Biological and Water Quality Study of the Deer Creek Watershed, 2011

Madison, Pickaway, Fayette and Ross Counties

OHIO EPA Technical Report EAS/2013-03-05

Division of Surface Water
Ecological Assessment Section
March 12, 2013

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Ohio EPA Technical Report DSW/EAS 2012-03-05

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Table of Contents

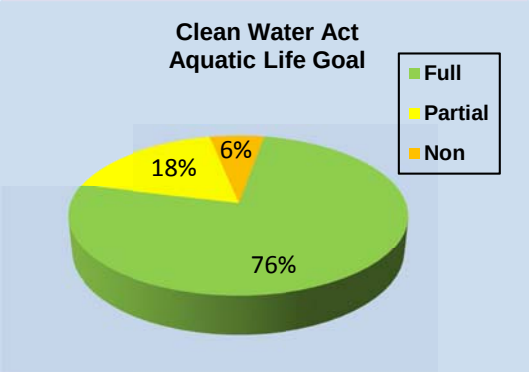
List of Tables

List of Figures

List of Appendices

EXECUTIVE SUMMARY

Rivers and streams in Ohio support a variety of uses such as recreation, water supply, and aquatic life. Ohio EPA evaluates each stream to determine the appropriate use designation and to also determine if the use is meeting the goals of the federal Clean Water Act. In 2011, twenty streams in the Deer Creek study area, located in Madison, Fayette, Pickaway and Ross counties, were evaluated for aquatic life and recreation use potential (see Figure 1 and Table 1 for sampling locations). The study area included the mainstem and selected tributaries of Deer Creek.



Of the 51 biological sites assessed, 39 sites (76%) were fully attaining the designated or recommended aquatic life use, nine (18%) were in partial attainment and three (6%) were in non-attainment (Table 2, Figure 1). Elevated nutrients and sedimentation related to agricultural practices within the watershed were two principal causes of impairment. Three dams and their resultant impoundments also impaired the fish and macroinvertebrate communities on the mainstem. Frequently, the fish communities in the vicinity of the reservoirs included a substantial lentic component such as large piscivores or masses of gizzard shad (*Dorosoma cepedianum*). The macroinvertebrate communities below Deer Creek Lake contained an inordinately high density of filter feeding midges and other taxa taking advantage of the suspended algae and organic material contained in the dam release. Free flowing reaches of Deer Creek generally had good habitat that in turn supported well balanced aquatic communities.

Twenty-two of 30 sites on tributary streams within the Deer Creek basin were in full attainment of the Warmwater Habitat (WWH) aquatic life use designation. Three remaining sites were in non-attainment of WWH; two sites partially met WWH expectations and three sites partially met the more stringent Exceptional Warmwater (EWH) use (Table 2).

Stream water chemistry conditions in the Deer Creek watershed were influenced by agricultural conditions. Nitrate+nitrite concentrations were generally above statewide ecoregion targets for sites studied on both the Deer Creek mainstem and tributary streams. Seventy-five percent (75%) of aquatic life stream impairments included nutrient enrichment as a contributing cause. Enrichment sources include agricultural activities (livestock operations, row crop production), home sewage treatment systems (HSTS) and nutrient laden reservoir releases.

Otherwise stream chemistry conditions were mostly satisfactory. Few violations of Ohio Water Quality Standards (WQS) criteria were detected during the stream study. Dissolved oxygen conditions were mostly healthy and water column inorganic parameters were generally within acceptable ecological levels.

Sediment samples were collected from five sites in the Deer Creek study area by the Ohio EPA in the fall of 2011. Samples were analyzed for metals, organics, nutrients, total organic carbon (TOC) and particle size. Sediment sample results were evaluated using published guidelines and were found protective of biological integrity.

Thirty-seven locations in the Deer Creek study area were sampled for *E. coli* bacteria five to nine times, between May and October 2011 to assess the Primary Contact Recreation (PCR) use. Evaluation of *E. coli* results revealed that 36 of the 37 locations sampled failed to attain the applicable WQS criterion, indicating an impairment of the PCR use at these locations. Sources of elevated bacteria concentrations were ubiquitous and most likely due to a variety of inputs depending on the site location. These sources include agricultural activities (livestock operations, manure application) and HSTS.

Table 1. Deer Creek watershed sampling locations, 2011. The color of the site number corresponds to the narrative biological score (blue is exceptional to very good (meets EWH goals), green is good to marginally good (meets WWH goals) yellow is fair, orange is poor and red is very poor (fair, poor and very poor do not meet the goals of WWH).

Site Number	Stream Name /Location	River Mile	Drainage Area (mi^2)	Longitude	Longitude
1	Deer Creek At Summerford Cemetery	69.60	6.5	39.946460	-83.504122
2	Deer Creek at St. Rt. 56	69.30	17.2	39.945860	-83.502422
3	Deer Creek ust. Richmond Run	66.10	28.9	39.959300	-83.462800
4	Deer Creek at St. Rt. 38	64.70	33.0	39.949908	-83.444596
5	Deer Creek at U.S. Rt. 40	62.00	38.4	39.937561	-83.413819
6	Deer Creek at St. Rt. 142	58.54	50.7	39.905061	-83.393019
7	Deer Creek dst. at Glade Run Rd.	53.30	60.0	39.854261	-83.360217
8	Deer Creek at Big Plain-Circleville Rd.	51.39	82.0	39.842861	-83.342717
9	Deer Creek at Turkey Run	49.40	129.0	39.816161	-83.344117
10	Deer Creek at Robison Rd.	44.37	141.0	39.788661	-83.301616
11	Deer Creek ust. Anderson Rd.	41.30	147.0	39.757261	-83.289615
12	Deer Creek at St. Rt. 56	35.56	228.0	39.715361	-83.257415
13	Deer Creek dst. Mt. Sterling WWTP	35.47	228.0	39.713961	-83.258015
14	Deer Creek at Yankeetown Rd.	31.10	237.0	39.659761	-83.263014
15	Deer Creek at Crownover Mill Rd.	23.72	278.0	39.620662	-83.213213
16	Deer Creek adj. Williamsport-Crownover Rd.	21.20	284.0	39.605062	-83.188012
17	Deer Creek at Walston Rd. Access	17.60	310.0	39.611962	-83.139610
18	Deer Creek at U.S. Rt. 22	14.76	333.0	39.585487	-83.121802
19	Deer Creek at St. Rt. 138	11.65	340.0	39.550862	-83.108009
20	Deer Creek at Westfall Rd.	5.75	381.0	39.486762	-83.083807
21	Deer Creek at St. Rt. 104	1.05	411.0	39.458162	-83.019105
22	N. Fk. Deer Creek near mouth	0.10	10.6	39.947860	-83.503522
23	Georges Fork at St. Rt. 187	1.69	3.4	39.980660	-83.499922
24	Glade Run ust. St. Rt. 142	5.17	4.8	39.918661	-83.351018
25	Glade Run near Mouth	0.50	19.5	39.859347	-83.350270
26	Walnut Run at St. Rt. 38	5.20	11.6	39.842171	-83.467207
27	Walnut Run at St. Rt. 56	0.20	15.3	39.843661	-83.389918
28	Oak Run at Old Springfield Rd.	10.28	9.3	39.890948	-83.459638

Site Number	Stream Name /Location	River Mile	Drainage Area (mi^2)	Longitude	Longitude
29	Oak Run ust. London WWTP	7.94	14.7	39.874527	-83.435560
30	Oak Run dst. London WWTP	7.8	19.7	39.874760	-83.433819
31	Oak Run at Old Xenia Rd.	6.78	20.3	39.865860	-83.423819
32	Oak Run at Gregg Mill Rd.	2.10	41.0	39.840361	-83.366818
33	Bradford Branch at Johnston Rd.	1.95	5.3	39.790513	-83.413785
34	S. Fk. Bradford Creek at Yankeetown-Chenowith Rd.	1.30	8.8	39.773626	-83.393154
35	Bradford Creek at Moorman Rd.	7.15	16.2	39.784918	-83.382950
36	Bradford Creek ust. I-71	1.20	36.6	39.748661	-83.325216
37	Mud Run at Bragg Rd.	0.70	6.6	39.727161	-83.337216
38	Sugar Run ust. U.S. Rt. 56	0.50	51.7	39.752261	-83.294616
39	Opossum Run at Mantle Rd.	4.40	10.3	39.798161	-83.236614
40	Opossum Run at Tenny Rd.	0.85	17.5	39.752826	-83.246054
41	Duffs Fork at St. Rt. 207	0.50	12.4	39.656461	-83.271615
42	Clark Run at Dawson-Yankeetown Rd.	1.30	7.6	39.650062	-83.238514
43	Buskirk Creek at Five Points Rd.	5.20	9.1	39.675662	-83.182712
44	Buskirk Creek at Crownover Mill Rd.	1.20	17.6	39.628162	-83.161611
45	Dry Run at St. Rt. 56	3.60	13.5	39.659722	-83.126462
46	Dry Run at Palestine-Williamsport Rd.	0.42	21.0	39.615362	-83.127710
47	Brush Creek at St. Rt. 207	0.25	6.5	39.514895	-83.157459
48	Hay Run at Judas Rd.	7.00	4.8	39.540400	83.157400
49	Hay Run at St. Rt. 138	3.91	21.9	39.506162	-83.150710
50	Hay Run dst. Clarksburg WWTP	3.80	21.9	39.505662	-83.150510
51	Hay Run at Twp. Rd. 132	0.90	28.7	39.492862	-83.114308
52	Stall Run at St. Rt. 207	0.40	4.0	39.487117	-83.127590
53	Waugh Run at Egypt Rd.	4.95	7.5	39.456157	-83.137739
54	Waugh Run at Westfall Rd.	1.03	17.3	39.478162	-83.088007

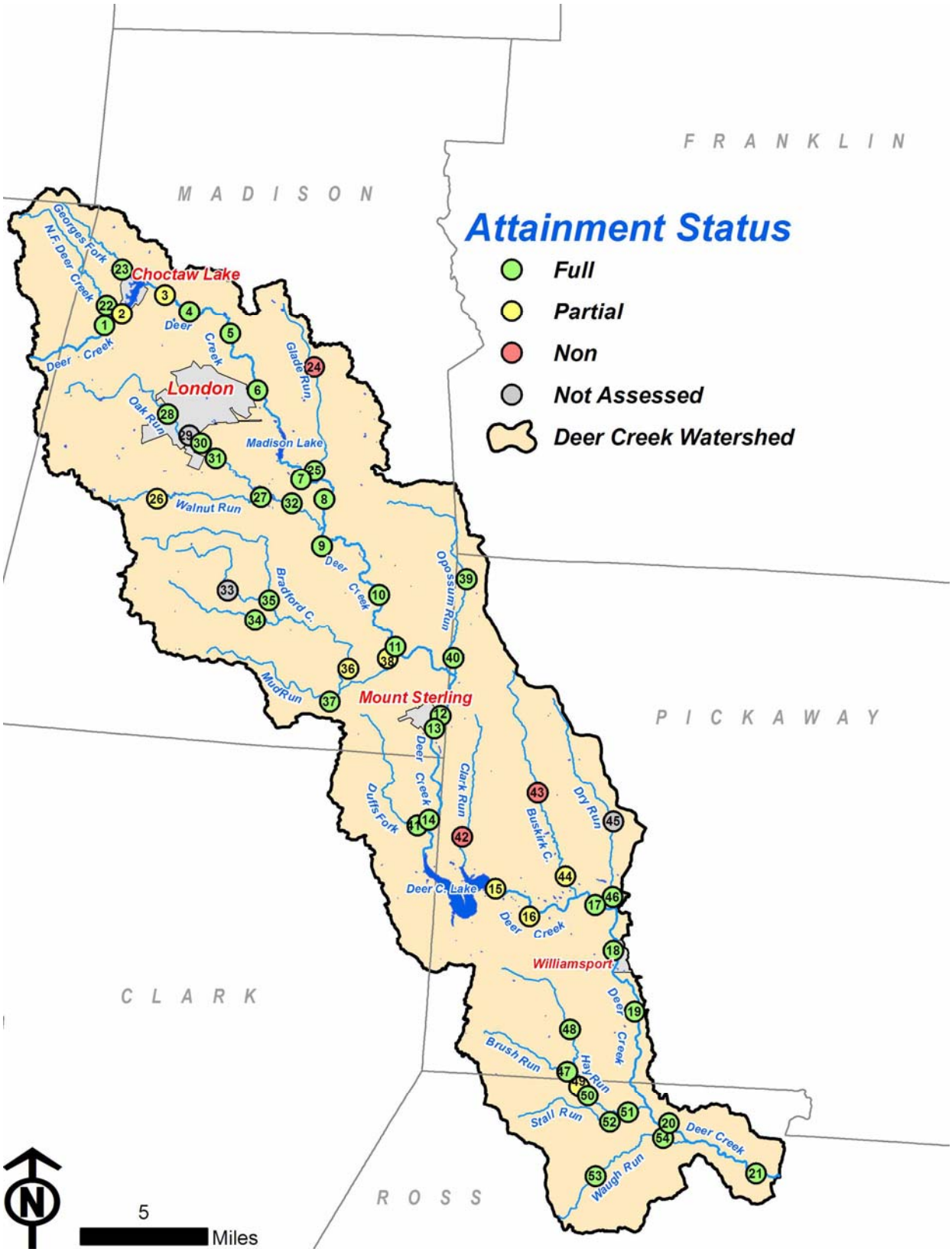


Figure 1. Deer Creek study area sampling locations and biological community performance, 2011. Site numbers correspond to Table 1.

