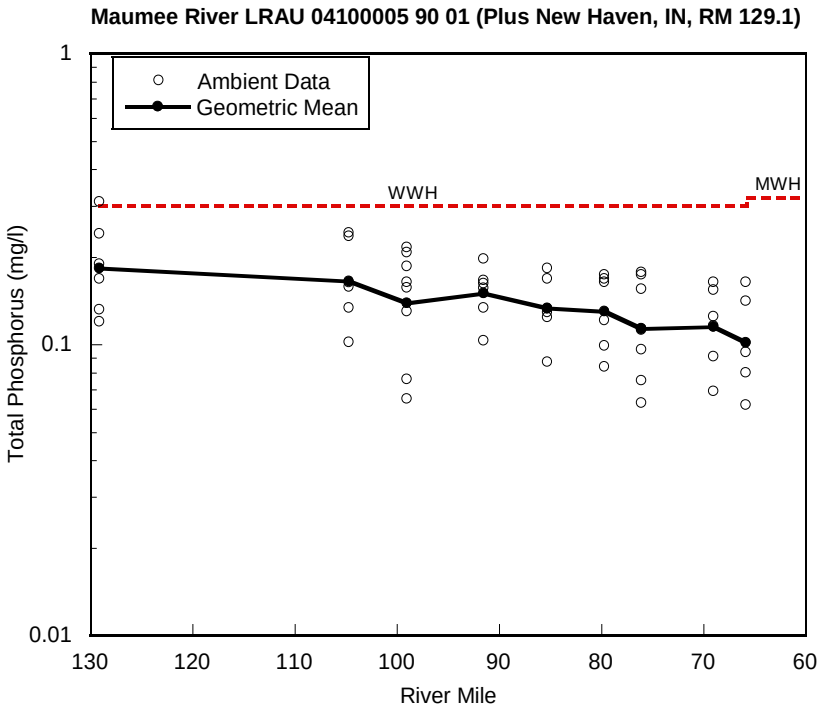

Figure 16. Total phosphorus data for the Maumee River from the Indiana-Ohio state line to the Tiffin River for 2012 with geometric mean and specified target for large river WWH and MWH designated use.

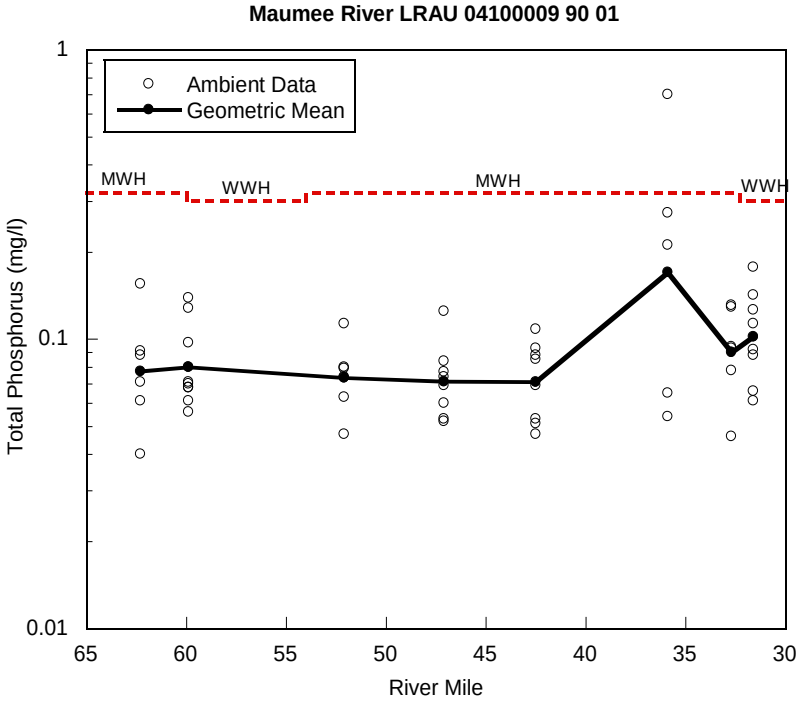

Figure 17. Total phosphorus data for the Maumee River from the Tiffin River to Beaver Creek for 2012 with geometric mean and specified targets for large river WWH and MWH designated use.

and total phosphorus. Summary statistics for nutrients measured in the Maumee River and Auglaize River large river assessment units are detailed in Table 17. Recommended seasonal geometric mean nutrient target levels for phosphorus are 0.30 mg/l (WWH) and 0.32 mg/l (MWH) for large rivers and 0.17 mg/l (WWH) for small rivers. Recommended seasonal geometric mean nutrient target levels for nitrate-nitrite are 2.0 mg/l (WWH) and 2.4 mg/l (MWH) for large rivers and 1.5 mg/l (WWH) for small rivers (Ohio EPA, 1999). Total phosphorus and nitrate-nitrite geometric means calculated from the 2012 survey season data (May through October) were below the recommended target at most monitoring locations in the study area and no geometric means higher than the targets were found for the 2013 data or there was only one sample taken at the location. Total Phosphorus single sample results for 2012 exceeded the target limit three times on the Maumee River and the geometric mean phosphorus levels were well below the target at all sampling locations for the sampling season (Figures 16 - 18). Ammonia results did not exceed the water quality criteria for the protection of aquatic life in all samples collected. Other nutrient samples collected for TKN, orthophosphate, and total dissolved phosphorus do not have statewide targets or water quality criteria to evaluate results against. These

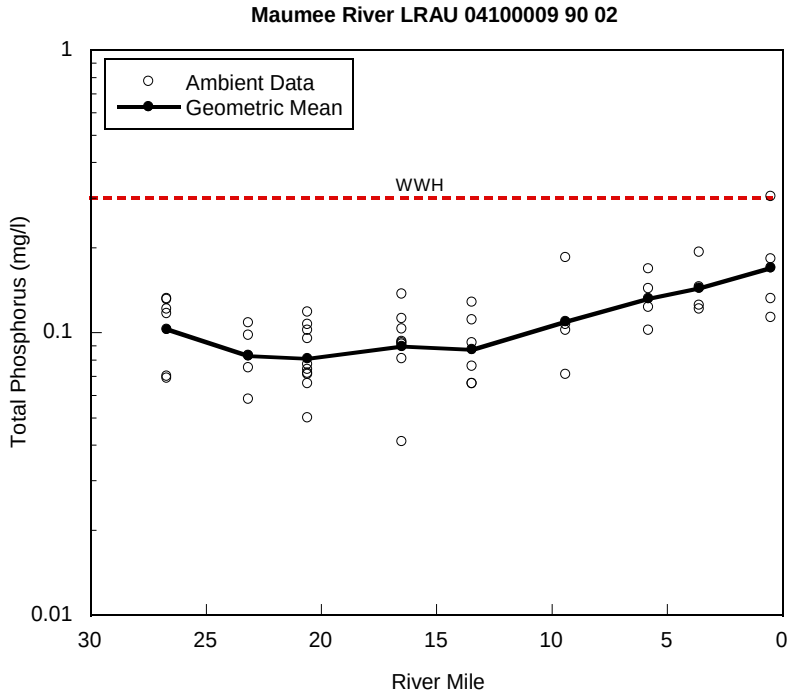

Figure 18. Total phosphorus data for the Maumee River from Beaver Creek to the mouth for 2012 with geometric mean and specified targets for large river WWH and MWH designated use.

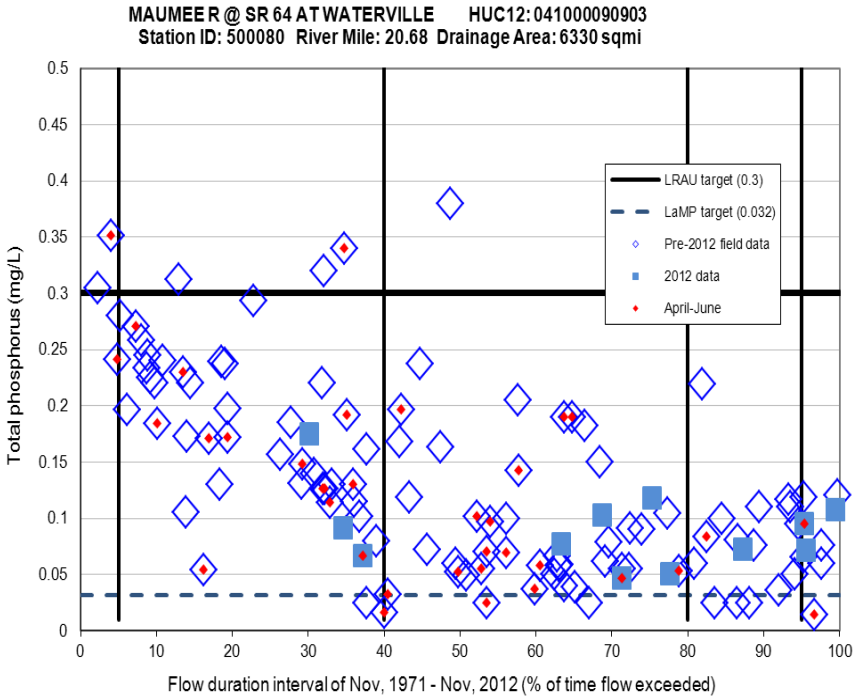

Figure 19. Total phosphorus data for the Maumee River at Waterville (State Route 64) represented as a concentration duration curve for November 1971 to November 2012 with spring (April to June) samples marked with a red diamond.

parameters were collected for additional information to assist in the overall evaluation of nutrient availability and results are documented in Appendix G.

The 2012 total phosphorus data is consistent to slightly lower than historical data collected associated with similar flow velocities as demonstrated in the concentration duration curves (Figures 19 and 20). However, due to the low flows from April to July in 2012, only a few samples were collected during higher flow events in the Maumee River.

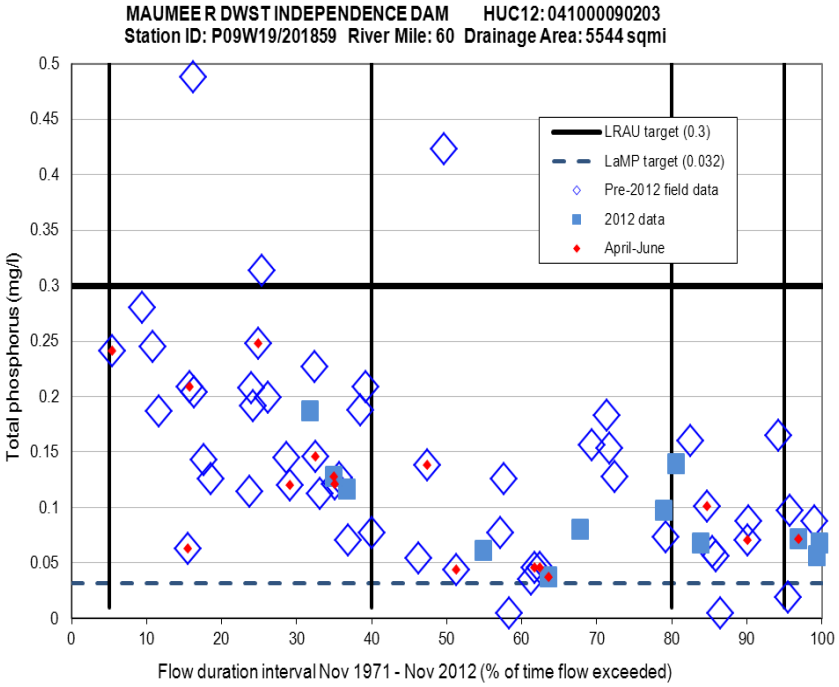

Figure 20. Total phosphorus data for the Maumee River at Independence Dam represented as a concentration duration curve for November 1971 to November 2012 with spring (April to June) samples marked with a red diamond.

The Maumee River serves as a conduit for nutrients to Lake Erie. An important factor in the formation of harmful algal blooms in Lake Erie is the timing of the availability of the phosphorus loads. *Microcystis* is a cyanobacterium that blooms usually when the water temperature is approximately 20 degrees Celsius or greater. Water temperatures in Maumee Bay are usually not warm enough for *Microcystis* to bloom until late June to early July. Retention time in the western basin is estimated to be 20 to 50 days, resulting in the April to June phosphorus loads having the most impact on *Microcystis* blooms. Historic total phosphorus concentrations for April to June increase with the flow, however, very few samples exceeded the Ohio EPA phosphorus state-wide target. Conversely, most historic samples exceed the phosphorus target specified in the Lake Erie Lakewide Management Plan (LaMP) for tributaries flowing into Lake Erie. The Lake Erie LaMP is a document created by the United States, Canada, watershed groups, scientists, local officials, and water enthusiasts that sets a plan of action to restore and protect Lake Erie. Exceedances of the Lake Erie LaMP target are reported at the USGS gage stations at the City of Waterville and Independence Dam on the Maumee River and depicted in Figures 19 and 20. In addition, Figures 19 and 20 clearly demonstrate the overall trend of nutrients in the river, in that during higher flows more nutrients enter the stream from agricultural run-off, urban run-off, and combined sewer overflow discharges. Nutrient concentrations in the Maumee River decrease significantly with a reduction in run-off and flow and continue to remain at lower concentrations outside of higher flow events.

Table 17. Seasonal geometric mean values (mg/L) for nutrients calculated from grab samples collected in 2012 in the Maumee River and the Auglaize River. Results highlighted are above statewide recommended targets. Data is organized by Large River Assessment Unit (LRAU). Nutrient geometric means calculated from the 2013 survey (May through October) were all below nutrient targets for nitrate-nitrite and total phosphorus or only one sample was collected at a location.

Large River (drainage area >1000 mi^2)	
129.1	phosphorus (0.18), nitrate-nitrite (3.28)
04100005 90 01: Maumee River LRAU (Indiana Border to Tiffin River)	
104.7	phosphorus (0.16), nitrate-nitrite (2.08)
99.0	phosphorus (0.14), nitrate-nitrite (2.25)
91.5	phosphorus (0.15), nitrate-nitrite (1.35)
85.3	phosphorus (0.13), nitrate-nitrite (1.45)
79.7	phosphorus (0.13), nitrate-nitrite (1.52)
76.1	phosphorus (0.11), nitrate-nitrite (1.78)
69.0	phosphorus (0.11), nitrate-nitrite (0.80)
65.84	phosphorus (0.10), nitrate-nitrite (0.70)
04100009 90 01: Maumee River LRAU (Tiffin River to Beaver Creek)	
62.3[#]	phosphorus (0.08), nitrate-nitrite (0.64)
59.9	phosphorus (0.08), nitrate-nitrite (1.21)
52.1[#]	phosphorus (0.07), nitrate-nitrite (0.40)
47.1[#]	phosphorus (0.07), nitrate-nitrite (0.33)
42.5[#]	phosphorus (0.07), nitrate-nitrite (0.52)
35.91[#]	phosphorus (0.17), nitrate-nitrite (0.20)
32.7[#]	phosphorus (0.09), nitrate-nitrite (0.24)
31.6	phosphorus (0.10), nitrate-nitrite (0.42)
04100009 90 02: Maumee River LRAU (Beaver Creek to Maumee Bay)	
26.7	phosphorus (0.10), nitrate-nitrite (0.17)
23.16	phosphorus (0.08), nitrate-nitrite (0.14)
20.6	phosphorus (0.08), nitrate-nitrite (0.22)
16.5	phosphorus (0.09), nitrate-nitrite (0.45)
13.45	phosphorus (0.09), nitrate-nitrite (0.37)
9.4	phosphorus (0.11), nitrate-nitrite (0.23)
5.8	phosphorus (0.13), nitrate-nitrite (0.61)
3.6	phosphorus (0.14), nitrate-nitrite (0.96)
0.5	phosphorus (0.17), nitrate-nitrite (0.62)
04100007 90 01: Auglaize River LRAU (Ottawa River to Mouth)	
19.3	phosphorus (0.19), nitrate-nitrite (1.35)
15.0	phosphorus (0.12), nitrate-nitrite (1.09)
5.9	phosphorus (0.08), nitrate-nitrite (0.70)
4.14	phosphorus (0.09), nitrate-nitrite (1.32)
Small River (drainage area ≥ 200 to <1000 mi^2)	
04100007 90 01: Auglaize River LRAU (Ottawa River to Mouth)	
28.5	phosphorus (0.26), nitrate-nitrite (1.47)

[#] Modified Warmwater Habitat

The nutrient targets were determined using correlations to IBI ranges (a metric measuring quality of fish communities) and do not consider the response variables that have a direct impact on aquatic life (especially macroinvertebrates). Currently, the scientific community is moving towards considering multiple metric analyses because nutrient concentrations alone are not adequate to address eutrophication of streams. Literature suggests that the Ohio EPA target, while it does correlate to fish community performance, may not cause limitation of algal growth. Literature sources identify a range of nutrient values that will cause limitation of algal growth: Dodds and others (1998) suggest a boundary for mesotrophic and eutrophic streams of 0.075 mg/L total phosphorus, Miltner (2010) suggests a breakpoint for stream protection at 0.04 mg/L total phosphorus and management of enriched systems at 0.1 mg/L total phosphorus in smaller streams (dominated by periphyton), and Royer and others (2008) noted a threshold for excess sestonic chlorophyll when total phosphorus values exceeded 0.07 mg/L. This suggests that given stream conditions that do not limit algae due to any other mechanism (e.g., light/shading), eutrophication can occur when ambient nutrient concentrations are below the Ohio EPA targets.

The second metric considered as an indicator of the trophic status of a stream is the productivity of algae in the system. Benthic (attached) and sestonic (water column) chlorophyll-*a* sampling took place at selected sites in the study area to assist with the assessment of the trophic status of the stream. Ohio does not currently have criteria for chlorophyll-*a* levels but it is a common indicator used in the scientific community to assess trophic status. Literature sources identify a range of nutrient values that will cause limitation of algal growth: Dodds and others (1998) suggest a boundary for mesotrophic and eutrophic streams of a maximum of 200 mg/m^2 for benthic chlorophyll-*a* and 30 µg/L for sestonic chlorophyll-*a*; Miltner (2010) suggests a breakpoint for stream protection at 107 mg/m^2 benthic chlorophyll-*a* and management of enriched systems at 182 mg/m^2 benthic chlorophyll-*a* in smaller streams (dominated by periphyton). Chlorophyll-*a* sampling took place across two different summers – 2012 representing a dry, hot summer and 2013 representing a cooler, wetter summer. The data from the Maumee River samples were summarized by averaging all samples taken, by means of averaging samples taken in deep river reaches and samples taken in shallow river reaches (Table 18).

Table 18. Summary of chlorophyll-a data collected in 2012 and 2013. Note: Shallow sites are all sites downstream of Grand Rapids and the site below the Independence Dam. Deep sites are all other sites.

	Benthic Chlorophyll-*a* (mg/m^2)			Sestonic Chlorophyll-a (µg/L)		
	Average (all sites)	Average (Shallow)	Average (Deep)	Average (all sites)	Average (Shallow)	Average (Deep)
2012	157	215	98	32	23	35
2013	111*	111*	N/A*	80	77	83

*The deep sites were not resampled because benthic algae were not the primary concern in these reaches.

The separation of shallow and deep reaches is justified by field observations and signatures noted in the data. In 2012, the deep reaches of the river, as expected, demonstrated a lower potential to have excessive benthic algal growth. However, in these reaches the sestonic algae levels were higher. The Maumee River has nutrients in excess of the requirements to meet ecosystem needs, however, the geomorphology of the river and the impact of manmade impoundments determine whether sestonic algal growth or benthic algal growth will dominate. The data collected in 2013 showed overall higher sestonic algal growth and lower benthic algal growth compared to 2012 data. Increased sestonic algal levels and high flows during much of the summer likely had a significant effect on the establishment of a substantial benthic community. The conditions of the 2013 season favored development of the sestonic algae which were produced at a level identified in the Dodds and others (1998) article as being indicative of eutrophic conditions.

Algal productivity has a substantial impact on the dissolved oxygen quality of a stream through daytime photosynthesis and evening respiration. The result is a diel fluctuation of dissolved oxygen with highs occurring from daytime photosynthesis and minimums occurring due to night time respiration. Diel fluctuations of dissolved oxygen of 7 mg/l describe a significant amount of variation in the number of EPT taxa (important component of macroinvertebrate quality) in Ohio streams (Miltner, 2010).

As noted previously, DataSonde® monitoring occurred at 26 locations on the Maumee and Auglaize Rivers in 2012 and 11 locations on the Maumee River in 2013 (Appendix J). Substantial diel dissolved oxygen ranges greater than 7 mg/l were observed at many monitoring locations along with concentrations remaining low for greater than six hours at six locations in July and five locations in August.

The geomorphology of the Maumee River makes it prone to eutrophication; however, it is not one of Ohio's most eutrophic rivers. It is probable that the algal crop observed in the Maumee River was nutrient limited during the July 2012 and September 2013 surveys; however, that amount of algae is still in excess of ecosystem needs. A lower trophic status of the river is required to address the impact on aquatic life. The Maumee River requires lower nutrient levels than observed, and a reduction in nutrients will likely result in a reduction of algae in the river.

Historic Trends

Historical nutrient data from the previous assessment of the Maumee River in 1997 were compared to the 2012 data for nitrate-nitrite, total phosphorus, and ammonia. The geometric means of the summer sampling period data were used to even out the effect of very high or very low values. Figures 21 through 29 show the field parameter results and the geometric means connected with lines to demonstrate the overall rise or fall of the data.