Table 2. Aquatic life use attainment status for sampling locations in Deer Creek watershed, 2011. The Index of Biotic Integrity (IBI), Modified Index of Well-being (MIwb), and Invertebrate Community Index (ICI) scores are based on the performance of the biological community. Stream habitat reflects the ability to support a biological community. Deer Creek watershed is located in the Eastern Corn Belt Plain ecoregion. If biological impairment has occurred, the cause(s) and source(s) of the impairment are noted. NA = not applicable. For the Aquatic Life Use Designation, R denotes a new recommendation that differs from the current use designation.

Stream	River Mile[a]	Drainge Area (Mi^2)	Aquatic Life Use Designation	Aquatic Life Attainment Status[b]	IBI	MIwb[c]	ICI[d]	Stream Habitat	Cause of Impairment	Source of Impairment
Deer Creek	69.60	6.5[H]	WWH	Full	42		MG	75.50		
Deer Creek	69.30	17.2[H]	WWH	Partial	34*		G	76.00	Other flow regime alterations	Impoundment (Choctaw Lake)
Deer Creek	66.10	28.9[W]	WWH	Partial	40	7.06*	40	76.00	Other flow regime alterations	Impoundment (Choctaw Lake)
Deer Creek	64.70	33.0[W]	WWH	Full	44	8.51	40	79.80		
Deer Creek	62.00	38.4[W]	WWH	Full	41	7.89[ns]	46	68.00		
Deer Creek	58.54	50.7[W]	WWH	Full	44	7.80[ns]	50	70.50		
Deer Creek	53.30	60.0[W]	WWH	Full	51	10.81	46	89.50		
Deer Creek	51.39	82.0[W]	WWH	Full	52	9.91	42	79.50		
Deer Creek	49.40	129[W]	WWH	Full	45	9.61	48	73.50		
Deer Creek	44.37	141[W]	WWH	Full	54	10.16	44	85.30		
Deer Creek	41.30	147[B]	WWH	Full	56	10.69	54	88.00		
Deer Creek	35.56	228[B]	EWH	Full	54	9.99	48	88.30		
Deer Creek	35.47	228[W]	EWH	Full	53	9.86	48	86.50		
Deer Creek	31.10	237[B]	EWH	Full	50	10.3	E	85.30		
Deer Creek	23.72	278[B]	EWH	Partial	47[ns]	10.16	30*	81.00	Nutrient/eutrophication biological indicators	Impoundment (Deer Creek Lake)
Deer Creek	21.20	284[B]	EWH	Partial	48	9.74	40*	85.80	Nutrient/eutrophication biological indicators, low dissolved oxygen	Impoundment (Deer Creek Lake)
Deer Creek	17.60	310[W]	EWH	Full	52	9.41	48	83.50		
Deer Creek	14.76	333[W]	EWH	Full	52	9.3	50	89.80		
Deer Creek	11.65	340[W]	EWH	Full	54	9.57	46	91.50		
Deer Creek	5.75	381[W]	EWH	Full	50	9.03[ns]	54	89.50		

Stream	River Mile[a]	Drainge Area (Mi^2)	Aquatic Life Use Designation	Aquatic Life Attainment Status[b]	IBI	MIwb[c]	ICI[d]	Stream Habitat	Cause of Impairment	Source of Impairment
Deer Creek	1.05	411 [B]	EWH	Full	48	10.24	54	86.00		
N. Fk. Deer Creek	0.10	10.6 [H]	WWH	Full	42	N/A	G	73.50		
Georges Fork	1.69	3.4 [H]	WWH-R	Full	40	N/A	G	67.50		
Glade Run	5.17	4.8 [H]	WWH	NON	50	N/A	P*	55.30	Nutrients, sedimentation/siltation	Ag- nonirrigated cropland
Glade Run	0.50	19.5 [H]	WWH	Full	42	N/A	E	64.00		
Walnut Run	5.20	11.6 [H]	WWH	Partial	32*	N/A	E	81.00	Nutrients	Agriculture
Walnut Run	0.20	15.3 [H]	WWH	Full	48	N/A	E	80.00		
Oak Run	10.28	9.3 [H]	WWH	Full	36[ns]	N/A	E	56.00		
Oak Run	7.94	14.7	WWH	-	-	-	E			
Oak Run	7.80	19.7 [H]	WWH	(Full)	38[ns]	N/A	-	68.00		
Oak Run	6.78	20.3	WWH	Full	47	7.93[ns]	50	73.50		
Oak Run	2.10	41.0 [W]	WWH	Full	53	9.97	44	88.00		
Bradford Branch	1.95	5.3 [H]	WWH-R	-	-	-	G			
S. Fk. Bradford Creek	1.30	8.8 [H]	WWH	Full	52	N/A	E	77.50		
Bradford Creek	7.15	16.2 [H]	WWH	Full	48	N/A	E	55.00		
Bradford Creek	1.20	36.6 [W]	EWH	Partial	54	8.17*	52	81.30	Nutrient/eutrophication biological indicators	Agriculture
Mud Run	0.70	6.6 [H]	WWH	Full	54		VG	72.50		
Sugar Run	0.50	51.7 [W]	EWH	Partial	50	8.54*	46	86.50	Nutrient/eutrophication biological indicators	Agriculture
Opossum Run	4.40	10.3 [H]	WWH	Full	38[ns]	N/A	G	61.50		
Opossum Run	0.85	17.5 [H]	WWH	Full	54	N/A	E	65.50		

Stream	River Mile[a]	Drainge Area (Mi^2)	Aquatic Life Use Designation	Aquatic Life Attainment Status[b]	IBI	MIwb[c]	ICI[d]	Stream Habitat	Cause of Impairment	Source of Impairment
Duffs Fork	0.50	12.4 H	WWH	Full	54	N/A	G	87.00		
Clark Run	1.30	7.6 H	WWH	NON	30*	N/A	F*	68.30	Nutrient/eutrophication biological indicators	Agriculture, HSTS
Buskirk Creek	5.20	9.1 H	WWH	NON	36ns	N/A	P*	76.00	Nutrient/eutrophication biological indicators, Ammonia	Agriculture
Buskirk Creek	1.20	17.6 H	EWH	Partial	54	N/A	G	82.00	Nutrient/eutrophication biological indicators	Agriculture
Dry Run	3.60	13.5 H	WWH	-	-	-	G	42.00		
Dry Run	0.42	21.0 W	WWH	Full	52	8.53	48	71.00		
Brush Creek	0.25	6.5 H	WWH-R	Full	48	N/A	G	73.50		
Hay Run	7.00	4.8 H	WWH	Full	46	N/A	MG	59.00		
Hay Run	3.91	21.9 W	WWH	Partial	46	7.58*	G	77.00	Intermittent flow	Natural
Hay Run	3.80	21.9 W	WWH	Full	42	8.62	MG	72.30		
Hay Run	0.90	28.7 W	WWH	Full	50	8.94	E	72.00		
Stall Run	0.40	4.0 H	WWH	Full	50	N/A	G	69.00		
Waugh Run	4.95	7.5 H	WWH	Full	44	N/A	MG	53.50		
Waugh Run	1.03	17.3 H	WWH	Full	50	N/A	G	78.30		

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

b - MIwb is not applicable to headwater streams with drainage areas ≤ 20 mi^2.

c - A narrative evaluation of the qualitative sample based on attributes such as EPT taxa richness, number of sensitive taxa, and community composition was used when quantitative data was not available or considered unreliable. VP=Very Poor, P=Poor, LF=Low Fair, F=Fair, MG=Marginally Good, G=Good, VG=Very Good, E=Exceptional

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

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

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

B - Boat site.

H - Headwater site.

W - Wading site.

Biological Criteria Eastern Corn Belt Plains			
Index – Site Type	**EWH**	**WWH**	**MWH**
IBI – Headwaters	50	40	24
IBI – Wading	50	40	24
IBI – Boat	48	42	24
MIwb – Wading	9.4	8.3	6.2
MIwb – Boat	9.6	8.5	5.8
ICI	46	36	22

RECOMMENDATIONS

The streams in the Deer Creek study area currently listed in the Ohio Water Quality Standards (WQS) are assigned one of the following aquatic life use (ALU) designations: Warmwater Habitat (WWH) and Exceptional Warmwater Habitat (EWH). The aquatic life use designation of the streams in this survey have been previously verified using biological data with the exception of Stall Run, Dry Run, Duffs Fork, Opossum Run, Mud Run, Bradford Creek upstream from RM 6.1, and Glade Run. These streams were originally designated for aquatic life use in the 1978 Ohio WQS but the techniques used then did not include standardized approaches to the collection of instream biological data or numerical biological criteria. This study used biological data to evaluate and establish aquatic life uses.

Twenty streams in the Deer Creek study area were evaluated for aquatic life and recreational use potential in 2011 (Table 3). Significant findings include the following:

- Sixteen streams with an existing WWH use designation should be maintained. These streams include Deer Creek upstream from Sugar Run (RM 41.22), North Fork Deer Creek, Walnut Run, Stall Run, Dry Run, Duffs Fork, Opossum Run, Mud Run, Bradford Creek upstream from RM 6.1, South Fork Bradford Creek, Clark Run, Buskirk Creek, Dry Run, Hay Run, Stall Run, Waugh Run and Glade Run. Additionally, the 2011 survey demonstrated the WWH use designation was appropriate for three undesignated streams: Georges Fork, Bradford Branch and Brush Creek.

- The Exceptional Warmwater Habitat (EWH) use designation is appropriate for Deer Creek downstream from Sugar Run (RM 41.22), Buskirk Creek downstream from RM 2.7, Sugar Run and Bradford Creek downstream from RM 6.1.

- All twenty streams in this study should retain the Primary Contact Recreation use (Class A for Deer Creek upstream from Mt. Sterling (RM 44.37) to the mouth and Class B for all other streams), along with the Agricultural Water Supply and Industrial Water Supply uses.

Deer Creek from the Sugar Creek confluence (RM 41.22) to Deer Creek reservoir (RM 29.40) is listed as a Superior High Quality Water (SHQW) and the reach from RM 23.89 (below dam) to the mouth is classified as Outstanding State Water (OSW) based on exceptional ecological values in the Antidegradation Rule (OAC 3745-1-05) of the Ohio Water Quality Standards. Included in evaluating exceptional biological value was a determination of declining fish species, high quality habitat to support declining and threatened fish species, and a display of biological integrity equivalent to the Exceptional Warmwater Habitat Index of Biotic Integrity and /or Invertebrate Community Index criteria listed in rule 3745-1-07 of the Ohio Administrative Code.

Outreach efforts to the local farming community with soil and Water Conservation Districts should be undertaken to encourage best management practices (BMPs) aimed at addressing the effects of agricultural activities on water quality. Particular attention should be paid to the Rising Sun Dairy operation (Assen Dairy LLC) which has recently expanded. They have a history of manure spills in the Bradford Branch and Sugar Creek watersheds.

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

Water Body Segment	Use Designations													Comments
		Aquatic Life Habitat						Water Supply			Recreation			
	SRW	WWH	EWH	MWH	SSH	CWH	LRW	PWS	AWS	IWS	BW	PCR	SCR	
Deer creek - Sugar run (RM 41.22) to the mouth			+						+	+		+		
- all other segments		+							+	+		+		
Waugh run		+							+	+		+		
Hay run		+							+	+		+		
Stall run		+*							+*	+*		+*		
Brush creek		▲							▲	▲		▲		
Dry run		+*							*	*		*		
Buskirk creek - headwaters to RM 2.7		+							+	+		+		
- RM 2.7 to the mouth			+						+	+		+		
Clark run		+							+	+		+		
Georges run		*							*	*		*		
Long branch		*							*	*		*		
Duffs fork		+*							+*	+*		+*		
Opossum run		+*							+*	+*		+*		
Sugar run			+						+	+		+		
Mud run		+*							+*	+*		+*		
Bradford creek - headwaters to RM 6.1		+*							+*	+*		+*		
- RM 6.1 to the mouth			+						+	+		+		
South fork		+							+	+		+		
Bradford branch		▲							▲	▲		▲		
Turtle run		*							*	*		*		
Turkey run		+*							+*	+*		+*		
Oak run		+							+	+		+		
Walnut run		+							+	+		+		
Glade run		+*							+*	+*		+*		
Georges fork		▲							▲	▲		▲		
North fork		+							+	+		+		

INTRODUCTION

Fifty-four stream sampling locations were evaluated in the Deer Creek watershed in Madison, Fayette, Pickaway, and Ross counties in 2011 (Figures 1 and 2). Twenty-one sites on the mainstem of Deer Creek were sampled along with 33 locations on tributaries including Bradford Creek, Oak Run and Hay Run. A total of 21 National Pollutant Discharge Elimination System (NPDES) permitted facilities discharge sanitary wastewater, industrial process water, and/or industrial storm water into the Deer Creek watershed.

During 2011, Ohio EPA conducted a water resource assessment of Deer Creek and 19 tributaries using standard Ohio EPA protocols.. Included in this study were assessments of the biological, surface water, sediment, fish tissue and recreation (bacterial) condition. A total of 53 biological, 54 water chemistry, and 36 bacterial stations were sampled in the Deer Creek study area. All of the biological, chemical and bacteria results can be downloaded from the Ohio EPA GIS interactive maps at the following link: http://www.epa.state.oh.us/dsw/gis/index.aspx.

11.

Specific objectives of the evaluation were to:

- ascertain the present biological conditions in the Deer Creek study area by evaluating fish and macroinvertebrate communities,
- identify the relative levels of organic, inorganic, and nutrient parameters in the sediments and surface water,
- evaluate influences from NPDES outfall discharges,
- assess physical habitat influences on stream biotic integrity,
- determine recreational water quality,
- compare present results with historical conditions, and
- determine beneficial use attainment status 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

Deer Creek watershed is located predominantly in Madison, Pickaway and Ross counties in south central Ohio. Deer Creek watershed encompasses three 10-digit'Hydrologic Unit Codes (HUCs): Headwaters Deer Creek (0506000201), Sugar Run (0506000202) and Hay Run (0506000203). The watershed covers approximately 412 mi^2.

The aquatic life use designations for streams in this study include Exceptional Warmwater Habitat (EWH) and Warmwater Habitat (WWH). Two sections of Deer Creek have been identified as Special High Quality Waters under Ohio's antidegradation rule. Deer Creek from RM 23.89 (below dam) to the mouth is classified as Outstanding State Water – Based on Ecological Value (OSW-E) and Deer Creek from RM 41.22 (Sugar Creek confluence) to the reservoir (RM 29.4) is classified as Superior High Quality Water (SHQW). In addition, a segment of Deer Creek has been designated as Class A primary contact recreation (popular paddling stream) under criteria for recreation uses. This segment begins at Robison Road (RM 44.37) and extends to the mouth.

The Deer Creek mainstem is 67.1 miles long and generally flows from a northwest to southeast direction towards the confluence with the Scioto River approximately 6 miles north of Chillicothe. Water quality conditions in Deer Creek are influenced by Deer Creek Lake (1,277 acres), Madison Lake (106 acres) and Choctaw Lake (285 acres). Within the lake impoundments, Deer Creek is no longer free-flowing and becomes inevitably more lacustrine. Downstream from the dams, water quality conditions are affected by the volume, frequency, duration, and quality of dam releases.

The study area is located entirely within the Eastern Corn Belt Plains (ECBP) ecoregion. The dominant physiographic feature of this ecoregion is the Darby till plains. The till plains have moderately low relief topography with broad moraines and swales which generally were historically wet prairies and meadows. The soils are mostly well drained and of medium to high agricultural productivity (Omernik, J.M. 1988).

Land use and land cover have an important influence on water quality conditions found in the watershed. Overall, agricultural land uses (row crop, pasture) dominate the study area with about 86% of the study area in this classification. Forested cover (7%) and development (6%) represent the other main land use and land cover types. Subwatershed (HUC12) land use generally follows this pattern, as well. The most developed subwatersheds include Richmond Run and Oak Run (both at approximately 13%). These subwatersheds include portions of the Choctaw Lake development and the city of London. The subwatershed with the most forested area at more than 16% is Waugh Creek in the extreme southern portion of the study area (Xian and Fry 2009).

With the exception of London, Ohio, communities located in the study area have experienced relatively little growth over the past decade. From 2000 to 2010, the population of the city of London has increased 12.9%. The 2010 population of London was 9,904. Other communities located in the study area have not experienced significant population growth. These communities (and their 2010 population) include Choctaw Lake (1,546), village of Mount Sterling (1,782) and the Village of Williamsport (1,023) (US Census Bureau, 2012).

There are twenty-one NPDES individual permitted facilities that discharge sanitary wastewater, industrial process water and/or industrial storm water into streams in the watershed. Thirteen of these facilities are minor sanitary waste water treatment facilities. The city of London Wastewater Treatment Plant (WWTPs) is the only major NPDES facility in the study area. The design flow for the WWTP is 5.8 million gallons per day with discharge to Oak Run at RM 7.90. There are two concentrated animal feeding operations (CAFOs) in the study area. The largest is Assen Dairy, LLC. (also known as Rising Sun Dairy), located in the South Fork Bradford Creek subwatershed. This CAFO is permitted for 2,558 dairy livestock. Gill Livestock has 3,200 swine and is located in the Walnut Run subwatershed. Five Points Dairy, LLC. has not been built but is permitted for 2,210 dairy livestock and is to be located in the Buskirk Creek subwatershed.

RESULTS

Water Chemistry

Surface water chemistry samples were collected from the Deer Creek study area from February through October 2011 at 54 locations (Figure 1 and Table 1). Stations were established in free-flowing sections of the stream and were primarily collected 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 Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (Ohio EPA 2011). Interactive maps of surface water chemical data, downloadable to excel files, are available at the following link: http://www.epa.ohio.gov/dsw/gis/index.aspx .

USGS gage data from Deer Creek at Mount Sterling on State Route 56 was used to show flow trends in the Deer Creek watershed during the 2011 summer field season (Figure 3). Dates when stream samples were collected in the study area are noted on the graph. Flow conditions during the summer field season were typically lower than the historic mean. Significant rain and runoff events ocurred in early June and late July. Water samples generally captured a variety of flow conditions in the study area during the field season. Bacteria was collected within the recreation use season (May 1 through October 31) at the same time chemistry samples were collected.

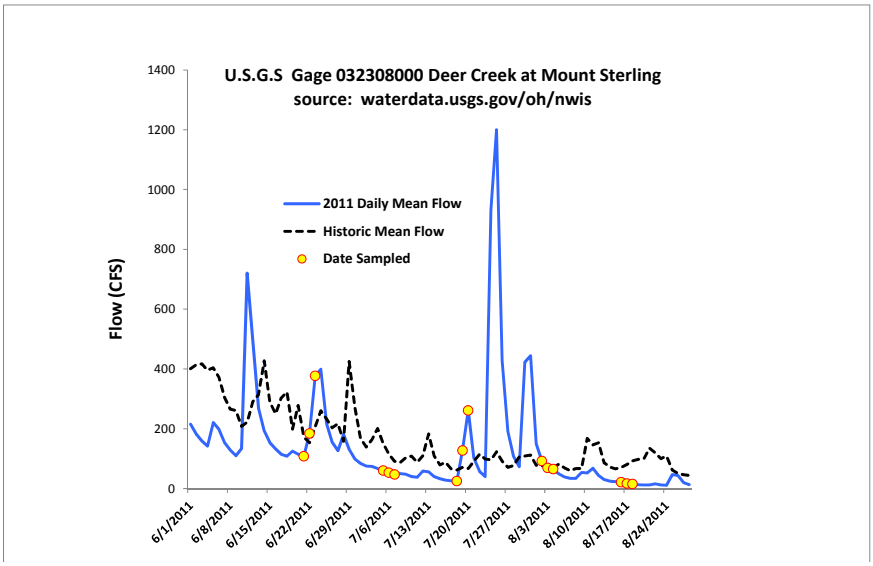


Figure 3. Flow conditions in Deer Creek during the 2011 summer field season

Surface water samples were analyzed for metals, nutrients, bacteria, pH, temperature, conductivity, dissolved oxygen (D.O.), percent D.O.saturation, and suspended and dissolved solids (Appendix 2.). Parameters which were in exceedance of the Ohio WQS criteria are reported in Table 4. Summary statistics for nutrients measured in the Deer Creek watershed are detailed in Table 1. Nutrient and dissolved oxygen results are longitudinally presented in Figure 4 and Figure 5, respectively. Bacteriological samples were collected from 37 locations, and the results are reported in the Recreation Use section. Datasonde™ water quality recorders were placed at thirty locations to monitor hourly levels of dissolved oxygen, pH, temperature, and conductivity (Appendix 3).

Table 4 Exceedances of Ohio Water Quality Standards criteria (OAC 3745-1) for chemical/physical parameters measured in the Deer Creek study area, 2011

Stream/RM	**Location**	**Parameter (value – ug/l unless noted)**
Deer Creek	*WWH Existing*	
53.30	Glade Run Road	Dissolved Oxygen [c] (2.63 mg/l)
44.37	Robison Road	Iron [b] (5,790)
Deer Creek	*EWH Existing*	
35.56	SR 56	Iron (8,280)
21.20	Adj. Crownover-Williamsport Rd.	Dissolved Oxygen (4.94 and 4.95 mg/l)
14.76	SR 22	Iron (7,000 and 18,200)
11.65	SR 138	Iron (11,800)
1.05	SR 104	Iron (5,830 and 9,360)
Bradford Creek	*EWH Existing*	
2.60	Junk Road	Iron (6,960 and 8,730)
1.70	Ust. I-71	Iron (5,720)
Brush Creek	*WWH Recommended*	
6.80	SR 207	Dissolved Oxygen (3.69 mg/l)
Buskirk Creek	*WWH Existing*	
5.20	SR 56	Ammonia [a] (4.27 mg/l)
Hay Run	*WWH Existing*	
3.91	SR 138	Dissolved Oxygen (3.97 mg/l)
Mud Run	*WWH Existing*	
0.70	Bragg Road	Iron (13,400)
Oak Run	*WWH Existing*	
2.10	Gregg-Mill Road	Iron (5,290)
Opossum Run	*WWH Existing*	
0.85	Tenny Road	Dissolved Oxygen (3.74, 2.03 and 2.47 mg/l)
Stall Run	*WWH Existing*	
0.40	SR 207	Dissolved Oxygen (3.93 mg/l)

a Exceedance of the aquatic life Outside Mixing Zone Average water quality criterion.
b Exceedance of the statewide water quality criteria for the protection of agricultural uses.
c Exceedance of the aquatic life Outside Mixing Zone Minimum water quality criterion.