The 1997 and 2012 levels of nitrate-nitrite are similar at the most upstream portions of the Maumee River from RM 107 to RM 76; however, progressing downstream, the nitrate-nitrite levels in 2012 are much lower than the levels in 1997. Total phosphorus levels are lower in 2012 as compared to the 1997 data across the entire Maumee River mainstem. The ammonia levels recorded in 2012 are less than the levels in 1997 excluding one large increase in ammonia at RM 35.91. The elevated ammonia level observed at RM 35.91 returned to lower levels consistent with the rest of the river by the next downstream sampling location at RM 32.7 upstream of the Grand Rapids Dam.

A quick drop in nitrate-nitrite and ammonia was observed in the 2012 data between the sampling location in New Haven, Indiana (approximate RM 129) and the first sampling site in Ohio (RM 104.7). Without this initial drop in nitrate-nitrite and ammonia, the levels observed in 2012 potentially would have remained more similar to the 1997 levels for these two parameters.

These results suggest that point source permitting, CSO reductions, and conservation practices, are having a positive impact in the Maumee River watershed in Ohio and Indiana. In addition, flow in the Maumee River was substantially higher throughout the summer of 1997 as compared to the summer of 2012. The lower flows in the summer of 2012 potentially resulted in a reduction of nutrient rich agricultural and urban runoff and CSO discharges to the river contributing to lower geometric mean levels of nutrients being observed (Figure 30).

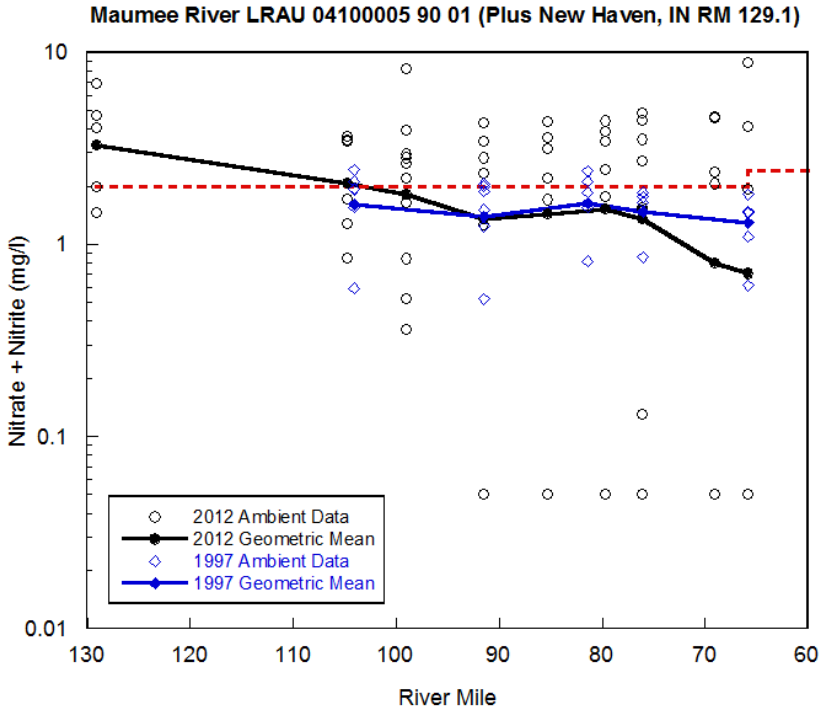

Figure 21. Nitrate-nitrite data for the Maumee River LRAU 04100005 90 01 from 2012 and 1997 with geometric mean and specified target for large river WWH and MWH designated use.

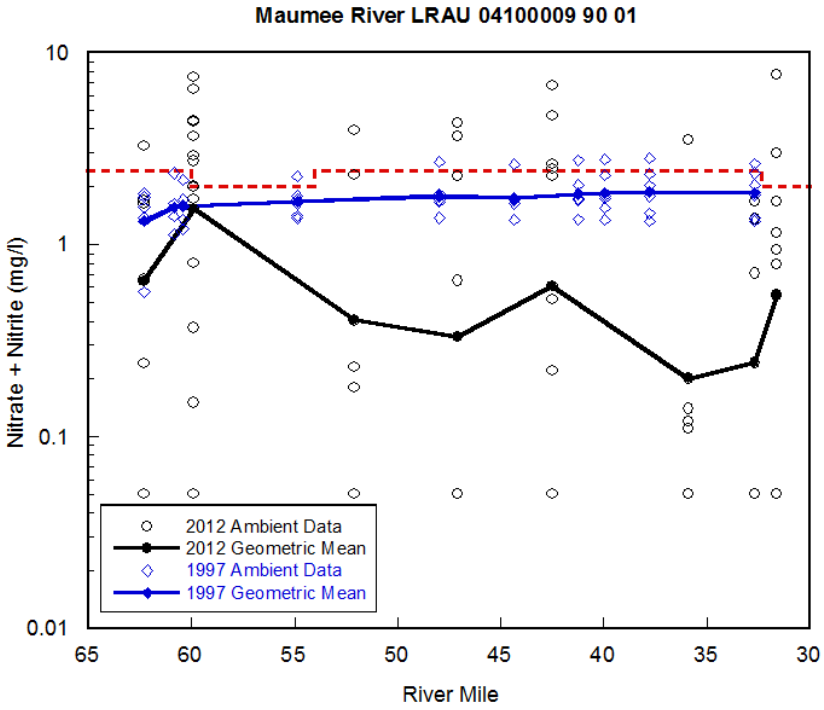

Figure 22. Nitrate-nitrite data for the Maumee River LRAU 04100009 90 01 from 2012 and 1997 with geometric mean and specified target for large river WWH and MWH designated use.

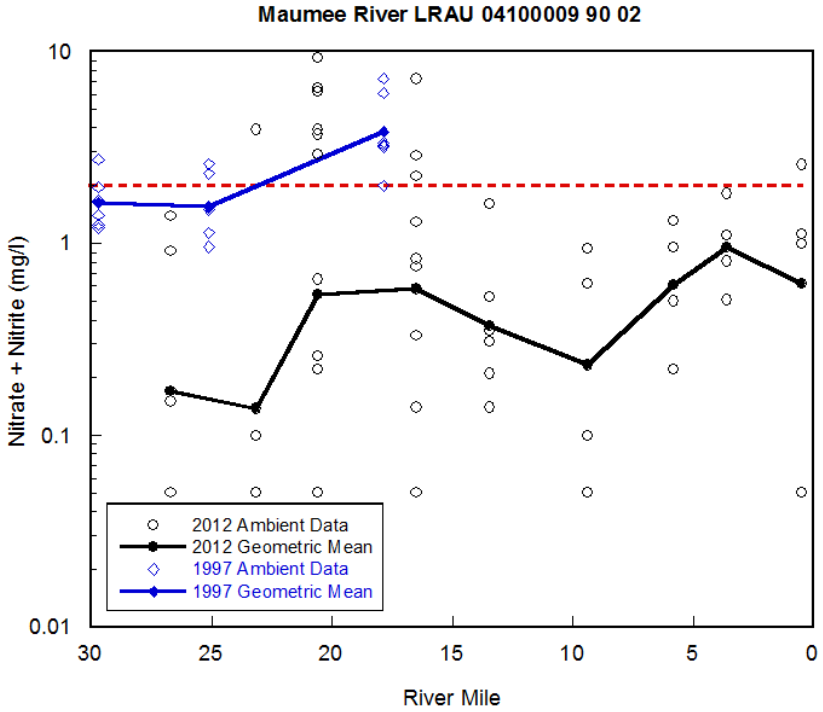

Figure 23. Nitrate-nitrite data for the Maumee River LRAU 04100009 90 02 for 2012 and 1997 with geometric mean and specified target for large river WWH and MWH designated use.

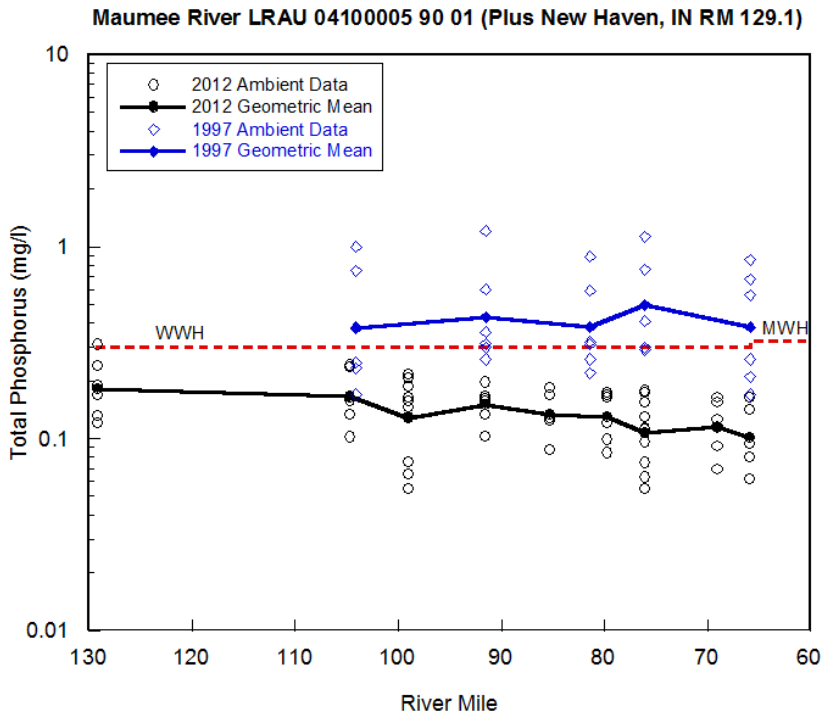

Figure 24. Total phosphorus data for the Maumee River LRAU 04100005 90 01 for 2012 and 1997 with geometric mean and specified target for large river WWH and MWH designated use.

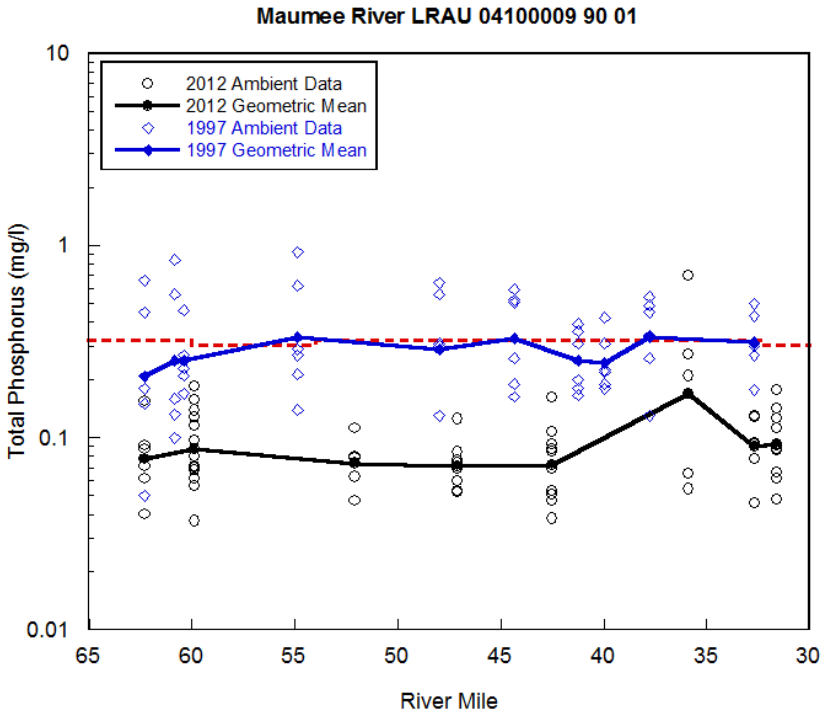

Figure 25. Total phosphorus data for the Maumee River LRAU 04100009 90 01 for 2012 and 1997 with geometric mean and specified target for large river WWH and MWH designated use.

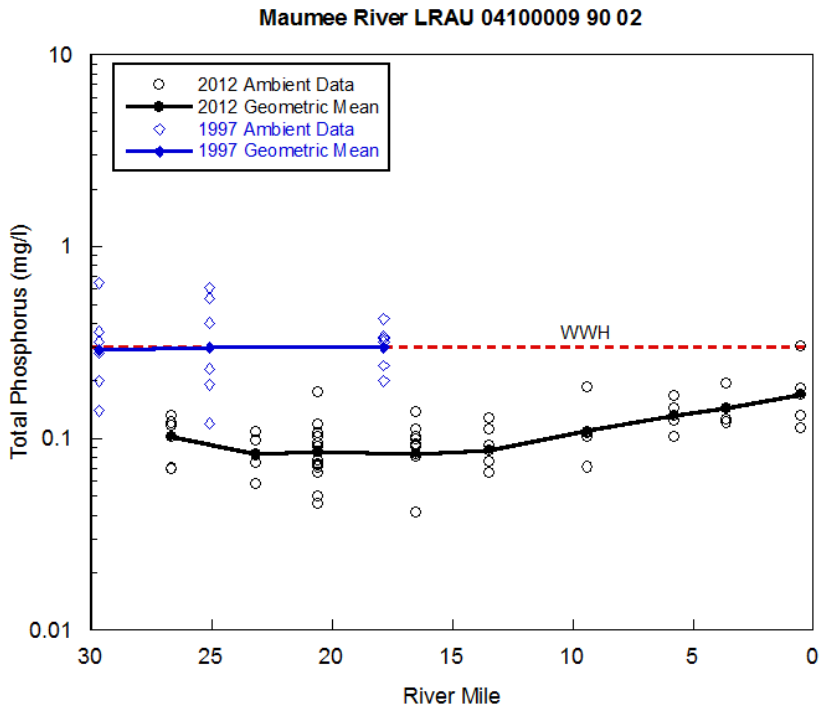

Figure 26. Total phosphorus data for the Maumee River LRAU 04100009 90 02 for 2012 and 1997 with geometric mean and specified target for large river WWH and MWH designated use.

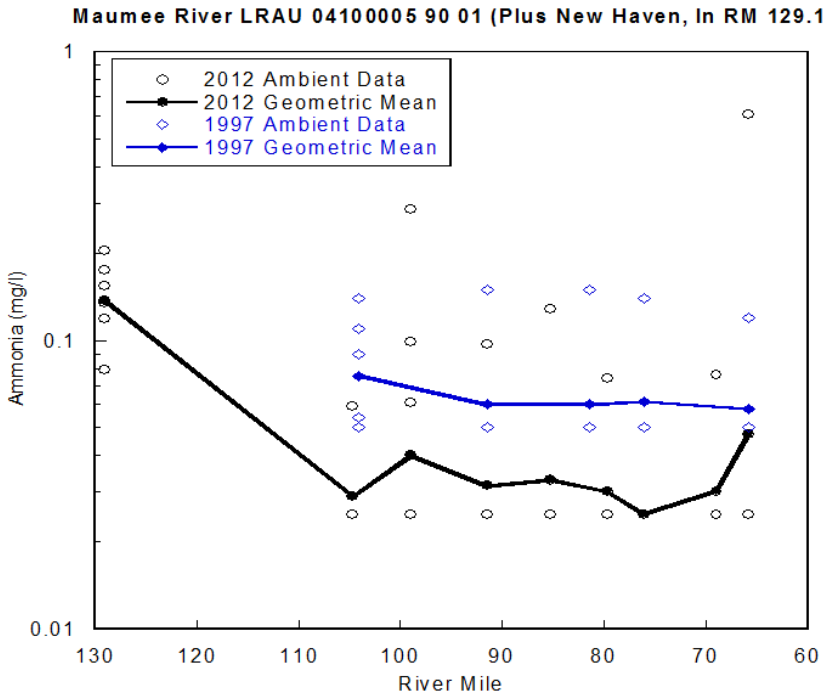

Figure 27. Ammonia data for the Maumee River LRAU 04100005 90 01 for 2012 and 1997 with geometric mean and specified target for large river WWH and MWH designated use.

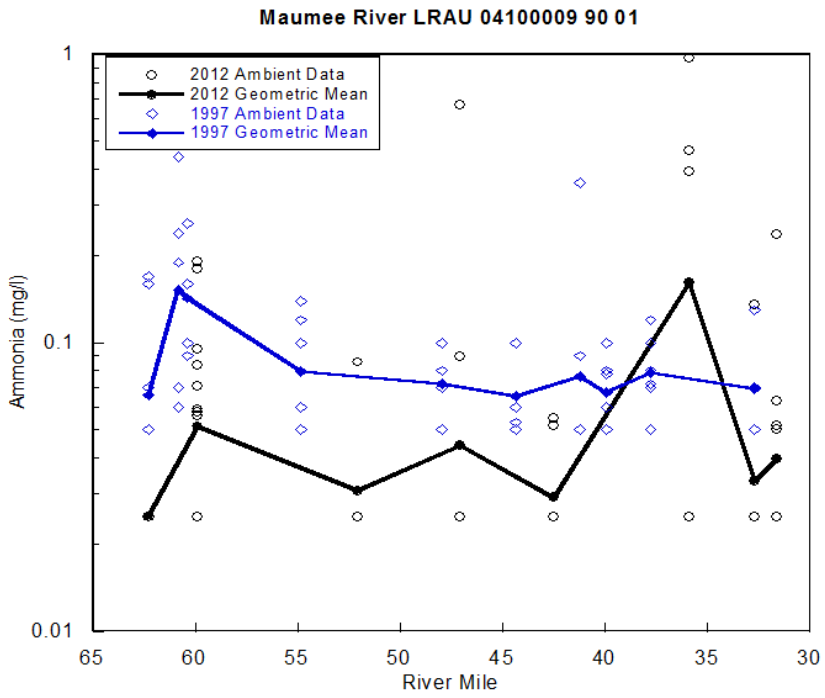

Figure 28. Ammonia data for the Maumee River LRAU 04100009 90 01 for 2012 and 1997 with geometric mean and specified target for large river WWH and MWH designated use.

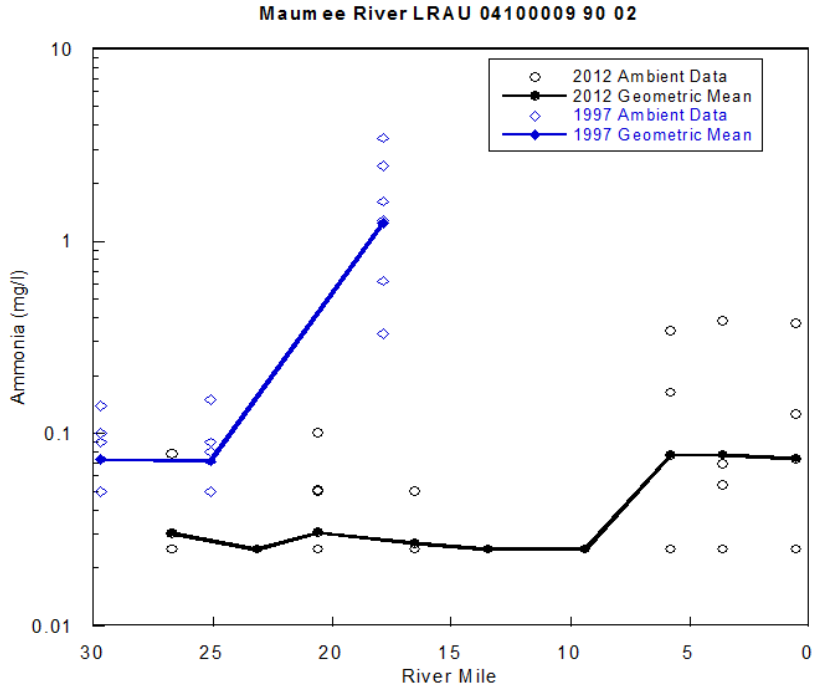

Figure 29. Ammonia data for the Maumee River LRAU 04100009 90 02 for 2012 and 1997 with geometric mean and specified target for large river WWH and MWH designated use.