Table 5. Summary geometric mean nutrient results (May 1 – October 30) for select tributary headwater streams sampled in the Deer Creek watershed (2011). Results shaded are above statewide recommended targets (OEPA, 1999). Results are reported in mg/l.

Stream	Drainage Area (mi^2)	River Mile	Ammonia	Nitrate+Nitrite	Phosphorus
Buskirk C.	9.10	5.2	0.19	4.59	0.03
Buskirk C.	17.6	1.2	0.05	1.3	0.03
Bradford C.	16.19	7.15	0.05	2.9	0.02
Bradford Branch	5.30	1.95	0.05	3.8	0.02
S.F. Bradford C.	8.82	1.30	0.05	1.80	0.02
Brush C. @ SR 207	9.50	6.80	0.06	1.50	0.11
Clark Run	7.60	1.30	0.05	1.80	0.04
Dry Run	13.47	3.60	0.05	2.2	0.01
Duffs Fork	12.40	0.50	0.05	0.9	0.02
Georges Fork	4.20	0.80	0.05	0.40	0.02
Glade Run	4.80	5.17	0.05	4.1	0.07
Hay Run	9.50	6.80	0.11	4.70	0.06
Mud Run	6.60	0.70	0.07	1.5	0.04
N.F. Deer C.	10.60	0.10	0.05	0.40	0.04
Oak Run ust. London	14.70	7.94	0.05	1.20	0.08
Oak Run	9.30	10.28	0.06	1.80	0.10
Opossum Run	10.30	4.40	0.05	0.7	0.05
Opossum Run	17.52	0.85	0.05	0.5	0.02
Stall Run @ SR 207	4.00	0.40	0.05	0.40	0.02
Walnut Run	11.61	5.20	0.05	3.5	0.04
Walnut Run	15.30	0.20	0.05	2.30	0.03
Waugh Run	19.60	4.95	0.05	4.1	0.02
Waugh Run @ Westfall	16.90	1.03	0.05	3.90	0.02
Statewide Target WWH Drainage Area <20 miles²			**NA**	**1.0**	**0.08**

Summary - Deer Creek Mainstem

Twenty-one locations on the Deer Creek mainstem were sampled and evaluated for stream water chemistry. The sites were located just upstream from Choctaw Lake in Madison County (RM 69.6) to near the mouth at State Route 104 (RM 1.0) in Ross County. Selected stream water chemistry results are provided in Appendix 2.

In general, stream water quality conditions were good. Most results compared favorably to reference site conditions. There were few violations of Ohio EPA numeric water criteria identified during survey sampling. The violations were limited to a few dissolved oxygen and iron violations. Exceedances of Ohio EPA criteria are summarized in Table 4.

Nutrient results for total phosphorus and Nitrate+nitrite varied when compared to ecoregion target criteria (Figure 4). Total phosphorus results generally were below target criteria on Deer Creek (Table 5). Total phosphorus results averaged 0.097 mg/l (n=141) for all sites studied. Conversely, most results for Nitrate+nitrite were found to be above ecoregion target criteria. Nitrate+nitrite results averaged 2.32 mg/l (n=141) for all sites studied. Nutrient or organic enrichment contributed to aquatic life use impairment at three of the four non-attaining sites on Deer Creek. Contributing to non-attainment were several dams or impoundments (e.g. Choctaw

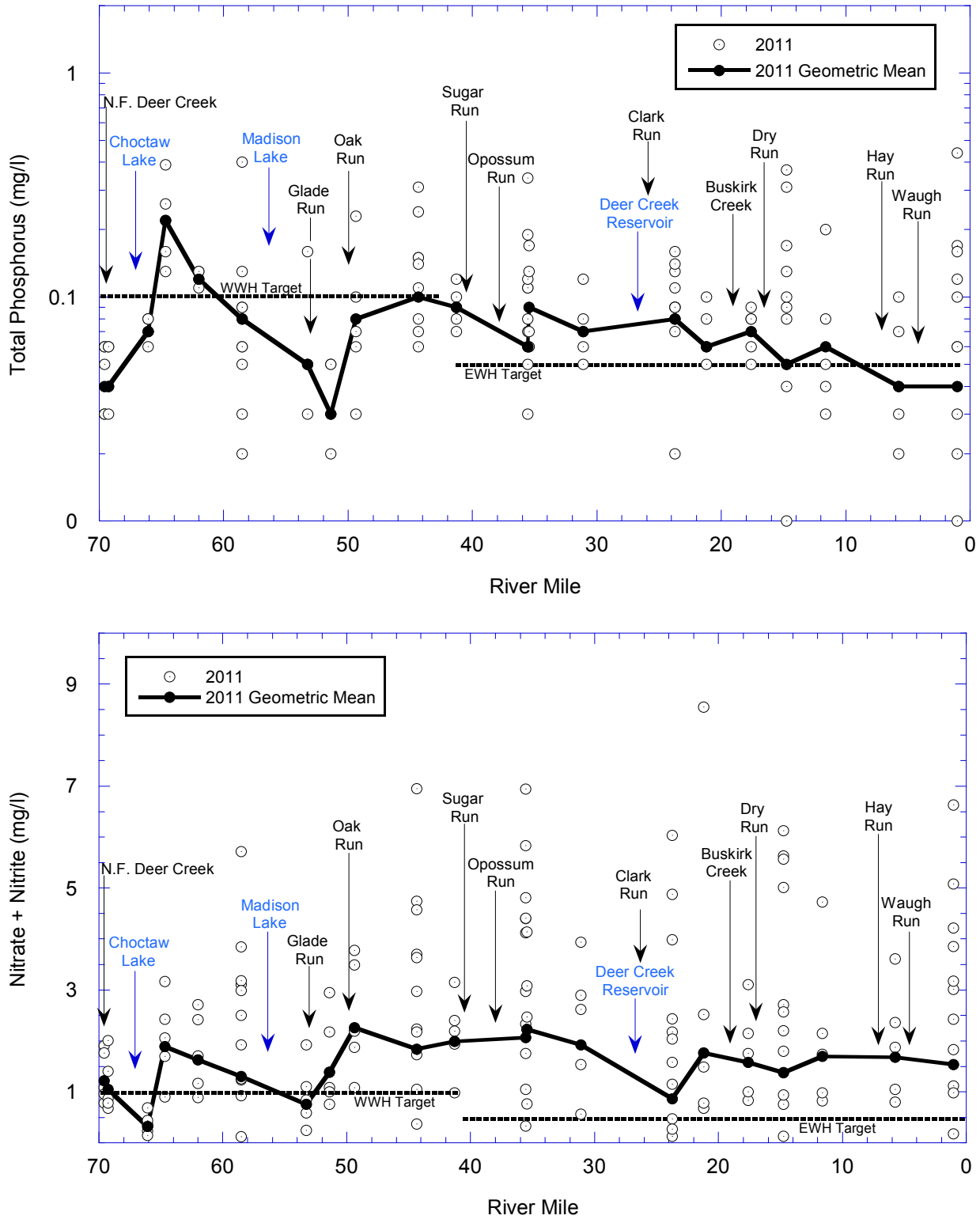


Figure 4. Longitudinal concentration of total phosphorus and nitrate + nitrite, Deer Creek, May to October, 2011.

Lake, Deer Creek Lake) that disrupted normal stream flow conditions and nutrient processing.

Positive water quality results for the mainstem included excellent dissolved oxygen conditions averaging 7.78 mg/l (n=141) for all sites (Figure 5). Only three readings failed to meet water quality criteria (Table 4). Included was a site studied downstream from the Deer Creek Lake dam (adj. Crownover-Mill Road) where two readings were below the EWH criterion of 5 mg/l. Further investigation is needed here to determine the presence of a dissolved oxygen sag related to enrichment and flow conditions from Deer Creek Lake releases.

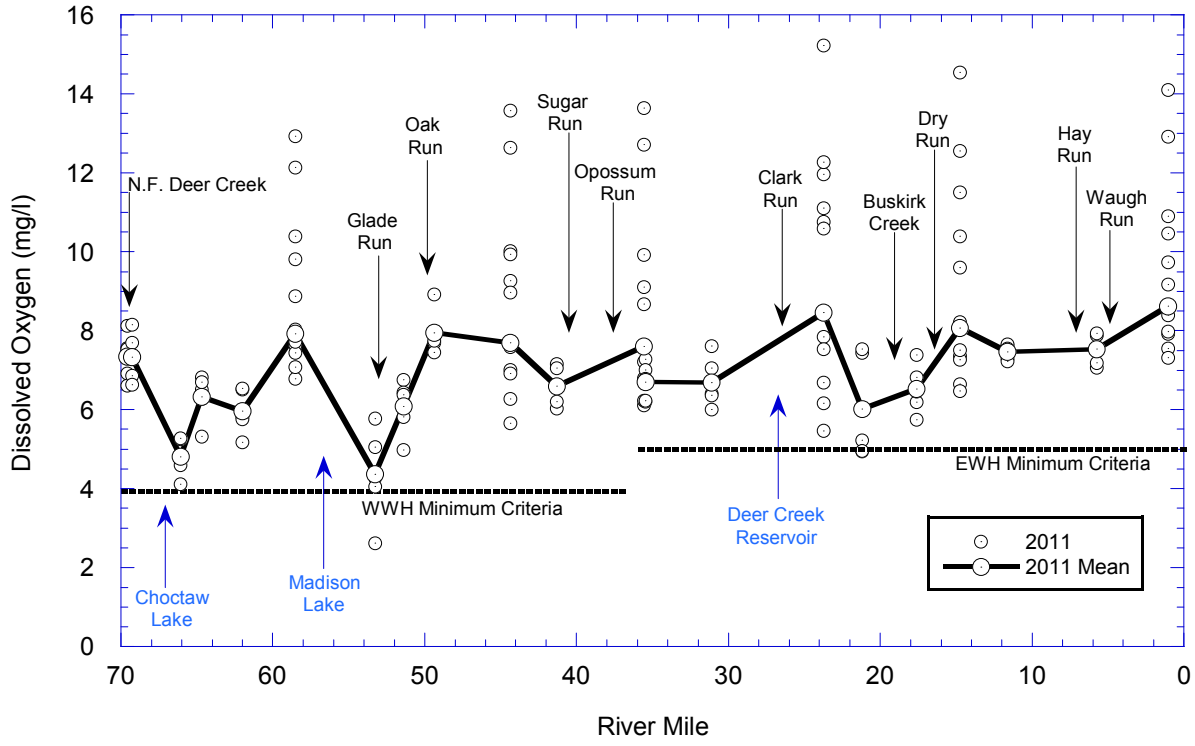


Figure 5. Longitudinal concentration of dissolved oxygen, Deer Creek, May to October, 2011.

Summary – Deer Creek HUC10 Watersheds

Headwaters – Deer Creek HUC10 (0506002 01)

The Headwaters Deer Creek HUC10 consists of five subwatershed HUC12 areas. Principal streams studied in the watershed included North Fork Deer Creek, Glade Run, Walnut Run and Oak Run. Choctaw Lake and Madison Lake are also important hydrologic features found in the watershed. Overall, seventeen of the twenty-one stream sites (81%) met aquatic life use standards. This includes ten Deer Creek mainstem sites.