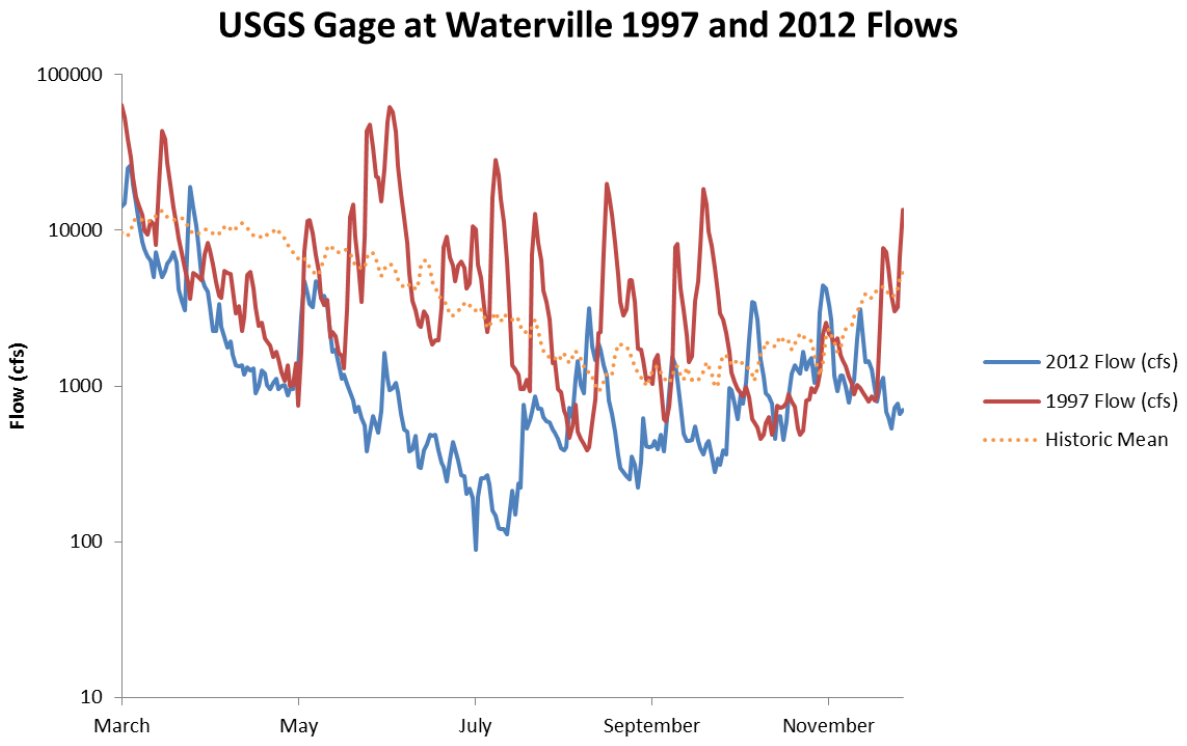

Figure 30. Mean flow conditions in the Maumee River at the Waterville USGS Gage Station for March through November 1997 and 2012.

Recreation Use

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

Escherichia coli (*E. coli*) bacteria are microscopic organisms that are normally present in large numbers in the feces and intestinal tracts of humans and other warm-blooded animals. *E. coli* typically comprises approximately 97 percent of the organisms found in the fecal coliform bacteria of human feces (Dufour 1977). Source tracking methods to differentiate between human and animal sources of coliform bacteria in surface waters are becoming more feasible but are not cost effective at this time. These microorganisms can enter water bodies where there is a direct discharge of human and animal wastes, or may enter water bodies along with runoff from soils where these wastes have been deposited.

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

The Maumee River and Auglaize River Large River Assessment Units are designated as primary contact recreation (PCR) use in OAC Rule 3745-1-07 and 3745-1-11. Water bodies with a designated recreation use of PCR "...are suitable for one or more full-body contact recreation activities such as, but not limited to, wading, swimming, boating, water skiing, canoeing, kayaking, and scuba diving" [OAC 3745-1-07 (B)(4)(b)]. There are three classes of PCR use to reflect differences in the potential frequency and intensity of use. Streams designated PCR class A support, or potentially support, frequent primary contact recreation activities. Streams designated PCR class B support, or potentially support, occasional primary contact recreation activities. The streams in the study area are designated as Class A and Class B waters.

The *E. coli* criterion that applies to PCR class A streams is a geometric mean of ≤126 colony forming units (cfu)/100 ml. The *E. coli* criterion that applies to PCR class B streams is a geometric mean of ≤161 cfu/100 ml. The geometric mean is based on two or more samples and is used as the basis for determining the attainment status of the recreation use (Table 19). The complete bacteria results dataset is reported in Appendix J.

Twenty-seven locations in the LRAUs were tested for *E. coli* levels five to seven times between May 22, 2012 and September 6, 2012. Evaluation of *E. coli* results revealed that three of the 27 locations sampled failed to attain the applicable geometric mean criterion, indicating an impairment of the recreation use at these locations.

Sources of *E. coli* contamination include pasture and cropland runoff, urban stormwater, and waterfowl accumulations. Failing home sewage treatment systems (HSTS) in both rural areas and communities without central sewage collection and treatment (unsewered) are also common sources. Many locations

along the Maumee and Auglaize Rivers had extensive amounts of agricultural land and drastically reduced riparian buffer along the stream. In addition, land used for livestock rearing and grazing was sporadically located along the banks of the rivers.

The most upstream sampling location on the Auglaize River is located adjacent to the Village of Cloverdale, an unsewered community. Attainment of the recreation use standards in this location could potentially be achieved with the installation of sewers and a treatment system in the community. Other areas listed in non-attainment of the recreation use standard for failing HSTS may need individual system improvements to reduce the discharge of bacteria. Runoff from livestock manure application and livestock grazing areas could be improved by the installation of buffers between the activity and the stream.

Table 19. Recreation beneficial use attainment table for 27 locations in the Maumee River and the Auglaize River Large River Assessment Units, May 1 through October 31, 2012. *Note:* All *E. coli* values are expressed as colony forming units (cfu) per 100 ml of water. Shaded values exceed applicable criteria.

LRAU	Location	River Mile	Rec Class*	Number of Samples	Geometric Mean†	Attainment Status	Potential Source(s) of Bacteria
04100005 90 01	Maumee River WWH Existing						
	Maumee River 1.0 Mile W. of Antwerp	104.7	B	5	89.71	FULL	
	Maumee River @ Antwerp City Park	99.0	B	5	90.97	FULL	
	Maumee River @ Eater Road	91.5	B	5	59.86	FULL	
	Maumee River @ County Road 105	85.3	B	5	126.55	FULL	
	Maumee River @ US Route 127	79.7	B	5	71.65	FULL	
	Maumee River @ The Bend Road	76.1	A	5	135.31	NON	Livestock-Ag Runoff / Failing HSTS
	Maumee River @ Switzer and Dowe	69.0	A	5	89.94	FULL	
04100009 90 01	Maumee River MWH-I Existing						
	Maumee River @ State Route 281	62.3	A	6	69.47	FULL	
	Maumee River WWH Existing						
	Maumee River DST Independence Dam	59.9	A	7	5.84	FULL	
	Maumee River MWH-I Existing						
	Maumee River @ Wade Creek	52.1	A	5	19.29	FULL	
	Maumee River @ Napoleon Water Intake	47.1	A	5	4.92	FULL	
	Maumee River @ State Route 6	42.5	A	5	5.61	FULL	
	Maumee River UPST Grand Rapids Dam	32.7	A	5	19.36	FULL	
	Maumee River @ State Route 578	31.6	A	5	163.23	NON	Failing HSTS / Waterfowl Accumulation
04100009 90 02	Maumee River WWH Existing						
	Maumee River @ Otsego Park	26.7	A	5	35.58	FULL	
	Maumee River @ Waterville / SR 64	20.6	A	7	89.84	FULL	
	Maumee River @ Buttonwood Park	16.5	A	5	75.24	FULL	
	Maumee River @ Maple Street	13.45	A	5	54.49	FULL	
	Maumee River @ Eagle Point Colony	9.4	A	5	16.92	FULL	
	Maumee River @ Anthony Wayne Bridge	5.8	A	5	24.04	FULL	
	Maumee River @ Interstate 280 Bridge	3.6	A	5	38.76	FULL	
	Maumee River Near Mouth	0.5	A	5	10.86	FULL	
04100007 90 01	Auglaize River WWH Existing						
	Auglaize River @ Cloverdale / SR 114	28.5	A	5	159.86	NON	Unsewered Community / Failing HSTS
	Auglaize River MWH-I Recommended						
	Auglaize River @ Oakwood / SR 613	19.3	A	5	21.53	FULL	
	Auglaize River @ Charloe / CR 138	15.0	A	5	7.82	FULL	
	Defiance Power Dam L-1	5.9	A	5	9.23	FULL	
	Auglaize River WWH Existing						
	Auglaize River @ Harding Road	4.14	A	5	33.21	FULL	

* Recreation class includes primary contact recreation classes A or B.

† Attainment status is determined based on the seasonal geometric mean. The status cannot be determined at locations where fewer than two samples were collected during the recreation season.

Public Drinking 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 2014 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.

There are five public water systems (Defiance, Napoleon, Campbell Soup Company, McClure, and Bowling Green) directly served by surface water from the Maumee River. McClure (RM 35.91), however, is no longer using its intake on the Maumee River and is instead purchasing water from the Village of Malinta, who ultimately gets its water from Napoleon. Defiance (RM 65.84), Napoleon (RM 47.1), Campbell Soup Company (RMs 45.88 and 47.10), and Bowling Green (RM 23.16) all have intakes on the Maumee River mainstem. Table 20 provides a summary of exceedances for the PWS use while Appendix G contains all of the water quality analytical results.

City of Defiance

The City of Defiance operates a community public water system that serves a population of approximately 20,000 people through 6,668 service connections, including water sold to the villages of Ayersville, Brunersburg, and Christi. The City of Defiance draws water from a surface water intake on the Maumee River and pumps into an upground reservoir. The system's treatment capacity is approximately 8 million gallons per day, but current average production is 3.4 million gallons per day. The City of Defiance's water treatment system consists of coagulation, lime softening, flocculation, sedimentation, stabilization, filtration, fluoridation, and disinfection.

Ohio EPA collected ten water quality samples in 2012 and eleven in 2013 at the Defiance intake on the Maumee River (RM 65.84). To assess the PWS beneficial use, samples were analyzed for nitrate and pesticides. Nitrate ranged from below detection limit (BDL) to 8.78 mg/L and averaged 3.64 mg/L. All results were below the water quality criterion for nitrate (10.0 mg/L). Atrazine ranged from BDL to 6.19 µg/L. Samples were not collected during the first and last quarters of 2012 and 2013, but assuming fall and winter quarter averages for atrazine of zero, the annual quarterly average atrazine concentrations were 0.87 µg/L in 2012 and 1.25 µg/L in 2013, which is below the water quality criterion for atrazine (3.0 µg/L).

City of Bowling Green

The City of Bowling Green operates a community public water system that serves a population of approximately 39,000 people through 10,748 service connections, including water sold to Northwestern

Water and Sewer District, and the villages of Grand Rapids and Tontogany. The city obtains its water from the Maumee River (RM 23.16), which is pumped into an upground reservoir. The system's treatment capacity is approximately 11 million gallons per day, but current average production is 4.8 million gallons per day. The City of Bowling Green's water treatment system consists of coagulation, lime softening, flocculation, sedimentation, stabilization, granular activated carbon (GAC) filtration, filtration, and fluoride.

Ohio EPA collected a total of 10 water quality samples at the Bowling Green intake on the Maumee River during 2012 and 12 samples in 2013. To assess the PWS beneficial use, samples were analyzed for nitrate and pesticides. Nitrate ranged from BDL to 9.95 mg/L and averaged 3.34 mg/L. All results were below the water quality criterion for nitrate (10.0 mg/L). Atrazine ranged from BDL to 12.8 µg/L. Samples were not collected during the first and last quarters of 2012 and 2013, but assuming fall and winter quarter averages for atrazine of zero, the annual quarterly average atrazine concentrations were 1.67 µg/L in 2012 and 2.12 µg/L in 2013, which is below the water quality criterion for atrazine (3.0 µg/L).

City of Napoleon

The City of Napoleon operates a community public water system that serves a population of approximately 11,800 people through 3,765 service connections, including water sold to the Henry County Regional Water and Sewer District, and the villages of Malinta, Liberty Center, and Florida. The water treatment system obtains its water from a surface water intake on the Maumee River and pumps into two upground reservoirs. The system's treatment capacity is approximately 4.5 million gallons per day, but current average production is approximately 1.3 million gallons per day. The City of Napoleon's water treatment system consists of coagulation, lime softening, flocculation, sedimentation, stabilization, filtration, fluoridation, and disinfection.

Ohio EPA collected 10 water quality samples in 2012 and 12 in 2013 at the Napoleon intake on the Maumee River (RM 47.1). To assess the PWS beneficial use, samples were analyzed for nitrate and pesticides. Nitrate ranged from BDL to 7.81 mg/L and averaged 2.91 mg/L. All results were below the water quality criterion for nitrate (10.0 mg/L). Atrazine ranged from BDL to 14.6 µg/L. Samples were not collected during the first and last quarters of 2012 and 2013, but assuming fall and winter quarter averages for atrazine of zero, the annual quarterly average atrazine concentrations were 1.87 µg/L in 2012 and 2.15 µg/L in 2013, which is below the water quality criterion for atrazine (3.0 µg/L).

Campbell Soup Company

The Campbell Soup Supply Company operates a non-transient non-community public water system, which is a water system that serves at least 25 of the same persons per day for at least six months of the year. The company’s water treatment plant provides drinking water for approximately 1,300 employees. It also provides the water used in food production. The water treatment system obtains its water from two intakes located approximately a mile apart on the southern bank of the Maumee River. The system's treatment capacity is approximately 15 million gallons per day, but the current average production is 6.5 million gallons per day. The Campbell Soup Supply Company's water treatment system consists of coagulation, lime softening, flocculation, sedimentation, stabilization, filtration, and disinfection.

Ohio EPA did not collect water quality samples at the Campbell Soup Supply Company’s intakes because the intakes were located near the intake for Napoleon, and the Napoleon sampling data was considered representative of the source water quality for the Campbell Soup Supply Company.

Harmful Algal Blooms

The City of Bowling Green experienced a harmful algal bloom in their reservoir in June, 2013. In response, Ohio EPA collected raw and finished water samples from June 11, 2013 to June 26, 2013 and analyzed them for the cyanotoxins microcystin and saxitoxin (Appendix M). Cyanotoxins were not detected in finished water, and saxitoxin was not detected in the source water. Microcystin was detected in the source water at concentrations ranging from BDL to 2.0 µg/L. The microcystin drinking water threshold of 1.0 µg/L was exceeded in the source water on two occasions, but the exceedances were less than 30 days apart so the water system does not meet the impairment target for algae. The raw water microcystin detections place Bowling Green on a watch list for algae.

Finished Water Violations and PDWS Use Impairments

The City of Defiance, City of Napoleon, Campbell Soup Company, and the Village of McClure all had historic (2002-2007) finished water nitrate concentrations that exceeded the 10.0 mg/L water quality criterion and led to impairments for the Public Drinking Water Supply (PDWS) beneficial use. Defiance and Napoleon now have upground reservoirs and can selectively pump to avoid periods of high nitrate concentrations in their source water. Only Campbell Soup Company has had a nitrate violation since 2008. They exceeded the water quality criterion in finished water and received a violation for nitrate in December, 2012. Since the water quality criterion was exceeded, the Maumee River mainstem from the Tiffin River to Beaver Creek will remain impaired for the PDWS beneficial use. This segment will also remain on the pesticide watch list due to raw water concentrations in excess of 12.0 mg/L.

Since Defiance has not had a recent exceedance of the water quality criterion for nitrate in finished water and the source water samples Ohio EPA collected were below the criterion, the existing PDWS use impairment on the Maumee River mainstem from the Indiana border to the Tiffin River will be removed in the next reporting cycle (unless additional sampling in 2014 demonstrates a continued impairment). This segment of the Maumee River will remain on a watch list for nitrates based on raw water samples exceeding 8 mg/l.

Bowling Green has an upground reservoir and therefore finished water data is not indicative of source water quality. Source water sampling conducted by Bowling Green in 2011 and 2012 resulted in three exceedances of the nitrate water quality criterion. More frequent source water sampling conducted by Heidelberg University at the PWS intake resulted in 15 exceedances of the nitrate water quality criterion from 2008 to 2012. Therefore, the Maumee River mainstem from Beaver Creek to Maumee Bay will be listed as impaired for the PDWS beneficial use. This segment will also remain on the pesticide watch list, due to raw water concentrations in excess of 12.0 mg/l, and on the algae watch list due to raw water microcystin detections.

Table 20. Summary of available Ohio EPA water quality data for parameters of interest at sampling sites near/at PWS intakes, 2012-2013. This table does not include finished water sample results or data from Heidelberg Water Quality lab.

Location	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)	Annual Average (2012)[3]	Annual Average (2013)[3]	Maximum Single Detection
Maumee River @ Bowling Green WTP Intake	3.34 mg/L n=12	9.95 mg/L (0)	3.53 ug/L (10)	1.67 ug/L	2.12 ug/L	12.8 ug/L
Maumee River @ Napoleon WTP Intake	2.91 mg/L n=12	7.81 mg/L (0)	3.89 ug/L (10)	1.87 ug/L	2.15 ug/L	14.6 ug/L
Maumee River @ Defiance WTP Intake	3.64 mg/L n=11	8.78 mg/L (0)	2.05 ug/L (10)	0.87 ug/L	1.25 ug/L	6.19 ug/L

1 Nitrate Water Quality Criteria (WQC) evaluated as maximum value not to be exceeded. Impaired waters are defined as having two or more excursions above the criteria.
2 Atrazine WQC evaluated as annual average of the quarterly averages.
3 Atrazine data was only collected for two quarters of 2012 and 2013. Quarterly average assumes fall and winter quarter atrazine concentrations are zero.

NPDES Permitted Facilities

A total of 21 major National Pollutant Discharge Elimination System (NPDES) permitted facilities discharge sanitary wastewater, industrial process water and/or industrial storm water into the three Maumee River LRAUs. "Major" NPDES permitted facilities are facilities that have a design flow of one million gallons per day (MGD) or more. The major NPDES permitted facilities in the above specified watersheds are located in Lucas, Wood, Fulton, Henry, Defiance, Van Wert, Allen, and Auglaize counties and are listed in Table 21. There are no major NPDES permitted facilities that discharge directly to the Auglaize River LRAU that was evaluated in this assessment.

Table 21. Major NPDES permitted facilities discharging in the Maumee and Auglaize Rivers LRAUs

NPDES Facility	Permit Number	Discharge RM	Waste Type	Discharge Volume (MGD)
City of Defiance WWTP	2PD00013	62.05	Municipal	6.0
GM Powertrain Defiance Plant	2IN00004	62.04, 61.78	Industrial	1.5
GM Defiance NPA Systems	2IN00202	61.94	Industrial	0.0175
Campbell Soup Supply Co.	2IH00021	45.84-43.5	Industrial	10
City of Napoleon WWTP	2PD00000	46.05	Municipal	2.5
North Star Blue Scope Steel	2ID00015	42.51	Industrial	0.29
Worthington Steel	2ID00014	42.51	Industrial	0.225
City of Perrysburg WWTP	2PD00002	14.5	Municipal	5.4
Lucas County Maumee River WWTP	2PK00000	18.2	Municipal	22.5
City of Toledo Bay View WWTP	2PF00000	1.0	Municipal	130

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). Appendix L lists all permitted discharges to the Lower Maumee River Watershed Assessment Unit (04100009), Upper Maumee River Watershed Assessment Unit (04100005) and Auglaize River Watershed Assessment Unit (04100007). Descriptions for the ten major NPDES permitted facilities that discharge directly to the Maumee River are reported below. Effluent flow and total phosphorus loads for selected Major facilities that directly discharge to the Maumee River are included with the facility descriptions.

City of Defiance WWTP (Ohio EPA Permit # 2PD00013)

The Defiance WWTP located at 26273 State Route 281 East, Defiance, came on-line in 1956 with the latest modification made in 1999. The facility has a design flow of 6.0 MGD and serves an estimated population of 21,600 people. Outfall 001 discharges to the Maumee River at RM 62.05. The current system includes screening and aerated grit removal, primary settling, activated sludge aeration, chemical phosphorus removal, secondary clarifiers, chlorination and dechlorination. Solids are treated by sludge stabilization and anaerobic digestion and stored until they are disposed by land application at agronomic rates. The treatment plant has two bypasses, outfalls 050 and 051. Outfall 050 is a bypass of secondary treatment and outfall 051 bypasses both primary and secondary treatment. From 2011 – 2013, outfall 051 has not discharged. From 2011-2013, the numbers of bypass events and total flows for outfall 050 have been 17 days for a total of 7.648 million gallons (MG) in 2010, 71 days for a total of 102.912 MG in 2011, and 34 days for a total of 9.218 MG in 2012.

The Defiance WWTP collection system serves the City of Defiance, Village of Ayersville and portions of Defiance County. During permit issuance in 2010, the collection system contained both separate (80%) and combined (20%) sewers. The combined sewer overflows (CSOs) are authorized in the current NPDES permit. In December 1998, the city submitted a CSO long-term control plan. After negotiations with

Ohio EPA, the city entered into a consent order in 2010 that includes a revised long-term control plan and CSO abatement schedule.

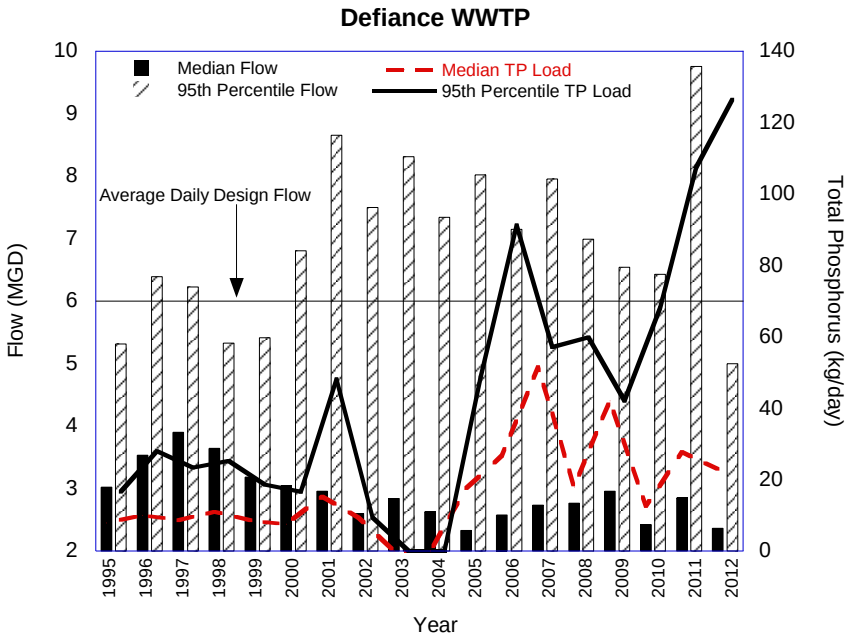

Figure 31. Annual median and 95th percentile conduit flow and loadings of total phosphorus from the Defiance WWTP, 1995 – 2012.

Defiance WWTP is required to submit monthly monitoring reports to Ohio EPA as part of their permit requirements. Annual median and 95th percentile data collected at outfall 001 show that median flows remain well below the average annual design flow of the plant. However, the 95th percentile flow data indicates that exceedances do occur regularly. These higher flow volumes are likely due to inflow and infiltration in the collection system. The lowest and highest 95th percentile flow data, in general, correlates to the lowest and highest annual rainfall totals as reported by the National Oceanic and Atmospheric Administration, National Weather Service (http://www.erh.noaa.gov/cle/climate/tol/climatetol.html). The annual loading of total phosphorus is displaying an increasing trend since 2004, especially in the 95th percentile data (**Figure 31**).

Defiance implements an Ohio EPA approved industrial pretreatment program. The 2007 annual program report specifies that four categorical industrial users and 10 significant non-categorical users discharge to the wastewater treatment plant. All categorical industries are metal finishing plants.

Ohio EPA most recently conducted a compliance sampling inspection and bioassay of the Defiance WWTP on April 23-24, 2012. The effluent from outfall 001 was found to be acutely toxic to *Pimephales promelas*. No mortality or adverse effects were found in *Ceriodaphnia dubia*. No other permit limit violations were found in the composite sample.

The Defiance WWTP was in significant noncompliance for 2 months in 2012 due to total chlorine, *E. coli* and ammonia-nitrogen exceedances. A Notice of Violation was sent to the facility due to the exceedances; however, no formal enforcement action was taken by Ohio EPA. The City of Defiance has been under Director's Final Findings and Orders for CSOs.

General Motors Powertrain (GMPT) – Defiance Plant (Ohio EPA Permit # 2IN00004)
GMPT located at 26427 State Route 281 East, Defiance, is a production facility for the manufacturing of grey and nodular iron castings and aluminum castings for automotive, truck and industrial uses. Industrial and storm water runoff from the facility are collected and treated in the on-site wastewater treatment plant. GMPT discharges to the Maumee River at RM 62.04 (outfall 001) and 61.78 (outfall 002).

Outfall 001 discharges process wastewater, cooling water and storm water. Most of the wastewater (approximately 31 MGD) is recycled. Approximately 1.5 MGD on average is discharged from outfall 001. The average design flow of the plant is 2.0 MGD. The effluent is treated by settling, ion exchange, precipitation, filtration and carbon adsorption.

Outfall 002 contains process and storm water and discharges only during heavy storm events. Discharges from this outfall are considered to be bypasses because settling is the only treatment. Between 2010 and 2012, outfall 002 bypassed the system 11 times in 2011 for a total bypass flow of 10.023 million gallons.

Outfall 004 discharges storm water from a ditch on the west side of the property. Outfall 005 discharges storm water runoff from the on-site solid waste facility.

Ohio EPA conducted a compliance sampling inspection and bioassay of the GMPT WWTP on April 16-17, 2012. The effluent from outfall 001 was not acutely toxic. No mortality or adverse effects were found in the ambient waters or effluents for either *Pimephales promelas* or *Ceriodaphnia dubia*. No other permit limit violations were found in the composite sample.

GM Defiance NPA Systems (Ohio EPA Permit # 2IN00202)
GM Defiance North Perimeter Area (NPA) Systems located at 26427 State Route 281 East, Defiance, is a wastewater treatment system for ground water from a leachate collection trench associated with the on-site landfill that has been in operation since December 2002. The treatment process includes multi-stage bag and cartridge filtration, granular activated carbon filtration and pH neutralization utilizing hydrochloric acid. Outfall 001 discharges to the Maumee River at RM 61.94. Calculated average daily flow is 17,520 gallons per day with a design flow of 100,800 gallons per day.

Campbell Soup Supply Company (Ohio EPA Permit # 2IH00021)
Campbell Soup Supply Company located at 12-773 State Route 110, Napoleon, is a heat process - canned food facility. Its major products consist of canned soups, sauces and juices. Cooking, blending, juice extractions, sterilization, packing, cooling, labeling and clean-up are the operations performed at this facility.

The wastewater generated from boiler house/refrigeration, restrooms, container and vegetable washing, blending/mixing, filling and cookers/cooling are treated in the wastewater treatment unit and discharged through outfall 001. The treatment plant has a design capacity of 10 MGD and outfall 001 is the major outfall that discharges into the Maumee River RM 45.84. The conventional waste treatment plant consists of a mechanical screen, grit chamber, primary dissolved air floatation, roughing tower, settling tanks, primary trickling filter, secondary trickling filter, aerated lagoons, final dissolved air floatation and chlorine contact basin.

Outfalls 003-009 are treated by micro-straining, screening and spray irrigation. The operations contributing flows to these outfalls are storm water, container washing, vegetable washing, preparation washing, blending/mixing, filling and cookers/cooling. Outfalls 003-009 discharge to the Maumee River between RMs 45.84 and 43.50.

Annual flow data show that discharge flow from outfall 001 has been declining since 2008 and has remained below the average design flow of 10 MGD. The total phosphorus loading has decreased in conjunction with the flow since 2008 (Figure 32). However, additional total phosphorus loading from spray irrigation outfalls 003 through 009 have not been significantly monitored (once per year) by the facility and therefore are not included in the load represented in Figure 32.

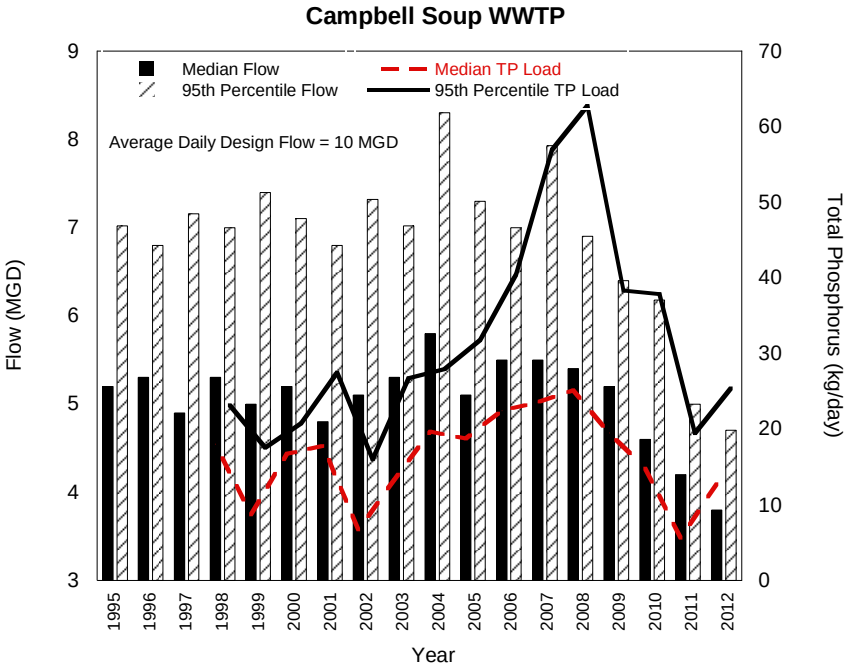

Figure 32. Annual median and 95th percentile conduit flow and loadings of total phosphorus from the Campbell Soup Supply Co. WWTP, 1995 – 2012.

City of Napoleon WWTP (Ohio EPA Permit # 2PD00000)
The Napoleon WWTP was constructed in 1958. The facility located at 735 East Washington Street, Napoleon, has a design flow of 2.5 MGD and serves a population of approximately 8,749 people. Wet waste stream processes are screening, comminution, grit removal, primary settling, biotowers, aeration, final clarification, disinfection by chlorination, and dechlorination. An equalization basin (EQ) to store peak flows was constructed in 2010. The wastewater treatment plant discharges to the Maumee River at RM 46.05. Solid waste stream processes include sludge stabilization by anaerobic digestion, drying beds, sludge storage and recycling of stabilized sludge by land application at agronomic rates.

As of permit issuance in 2009, the Napoleon WWTP collection system consisted of separate (70%) and combined (30%) sewers and 100% of the service area has sewers. The current permit contains a compliance schedule for implementing the City's approved CSO Long Term Control Plan.

The City of Napoleon completed construction of a 2.5 million gallon EQ basin in 2010 to store and treat wastewater from combined portions of their sewer system that discharge into the WWTP from the east. There are two other lines, one express and one gravity, which discharge into the WWTP from the south. The EQ basin has an influent building that diverts wastewater during rain events, using screw pumps. Wastewater from the EQ basin is collected and will then be pumped into the plant and treated once the rain event has ceased and the plant is hydraulically capable. However, the EQ basin has a limited capacity and once the capacity is exceeded, the screw pumps will be shut off and wastewater will not be pumped into the EQ basin. The flow that the treatment plant cannot hydraulically accept at this point will be diverted into the effluent chamber of the UV treatment system. This wastewater will not receive

treatment and will be sampled prior to entering the blended waste streams discharging from the UV treatment tank. The number of bypass events and total flows for Outfall 011 were 5 days for a total of 5.117 million gallons (MG) in 2010, 13 days for a total of 6.607 MG in 2011, and no bypasses in 2012. Since completion of the construction of the EQ basin, 12 MG of wastewater in 2010 and 44.3 MG of wastewater in 2011 have been captured and treated instead of bypassed around the plant.

Napoleon's Sanitary Sewer Overflows (SSOs) are all triggered by wet weather occurrences. The remaining three SSOs discharge directly to the Maumee River when it is flowing at 653 cubic feet per second (harmonic mean flow) and would not constitute a high impact. Increased inspections, preventative maintenance, increased operations and maintenance, modeling and elimination of inflow and infiltration (I&I) and throttling back the flow into the collection system are all used to reduce the frequency of the discharge from the SSOs. However, the 2.5 million gallon EQ basin is projected to capture a large portion of the additional flow during most rain events.

The median annual flow data appears to be fairly consistent for the last 18 years with an increasing trend in the 95th percentile data. The median total phosphorus loading data shows a slight increase over time and despite the large fluctuation in the 95th percentile annual total phosphorus load, the data shows a slight decreasing trend (Figure 33).

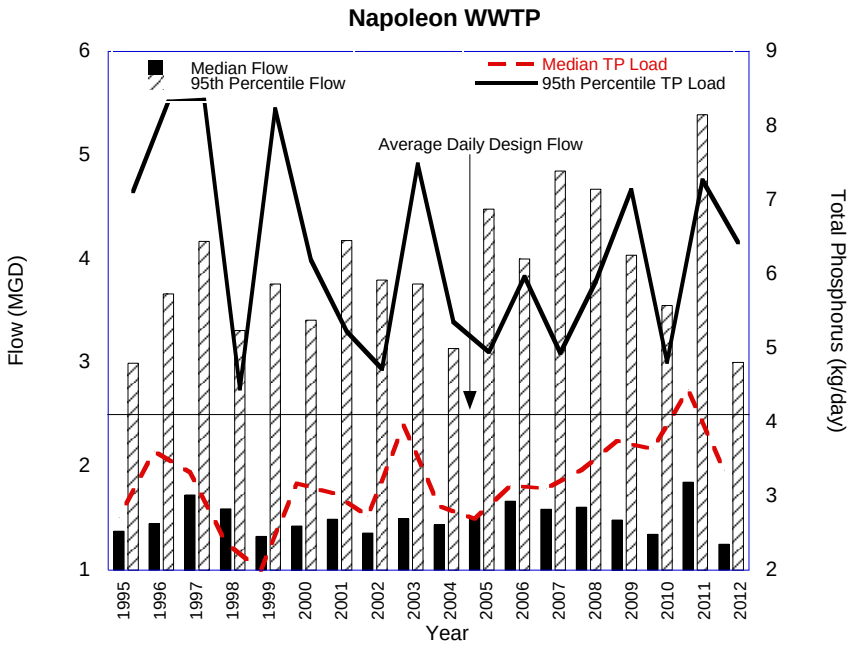

Figure 33. Annual median and 95th percentile conduit flow and loadings of total phosphorus from the Napoleon WWTP, 1995 – 2012.

Napoleon does not implement an Ohio EPA approved industrial pretreatment program. The city has two significant industrial users that are not covered by federal categorical treatment standards. These facilities contribute approximately 0.073 MGD to the treatment plant. The total flow from all industrial users is 0.668 MGD.

Ohio EPA conducted a compliance sampling inspection and bioassay of the City of Napoleon WWTP on October 15-16, 2012. The effluent from outfall 001 was not acutely toxic. No mortality or adverse effects were found in the ambient waters or effluents for either *Pimephales promelas* or *Ceriodaphnia dubia*. No permit limit violations were found in the composite sample.

North Star BlueScope Steel (Ohio EPA Permit # 2ID00015)
North Star BlueScope Steel owns and operates a steel rolling and casting mill located at 6767 C.R. 9, Delta,. Processes include continuous casting of steel and hot rolling of steel strip.

Water is used in the casting and rolling operations to directly cool the hot formed steel. Hot strip mill waters are pre-treated by oil skimming and both process waters are treated by sand filtration before entering the wastewater treatment plant. The main wastewater treatment plant consists of pH adjustment, chemical precipitation and rapid sand filtration with a design flow of 0.29 MGD. The outfall from the main treatment system is designated outfall 601 in the permit. Ohio EPA has specified this in-plant sampling point to monitor compliance with effluent guideline limitations. Monitoring at an in-plant sampling location is necessary in this case to monitor federally regulated wastewaters before they are diluted by other non-process flows. The federal effluent guidelines do not allow dilution to substitute for treatment.

Outfall 001 contains the 601 effluent, non-contact cooling water from the oxygen plant and intermittent non-contact cooling water blowdown from the steel plant cooling water reservoir. All of these waters are aerated prior to discharge. The 001 effluent mixes with effluent from the adjacent Worthington Steel plant in the storm sewer that discharges to the Maumee River at RM 42.51.

Worthington Steel (Ohio EPA Permit # 2ID00014)
Worthington Steel Company is a finished steel processing plant and manufacturer of galvanized steel strips. Processes include hydrochloric acid pickling, hot-dip zinc galvanizing, alkaline cleaning and slitting of steel coils. The facility is located at 6303 County Road 10, Delta. Their production rates are 2700 tons/day for the hydrochloric acid pickling operation and 2000 tons/day for alkaline cleaning operation/hot dip galvanizing operation. Total flow from outfall 001 is 0.225 MGD. The effluent is discharged to the Maumee River at RM 42.51 via an eleven mile county maintained sewer that contains combined effluents from Worthington Steel and North Star BHP Steel.

The process wastewater from the equalization tank (transferred from the waste holding tank) goes thru neutralization (by lime or caustic) and clarification before it is stored in clean water holding tanks. There is an internal monitoring station 601 for checking compliance with federal effluent guideline limits. After sampling point 601, the effluent combines with non-contact cooling water and is sampled at outfall 001 before finally entering the sewer line. The sanitary waste is disposed of at the Village of Delta.

City of Perrysburg WWTP (Ohio EPA Permit # 2PD00002)
The Perrysburg WWTP was constructed in 1957 with the most recent upgrade in 2010. The WWTP is a secondary treatment facility located at One West Boundary St., Perrysburg with an average design flow of 5.4 MGD serving approximately 22,000 people. The current wet stream processes consist of bar screening, grit removal, pre-aeration, primary sedimentation, activated sludge aeration, outfall pumping, secondary clarification, phosphorus removal and ultraviolet disinfection. Wastewater discharges to the Maumee River at RM 14.5. Solid stream processes are anaerobic digestion, mechanical dewatering and polymer addition. Treated sludge is disposed of by land application at agronomic rates.

The Perrysburg collection system is predominantly separate, although a portion is combined. The system had four CSOs as of the 2011 NPDES permit. City personnel inspect regulators daily to check for dry weather overflows and maintain inspection and maintenance records. The city has repaired and optimized the height of weirs in the regulators and some separate sewer areas have been routed around combined areas.

Perrysburg implements the nine minimum controls for CSOs under a CSO Operation and Control Plan that was approved on February 24, 1997. Sewer separation was the chosen alternative and it is being implemented under an enforcement schedule in the NPDES permit. The date of separation is scheduled for 2014. Perrysburg had a secondary bypass until late 2010. This bypass was eliminated.

The median and 95th percentile total phosphorus data shows that there has been an increase in load since 2006. The increased total phosphorus load is potentially due to an increase in the flow to the plant. The median flow is consistently below the average design flow of the plant with the 95th percentile data regularly exceeding the design flow likely as a result of population growth in the Perrysburg area (Figure 34).

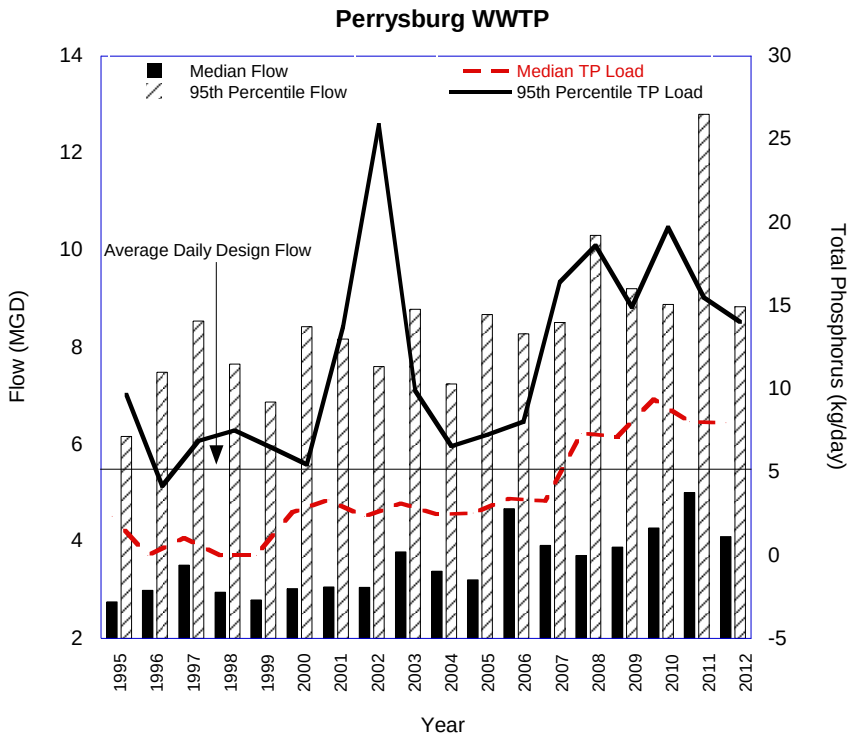

Figure 34. Annual median and 95th percentile conduit flow and loadings of total phosphorus from the Perrysburg WWTP, 1995 – 2012.

Perrysburg does not implement an approved pretreatment program and no significant industrial users discharge to the WWTP. The 10 current non-significant users contribute approximately 0.001 MGD to the flow.

The Perrysburg WWTP was in significant noncompliance for low level total mercury for four months in 2012. The City submitted and implemented a pollutant minimization plan. A notice of violation was issued to the facility in August 2012, however, no formal enforcement action was taken by Ohio EPA.

Lucas County Maumee River WWTP (Ohio EPA Permit # 2PK00000)
The Lucas County Maumee River Wastewater Treatment Plant located at 5758 North River Road Waterville, has an average design flow of 22.5 MGD and serves an estimated 84,312 people. Wet stream processes include screening and grit removal, primary settling, activated sludge aeration, phosphorus removal, final clarification and disinfection using ultraviolet (UV) light. The wastewater discharges to the Maumee River at RM 18.22. Solid stream processes are sludge stabilization by anaerobic digestion, dewatering using drying beds and belt filter press and sludge storage. Stabilized sludge is recycled by land application at agronomic rates.

All of the plant's collection system is separate sanitary sewers. There are no overflows in the collection system. There are 31 lift stations on the separate sanitary portion of the system. The plant receives five satellite collection systems, each of which is responsible for the maintenance of its own system.

Lucas County Maumee River WWTP monitoring data shows a slight increasing trend in the flow with a corresponding slight increase in total phosphorus load over the 18 year period. Since the 2003 peak in 95th percentile total phosphorus load, plant expansion that occurred in 2003 to 2005 has resulted in a significant decline in the load to the Maumee River (Figure 35).