Notable stream chemistry results for this watershed included elevated Nitrate+nitrite results for most of the watershed (Appendix 2). Geometric mean results for sites studied on Glade Run, Walnut Run and Oak Run easily exceeded the ecoregion target value. Oak Run geometric mean sample results barely exceeded target values for total phosphorus (Table 5).

Nutrient enrichment was a contributing cause to biological impairment found on both Glade Run (upper site at State Route 142) and Walnut Run (upper site at State Route 38). Dissolved oxygen percent saturation values for Glade Run were the highest found in the entire survey and included readings of 168.3%, 156.8% and 145.1% (Appendix 2). Not surprisingly, observations documented here during the survey included excessive stream algal growth.

All other tributary streams and stream site ’in this watershed met aquatic life uses. Healthy dissolved oxygen levels were common and easily exceeded minimum criteria. Ammonia concentrations were almost always below detection. Only a single exceedance of Ohio water quality standards criteria was identified during the survey and this occurred on Oak Run for iron (Table 4).

Sugar Run – Deer Creek HUC10 (0506002 02)

The Sugar Run Deer Creek HUC10 consists of six (6) subwatershed HUC12 areas. Principal streams studied in the watershed included Sugar Run, Buskirk Creek, Bradford Creek, Clark Run, Opossum Run and Duffs Fork. Deer Creek Lake is a large impoundment built for flood control that is found in the watershed.

Thirteen sites were studied in the watershed and aquatic life use impairment occurred at five sites. Nutrient enriched conditions impaired sites on Bradford Creek, Sugar Run, Clark Run and Buskirk Creek. Geometric mean results for Nitrate+nitrite at impaired sites easily exceeded target values while phosphorus geometric mean results were generally less than target values. Bradford Branch and Buskirk Creek (RM 5.20) had among the highest geometric mean Nitrate+nitrite results found in the study, 3.8 mg/l and 4.6 mg/l, respectively (Table 5). Agricultural land use dominates both subwatersheds. Manure spills associated with Rising Sun Dairy (aka Assen Dairy) impacted area streams in the Bradford Creek subwatershed in 2008 and 2010.

Opossum Run and Duffs Fork had among the lowest geometric mean Nitrate+nitrite results found in the survey (Table 5). However, evidence of some enrichment was noted at the lower site on Opossum Run with elevated D.O. saturation levels. In addition, three minimum dissolved oxygen criteria violations (3.74 mg/l, 2.03 mg/l and 2.47 mg/l) also occurred here (Table 4). Otherwise, Opossum Run stream chemistry results were generally satisfactory as aquatic life use attainment was met at both sites.

Hay Run – Deer Creek HUC10 (0506002 03)

The Hay Run HUC10 consists of four subwatershed HUC12 areas. Stream water chemistry sampling occurred at ten sites on Hay Run, Waugh Run, Stall Run, Brush Creek and Dry Run.

Overall, stream water chemistry conditions were similar to those found in other parts of the Deer Creek watershed. Geometric mean results for Nitrate+nitrite exceeded target values for all sites studied while total phosphorus results were generally lower than target values. The highest geometric mean results for Nitrate+nitrite were found on Hay Run and Waugh Run. As an example, Hay Run at Judas Road (RM 6.8) and Waugh Run at Egypt Road (RM 4.95) both had geometric means more than four times the target value at 4.70 mg/l and 4.1 mg/l, respectively (Table 5).

Other water quality conditions in the watershed were generally satisfactory. However, four minor dissolved oxygen exceedances were recorded on Hay Run, Stall Run, Brush Creek and Waugh Run. These readings were just below the 4.0 mg/l minimum criterion (Table 4) and occurred in late summer during low flow conditions. Otherwise, dissolved oxygen conditions were satisfactory across the subwatershed.

All streams studied in the subwatershed met aquatic life uses with the exception of Hay Run at SR 138 (RM 3.91). Here extreme low flow conditions were noted during the study. Sites upstream and downstream from this location on Hay Run had similar stream chemistry and habitat conditions and met aquatic life uses. Therefore, the partial attainment observed here was thought to be due to natural factors related to the low flow conditions.

Recreation Use

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

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

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

The streams of the Deer Creek watershed are designated as Primary Contact Recreation (PCR) use in OAC Rule 3745-1-24. Water bodies with a designated recreational use of PCR "...are waters that, during the recreation season, are suitable for one or more full-body contact recreation activities such as, but not limited to, wading, swimming, boating, water skiing, canoeing, kayaking and SCUBA diving" [OAC 3745-1-07 (B)(4)(b)]. There are three classes of PCR use to reflect differences in the potential frequency and intensity of use. Streams designated PCR Class A typically have identified public access points and support primary contact recreation. Streams designated PCR Class B support, or potentially support, occasional primary contact recreation activities. The Deer Creek mainstem is designated Class A PCR waters from Bradford Creek/Sugar Creek confluence (RM 41.22) to the mouth; all other streams assessed during this survey are designated Class B PCR waters. The *E. coli* criteria that apply to PCR Class A and B streams include a geometric mean of 126 and 161 cfu/100 ml, and a maximum value of 298 and 523 cfu/100 ml, respectively. The geometric mean is based on two or more samples and is used as the basis for determining attainment status when more than one sample is collected.

Summarized bacteria results are listed in Table 6, and the complete dataset is reported in Appendix 2. Downloadable bacteria results are also available from the Ohio EPA GIS interactive maps at the following link: http://www.epa.ohio.gov/dsw/gis/index.aspx .

Thirty-seven locations in the Deer Creek study area were sampled for *E. coli* five to nine times, between May and October 2011. Evaluation of *E. coli* results revealed that 36 of the 37 locations sampled failed to attain the applicable geometric mean criterion, indicating an impairment of the recreation use at these locations as depicted in Table 6. Sources of elevated bacteria concentrations were ubiquitous and most likely due to a variety of inputs depending on the site location.

Agricultural activities and home sewage treatment systems (HSTS) are the most probable sources of bacteria to streams in the study area. Agricultural activities include land application of manure and biosolids as well as livestock production. Concentrated animal feeding operations (CAFOs) are also located in the study area and are documented sources in subwatersheds such as Bradford Creek. Unsewered areas can also be a source of bacteria. For this study, this includes the Madison Lake community in the Turkey Run subwatershed and the village of Lafayette in the Richmond Ditch subwatershed.

Bacterial contamination in most streams was present during both wet and dry weather events. This indicates that strategies to reduce bacteria levels in streams should include both nonpoint source and point source measures. Summarized *E. coli* results and potential sources of bacterial contamination for the study area are provided in Table 6 At the time of this study, some of the sources listed have not necessarily been confirmed as a source of impairment nor are they exclusive of other possible sources.

Table 6. A summary of *E. coli* data for locations sampled in the Deer Creek watershed, May 1 through October 31, 2011. Recreation use attainment is based on comparing the geometric mean to the Primary Contact Recreation (PCR) Classes A or B geometric mean water quality criterion of 126 or 161 cfu/100 ml (Ohio Administrative Code 3745-1-07). All values are expressed in colony forming units (cfu) per 100 ml of water. Gray shaded values exceed the applicable PCR Class A or B geometric mean criterion.

Location	River Mile	# of Samples	Recreation Use	Geometric Mean	Maximum Value	Recreational Attainment Status	Probable Source(s) of Bacteria
HUC 05060002 01 01 Headwaters Deer Creek							
Deer Creek	69.6	5	B	1260	5400	**NON**	AG, Livestock, HSTS, WWTP
Deer Creek	69.3	5	B	750	2500	**NON**	AG, HSTS, WWTP
N.F. Deer Creek	0.10	5	B	539	2600	**NON**	AG, HSTS
HUC 05060002 01 02 Richmond Ditch							
Deer Creek	66.1	5	B	368	1500	**NON**	AG, HSTS
Deer Creek	64.70	5	B	520	900	**NON**	AG, HSTS,
Deer Creek	62.0	5	B	1485	3100	**NON**	AG, HSTS, Lafayette (unsewered)
HUC 05060002 01 0 Glade Run 3							
Glade Run	0.5	5	B	678	1200	**NON**	AG, HSTS, WWTP
HUC 05060002 01 04 Walnut Run							
Walnut Run	0.2	5	B	384	630	**NON**	AG, HSTS, CAFO (Gill Livestock)
HUC 05060001 01 05 Oak Run							
Oak Run	6.78	5	B	602	1200	**NON**	AG , Livestock, London WWTP
Oak Run	2.10	10	B	256	490	**NON**	AG, HSTS
HUC 05060002 01 06 Turkey Run							
Deer Creek	58.54	8	B	296	940	**NON**	AG, HSTS
Deer Creek	53.3	5	B	136	290	**NON**	HSTS, Madison Lake (unsewered)
Deer Creek	51.39	5	B	324	670	**NON**	AG, Livestock
Deer Creek	49.40	5	B	504	740	**NON**	AG, Livestock
Deer Creek	44.37	10	A	463	2900	**NON**	AG, Livestock

Location	River Mile	# of Samples	Recreation Use	Geometric Mean	Maximum Value	Recreational Attainment Status	Probable Source(s) of Bacteria
HUC 05060002 02 01 S.F. Bradford Creek							
Bradford Creek	7.15	5	B	958	2900	**NON**	AG, CAFO (Assen Dairy), Livestock
HUC 05060002 02 02 Sugar Run							
Bradford Creek	2.6	7	B	345	3400	**NON**	AG, CAFO (Assen Dairy), Livestock
Sugar Run	0.5	5	B	550	3700	**NON**	AG, Livestock, HSTS
HUC 05060002 02 03 Opossum Run							
Opossum Run	0.85	5	B	457	1400	**NON**	AG, Livestock, HSTS
HUC 05060002 02 04 Town of Mount Sterling							
Duffs Fork	0.5	1	A	600	600	**NON**	AG, Livestock, HSTS
Deer Creek	41.3	5	B	339	680	**NON**	AG, HSTS
HUC 05060002 02 04 Town of Mount Sterling							
Deer Creek	35.56	8	A	251	460	**NON**	AG, HSTS
Deer Creek	35.47	5	A	531	18000	**NON**	AG, Mt. Sterling WWTP
Deer Creek	31.10	5	A	211	320	**NON**	AG, WWTP, HSTS
HUC 05060002 02 05 Clark Run							
Clark Run	1.30	5	B	1576	17000	**NON**	AG, Livestock, HSTS
HUC 05060002 02 06 Buskirk Creek							
Buskirk Creek	1.20	5	B	431	950	**NON**	AG, AFO, Livestock, HSTS
HUC 05060002 02 07 Deer Creek Dam							
Deer Creek	23.72	8	A	38	200	FULL	
Deer Creek	21.20	5	A	198	1100	**NON**	AG, WWTPs
Deer Creek	17.60	5	A	208	370	**NON**	AG
HUC 05060002 03 01 Dry Run							
Dry Run	0.42	5	B	437	760	**NON**	AG, Livestock
HUC 05060002 03 02 Hay Run							
Hay Run	3.80	4	B	420	940	**NON**	AG, Clarksburg WWTP, Livestock
Hay Run	0.90	8	B	429	1100	**NON**	AG, Livestock, WWTP
HUC 05060002 03 03 Waugh Run							
Waugh Run	4.95	5	B	1157	2700	**NON**	AG, HSTS
HUC 05060002 03 04 State Run							
Deer Creek	14.76	8	A	278	1100	**NON**	AG
Deer Creek	11.65	5	A	484	7400	**NON**	AG, Williamsport WWTP, Livestock, HSTS
Deer Creek	5.75	5	A	261	830	**NON**	AG, Livestock, HSTS
Deer Creek	1.05	8	A	165	661	**NON**	AG, Livestock, HSTS