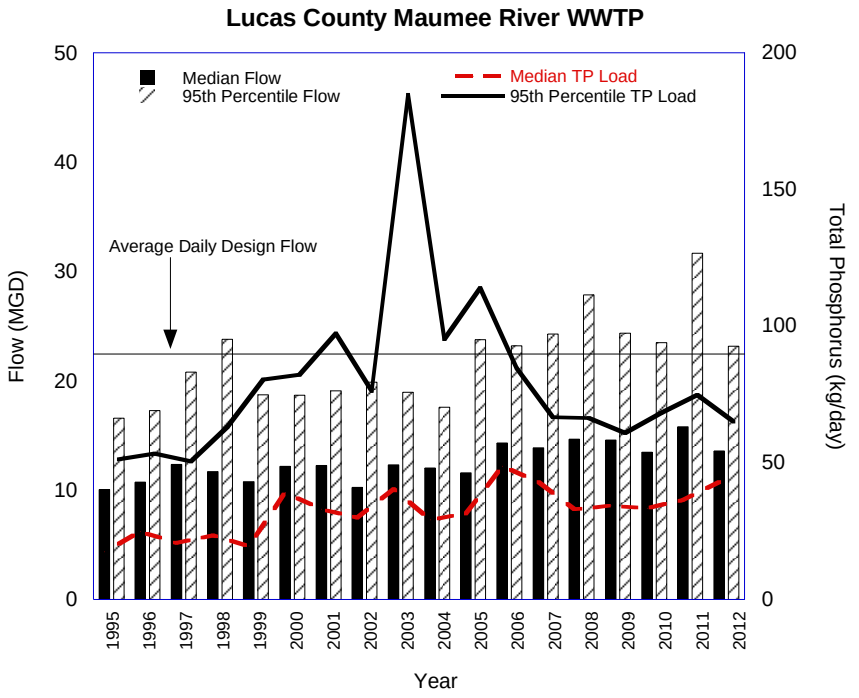

Figure 35. Annual median and 95th percentile conduit flow and loadings of total phosphorus from the Lucas County Maumee River WWTP, 1995 – 2012.

Lucas County has an Ohio EPA-approved industrial pretreatment program. There are nine industrial users that discharge to the collection system and seven of these are categorical industries. Based on the current application, the industrial users contribute 0.313 MGD to the treatment system inflow.

Ohio EPA conducted a compliance sampling inspection and bioassay of the Lucas County Maumee River WWTP on May 21-22, 2012. The effluent from outfall 001 was not acutely toxic. One *Pimephales promelas* minnow died in the Maumee River upstream water. *Ceriodaphnia dubia* mortality was 10, 5, and 5 percent in the May 21 and 22 effluent grabs and composite effluent, respectively. One *C. dubia* in the composite effluent was lethargic in behavior. Survival in the laboratory controls was 95 percent or greater for both species.

The ammonia-N limit of 4.5 mg/l specified in the permit was exceeded in the 24 hour composite sample collected on May 22, 2012 (9.55 mg/l) resulting in a permit limit violation.

Toledo Bay View Park WWTP (Ohio EPA Permit # 2PF00000)
The Toledo WWTP is designed to treat an average daily flow of 130 MGD. The treatment plant located at 3900 North Summit Street, Toledo, was originally constructed in 1932 with the most recent major upgrade occurring in 2007.

Treatment plant processes and/or equipment include influent pumping, bar screen, grit removal, pre-aeration, scum removal, primary sedimentation, ferrous chloride addition (phosphorus removal), polymer addition, activated sludge (conventional), clarification (tube settlers), secondary clarification, chlorination/dechlorination and post-aeration. The plant discharges to the Maumee River at RM 1.0.

A number of treatment units have also been installed for managing wet weather flows at the facility and within the collection system. The city installed a separate treatment train at the WWTP to manage wet

weather flows, which became operational in 2006. Wet weather treatment units include a pumping station, grit removal, ballasted flocculation, a 25 million gallon equalization basin (completed in 2007) and a chlorine contact tank. In addition, multiple tunnels were constructed to provide storage of CSO discharge from the first flush of combined runoff.

Sludge is processed with gravity thickening, air flotation thickening, polymer addition, digester gas utilization facilities and a belt filter press for de-watering. Since 2005, the majority of the sludge produced has been managed by land application.

The collection system serves the City of Toledo, the Village of Walbridge, the City of Northwood, the City of Rossford, the Village of Ottawa Hills, Sylvania Township and northern Wood County as well as other small areas for an estimated population of 363,500. As of 2011, 80% of the collection system is estimated to be separate sanitary sewers and 20% combined. The collection system included 34 CSOs and a direct bypass to the Maumee River (outfall 002) prior to treatment. The estimated daily inflow and infiltration rate is 39 MGD. The wastewater flow from all industrial users is estimated to be 9.23 MGD, with 47 non-categorical significant industrial users contributing approximately 3.72 MGD and 24 categorical users discharging the remaining industrial wastewater flow.

Based on the monitoring report data submitted by the facility, the median annual flow rate has remained consistent while the 95th percentile flow has followed a slight increasing trend over the 18 year period. The median and total phosphorus loads have displayed a slight increasing trend that is most likely a result of the slight increase in flow (Figure 36).

The city has operated an Ohio EPA approved pretreatment program since March 1986.

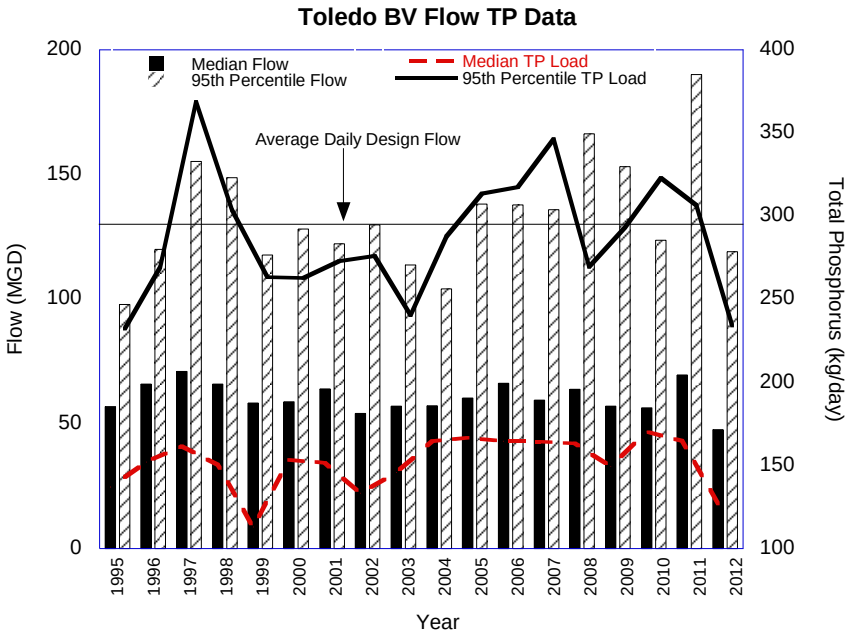

Figure 36. Annual median and 95th percentile conduit flow and loadings of total phosphorus from the Toledo Bay View Park WWTP, 1995 – 2012.

Sediment

Surficial sediment samples were collected at two locations in the Maumee and Auglaize Rivers by the Ohio EPA on October 11, 2012. Sampling locations were co-located with biological sampling sites. Samples were analyzed for semi-volatile organic constituents, PCBs, and metals including mercury. Specific chemical parameters tested and results are listed in Appendix H. Sediment data were evaluated using Ohio Sediment Reference Values (Ohio EPA 2010), along with guidelines established in *Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems* (MacDonald *et.al*. 2000). 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 a *Probable Effect Concentration* (PEC) that indicates a level above which harmful effects are likely to be observed.

Sediment samples were collected conservatively by focusing on depositional areas of fine grain material (silts and clays). These areas typically are represented by higher contaminant levels, compared to coarse sands and gravels. Fine grained depositional areas were not a predominant substrate type immediately behind the dams on the Maumee and Auglaize Rivers. As a result of the lack of fine grained sediment and/or an abundance of organic material in the sample, sediment samples were collected at small marinas upstream of the Power Dam on the Auglaize River (RM 5.90) and upstream of the Grand Rapids Dam on the Maumee River (RM 32.60). Fine grain sediment that was not dominated by organic material could not be collected upstream of the Independence Dam on the Maumee River and as a result a sample was not collected at this location.

Metals above screening benchmarks are presented in Table 22. No semi-volatile organics or PCBs were detected in the sediments at both sampling locations. Levels of nickel slightly exceeded the TEC and levels of cadmium exceeded the SRV and the TEC at both sampling locations. However, the PEC was not exceeded in either instance. As a result, the sediment collected from the above locations may be adversely affected by sediment-associated contaminants but it is not likely to be toxic to sediment-dwelling organisms. In addition, the elevated sediment metals did not negatively affect the biological community of these areas due to the co-located biological sampling results achieving full attainment.

Possible sources of elevated nickel and cadmium could be from gasoline/oil discharges from boats at the ramps and/or historical wastewater discharges. Overall, sediment contamination in the two locations sampled in the Maumee and Auglaize Rivers is minimal and protective of the river biology based on aquatic life use attainment data.

Table 22. Chemical parameters measured above screening levels in samples collected by Ohio EPA from surficial sediments in the Auglaize River and Maumee River, October, 2012. Sampling locations are indicated by river mile (RM).

Parameter	Auglaize River (RM 5.9)	Maumee River (RM 32.7)
Cadmium (mg/kg)	1.16[1,2]	1.30[1,2]
Nickel (mg/kg)	26.0[2]	27.2[2]

[1] Exceedance of the Ohio Sediment Reference Values for the Huron/Erie Lake Plains Ecoregion
[2] Exceedance of the Threshold Effect Concentration (MacDonald, et.al. 2000)

Fish Tissue Contamination

Ohio has been sampling streams annually for sport fish contamination since 1993. Fish are analyzed for contaminants that bioaccumulate in fish and that could pose a threat to human health if consumed in excessive amounts. Contaminants analyzed in Ohio sport fish include mercury, PCBs, DDT, mirex, hexachlorobenzene, lead, selenium, and several other metals and pesticides. Other contaminants are sometimes analyzed if indicated by site-specific current or historic sources. For more information about the chemicals analyzed, how fish are collected, or the history of the fish contaminant program, see: State Of Ohio Cooperative Fish Tissue Monitoring Program Sport Fish Tissue Consumption Advisory Program, Ohio EPA, January 2010 (http://www.epa.state.oh.us/portals/35/fishadvisory/FishAdvisoryProcedure10.pdf).

Fish contaminant data are primarily used for three purposes: 1) to determine fish advisories; 2) to determine attainment with the water quality standards; and 3) to examine trends in fish contaminants over time.

Fish advisories

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

For the Maumee River, enough data were collected to issue advisories for freshwater drum, flathead catfish, smallmouth buffalo, smallmouth bass, and common carp. All other species caught in the Maumee should follow the statewide advice of two meals a week for sunfish and yellow perch, one meal a week for most other fish, and one meal a month for flathead catfish 23” and over, and northern pike 23” and over. These advisories are tabulated below:

Table 23. Fish Consumption Advisories for the Maumee River.

One meal per	Species	Contaminant	Reach
Month	Freshwater Drum	Mercury, PCBs	
	Flathead Catfish		
	Smallmouth Buffalo		
	Smallmouth Bass		
	Common Carp		Indiana state line to Defiance (Paulding, Defiance Counties)
Month	Freshwater Drum	Mercury, PCBs	
	Flathead Catfish		
	Smallmouth Buffalo		
	Smallmouth Bass		
	Common Carp		
Month	Channel Catfish	PCBs	Defiance to Perrysburg (Defiance, Henry, Lucas, Wood Counties)
Month	Freshwater Drum	Mercury, PCBs	
	Flathead Catfish		
	Smallmouth Buffalo		
	Smallmouth Bass		
	Common Carp		
2 Months	Channel Catfish	PCBs	Perrysburg to Interstate 75 (Toledo) (Wood and Lucas Counties)
Month	Freshwater Drum	Mercury, PCBs	
	Flathead Catfish		
	Smallmouth Buffalo		
	Common Carp		
Month	Smallmouth Bass	PCBs	
2 Months	Channel Catfish	PCBs	Interstate 75 (Toledo) to mouth (Lake Erie) (Lucas County)

Fish Tissue/Human Health Use Attainment

In addition to determining safe meal frequencies, fish contaminant data are also used to determine attainment with the human health water quality criteria pursuant to OAC Rules 3745-1-33 and 3745-1-34. The human health water quality criteria are presented in water column concentrations of µg/Liter, and are then translated into fish tissue concentrations in mg/kg. [See Ohio's 2012 Integrated Report, Section E (http://www.epa.ohio.gov/portals/35/tmdl/2012IntReport/IR12SectionEfinal.pdf) for further details of this conversion.]

In order to be considered in attainment of the water quality standards, the sport fish caught within a HUC12 must have a weighted average concentration of the geometric means for all species below 0.350 mg/kg for mercury, and below 0.023 mg/kg for PCBs.

Within the Maumee River, represented by three Large River Assessment Units (LRAUs), fish tissue data were adequate to determine attainment status. At least 2 samples from each trophic level, 3 and 4, are needed. All three LRAUs were impaired for PCBs for the fish tissue use due to PCB concentrations which exceeded the criterion of 0.023 mg/kg for the Lake Erie basin. These LRAUs and their average PCB concentrations were as follows:

Maumee River, Indiana border to Tiffin River (04100005 90 01): 0.079 mg/kg PCBs (impaired)
Maumee River, Tiffin River to Beaver Creek (04100009 90 01): 0.081 mg/kg PCBs (impaired)
Maumee River, Beaver Creek to Maumee Bay (04100009 90 02): 0.157 mg/kg PCBs (impaired)

Mercury concentrations for each LRAU were below the basin criterion of 0.350 mg/kg and were not impaired for that or any contaminant other than PCBs.

Fish Contaminant Trends

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

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

Fish tissue samples were collected from the Maumee River in 1974, 1990, 1993, 1995, 2008, and 2012. No PCBs were detected in fish prior to 1990. Trophic level 4 PCB concentrations and trophic level 3 mercury concentrations seem generally stable across time. Trophic level 3 PCB concentrations and trophic level 4 mercury concentrations show substantial fluctuations across years, but no clear trend is evident. Average mercury and PCB concentrations are tabulated below. Trophic level 3 fish showed a substantial (92%) increase in PCB concentrations between 2008 and 2012, but this appears to be largely due to two individual fish caught with very high PCB concentrations, greater than 2 mg/kg. Trophic level 4 fish for PCBs and both trophic levels for mercury showed similar concentrations between 2008 and 2012. Trophic level 4 fish are top piscivores, including the walleye and smallmouth bass. Trophic level 3 fish include the common carp, flathead catfish, bluegill sunfish, and black crappie. Various pesticides have occasionally been detected at trace levels, but not at concentrations of concern.

Table 24. PCB concentrations by year and trophic level.

Trophic Level 3			Trophic Level 4		
Year	Average PCB concentration (mg/kg)	# Samples	Year	Average PCB Concentration (mg/kg)	# Samples
1990	0.034	36	1990	0.014	11
1993	0.786	7	1993	0.036	2
1995	0.160	34	1995	0.070	27
2008	0.144	51	2008	0.074	34
2012	0.277	47	2012	0.069	24

Table 25. Mercury concentrations by year and trophic level.

Trophic Level 3			Trophic Level 4		
Year	Average Mercury Concentration (mg/kg)	# Samples	Year	Average Mercury Concentration (mg/kg)	# Samples
1974	0.199	40	1974	0.248	16
1990	0.196	32	1990	0.268	9
1993	0.053	7	1993	0.1	2
1995	0.118	33	1995	0.151	27
2008	0.229	60	2008	0.312	25
2012	0.202	277	2012	0.375	69

Table 26. Select fish tissue data from the 2012 Maumee River sampling. The shading indicates the fish consumption advisory category that applies. Green = unrestricted or two meals per week, yellow = one meal per week, orange = one meal per month. The pesticides DDT and dieldrin were detected in some fish but generally at trace levels and never at concentrations that would trigger a fish consumption advisory.

Mercury and PCB concentrations for the Maumee River, 2012.				
Year	Site	Species Name	Mercury Concentration (mg/kg)	Total PCB Concentration (µg/kg)
2012	Maumee R. @ Antwerp City Park	CHANNEL CATFISH	**0.082**	0
2012	Maumee R. @ Antwerp City Park	WALLEYE	**0.156**	0
2012	Maumee R. @ Antwerp City Park	FRESHWATER DRUM	**0.216**	0
2012	Maumee R. @ Antwerp City Park	FLATHEAD CATFISH	**0.218**	**59.8**
2012	Maumee R. @ Antwerp City Park	COMMON CARP	**0.222**	**280**
2012	Maumee R. @ Buttonwood Park	SMALLMOUTH BUFFALO	**0.112**	**260.6**
2012	Maumee R. @ Buttonwood Park	COMMON CARP	**0.12**	**3100**
2012	Maumee R. @ Buttonwood Park	CHANNEL CATFISH	**0.16**	**453**
2012	Maumee R. @ Buttonwood Park	SMALLMOUTH BASS	**0.281**	**186.7**
2012	Maumee R. @ Buttonwood Park	WHITE BASS	**0.318**	**705**
2012	Maumee R. @ Buttonwood Park	WALLEYE	**0.385**	**320**
2012	Maumee R. @ Buttonwood Park	FRESHWATER DRUM	**0.398**	0
2012	Maumee R. @ Co. Rd. 105	COMMON CARP	**0.276**	0
2012	Maumee R. @ Co. Rd. 105	FLATHEAD CATFISH	**0.408**	**122.8**
2012	Maumee R. @ Co. Rd. 105	FRESHWATER DRUM	**0.73**	**178.5**
2012	Maumee R. @ Eagle Point Colony	COMMON CARP	**0.095**	**511**
2012	Maumee R. @ Eagle Point Colony	FLATHEAD CATFISH	**0.103**	**153.8**
2012	Maumee R. @ Eagle Point Colony	SMALLMOUTH BUFFALO	**0.147**	**248**
2012	Maumee R. @ Eagle Point Colony	LARGEMOUTH BASS	**0.238**	0
2012	Maumee R. @ Eagle Point Colony	FRESHWATER DRUM	**0.41**	**64.2**
2012	Maumee R. @ Mary Jane Thurston Park	SMALLMOUTH BUFFALO	**0.089**	0
2012	Maumee R. @ Mary Jane Thurston Park	BIGMOUTH BUFFALO	**0.165**	0
2012	Maumee R. @ Mary Jane Thurston Park	COMMON CARP	**0.227**	**175.1**
2012	Maumee R. @ Mary Jane Thurston Park	FRESHWATER DRUM	**0.5**	0
2012	Maumee R. @ Ostego Park	WALLEYE	**0.136**	0
2012	Maumee R. @ Ostego Park	LARGEMOUTH BASS	**0.156**	0
2012	Maumee R. @ Ostego Park	SMALLMOUTH BUFFALO	**0.181**	**257.1**
2012	Maumee R. @ Ostego Park	COMMON CARP	**0.182**	**1445**
2012	Maumee R. @ Ostego Park	FRESHWATER DRUM	**0.258**	0
2012	Maumee R. @ Ostego Park	FLATHEAD CATFISH	**0.259**	**86.6**
2012	Maumee R. @ St. Rt. 64	CHANNEL CATFISH	**0.114**	**951**
2012	Maumee R. @ St. Rt. 64	WALLEYE	**0.152**	0
2012	Maumee R. @ St. Rt. 64	COMMON CARP	**0.226**	**440**
2012	Maumee R. @ St. Rt. 64	FRESHWATER DRUM	**0.28**	0
2012	Maumee R. @ St. Rt. 64	SMALLMOUTH BASS	**0.334**	**51.8**

Mercury and PCB concentrations for the Maumee River, 2012.				
Year	Site	Species Name	Mercury Concentration (mg/kg)	Total PCB Concentration (µg/kg)
2012	Maumee R. @ Switzer Rd.	CHANNEL CATFISH	**0.054**	0
2012	Maumee R. @ Switzer Rd.	FLATHEAD CATFISH	**0.237**	**183.8**
2012	Maumee R. @ Switzer Rd.	SMALLMOUTH BUFFALO	**0.315**	0
2012	Maumee R. @ Switzer Rd.	COMMON CARP	**0.343**	0
2012	Maumee R. @ Switzer Rd.	FRESHWATER DRUM	**0.888**	0
2012	Maumee R. @ U.S. Rt. 127	COMMON CARP	**0.301**	**346**
2012	Maumee R. @ U.S. Rt. 127	CHANNEL CATFISH	**0.404**	**364.5**
2012	Maumee R. @ U.S. Rt. 127	FLATHEAD CATFISH	**0.417**	**163.9**
2012	Maumee R. @ U.S. Rt. 127	FRESHWATER DRUM	**0.803**	0
2012	Maumee R. @ U.S. Rt. 6	SMALLMOUTH BUFFALO	**0.09**	0
2012	Maumee R. @ U.S. Rt. 6	WHITE CRAPPIE	**0.106**	0
2012	Maumee R. @ U.S. Rt. 6	COMMON CARP	**0.139**	**145.9**
2012	Maumee R. @ U.S. Rt. 6	FLATHEAD CATFISH	**0.195**	0
2012	Maumee R. @ U.S. Rt. 6	FRESHWATER DRUM	**0.341**	**69.6**
2012	Maumee R. dst. Defiance GMC	COMMON CARP	**0.124**	0
2012	Maumee R. dst. Defiance GMC	WHITE CRAPPIE	**0.125**	0
2012	Maumee R. dst. Defiance GMC	SMALLMOUTH BUFFALO	**0.128**	**52.8**
2012	Maumee R. dst. Defiance GMC	FLATHEAD CATFISH	**0.183**	0
2012	Maumee R. dst. Defiance GMC	FRESHWATER DRUM	**0.203**	0
2012	Maumee R. near Girty Island	WHITE CRAPPIE	**0.156**	0
2012	Maumee R. near Girty Island	SMALLMOUTH BUFFALO	**0.218**	**277**
2012	Maumee R. near Girty Island	COMMON CARP	**0.293**	**2079**
2012	Maumee R. near Girty Island	FRESHWATER DRUM	**0.39**	0
2012	Maumee R. near Girty Island	CHANNEL CATFISH	**0.432**	**342.1**
2012	Maumee R. near Girty Island	FLATHEAD CATFISH	**0.496**	0
2012	Maumee R. upst. Auglaize R.	COMMON CARP	**0.185**	**284**
2012	Maumee R. upst. Auglaize R.	CHANNEL CATFISH	**0.197**	**50.8**
2012	Maumee R. upst. Auglaize R.	FLATHEAD CATFISH	**0.265**	**83.9**
2012	Maumee R. upst. Auglaize R.	BIGMOUTH BUFFALO	**0.28**	**82.1**
2012	Maumee R. upst. Auglaize R.	FRESHWATER DRUM	**0.421**	0
2012	Maumee R. upst. Napolean WWTP	SMALLMOUTH BUFFALO	**0.097**	0
2012	Maumee R. upst. Napolean WWTP	WHITE CRAPPIE	**0.1**	0
2012	Maumee R. upst. Napolean WWTP	COMMON CARP	**0.117**	0
2012	Maumee R. upst. Napolean WWTP	FLATHEAD CATFISH	**0.149**	0
2012	Maumee R. upst. Napolean WWTP	FRESHWATER DRUM	**0.636**	0

Stream Physical Habitat

Maumee River

The physical habitat quality in the Maumee River mainstem was sufficiently intact to support assemblages of fish consistent with beneficial aquatic life uses (Table 27). Within the free-flowing WWH sections of the river, QHEI scores from twelve stream sampling locations averaged 74.7 ± 6.1 SD. The free-flowing sections contained near and in-stream macrohabitat features consistent with WWH. The dominant substrates were sand, gravel, and bedrock originating from limestone and glacial tills. Silt coverage was normal to moderate with normal to moderate amounts of substrate embeddedness. Extensive to moderate amounts of instream cover, largely deep pools and large woody debris provide refugia for fish (Table 28).