AG – Agriculture
CAFO – Concentrated Animal Feeding Operation
HSTS – Home Sewage Treatment Systems
WWTP – Wastewater Treatment Plants

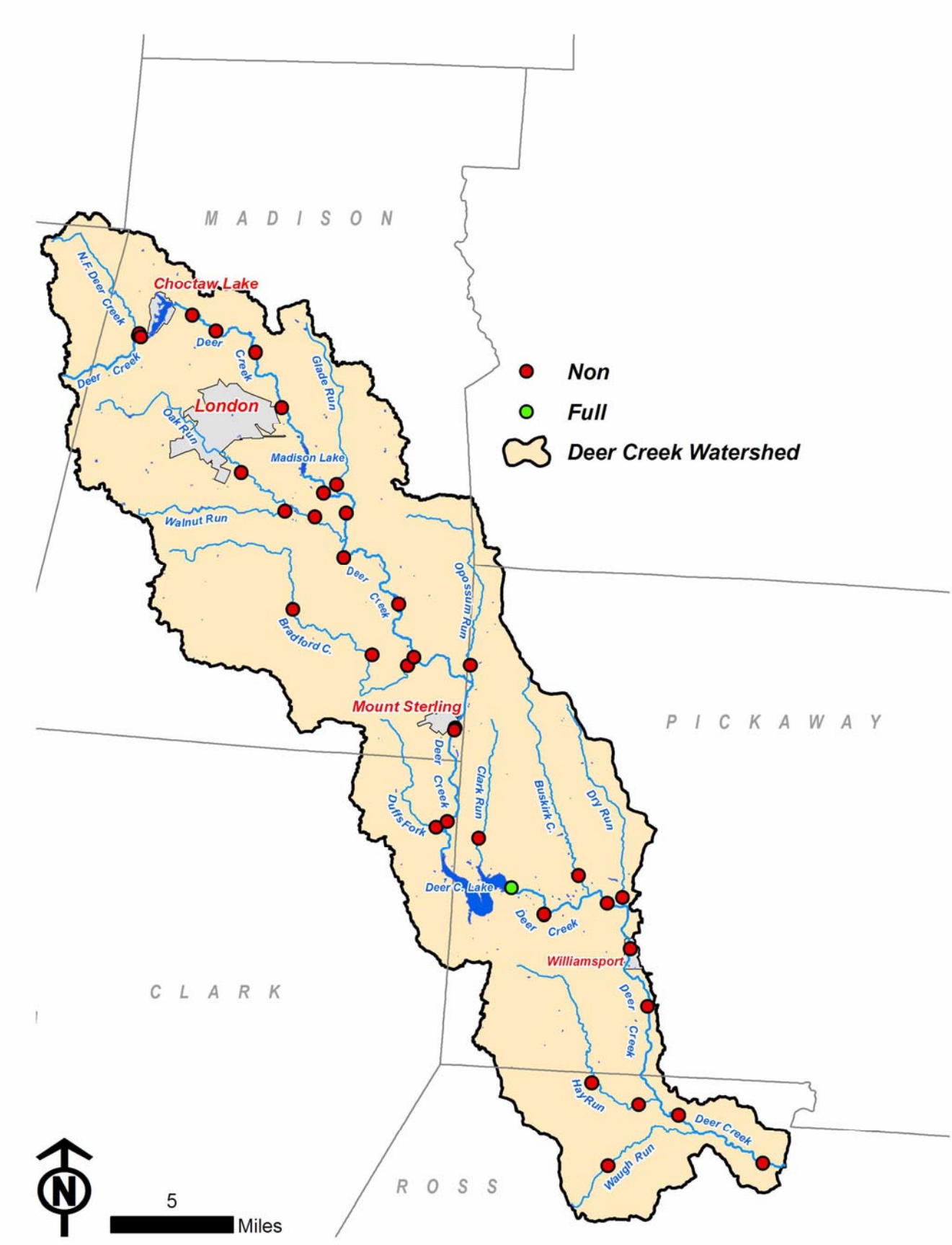


Figure 6. Primary Contact Recreation use attainment status for selected locations in the Deer Creek study area, 2011.

Effluent Dischargers

A total of 21 NPDES–individual permitted facilities discharge sanitary wastewater, industrial process water and/or industrial storm water into streams in the Deer Creek watershed study area (Table 7). Only one major municipal discharger, city of London WWTP, is located in the watershed. Other municipal dischargers include Choctaw Lake, Mount Sterling, Williamsport and Clarksburg. There are also four mobile home parks and two high schools that operate small wastewater package plants and discharge treated effluent in the watershed.

Each facility is required to monitor their discharges according to sampling and monitoring conditions specified in the individual NPDES permit and report results to the Ohio EPA in a Discharge Monitoring Report (DMR). Each permit includes a detailed list of each parameter to be monitored and the specific limits for both concentration and loading rate. They also include monthly average limits and daily or weekly limits, depending on monitoring requirements. The DMR data can be used to track compliance as well as to evaluate historic trends.

There also is one active CAFO that holds a current NPDES permit in the Deer Creek watershed. Rising Sun Dairy operated by Assen Dairy LLC. is authorized to discharge storm water to Madden Ditch. In September 2011 the Ohio Department of Agriculture (ODA) approved plans for the expansion of the facility from 699 dairy cows to 2,558. Local residents then filed a formal appeal with the state's Environmental Review Appeals Commission (ERAC). The appeal is largely based upon violations of manure application regulations. Documented manure spills occurred most recently in 2008 and again in the spring of 2010. The 2010 incident resulted in a fish kill in the Bradford Creek subwatershed. In October 2010, the dairy pleaded guilty to past water pollution incidents from improper manure application and paid $20,000 in restitution and fines (Ohio Department of Agriculture, 2011).

Additional facilities regulated by an Ohio EPA general NPDES permit are also found in the study area. Information on Ohio EPA's general permit program may be found at: http://epa.ohio.gov/dsw/permits/gpfact.aspx.

Table 7. Facilities regulated by an Individual NPDES permit in the Deer Creek Watershed.

OEPANO	TYPE	FACILITY	MAJOR	FLOW DESIGN (MGD)	STREAM	RIVER MILE	EXPIRATION	DISTRICT	COUNTY
4IK00026	Industrial	Assen Dairy LLC	No	NA	Madden Ditch	5.50	5/31/2011	CDO	Madison
4PG00049	Municipal	Choctaw Lake WWTP & SSD #2	No	0.300	Deer C.	68.90	7/31/2013	CDO	Madison
4PV00109	Municipal	Gary Stites DBA Spring Valley MHP	No	0.008	UT Deer C.	(@RM 60.9)	6/30/2014	CDO	Madison
4IM00001	Industrial	London Correctional Institution	No	NA	Jones Ditch #2	0.50	11/30/2010	CDO	Madison
4IW00090	Industrial	London WTP	No	0.300	Oak Run	9.60	5/31/2013	CDO	Madison
4PC00003	Municipal	London WWTP	Yes	5.800	Oak Run	7.90	10/31/2014	CDO	Madison
4PG00045	Municipal	Madison Co Sewer Dist No 1	No	0.150	Glade Run	7.90	6/30/2012	CDO	Madison
4PT00001	Municipal	Madison Plains HS	No	0.033	Roberts Ditch	3.35	7/31/2010	CDO	Madison
4PB00015	Municipal	Mount Sterling WWTP	No	0.500	UT Deer C.	0.20	3/31/2015	CDO	Madison
4PP00015	Municipal	ODOT Rest Area 6-21	No	0.020	UT Deer C.	1.00	7/31/2013	CDO	Madison
4IM00105	Industrial	Ohio Willow Wood Co	No	0.002	Deer C.	36.39	5/31/2012	CDO	Madison
4PV00105	Municipal	Pickett Fences MHP	No	0.003	UT Glade Run	0.80	4/30/2012	CDO	Madison
4IN00019	Industrial	Travel Centers of America London	No	NA	UT Glade Run	(@ RM 8.20)	8/31/2015	CDO	Madison
4PX00016	Municipal	Deer Creek Camping Resort	No	0.028	Deer C.	22.95	3/31/2014	CDO	Pickaway
4PP00000	Municipal	ODNR Deer Creek State Park STP	No	0.080	Deer C.	23.60	2/28/2013	CDO	Pickaway
4PY00014	Municipal	Sunset MHP	No	0.010	Deer C.	37.60	11/30/2014	CDO	Pickaway
4IJ00010	Industrial	The Melvin Stone Co	No	NA	Deer C.	22.60	7/31/2013	CDO	Pickaway
4PT00116	Municipal	Westfall High School	No	0.026	Dry Run	3.19	3/31/2012	CDO	Pickaway
4PA00004	Municipal	Williamsport WWTP	No	0.150	Deer C.	14.10	10/31/2015	CDO	Pickaway
0PA00001	Municipal	Clarksburg WWTP	No	0.060	Hay Run	3.90	6/30/2013	SEDO	Ross
0PV00025	Municipal	Country Woods Estates MHP	No	0.012	UT Deer C.	1.10	1/31/2012	SEDO	Ross

Source: Ohio EPA GIS – Individual NPDES Permits (January 11, 2011). River Mile Maps (September 24, 2009) (http://epa.ohio.gov/dsw/gis/index.aspx). Individual NPDES Permits Station Layer at Ohio EPA GIS Karta Server (undated).
NA – Not applicable

Sediment

Sediment samples were collected from five (5) sites in the Deer Creek watershed study area by the Ohio EPA in the fall of 2010 and are summarized in Table 8. Samples were analyzed for metals, organics, nutrients, total organic carbon (TOC) and particle size. Sediment sample results were evaluated using published guidelines discussed below.

Sediment samples were sampled by focusing on depositional areas of fine grain material (silts and clays). These areas are typically represented by higher contaminant levels, compared to sands and gravels. All sediment sampling occurred in areas along the stream bank, which were represented by sparse deposits of fine grained material. These near bank areas comprised only a small fraction of the bottom substrates of the streams surveyed. Bottom substrates at several sites surveyed were dominated by cobble, gravel and sand.

At each sample location, analyses were conducted for 130 organic parameters including polycyclic aromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs) and pesticides. Sediment sample results for organics were evaluated using guidelines established in *Development and Evaluation of Consensus-Based Sediment Quality Guidelines for Freshwater Ecosystems* (MacDonald et. al. 2000).

MacDonald consensus-based sediment guidelines define two levels of ecotoxic effects. A *Threshold Effect Concentration* (TEC) is a level of sediment chemical quality below which harmful effects are unlikely to be observed, and is comparable to background conditions. A *Probable Effect Concentration* (PEC) indicates a level above which harmful effects are likely to be observed.

No organic parameters were detected in stream sediments at sites sampled in the Deer Creek study area.

At most sites studied, concentrations of metals found in sediment were at or below Ohio EPA *Sediment Reference Values* (Ohio EPA 2008). The Ohio SRVs represent ecoregion background conditions based on data collected at Ohio reference sites. No metal sediment results exceeded the TEC level while most results were below the PEC level.

Nutrient sediment sampling included total organic carbon (TOC) and total phosphorus. These results were evaluated using guidelines established by Persuad et.al. (1993). This includes the Lowest Effect Level (LEL) and the Severe Effect Level (SEL). The LEL is a level of sediment concentration that can be tolerated by a majority of benthic organisms. The SEL is a concentration considered harmful to most benthic organisms. No sites sampled exceeded the SEL for TOC or total phosphorus.

Table 8. Chemical parameters measured above screening levels in samples collected by Ohio EPA from surficial sediments in Deer Creek, Bradford Creek and Oak Run, 2010. Contamination levels were determined for parameters using Ohio Sediment Reference Values (SRVs), guidelines established by MacDonald et. al. 2000, Ohio EPA 2008 and Persuad et. al. 1993. Shaded numbers indicate values above the following: Lowest Effect Level-LEL (blue), Sediment Reverence Value–SRV (yellow), Threshold Effect Concentration –TEC (orange).

		Bradford Creek @ Junk Road	Deer Creek @ SR 56	Deer Creek @ Robison Road	Deer Creek @ SR 142	Oak Run @ Gregg-Mill Road
Parameter	Units					
		NUTRIENTS				
TOC	%	4.4	5.6	4.2	4.6	3.3
Total Phosphorus	mg/kg	327	923	1120	1030	730
Ammonia	mg/kg	100	310	320	480	80
		METALS				
Aluminum	mg/kg	4000	9530	8930	12900	7560
Arsenic	mg/kg	6.21	7.98	9.48	15.2	11.8
Barium	mg/kg	43.5	116	129	163	90.2
Cadmium	mg/kg	0.383	0.648	0.693	0.979	0.629
Calcium	mg/kg	126000	55600	63700	61700	116000
Chromium	mg/kg	5.81	13	10.8	15.2	9.73
Iron	mg/kg	11500	19200	21000	28100	22000
Lead	mg/kg	6.55	20.9	17.2	20	17.1
Magnesium	mg/kg	56300	21500	23200	27500	54600
Manganese	mg/kg	353	395	491	574	501
Mercury	mg/kg	0.056	0.086	0.083	0.073	0.053
Nickel	mg/kg	12.7	18	19.6	23.9	20.1
Strontium	mg/kg	253	441	605	627	342
Zinc	mg/kg	42	93.4	103	132	87.1
		ORGANICS				
		None detected				
		Includes PCBs, PAHs, Pesticides				

Value greater than Lowest Effect Level, from Persuad et.al (1993)

Value greater than Sediment Reference Value, from Ohio EPA (2008)

Value greater than Threshold Effect Concentration, from MacDonald et.al.(2000)

Stream Physical Habitat

Deer Creek

Stream habitat was evaluated at 52 fish sampling locations in the Deer Creek study area during 2011 (Table 9, Appendix 5). Twenty-one of these stations were located on Deer Creek, where habitat quality ranged from good to excellent. The average Qualitative Habitat Evaluation Index (QHEI) score for all Deer Creek mainstem sites was 82.3, consistent with excellent overall habitat quality. The streambed was predominated by sand and gravel substrates, with lesser amounts of cobble, and boulders. However, moderate to heavy substrate embeddedness occurred at 14 sites. Embeddedness is the degree to which cobble, gravel, and boulder substrates are surrounded, impacted in, or covered by fine sand and silt. Extensive amounts are detrimental to bottom spawning fish and can impair macroinvertebrate populations. The high quality habitat present in Deer Creek undoubtedly benefited state designated threatened, special interest, and endangered fish species that were recorded in 2011. These included bluebreast *darters* (*Etheostoma camurum*), tippecanoe darters (*Etheostoma tippecanoe*), shortnose gar (*Lepisosteus platostomus*) and river redhorse (*Moxostoma carinatum*).

Figure 7. Deer Creek at St. RT. 138 (RM 11.65) contained numerous high quality habitat features that were reflected in a QHEI score of 91.5.

A comparison of habitat quality at thirteen sites sampled in 2011 and 1997 revealed a slight improvement over the intervening years. The average QHEI score increased from 73.7 in 1997 to 81.7 in 2011. Two sites displayed significant improvement in QHEI scores. Deer Creek at the mouth of Turkey Run (RMs 49.3-49.4) was historically channelized but has substantially recovered, resulting in a 25.5 point increase in the QHEI score [47.0 in 1997 to 73.5 in 2011 (Figure 8)]. Similar improvement was evident for the stream reach downstream from Deer Creek dam at Crownover Mill Road. More desirable riparian and instream habitat features were present in 2011; consequently, the QHEI increased from 63.5 in 1997 at RM 23.5 to 81.0, just upstream, at RM 23.75.

Figure 8. Deer Creek pictured facing upstream of the mouth of Turkey Run, RM 49.3. This general area was recovering from channelization in 1997. Additional recovery was evidenced by the establishment of American water-willow, *Justicia americana*, along the riffle margins and maturing trees along the banks in 2011.

Other Streams/Tributaries

QHEI scores for thirty-one sites on the tributaries to Deer Creek averaged 71.5. QHEI scores above 60 indicate habitat conditions should be favorable to support typical warmwater fish communities. Good to excellent habitat conditions were documented, with one exception. Waugh Run at RM 5.0 (Figure 8) is a small headwater stream (7.5 mi^2). Gravel was the predominant substrate at the site, with lesser amounts of boulders, cobble, and sand. Instream cover was sparse, and the riffle and pool depths were shallow which contributed to the fair quality habitat rating (QHEI = 53.5).

Figure 9. Waugh Run at Egypt Rd (RM 5.0). QHEI=53.5. Limiting habitat features include shallow depths and limited instream cover.

Table 9. Stream physical habitat (QHEI) summarized results for the Deer Creek study area, 2011. Site numbers correspond to Table 1.

Site Number	**Stream Name** /Location	River Mile	Drainage Area (mi^2.)	QHEI	Comments
1	Deer Creek at Summerford Cemetery	69.60	6.5	75.50	
2	Deer Creek at St. Rt. 56	69.30	17.2	76.00	
3	Deer Creek ust.. Richmond Run	66.10	28.9	76.00	
4	Deer Creek at St. Rt. 38	64.70	33.0	79.80	
5	Deer Creek at U.S. Rt. 40	62.00	38.4	68.00	
6	Deer Creek at St. Rt. 142	58.54	50.7	70.50	
7	Deer Creek dst. at Glade Run Rd.	53.30	60.0	89.50	
8	Deer Creek at Big Plain-Circleville Rd.	51.39	82.0	79.50	
9	Deer Creek at Turkey Run	49.40	129.0	73.50	
10	Deer Creek at Robison Rd.	44.37	141.0	85.30	
11	Deer Creek ust. Anderson Rd.	41.30	147.0	88.00	
12	Deer Creek at St. Rt. 56	35.56	228.0	88.30	
13	Deer Creek dst. Mt. Sterling WWTP	35.47	228.0	86.50	
14	Deer Creek at Yankeetown Rd.	31.10	237.0	85.30	
15	Deer Creek at Crownover Mill Rd.	23.72	278.0	81.00	
16	Deer Creek adj. Williamsport-Crownover Rd.	21.20	284.0	85.80	
17	Deer Creek at Walston Rd. Access	17.60	310.0	83.50	
18	Deer Creek at U.S. Rt. 22	14.76	333.0	89.80	
19	Deer Creek at St. Rt. 138	11.65	340.0	91.50	
20	Deer Creek at Westfall Rd.	5.75	381.0	89.50	
21	Deer Creek at St. Rt. 104	1.05	411.0	86.00	
22	N. Fk. Deer Creek near mouth	0.10	10.6	73.50	
23	Georges Fork at St. Rt. 187	1.69	3.4	67.50	

Site Number	Stream Name /Location	River Mile	Drainage Area (mi^2.)	QHEI	Comments
24	Glade Run ust. St. Rt. 142	5.17	4.8	55.30	
25	Glade Run near Mouth	0.50	19.5	64.00	
26	Walnut Run at St. Rt. 38	5.20	11.6	81.00	
27	Walnut Run at St. Rt. 56	0.20	15.3	80.00	
28	Oak Run at Old Springfield Rd.	10.28	9.3	56.00	
29	Oak Run ust. London WWTP	7.94	14.7		No fish sample collected; no QHEI score.
30	Oak Run dst. London WWTP	7.80	19.7	68.00	
31	Oak Run at Old Xenia Rd.	6.78	20.3	73.50	
32	Oak Run at Gregg Mill Rd.	2.10	41.0	88.00	
33	Bradford Branch at Johnston Rd.	1.95	5.3		No fish sample collected; no QHEI score.
34	S. Fk. Bradford Creek at Yankeetown-Chenowith Rd.	1.30	8.8	77.50	
35	Bradford Creek at Moorman Rd.	7.15	16.2	55.00	
36	Bradford Creek ust. I-71	1.20	36.6	81.30	
37	Mud Run at Bragg Rd.	0.70	6.6	72.50	
38	Sugar Run ust. U.S. Rt. 56	0.50	51.7	86.50	
39	Opossum Run at Mantle Rd.	4.40	10.3	61.50	
40	Opossum Run at Tenny Rd.	0.85	17.5	65.50	
41	Duffs Fork at St. Rt. 207	0.50	12.4	87.00	
42	Clark Run at Dawson-Yankeetown Rd.	1.30	7.6	68.30	
43	Buskirk Creek at Five Points Rd.	5.20	9.1	76.00	
44	Buskirk Creek at Crownover Mill Rd.	1.20	17.6	82.00	
45	Dry Run at St. Rt. 56	3.60	13.5		No fish sample collected; no QHEI score.
46	Dry Run at Palestine-Williamsport Rd.	0.42	21.0	71.00	
47	Brush Creek at St. Rt. 207	0.25	6.5	73.50	
48	Hay Run at Judas Rd.	7.00	4.8	59.00	
49	Hay Run at St. Rt. 138	3.91	21.9	77.00	
50	Hay Run dst. Clarksburg WWTP	3.80	21.9	72.30	
51	Hay Run at Twp. Rd. 132	0.90	28.7	72.00	
52	Stall Run at St. Rt. 207	0.40	4.0	69.00	
53	Waugh Run at Egypt Rd.	4.95	7.5	53.50	Recovering from channelization with sparse in-stream cover
54	Waugh Run at Westfall Rd.	1.03	17.3	78.30	

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

Aquatic Life

Aquatic life uses and attainment status were assessed for 51 sites within the Deer Creek study area. Recommended changes and additions to the applicable aquatic life uses are presented in Table 3 and attainment status is included in Table 2. Additional information is included in the appendices to this report. Appendix 6 contains Index of Biotic Integrity (IBI) scoring and fish species by site are listed in Appendix 7. Invertebrate Community Index (ICI) scoring and macroinvertebrate community attributes are contained in Appendices 8 and the macroinvertebrate taxa and densities recorded for each site are listed in Appendix 9.

Deer Creek

Twenty-one biological sampling sites were located along the Deer Creek mainstem. Seventeen of the sites met existing or recommended aquatic life use expectations. Partial attainment was related to impoundments at the remaining four sites. Dams impound Deer Creek beginning with Choctaw Lake in the headwaters followed by Madison Lake and Deer Creek Lake, the largest of the three. Flow regime alteration affected the fish community upstream and downstream from Choctaw Lake (RMs 69.30 and 66.10). The release of nutrient rich/ eutrophic water from Deer Creek Lake impacted the macroinvertebrate community at RMs 23.72 and 21.20.

Ecoregional expectations were met at the upper most mainstem site (RM 69.60) with an IBI score of 42 and a marginally good macroinvertebrate assemblage. Fish community structure was disrupted upstream and downstream from Choctaw Lake and resulted in partial attainment of the biocriteria. Gizzard shad comprised nearly 95 percent of total fish collected at RM 69.30. As a result, the IBI score was depressed into the fair range (IBI =32). Macroinvertebrate community diversity and number of EPT taxa both increased at RM 69.30 and netted a good rating. Downstream from Choctaw Lake (RM 66.10) an inordinate number of yellow bullheads (*Ameiurus natalis*) and bluegill sunfish (*Lepomis macrochirus*) negatively affected the MIwb scoring (MIwb= 7.06). Conversely, ICI and IBI scores were in the good range. The overwhelming presence of gizzard shad at RM 69.30 and depressed MIwb score at RM 66.10 were both attributable to the impoundment of Deer Creek. The reservoir served as a source for unusually high percentages of lentic fish that then populated the stream reaches immediately upstream and downstream from Choctaw Lake.