Within the MWH-I sections of the Maumee River, QHEI scores from six sampling locations averaged 52.2 ± 6.3 SD. The modified areas are defined by dam impoundments. These impoundments impede flow resulting in macrohabitat features that limit fish assemblages. The impounded sections had less development and rocky substrates than the free-flowing sections. These river sections also had more silt, less sinuosity, and less instream cover than the WWH sections.

Five lacustrine sampling locations classified as WWH were evaluated using the Lacustuary QHEI and averaged 45.7 ± 6.9 SD. Lack of flow, high sediment loads, and sparse in-stream cover limited the fish assemblages in this portion of the river. The declining gradient of habitat quality from the free-flowing sections of the Maumee River to the lacustrine section is mirrored by the fish community. The free-flowing sections had higher fish diversity and more pollution sensitive taxa than the lacustrine Maumee River.

Auglaize River

The two WWH sites sampled on the Auglaize River (RMs 28.5 and 3.2) had QHEI scores of 80.5 and 65.0, respectively. The substrates for each site were of limestone and glacial till, and the river has no signs of historic channelization. The strong WWH fish assemblages at these sites mirror the excellent to good habitat quality.

Three sites were sampled between Oakwood at SR 613 (RM 19.3) and Beetree Run (RM 6.59) that are classified as MWH–I. All three of the sites are impounded by the Toledo Edison Power Dam near Defiance. The sites averaged a 46.3 QHEI and had a range of 43.5 – 48.8. The macrohabitat throughout this reach lacks the flow, clean substrates, and the in-stream cover to support fish assemblages of the same quality as the free-flowing sections. The impounded reach had a higher proportion of omnivores and fewer insectivores than the free-flowing sections. If the impounded section was returned to more normal flows, the habitat would increase in quality to support a stronger WWH fish community.

Table 27. Stream physical habitat (QHEI) summarized results for the Maumee and Auglaize Rivers, 2012-13.

LRAU	STREAM	RIVER MILE	DRAINAGE AREA (mi^2)	LOCATION	QHEI (2012/2013)
04100005 90 01	Maumee River	107.10	2119.0	0.9 mile downstream Ohio/Indiana state line	74.3
	Maumee River	99.00	2129.0	At Antwerp, at Antwerp City Park	80.8
	Maumee River	91.48	2168.0	4 miles Northeast of Antwerp, at Eater Rd.	69.3
	Maumee River	85.26	2203.0	North of Cecil at Co. Rd. 105	73.8
	Maumee River	80.10	2275.0	South of Sherwood at mouth of Platter Creek	83.8
	Maumee River	76.15	2292.0	South of the bend at Bend Rd.	65.5/61.0
	Maumee River	69.20	2311.0	West of Defiance, downstream intersection Switzer Rd/Dowe Rd.	70.5
04100009 90 01	Maumee River	62.30	5540.0	Near Defiance at St. Rt. 281 (north bank)	46.0
	Maumee River	60.00	5543.0	Upstream Independence Dam (mid river)	49.0
	Maumee River	58.50	5551.0	East of Defiance, upstream Snyder Rd./Weichman Rd	85.8/71.0
	Maumee River	52.10	5578.0	East of Florida, downstream Wade Creek	62.5
	Maumee River	47.10	5649.0	At Napoleon at water works intake	51.5
	Maumee River	41.24	5693.0	Southwest of Liberty Center at railroad bridge, upstream St. Rt. 109	47.5
	Maumee River	32.60	6054.0	Upstream Grand Rapids Dam	56.5
	Maumee River	31.64	6058.0	At Grand Rapids, at St. Rt. 578 (Bridge St.)	71.5/77.0
04100009 90 02	Maumee River	26.70	6264.0	Near Otsego at confluence of Sugar Creek	72.0
	Maumee River	20.68	6330.0	At Waterville, at St. Rt. 64	72.0
	Maumee River	16.52	6340.0	At Buttonwood recreation area	84.3
	Maumee River	13.30	6367.0	Downstream Ewing Island	45
	Maumee River	9.40	6389.0	Near Eagle Point Colony	35
	Maumee River	5.80	6397.0	At Toledo, at Anthony Wayne bridge	51
	Maumee River	3.60	6602.0	At Toledo, downstream I-280	45
	Maumee River	0.50	6606.0	At Toledo, near mouth	52.5
04100007 90 0	Auglaize River	28.50	719.0	At Cloverdale, at St. Rt. 114	80.5
	Auglaize River	19.30	1509.0	At Oakwood, at St. Rt. 613	48.8
	Auglaize River	14.94	2041.0	At Charloe, at Co. Rd. 138	46.5
	Auglaize River	6.59	2315.0	Upstream Beetree Run at Package WWTP	43.5
	Auglaize River	3.2	2428.0	Near Defiance, downstream Powell Creek	65.0

General narrative ranges assigned to QHEI scores.

Narrative Rating		QHEI Range		
		Headwaters (≤20 sq mi)	Larger Streams	Lacustuary
Excellent		≥70	≥75	≥80
Good		55 to 69	60 to 74	60 to 80
Fair		43 to 54	45 to 59	45 to 59
Poor		30 to 42	30 to 44	30 to 44
Very Poor		<30	<30	<30

Table 28. QHEI attribute report for locations sampled in the Maumee and Auglaize Rivers, 2012-13.

QHEI Attributes: Maumee River/Auglaize River Mainstems 2012-13

River Mile	QHEI	Gradient (ft/mi)	Not Channelized or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Development	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low/Normal Embeddedness	Max Depth>40cm	Low/Normal Riffle Embeddedness	WWH Attributes	Channelized/No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth <40cm	High-influence Modified Attributes	Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Only 1 or 2 Cover Types	Low Sinuosity	Intermittent/Poor Pools	No Fast Current	High/Moderate Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	M.I. Modified Attributes	MWH M.I.+1/WWH+1 Ratio	MWH M.I./WWH Ratio
04-001-000			**Maumee River**																																
Year:		**2012**																																	
107.1	74.3	1.08	X	X		X	X	X			X		6				X		1		X							X	X	X		4	0.29	0.86
99.0	80.8	0.95	X	X		X	X	X	X	X	X	X	9						0		X								X			2	0.10	0.40
91.5	69.3	0.95	X	X		X		X	X		X		6					X	1		X				X				X	X		4	0.29	0.86
85.3	73.8	1.15	X	X		X		X	X		X		6						0		X				X				X	X		4	0.14	0.86
80.1	83.8	1.15	X	X		X		X	X		X		6						0		X				X				X	X		4	0.14	0.86
76.1	61.0	0.70	X	X		X		X			X		5			X			1		X			X				X	X		X	5	0.33	1.17
69.0	70.5	1.00	X	X		X		X	X		X		6					X	1		X				X				X	X		4	0.29	0.86
62.3	46.0	0.10	X					X			X		3		X	X		X	3		X			X				X	X		X	5	1.00	1.75
60.4	49.0	0.10	X					X			X		3		X	X		X	3		X			X				X	X		X	5	1.00	1.75
58.1	71.0	1.78	X	X		X	X	X			X		6					X	1		X				X				X	X	X	5	0.29	1.00
52.1	62.5	1.04	X	X				X			X		4			X	X		2		X			X				X	X		X	5	0.60	1.40
47.1	51.5	0.54	X	X				X			X		4		X	X	X		3		X			X				X	X		X	5	0.80	1.40
41.2	47.5	0.54	X								X		2		X	X	X		3		X			X				X	X		X	5	1.33	2.33
32.8	56.5	0.10	X	X				X			X		4			X			1					X				X	X		X	4	0.40	1.20
31.6	77.0	3.05	X	X		X		X	X	X	X		7			X			1											X		1	0.25	0.38
26.7	72.0	6.94	X	X		X		X			X		5						0		X				X			X	X	X		5	0.17	1.17
20.7	72.0	4.17	X			X	X	X	X	X	X	X	8					X	1						X							1	0.22	0.33
16.5	84.3	2.92	X	X		X	X	X	X	X	X	X	9						0						X							1	0.10	0.30
Year:		**2013**																																	
76.1	65.5	0.70	X	X				X			X		4						0	X	X			X	X			X	X		X	7	0.40	1.80
58.1	85.8	1.78	X	X		X	X	X	X		X		7						0		X								X	X		3	0.13	0.63
31.6	71.5	3.05	X			X			X		X	X	5					X	1		X				X				X			3	0.33	0.83
04-100-000			**Auglaize River**																																
Year:		**2012**																																	
28.8	80.5	5.56	X			X		X	X	X	X	X	7						0						X							1	0.13	0.38
19.3	48.8	0.10	X					X			X		3				X	X	2		X		X	X				X	X		X	6	0.75	2.00
15.0	46.5	0.10	X					X			X		3		X	X	X		3		X			X				X	X		X	5	1.00	1.75
6.6	43.5	0.10	X								X		2		X	X	X		3		X			X				X	X		X	5	1.33	2.33
3.2	65.0	0.65	X	X		X		X			X		5					X	1		X				X				X	X	X	X	6	0.33	1.33

Fish Community

Maumee River

A total of 23,378 fish representing 56 species and 6 hybrids were collected from the riverine section of the Maumee River study area between June and September, 2012, and June through October, 2013. The survey effort included 50 sampling events at 18 stations, evaluating 91 miles of the Maumee River between RM 107.1 (Ohio-Indiana border) and RM 16.5 (Buttonwood Recreation Area, Perrysburg, Ohio). Relative numbers and species collected per location are presented in Appendix C and IBI and MIwb scores are presented in Appendix D. Sampling locations were evaluated using WWH or MWH-I biocriteria. A summary of the fish scores over time are presented in Table 29.

Table 29. Mean IBI and MIwb scores for selected surveys of the Maumee River.

Year	IBI	MIwb
2013	40.67	9.82
2012	35.67	9.3
1997	28.96	7.68
1984-86	29.47	7.65

The riverine Maumee River mainstem sites sampled during 2012 and 2013 achieved the WWH fish biocriteria at all free-flowing sites (n = 12), and the MWH-I biocriteria at the dam impounded sections (n = 6). One hundred percent of the sites sampled achieved full attainment of designated aquatic life uses, and it is recommended that current aquatic life uses are retained (Table 34).

Based on aggregate catch statistics, Cyprinid minnows and gizzard shad were the numerically dominant taxa (no./km) in the Maumee River (Table 30). In terms of relative biomass (kg/km), common carp (26.4%), flathead catfish (16.3%), freshwater drum (15.3%), channel catfish (9.7%), and smallmouth buffalo (9.0%) were the dominant taxa. Fourteen percent of the aggregate catch consisted of 15 pollution sensitive taxa (Table 31).

Table 30. Minnows and gizzard shad were numerically dominant in the Maumee River in 2012 - 2013.

Species	Percent Relative Catch (no./km)
Spotfin Shiner	26.45%
Bluntnose Minnow	15.28%
Gizzard Shad	9.41%
Sand Shiner	9.21%
Ghost Shiner	6.60%
Emerald Shiner	5.94%
Total	**72.89%**

The lower 15 miles of the Maumee River are a lacustuary to Lake Erie, and are designated WWH. A total of 2,022 fish representing 35 species and 2 hybrids were collected from the lacustuary between June and August 2012. The survey effort included 11 sampling events at five stations, evaluating the lower 15 miles of the Maumee River lacustuary to the mouth. Sampling locations were evaluated using the proposed lacustuary metrics. These biocriteria are not promulgated into law so attainment status is based on a narrative determination of the designated use using IBI and MIwb scores adapted to lacustrine conditions. The lacustrine Maumee River failed to attain the WWH fish biocriteria at all sites sampled (n = 5).

Table 31. Fifteen pollution sensitive taxa were collected in 2012 – 2013, an increase of seven taxa since 1997.

2012-2013 Maumee River Survey Sensitive Taxa	
Eastern Sand Darter	River Redhorse
Greenside Darter	Shorthead Redhorse
Logperch	Silver Redhorse
Brindled Madtom	Golden Redhorse
Stonecat Madtom	Northern Hog Sucker
Brook Silverside	Smallmouth Bass
Sand Shiner	Longear Sunfish
Rosyface Shiner	

The Maumee River fish community is divided into three distinct assemblages; the free-flowing, the dam impounded, and the lacustrine assemblages. The fish assemblages of the free-flowing and the dam impounded sections were evaluated using biocriteria for the HELP ecoregion. The IBI and MIwb showed a declining trend in fish community quality as the Maumee River transitioned from free-flowing conditions to dam impounded conditions (Figure 37). Fish community scores rebounded downstream of each impoundment.

The free-flowing sections had on average 14 more fish species than the dam pools and nearly six more species classified as pollution sensitive (Table 32). Four species of the genus *Moxostoma* were consistently present in the samples collected from the free-flowing sections of the Maumee River. The silver, river, and shorthead redhorse are all sensitive to siltation and turbidity. This survey is the first time that the river redhorse has been collected on the Maumee River by the Ohio EPA. The recent re-emergence of the river redhorse, and the increased abundance of other silt sensitive sucker species, is indicative of reduced siltation and turbidity during low flow conditions. Richards et al. (2009) stated that loads and concentration of sediments have been declining in the Maumee River on the order of approximately 10% per decade since the 1970s.

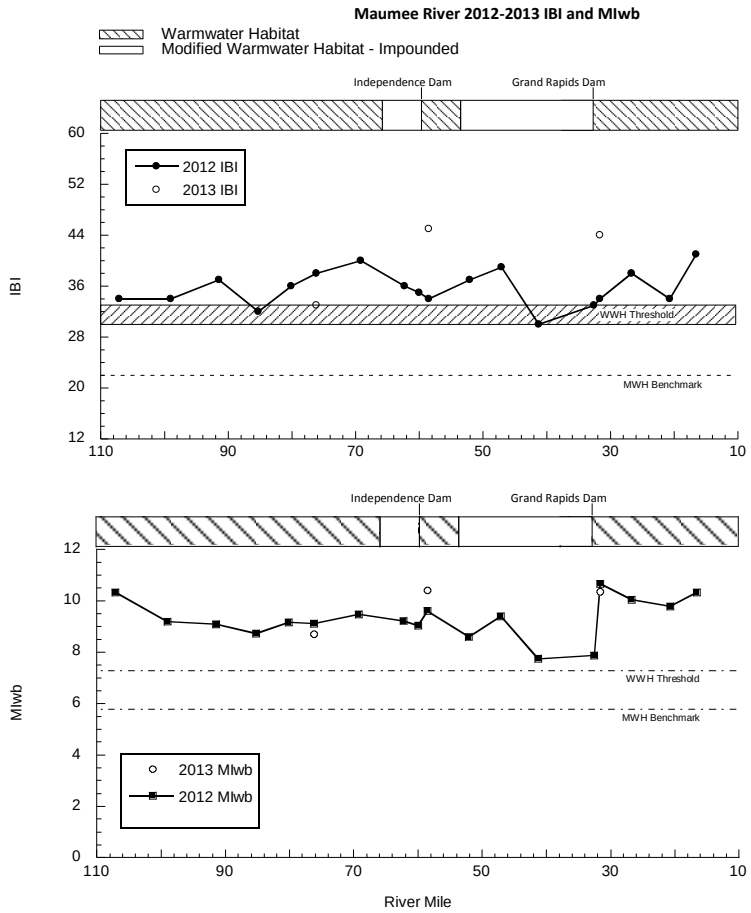

Figure 37. Longitudinal IBI and MIwb scores for the Maumee River survey in 2012 - 2013. Metric scores are depressed in the dam pools (MWH-I).

Other silt intolerant taxa collected in the free-flowing sections included the brindled madtom, the rosyface shiner, and the eastern sand darter. Two specimens of the eastern sand darter (*Ammocrypta pellucida)* were collected on the Maumee River; one at RM 99.0, at Antwerp, and one at RM 58.1 downstream of the Independence dam in Defiance. The eastern sand darter was once found throughout the Maumee River watershed, but increased siltation from channelization, drainage activities, urban development, and removal of riparian areas caused the eastern sand darter to be extirpated from the Ohio portion of the Maumee River for over 65 years. Recent collections in the Ohio portion of the Maumee River by Tessler et al. (2011) provide evidence of improved habitat conditions in the Maumee River near Antwerp. In 2013, the Ohio EPA collected an eastern sand darter nearly 40 miles downstream at RM 58.1 in Defiance. Changes in upstream agricultural practices

and reduced sediment loads since the 1970s may be reducing siltation in the Maumee River, allowing for the recolonization of the eastern sand darter and other sensitive fish taxa.

The two sections of the Maumee River impounded by the Independence and Grand Rapids dams had IBI scores that were similar to the free-flowing section of the river, and median MIwb scores that were lower than the free-flowing sections. While the IBI scores are similar, the fish assemblages in the impounded sections were less diverse, contained fewer pollution-sensitive taxa, and contained a higher proportion of common carp than the free-flowing sections (Table 32).

Table 32. The free-flowing sections of the Maumee River support more fish species and more pollution sensitive fish taxa than the impounded and lacustuary sections. The number of sampling events is presented in parentheses.

Maumee River 2012-2013			
	No. of Taxa	No. Sensitive Taxa	No. Tolerant Taxa
Free-Flowing (n = 30)	56	16	10
Dam Impounded (n = 16)	34	8	7
Lacustuary (n = 11)	35	6	12

The lower 15 miles of the Maumee River are classified as a lacustuary to the western basin of Lake Erie. The lower 7 miles are a Federal Navigation Channel, of which the lower 6.5 miles are actively dredged. The impounded nature of the lacustrine portion of the river and the active habitat modification in the shipping channel, along with an urban landscape, is reflected in the fish assemblage. The lacustuary has fewer total taxa, fewer sensitive taxa, and a higher proportion of exotic fish. The exotic fishes, round goby and white perch, were collected exclusively in the lower 13.3 miles of the Maumee River. This is likely due to the back flow of Lake Erie water into the lacustuary portion of the river.

Auglaize River

A total of 2,618 fish representing 41 species and two hybrids were collected in the lower 29 miles of the Auglaize River study area in 2012. The survey effort included 10 sampling events at five stations evaluating 33.2 river miles from RM 33.2 to the mouth. Relative numbers and species collected per location are presented in Appendix C and IBI and MIwb scores are presented in Appendix D. Sampling locations were evaluated using WWH or MWH-I biocriteria.

2012 Auglaize River Survey Sensitive Taxa	
Golden Redhorse	Stonecat Madtom
Black Redhorse	Greenside Darter
Silver Redhorse	Logperch
Shorthead Redhorse	Brook Silverside
Northern Hog Sucker	Sand Shiner
Smallmouth Bass	Longear Sunfish

Table 33. Approximately 13% of the fish collected on the Auglaize River consisted of 12 pollution sensitive taxa.

The Auglaize River sites sampled in 2012 achieved the WWH fish biocriteria at all free-flowing sites (n = 2), and the recommended MWH-I biocriteria were achieved at the dam impounded sections (n = 3). Previous monitoring in this assessment unit focused on free-flowing reaches as the Defiance Power Dam impoundment was considered a reservoir and assessed as part of the Ohio inland lakes and reservoirs program. However, due to renewed power generation at the EGS facility, which modified reservoir retention time considerably, the recommendation was made to assign the MWH-I aquatic life use to the riverine impounded reach. One hundred percent of the sites sampled achieved full attainment of designated or recommended aquatic life uses, and it is recommended that assigned aquatic life uses are retained (Table 34).

Nearly a third of the fish biomass collected in the Auglaize River can be attributed to common carp (715 kg, 32.75%); popular sport fishes, the channel catfish (222 kg, 11%) and the flathead catfish (103 kg, 6%)

also contribute a significant amount of biomass. Similar to the Maumee River fish community, approximately 13% of the total catch consisted of pollution sensitive taxa (Table 33). The fish assemblage of the impounded section were similar to the free-flowing sections. The impounded sections had a higher proportion of omnivores and fewer insectivores than the free-flowing sections. If the Auglaize River returned to a more natural flow throughout the impounded section, it is likely that the fish community will fully meet WWH expectations.

Table 34. Fish community summaries based on pulsed D.C. electrofishing sampling conducted by Ohio EPA in the Maumee River and Auglaize River study areas during the 2012 – 2013 sampling seasons. Relative numbers and weight are per 1.0 km for boat sites. Sites highlighted in yellow were evaluated based on proposed lacustuary biocriteria.

LRAU	River Mile	Sampling Method	Fish Species (Total)	Relative Number (no./km)	Relative Weight (kg/km)	QHEI (Habitat)	**IBI**	**MIwb**	Narrative Evaluation
04100005 90 01	**Maumee River 2012 (04-001)**								
	Aquatic Life Use WWH (Existing)								
	107.10	Boat	27	1452.0	94.02	74.3	**34**	**8.18**^{ns}	Marginally Good
	99.00	Boat	25	2247.0	188.67	80.8	**34**	**9.19**	Marginally Good
	91.48	Boat	26	1280.0	132.44	69.3	**37**	**9.08**	Marginally Good
	85.26	Boat	24	1638.0	90.42	73.8	**32**^{ns}	**8.72**	Fair
	80.10	Boat	26	1464.0	201.99	83.8	**36**	**9.17**	Marginally Good
	76.15	Boat	21	1298.0	109.81	63.3	**38**	**9.1**	Good
	69.20	Boat	25	1987.0	73.68	70.5	**40**	**9.47**	Good
04100009 90 01	**Aquatic Life Use MWH-I (Existing)**								
	62.30	Boat	24	1028.0	94.98	46.0	**36**	**9.22**	Marginally Good
	60.00	Boat	26	803.0	97.39	49.0	**35**	**9.04**	Marginally Good
	Aquatic Life Use WWH (Existing)								
	58.50	Boat	30	2236.3	42.46	78.4	**34**	**9.6**	Marginally Good
	Aquatic Life Use MWH-I (Existing)								
	52.10	Boat	27	1408.0	54.05	62.5	**37**	**8.60**	Marginally Good
	47.10	Boat	24	604.0	114.19	51.5	**39**	**9.39**	Good
	41.24	Boat	22	737.0	37.06	47.5	**30**	**7.74**	Fair
	32.60	Boat	25	376.0	63.09	56.5	**33**	**7.88**	Fair
	Aquatic Life Use WWH (Existing)								
	31.64	Boat	28	728.0	263.70	74.3	**34**	**10.65**	Marginally Good

04100009 90 02	26.70	Boat	28	534.0	131.88	72.0	**38**	**10.03**	Good
	20.68	Boat	24	668.0	125.54	72.0	**34**	**9.78**	Marginally Good
	16.52	Boat	30	684.0	186.68	84.3	**41**	**10.33**	Good
	13.3	Boat	22	377.0	50.31	45.0	**33**	**8.77**	Fair
	9.40	Boat	16	329.0	42.64	35.0	**27**	**7.32**	Poor
	5.80	Boat	26	559.0	187.85	51.0	**36**	**8.60**	Fair
	3.6	Boat	22	507.0	171.65	45.0	**39**	**8.88**	Fair
	0.5	Boat	16	315.0	23.17	52.5	**36**	**7.92**	Fair
	Maumee River 2013 (04-001)								
	Aquatic Life Use WWH (Existing)								
	76.15	Boat	24	824.5	164.59	65.5	**33**[ns]	**8.7**	Fair
	58.50	Boat	37	1051.0	178.35	85.75	**45**	**10.4**	Very Good
	31.64	Boat	35	691.0	319.85	71.5	**44**	**10.35**	Very Good
04100007 90 01	**Auglaize River 2012 (04-100)**								
	Aquatic Life Use WWH (Existing)								
	28.50	Boat	29	693.4	142.33	80.5	**45**	**9.79**	Very Good
	Auglaize River 2012 (04-100)								
	Aquatic Life Use MWH-I (Recommended)								
	19.30	Boat	20	330.0	66.31	48.8	**31**	**8.67**	Fair
	14.94	Boat	22	387.0	90.63	46.5	**37**	**8.66**	Marginally Good
	6.59	Boat	16	678.0	36.24	43.5	**33**	**8.22**	Fair
	Auglaize River 2012 (04-100)								
	Aquatic Life Use WWH (Existing)								
	3.20	Boat	26	696.0	85.71	65.0	**35**	**8.87**	Marginally Good

[ns] - Nonsignificant departure from biocriterion (≤4 IBI units; ≤0.5 MIwb units).

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

Biological Criteria							
	Huron-Erie Lake Plain		Lacustuary[1]				
Index - Site Type	WWH	MWH	Exceptional	Good	Fair	Poor	Very Poor
IBI - Boat	34	22	50	42	31	17	<16
MIwb - Boat	8.6	5.7	>9.5	8.6	6.76	5.1	<5.1
ICI	34	-	52	42	25	12	<12

Maumee River Fish Community Trends

Ohio-Indiana Stateline to RM 15

The Maumee River has been extensively surveyed by the Ohio EPA in 1984 - 1986, 1997, and 2012 - 2013. During this time the fish community has significantly improved. The average IBI for Maumee River fish assemblages has increased from the low fair range to marginally good good between 1984 and 2012, and from an average fair MIwb to a very good MIwb (Figure 38).

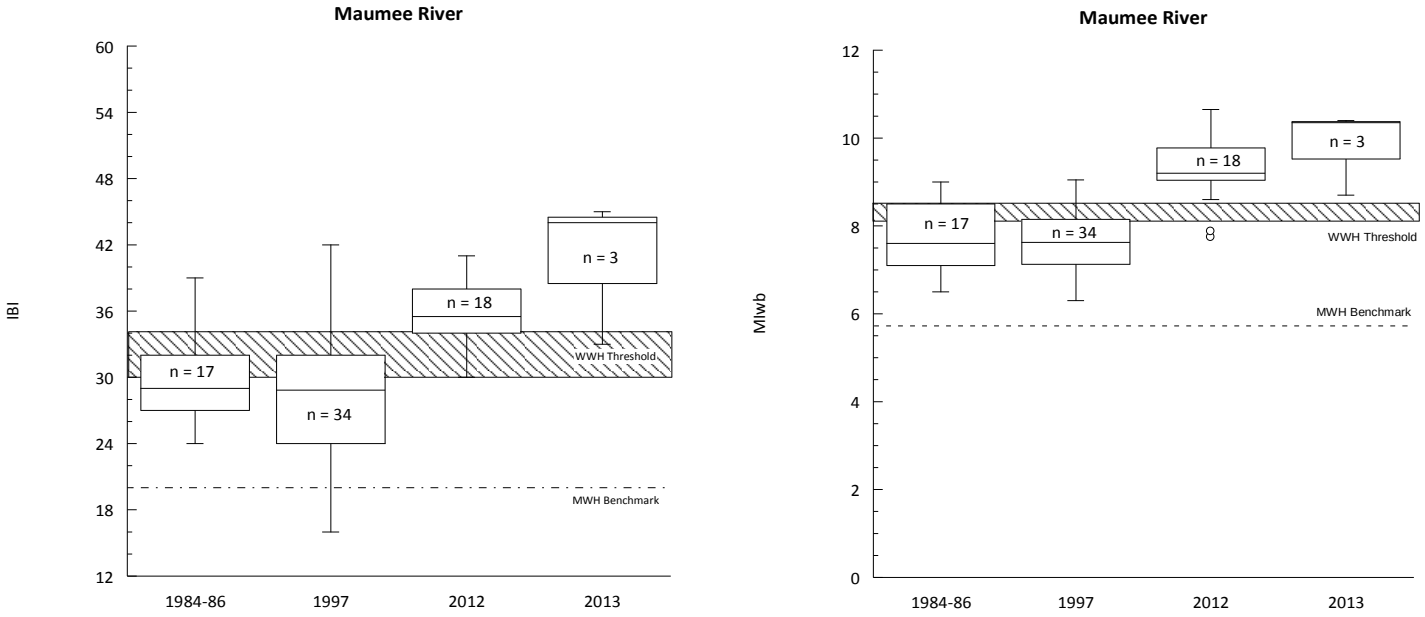

Figure 38. The fish community of the Maumee River has increased in quality as expressed by the IBI and MIwb. The riverine Maumee River is now meeting its designated aquatic life use at all sampling locations.

A One-way ANOVA test of the IBI through time shows that the increase in mean scores was not likely attributable to random variation ($F(3,68) = 10.22$, $p < 0.001$) (Table 35). Similarly, the changes in MIwb scores are not likely from random variation ($F(3,68) = 23.98$, $p < 0.001$) (Table 36).

Source	DF	SS	MS	F	p
Year	3	849.1	283	10.22	<0.001
Error	68	1884	27.7		
Total	71	2733.1			

S = 5.264 R-Sq = 31.07% R-Sq(adj) = 28.03%

Table 35. A one-way ANOVA depicting differences among IBI scores from three electrofishing surveys on the Maumee River in 1984-86, 1997, and 2012-13. IBI scores differed significantly between the three surveys, $F(3, 68) = 10.22$, $p < 0.001$.

Source	DF	SS	MS	F	p
Year	3	43.636	14.5	23.98	<0.001
Error	68	41.238	0.606		
Total	71	84.874			

S = 0.7787 R-Sq = 51.41% R-Sq(adj) = 49.27%

Table 36. A one-way ANOVA depicting differences among MIwb scores from three electrofishing surveys on the Maumee River in 1984-86, 1997, and 2012-13. MIwb scores differed significantly between the three surveys, $F(3, 68) = 23.98$, $p < 0.001$.

The most notable increase in IBI scores occurred upstream of the Independence dam in Defiance. The rest of the riverine portion also scored better in 2012-13 than in 1997, but to a lesser extent. The MIwb is higher at all free-flowing sampling locations in 2012-13 than in 1997 (Figure 39).

In addition to the primary fish community indexes (IBI and MIwb), aggregated metrics, or other indicators, also proved useful in describing gross trends of the environmental conditions of the Maumee River as reflected in the structure of the fish community. To that end, trends of selected components, species or other indicators of the fish assemblage are presented in Figure 40.

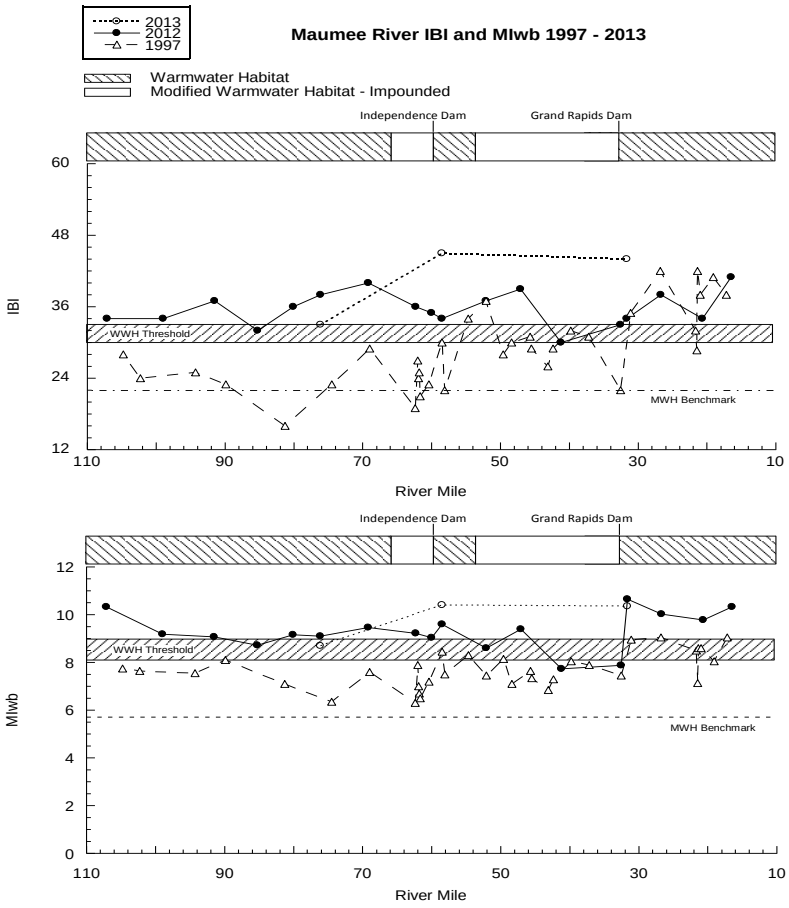

Figure 39. Fish community metrics, the IBI and MIwb, have improved in the Maumee River since comprehensive surveys in 1997.

From the first comprehensive survey in 1984 to the 2012 survey, the Maumee River has accrued six fish taxa, and the number of environmentally sensitive taxa has increased from eleven to fifteen. Additionally, the numbers and biomass of pollution tolerant taxa have declined in the same period. Recreational fishing is popular on the river; sport fish have steadily comprised more biomass of the Maumee River over the last twenty-eight years, representing 26 percent of the biomass collected in 2012-13. The flathead catfish constituted 63%of the biomass of all sport fish collected in 2012-13 and were absent in 1984. The Maumee River has provided ideal habitat for the flathead catfish; low gradient streams with long, deep pools, sluggish waters, and hard bottoms (Trautman 1981 pp 491-493). The flathead catfish was not recorded in the Maumee River until 1992. It is possible that the origin of the Maumee River flatheads was from the relict Lake Erie population or escaped stocked fish. Another fish that has become more prominent in the fish assemblages is the smallmouth buffalo.

The smallmouth buffalo has steadily increased in prominence from <1% of the sampled biomass in 1984-86 to 9% collected in 2012-13. In contrast, the common carp has decreased from 46%in 1984-86 and 54% in 1997 to just 32% of the collected biomass in 2012-13. The common carp is a classic generalist that has a high tolerance for disturbed habitats and degraded water quality (Panek 1987). In large numbers, the smallmouth buffalo inhabit deep, clearer waters of large rivers (Trautman 1981 pp 412-415). Another notable fish whose presence has changed over time is the pollution sensitive sand shiner. This minnow has rebounded considerably, from <1% of the catch (by number) in 1984 to >9% in 2012-13. The sand shiner observed a considerable decline in the Maumee River watershed in the early to mid- 20th century, and was

only collected at a few locations where the current was fast enough to have supported silt-free sand and gravel bottoms (Trautman 1981 pp 364-366).

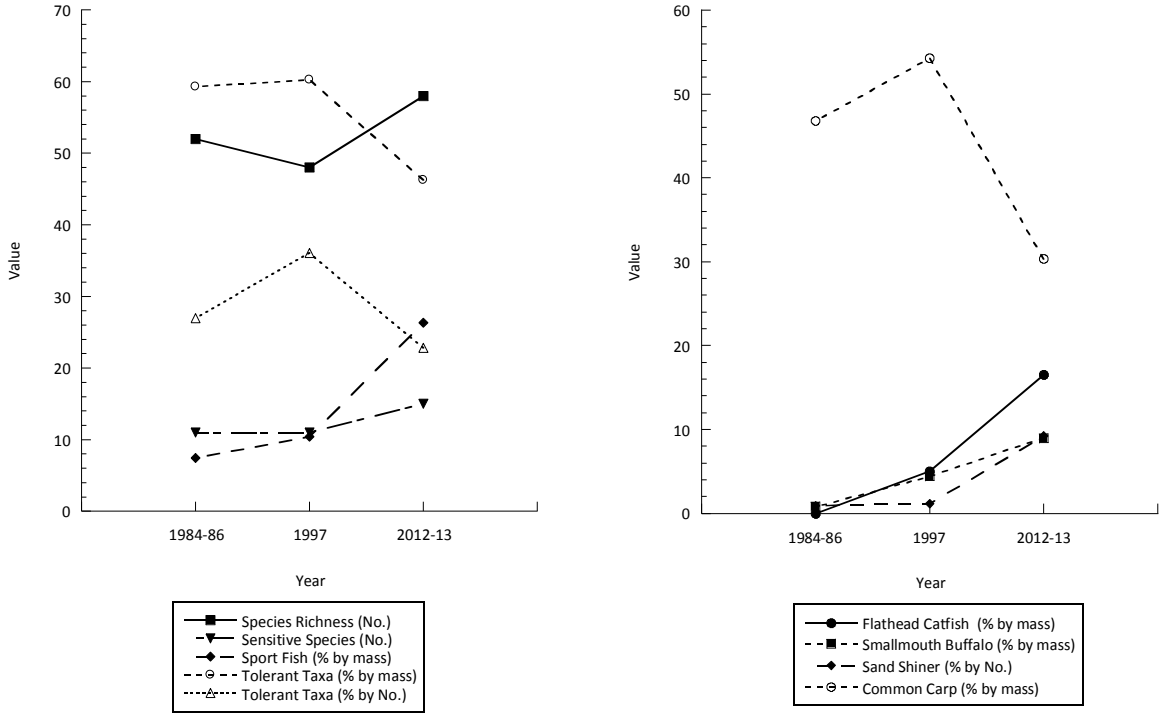

Figure 40. Trends in selected components of the fish assemblage of the non-lacustrine portion of the Maumee River. Results were derived from aggregated catch statistics for the field years: 1982-84, 1997, and 2012-13. Sensitive species included taxa classified as both highly intolerant and moderately intolerant. Common carp and smallmouth buffalo where broken out separately to show both the reduction of a particular pollution tolerant species (common carp) and the increase of a moderately sensitive species (smallmouth buffalo).

The reemergence of the above mentioned pollution sensitive taxa such as the eastern sand darter and sand shiner, the proportional increases in smallmouth buffalo and sport fish, and the decline of the common carp and other pollution tolerant taxa provide multiple lines of evidence that the water quality of the Maumee River has improved over the last 28 years. The changes in the river's fish community provide tangible evidence of successful agricultural best management practices to reduce soil erosion and to prevent sediment loss. This is also evidenced by a steady reduction of Maumee River sediment loads and concentrations on the order of about 10% per decade since the 1970s (Richards 2009).

Despite improvements to reduce sediment loads, low dissolved oxygen levels and large diel swings in the Maumee River may prove detrimental if chronic. Fish are generally able to tolerate, for a short time, dissolved oxygen concentrations below ideal levels (USEPA 1976, pp 123-127). If low dissolved oxygen becomes a "*chronic occurrence, it could have a detrimental effect on long-term survival*" of fish (Canadian Council of Ministers of the Environment 1999).

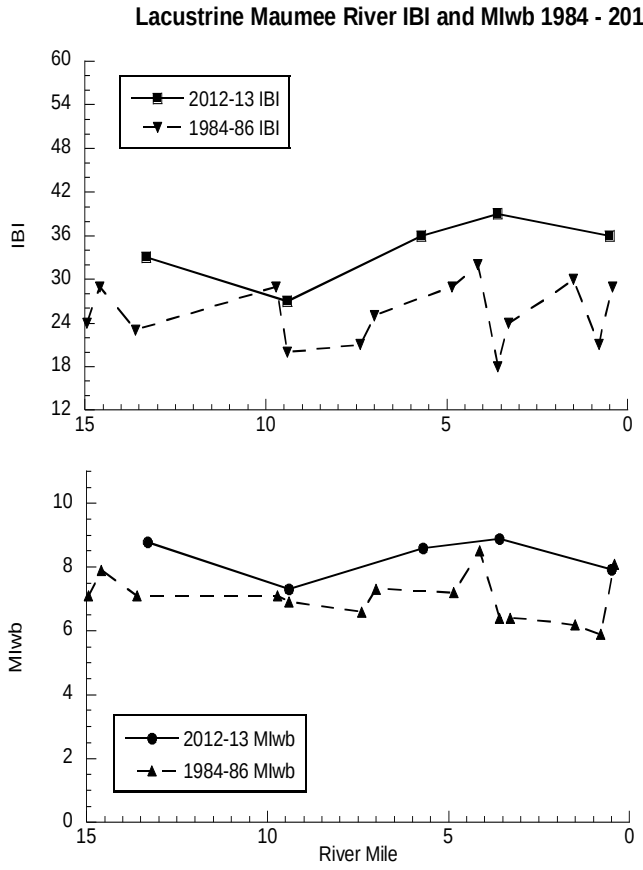

Figure 41. IBI and MIwb scores have improved over the last 28 years in the lower lacustrine Maumee River.

RM 15 to Mouth

The land use of the lower 16.5 river miles of the Maumee River is starkly different than the rest of the river. Here, instead of flowing through a landscape dominated by agriculture, the river flows through the highly urban landscape of the greater Toledo area. Fish community indices have increased slightly since the 1984-86 survey (Figure 41). The fish community in 2012-2013 was characterized as fair to poor for the IBI and fair to good for the MIwb. The fish community is not outside of what is expected for a highly modified river.The fish community here is more representative of a Lake Erie fish community, and due to its proximity to the western basin of Lake Erie, more likely to be impacted by harmful algal blooms than that of the upstream portion of the Maumee River.

Auglaize River Fish Community Trends

The section of the Auglaize River that was sampled in the summer of 2012 has been classified as a large river (>500 mi^2), and was last surveyed in 2000. Community metrics, the IBI and MIwb, have not changed significantly in the intervening period (Figure 42). The IBI is still in the very good to fair range, and the MIwb is in the exceptional to marginally good range. An IBI score jump of 13 points was observed at RM 15. The site went from poor to marginally good, and could be due to renewed flow over the power dam. From 2000 to 2012 the percent of pollution tolerant fish and omnivorous fish has declined, and the percent of top carnivores has increased. The lower Auglaize River flows through an agricultural landscape, and appears to be meeting expectations.

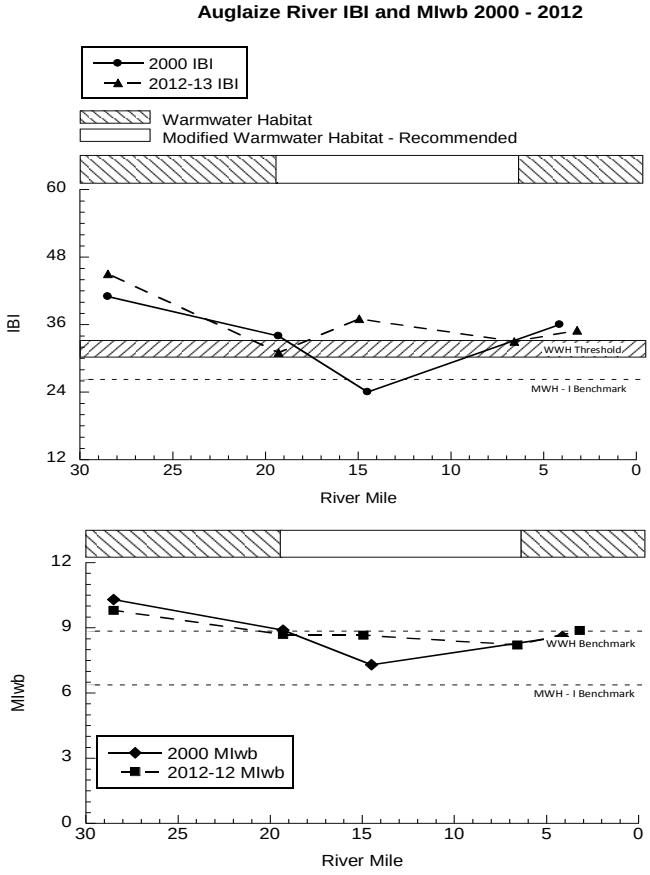

Figure 42. The fish community, as expressed by the IBI and MIwb, for the Auglaize River between 2000 and 2012.

Macroinvertebrate Community

The macroinvertebrate communities from 23 Maumee River locations and five Auglaize River sites were sampled in 2012. Additionally, sampling was repeated at four sites on the Maumee River in 2013. Qualitative sampling was conducted and quantitative Hester-Dendy artificial substrate samples were collected from all sampling locations. A summary of the macroinvertebrate data are presented in Table 39. The macroinvertebrate raw data are presented in Appendices A and B.

Twelve Maumee River and two Auglaize River sampling locations were free-flowing and evaluated based on HELP WWH expectations. Six Maumee River and three Auglaize River sites were impounded by dams and the lower five Maumee River sites (RM 13.3-0.5) were lacustrine. Macroinvertebrate biocriteria have not been developed for impounded and lacustrine river reaches; so a narrative evaluation based on community diversity and structure was used to assess these sites.

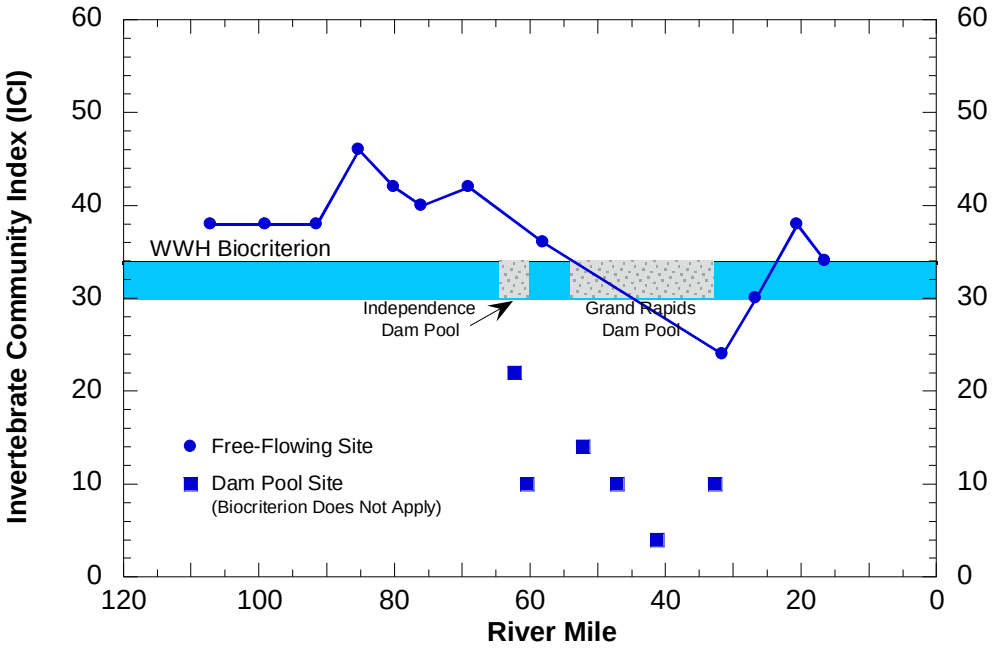

Figure 43. Longitudinal performance of Invertebrate Community Index (ICI) scores in the riverine portion of the Maumee River, 2012.

Eleven of 12 Maumee River and both Auglaize River free-flowing sites sampled during 2012 achieved the applicable macroinvertebrate biocriterion. However, elevated nutrients were indicated in an inordinately high numbers of flatworms and/or aquatic worms at 12 of 14 of the sites. Invertebrate Community Index scores ranged from 46 at RM 85.26 (CR 105) to 24 at RM 31.64 (SR 578). The Maumee River at SR 578 (Bridge St., RM 31.64)), the only site that failed to meet the WWH use, yielded an ICI score of 24 which is in the fair range (Figure 43). Two components of the ICI that were most significantly affected were an absence of mayflies and high tolerant taxa density (primarily aquatic worms) on the artificial substrates. This location was downstream from the Grand Rapids dam which impounds the Maumee River for approximately 22 miles. Hypereutrophic dam pool conditions produce excessive amounts of plankton that then are consumed by organisms downstream. Additionally, a predominance of shallow exposed bedrock substrate at RM 31.64, coupled with extended periods of very low flow, produced elevated water temperatures that exceeded the 31^{o}C WQS criterion during the summer of 2012. These factors negatively affected macroinvertebrate community structure and function in the free-flowing reach immediately

downstream from the impoundment. Under more normal flow and water temperature conditions, the community was modestly improved in 2013. Facultative hydropsychid caddisflies replaced aquatic worms as the predominant taxa and mayfly taxa were recorded. The 2013 ICI score of 30 at RM 31.64 represented a nonsignificant departure of the WWH aquatic life use biocriterion, but still indicated lower than expected community conditions.

Lacustrine macroinvertebrate communities of five Maumee River sites beginning at RM 13.3 were reflective of poor resource conditions. The combination of sedimentation, nutrients and habitat alteration limited taxa diversity and promoted the predominance of a few select facultative and tolerant taxa. As a result, aquatic worms and midges of the *Glyptotendipes* and *Dicrotendipes* genera proliferated at the four upper sites (RMs 13.30- 3.60). These were supplanted by zebra mussels (*Dreissenia polymorpha*) at the most downstream site (RM 0.50) owing to the proximity of the open waters of Maumee Bay.

Maumee River Macroinvertebrate Community Trends

The Maumee River macroinvertebrate sampling results from 2012-13 demonstrated a significant decline in community condition when compared to similar work conducted in 1997. Twelve free-flowing locations sampled between the Indiana-Ohio state line (RM 107.10) and Buttonwood Recreation Area (RM 16.50) in 1997 produced an average ICI score of 52.2 (Table 37). In 2012, the average of ten similar sites was 37.1 and the decline was persistent along the entire reach (Figure 44). Overall, 2012 macroinvertebrate assemblages consisted of fewer facultative and moderately intolerant hydropsychid caddisflies and mayflies and increased numbers of pollution tolerant taxa such as aquatic worms and flatworms. Subsequent resampling of four sites in 2013 demonstrated Marginally Good improved community conditions compared to ICI scores from 2012. It appears that changes in agricultural practices throughout the basin were manifest in the lower quality assemblages observed in 2012-13. The observed reduction in the macroinvertebrate community health in the Maumee River likely is part and parcel of the increased dissolved nutrient loadings that have been implicated in massive cyanobacteria blooms in Maumee Bay in recent years.

Table 37. Average ICI scores and total taxa for the Maumee River from RM 107.10 to RM 16.5 from 1997 and 2012.

Year	Mean ICI	Mean Total Taxa Per Site
1997	52.2	61.2
2012	37.1	57.1

The fish community has improved over the last 28 years while the macroinvertebrate community has seen a significant decline in quality. This is a unique situation. Typically, the Ohio EPA has documented increases, or no changes, of fish and macroinvertebrate community indices of large streams and rivers in Ohio. The reductions in sediment and particulate phosphorus loadings have allowed the bioavailable dissolved phosphorus loading to proportionally increase. The spring and summer of 2012 were characterized by drought conditions and high temperatures, and as a result, flow rates of the Maumee River were lower than normal. The low flow, elevated temperatures, a hypereutrophic dam pool, and shallow bedrock negatively affected the macroinvertebrate community in the Maumee River. In more normal flows, the Maumee acts like a conduit for nutrients. This is observed by the large harmful algal blooms in the Maumee Bay of Lake Erie. The drought conditions in 2012 allowed the excessive nutrient loads to manifest in the Maumee River.

The presence of freshwater mussel specimens, both live and fresh dead shells, is recorded as part of the qualitative sampling that occurs at each site. While it is not an exhaustive sampling effort, comparison of the results from 1997 versus 2012-13 showed a decline in species diversity (Table 38). Fifteen species were recorded in 1997 and included five that were designated as either threatened or a species of concern

(http://www.dnr.state.oh.us/Home/ExperienceWildlifeSubHomePage/Endangeredthreatenedspeciesplaceholder/resourcesmgtplansspecieslist/tabid/5664/Default.aspx). Just ten mussel species were noted in the more recent survey. Two special interest species and one threatened species were absent from sampling completed in 2012-2013. One special interest mussel (*Lasmigona compressa*) was collected in 2013 that was not collected in 1997. This trend is concerning and identifies a need for a more in-depth sampling of this relatively sensitive group of taxa.

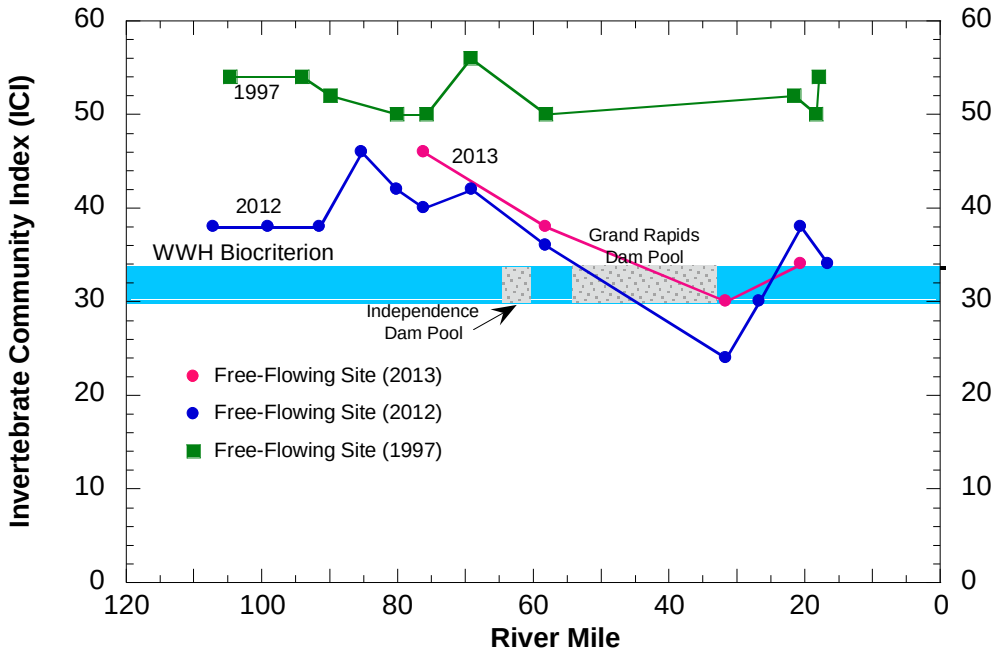

Figure 44. Longitudinal performance of Invertebrate Community Index (ICI) scores in the Maumee River, 1997, 2012 and 2013.

Table 38. Unionid mussel species collected live or fresh dead in the Maumee River, 1997-2012/13. State listed species are designated with T for Threatened Species and S for Species of Concern.

Survey Year	SPECIES TOTAL	*Pyganodon grandis*	*Utterbacia imbecillus*	*Alasmidonta marginata (S)*	*Lasmigona complanata*	*Lasmigona compressa (S)*	*Quadrula pusulosa pusulosa*	*Quadrula quadrula*	*Amblema plicata plicata*	*Fusconaia flava*	*Cyclonaias tuberculata (S)*	*Pleurobema sintoxia (S)*	*Obliquaria reflexa (T)*	*Truncilla truncata (S)*	*Leptodea fragilis*	*Potamilus alatus*	*Lampsilus cardium*	*Lampsilus radiata luteola*
Maumee River Watershed																		
1997	**15**	*		*	*		*	*	*	*	*	*	*	*	*	*	*	*
2012/13	**10**	*	*		*	*	*	*		*				*	*	*		

Table 39. Summary of macroinvertebrate data collected from artificial substrates (quantitative sampling) and natural substrates (qualitative sampling) in the Maumee and Auglaize Rivers, June to October, 2012/2013. Impounded sampling locations are indicated by blue shading. Yellow fill indicates sites assessed with lacustuary metrics and breakpoints; biocriteria are not applicable so community condition is based on a narrative determination of the designated use.

Stream RM	Dr. Area (mi^2)	Total Taxa		EPT Taxa		Sensitive Taxa		Density		Predominant Organisms on the Natural Substrates With Tolerance Category(ies)	ICI	Narrative Evaluation
		Ql.	Qt.	Ql.	Total	Ql.	Total	Ql.	Qt.			
Maumee River (04-001) **2012**												
107.10	2119	51	29	22	26	21	26	M	1681	Flatworms (T), Caddisflies (F, MI)	38	Good
99.00	2129	41	29	19	23	20	26	M	2403	Flatworms (T), Caddisflies (F, MI), Baetid Mayflies (F), Pond Snails (T)	38	Good
91.48	2168	49	36	19	23	18	24	M	3702	Flatworms (T), Baetid Mayflies (F)	38	Good
85.26	2203	48	38	16	25	12	21	M	1191	Flatworms (T), Baetid Mayflies (F)	46	Exceptional
80.10	2275	60	23	19	21	17	19	H	1182	Hydropsychid Caddisflies (F, MI), Baetid Mayflies (F), Riffle Beetles (F)	42	Very Good
76.15	2292	50	35	13	19	12	18	M	2266	Flatworms (T), Caddisflies (F, MI), Riffle Beetles (F)	40	Good
69.20	2311	55	34	19	22	16	21	M	1540	Flatworms (T), Riffle Beetles (F)	42	Very Good
62.30	5540	29	28	6	8	1	3	M	5117	Flatworms (T), Caddisflies (F,)	(22)	Fair
60.00	5544	26	18	4	6	0	0	M	3406	Midges (MT)	(10)	Fair
58.50	5548	38	30	13	16	13	17	M	3769	Flatworms (T), Caddisflies (F,) Midges (F)	36	Good
52.10	5578	39	25	7	9	2	3	L	5357	Midges (F)	(14)	Fair
47.10	5649	45	15	5	6	4	6	L	5588	Midges (F)	(10)	Fair
41.24	5693	15	10	3	4	1	1	L	10386	Aquatic worms (T), Midges (F)	(4)	Fair
32.60	6054	29	12	5	6	2	2	M	4985	Midges (F,T)	(10)	Fair
31.64	6058	50	27	11	12	6	8	H	10946	Aquatic worms (T), Caddisflies (F,MI) Midges (F)	24	Fair
26.70	6264	46	26	10	13	8	12	M	6234	Hydropsychid Caddisflies (F, MI) Midges (F)	30	Marginally Good
20.68	6330	43	31	12	14	9	12	M	1848	Hydropsychid Caddisflies (F, MI), Midges (F), River Snails (MI)	38	Good
16.52	6340	41	26	14	16	12	16	M	2946	Hydropsychid Caddisflies (F,MI), Midges (F), Baetid Mayflies (F), River Snails (MI)	34	Good
13.30	6367	24	13	6	8	5	6	H	3744	Midges(MT)	(12)	Poor
9.40	6389	15	10	1	3	0	1	M	6245	Midges(MT)	(6)	Poor
5.80	6397	22	14	2	4	0	1	H	3968	Aquatic worms (T), Midges(MT)	(14)	Poor
3.60	6602	15	13	1	3	1	2	H	2659	Midges(MT,T)	(14)	Poor
0.50	6606	24	23	2	4	2	2	H	4073	Zebra mussels (F)	(18)	Poor

Stream RM	Dr. Area (mi^2)	Total Taxa		EPT Taxa		Sensitive Taxa		Density		Predominant Organisms on the Natural Substrates With Tolerance Category(ies)	ICI	Narrative Evaluation
		Ql.	Qt.	Ql.	Total	Ql.	Total	Ql.	Qt.			
Auglaize River (04-100) **2012**												
28.50	719	54	36	16	21	17	22	M	929	Hydropsychid Caddisflies (F), Midges (F)	36	Good
19.30	1509	28	25	8	9	3	3	M	3658	Midges (F)	(12)	Fair
14.94	2041	19	17	2	6	1	1	L	3754	Midges (F)	(6)	Fair
6.59	2317	26	14	4	7	1	1	L	5506	Midges (F)	(6)	Fair
3.20	2428	54	37	15	21	10	16	L	1422	Hydropsychid Caddisflies (F), Midges (F,MT)	36	Good
Maumee River (04-001) **2013**												
76.15	2292	63	29	17	19	21	22	M	1832	Mayflies (F, MI), Hydropsychid Caddisflies (F)	46	Exceptional
58.50	5548	59	36	20	25	23	29	M	3104	Hydropsychid Caddisflies (F), Midges (F)	38	Good
31.64	6058	46	30	12	15	8	12	M	5320	Hydropsychid Caddisflies (F,MI), Midges (F)	30	Marginally Good
20.68	6330	49	32	12	14	9	12	M	1669	Flatworms (T), Caddisflies (F,) Mayflies (F, MI)	34	Good

RM: River Mile.
Dr. Area: Drainage Area
Ql.: Qualitative sample collected from the natural substrates.
Sensitive Taxa: Taxa listed on the Ohio EPA Macroinvertebrate Taxa List as MI (moderately intolerant) or I (intolerant).
Qt.: Quantitative sample collected on Hester-Dendy artificial substrates, density is expressed in organisms per square foot.
Qualitative sample relative density: L=Low, M=Moderate, H=High.
Tolerance Categories: VT=Very Tolerant, T=Tolerant, MT=Moderately Tolerant, F=Facultative, MI=Moderately Intolerant, I=Intolerant

Acknowledgements

The following Ohio EPA staff provided technical expertise for this project:

Report preparation and analysis	Ben Smith, Jordan Jenkins, Chuck McKnight, Paul Gledhill, Josh Griffin, Gary Klase, Heather Raymond
Data support	Dennis Mishne
Reviewers	Jeff Deshon, Holly Tucker, Dan Glomski
Stream sampling	Dave Altfater, Mike Gray, Chuck Boucher, Andrew Phillips, Jordan Jenkins, Chuck McKnight, Mike Bolton, Sarah Adams, Paul Gledhill, Josh Griffin, Heather Allamon, Scott Winkler, Mia Hall, Samantha Spence, Ellinas Dovgopolaya, Tyler Leggett, Luke Stoll, Eric Hoying, Ellie Kern, Laurel Cope, Jennifer Bare, John Sullenbarger, Eve Hochhauser, Megan Patterson, Jake Cochran, Cory Stratton, Jessica Adair

The Ohio EPA appreciates the cooperation of the property owners who allowed Ohio EPA personnel access to the project area.

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