Full attainment of biocriteria was documented in the WWH portion of Deer Creek downstream from the immediate influence of Choctaw Lake to upstream from Sugar Run (RM 64.70 to RM 41.22). Eight sites were sampled along this reach which includes Madison Lake. The lake is formed by a dam at RM 55.24 that impounds the creek upstream for approximately two miles. Madison Lake did not adversely impact the fish index scoring; however, an influence of the lake was evident in an inordinately high number (n=45) of channel catfish (*Ictalurus punctatus*) recorded downstream from the dam (RM 53.30). IBI and ICI scores were in the good to exceptional range and MIwb scores varied from marginally good to exceptional (Table 2). The higher fish community index scores corresponded with sites with excellent habitat (QHEI score > 75). A good diversity of pollution sensitive macroinvertebrate taxa was collected from the natural substrates upstream from Madison Lake (11 to 14 taxa). Downstream from the lake, sensitive taxa diversity increased into the exceptional range (18 to 25 taxa).

Deer Creek is designated as an Exceptional Warmwater Habitat (EWH) beginning downstream from Sugar Creek (RM 41.22) to the confluence with the Scioto River. No impact was discerned downstream from the Mt. Sterling WWTP (RM 31.10). The fish community at least marginally met EWH expectations throughout the entire reach. Shortnose gar (*Lepisosteus platostomus*), a state endangered species, was recorded at RM 21.20. The EWH macroinvertebrate biocriterion was met upstream from Deer Creek Lake but macroinvertebrate community quality declined at the two sites downstream from the lake (RMs 23.72 and 21.20). The release of phytoplankton rich water from the lake served as a food source for an overabundance of filter feeding midge taxa (*Rheotanytarsus* sp.) which resulted in an imbalanced structural and functional macroinvertebrate community condition. An additional contributory factor to impairment at RM 21.2 was lower dissolved oxygen levels caused by the breakdown of organic material from the lake water release. Improvement in the ICI scores to EWH levels at RMs 23.72 and 21.20 hinges on reducing nutrient inputs to Deer Creek Lake that, under current conditions, promotes the growth of phytoplankton. Recovery of macroinvertebrate communities below Deer Creek Lake should occur as an additional benefit related to successful implementation of lake-driven TMDLs to restore beneficial uses in Deer Creek Lake itself. Both fish and macroinvertebrate communities fully met EWH expectations from RM 17.60 to near the mouth (RM 1.05).

Figure 10. State endangered Shortnose gar (*Lepisosteus platostomus*) was collected from Deer Creek at RM 21.20.

Bluebreast darters (*Etheostoma camurum*), which have benefited from water quality improvements since the enactment of the 1972 Clean Water Act, were utilizing the high quality habitat that Deer Creek provided downstream from Madison Lake. They were collected at 13 of the 15 sampling locations between RMs 51.4 and 1.05. In addition, tippecanoe darters (*Etheostoma tippecanoe*), a state threatened species, were present at Deer Creek sites beginning at RM 17.60 to the confluence with the Scioto River. Deer Creek Lake blocks fish passage upstream from the lake. An effort to reintroduce tippecanoe darters upstream from Deer Creek Lake would likely be successful given the excellent habitat that is available.

Deer Creek Tributaries

Nearly three quarters of sites on tributary streams within the Deer Creek basin met the Clean Water Act biological integrity goal, as 22 of 30 sites were in full attainment of the WWH aquatic life use designation. Three remaining sites were in non-attainment of WWH (10%); two sites partially met WWH expectations (6%) and three sites partially met the more stringent EWH use (10%) (Table 2).

The WWH aquatic life use designation of seven streams in this survey were originally designated for aquatic life use in the 1978 Ohio WQS but the techniques used then did not include standardized approaches to the collection of instream biological data or numerical biological criteria. Six streams, Stall Run, Dry Run, Duffs Fork, Opossum Run, Mud Run, and Bradford Creek upstream from RM 6.1 supported biological communities consistent with the previously unverified WWH use.

A WWH aquatic life use is appropriate for Glade Run based on biological sampling conducted at two locations on Glade Run. Glade Run at RM 5.17 supported a relatively diverse fish assemblage but macroinvertebrate sampling yielded a poor result. Facultative

macroinvertebrates predominated and just three sensitive taxa were among the 42 taxa collected from the natural substrates. Impacts at RM 5.17 were related to row crop agriculture that resulted in excessive silt and sediment confined within the stream channel and elevated nutrients. Glade Run at RM 0.50 yielded a good fish assemblage (IBI=42) and an excellent macroinvertebrate community which included 15 sensitive taxa.

Three undesignated streams were evaluated for the first time in 2011 and are recommended for the WWH aquatic life use designation. Georges Fork and Brush Creek supported fish and macroinvertebrate communities in full attainment of the WWH aquatic life use designation. No fish sampling was conducted on Bradford Branch but qualitative macroinvertebrate sampling results produced a diverse fauna consistent with the WWH use.

Agricultural nutrients contributed to biological community impairment in Bradford Creek, Sugar Run, Walnut Run and Buskirk Creek. The fish communities were affected in Bradford Creek, Walnut Run and Sugar Run and a poor quality macroinvertebrate community was documented in Buskirk Creek at RM 5.2. Nitrate-nitrite levels were elevated above reference conditions in all four streams.

The fish communities in the EWH reaches of Bradford Creek (RM 1.20) and Sugar Run (RM 0.50) partially attained the designated aquatic life use. MIwb scores were below expectations even though both sites offered high quality habitat with QHEI scores in the excellent range. Operations at the Rising Sun Dairy, located in the headwaters of Bradford Creek, likely contributed significantly to nutrient loads in Bradford Creek and Sugar Run. This facility has been responsible for a series of fish kills related to manure handling as recently as November 2012. Low MIwb scores are reflective of an unbalanced fish community structure and likely represented incomplete recovery of the two streams following manure releases from the dairy.

Partial attainment of WWH expectations was documented in Walnut Run at RM 5.20 and the use was fully met near the mouth (RM 0.20). The macroinvertebrate community was rated as excellent and included 15 sensitive taxa. Conversely, the IBI score was in the fair range and pollution tolerant fish, principally creek chubs (*Semotilus atromaculatus*) accounted for 46% of the individuals collected.

The two locations on Buskirk Creek failed to meet designated aquatic life uses (WWH at RM 5.2 and EWH at RM 1.2). The diversity of EPT and sensitive taxa was depressed at both sites which contributed to a poor macroinvertebrate community rating at RM 5.2. The macroinvertebrate community improved downstream at RM 1.2, receiving a good narrative evaluation but remained below expectations of the EWH aquatic life use designation. The fish community marginally attained WWH expectations at RM 5.2 and was in exceptional condition at RM 1.2.

Neither organism group met WWH expectations at RM 1.3 on Clark Run. The fish and macroinvertebrate communities both were reflective of a fair condition. The fish community was dominated by pollution tolerant creek chubs (*Semotilus atromaculatus*). Qualitative macroinvertebrate sampling yielded just two relatively sensitive taxa among the 38 total collected. Additionally, geometric mean *E. coli* bacteria levels were the highest recorded in the Deer Creek study area. Agricultural nutrients, livestock and home septic treatment systems are all potential sources of the biological impairment seen in Clark Run.

Biological sampling was conducted at four sites on Hay Run. All of the locations produced ICI scores in the very good to exceptional range and marginally good to excellent macroinvertebrate assemblages. Natural intermittent flow conditions resulted in a depressed MIwb score at RM 3.91 on Hay Run and partial attainment of the designated WWH aquatic life

use. The discharge of treated wastewater from the Clarksburg WWTP had no perceptible impact on the biological communities in Hay Run.

Biological Community Trends

Compared to historical collections from a Deer Creek survey in 1997, 2011 macroinvertebrate sampling reflected little change in quality over the period (Figure 11; Table 10). ICI scores from eleven duplicated mainstem sampling sites averaged 44.7 and 46.2 during the 2011 and 1997 surveys, respectively. Both ICI averages fell in the lower exceptional range and both were within the range of acceptable variability (*i.e.,* +/- 4 ICI points) for the index. Like the ICI trend, comparison of the qualitative sampling results from the two years revealed similar diversities in the average number of total taxa, EPT taxa and pollution sensitive taxa collected from the natural substrates. Overall, macroinvertebrate community performance throughout Deer Creek was similar between surveys.

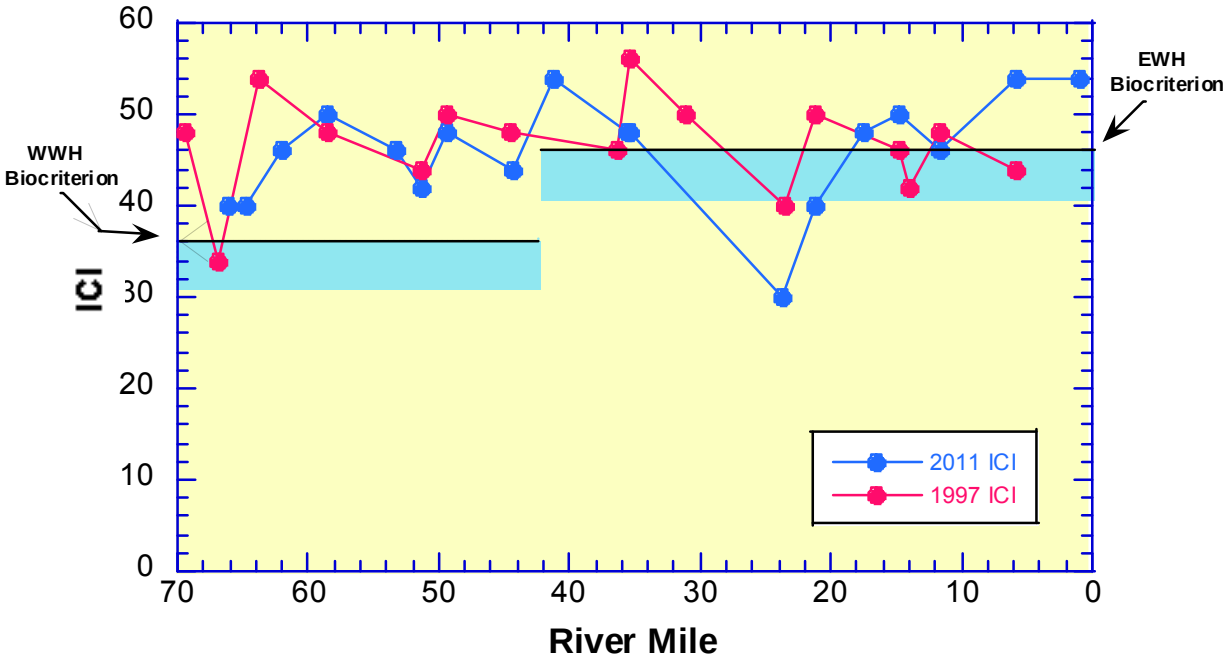


Figure 11. ICI scoring trends in Deer Creek, 1997and 2011.

Table 10. Average ICI scores and average number of qualitative taxa, EPT taxa and sensitive taxa collected from the natural substrates from eleven similar Deer Creek mainstem sites in 1997 and 2011.

Year	**ICI score**	Qual taxa	EPT taxa	Sens. taxa
2011	**44.7**	54.9	19.1	18.4
1997	**46.2**	56.8	16.5	18.8

The 2011 fish community in Deer Creek appeared to be marginally improved compared to the results of the 1997 survey (Figure 12). IBI scores from fourteen duplicated mainstem sampling

sites averaged 48.4 and 44.7 during the 2011 and 1997 surveys, respectively (Table 11). In particular, the sites from RM 44.37 downstream to RM 23.72 performed in the narratively good to very good range in 1997 and were found to have exceptional fish communities in 2011. Improvement in the fish community health was also manifest in the upstream extent of bluebreast darter occurrence in the mainstem. In 1997, the uppermost limit of this pollution sensitive darter was RM 36.4. By 2011, bluebreast darters were established in an additional fifteen miles of Deer Creek and collected as far upstream as RM 51.4.

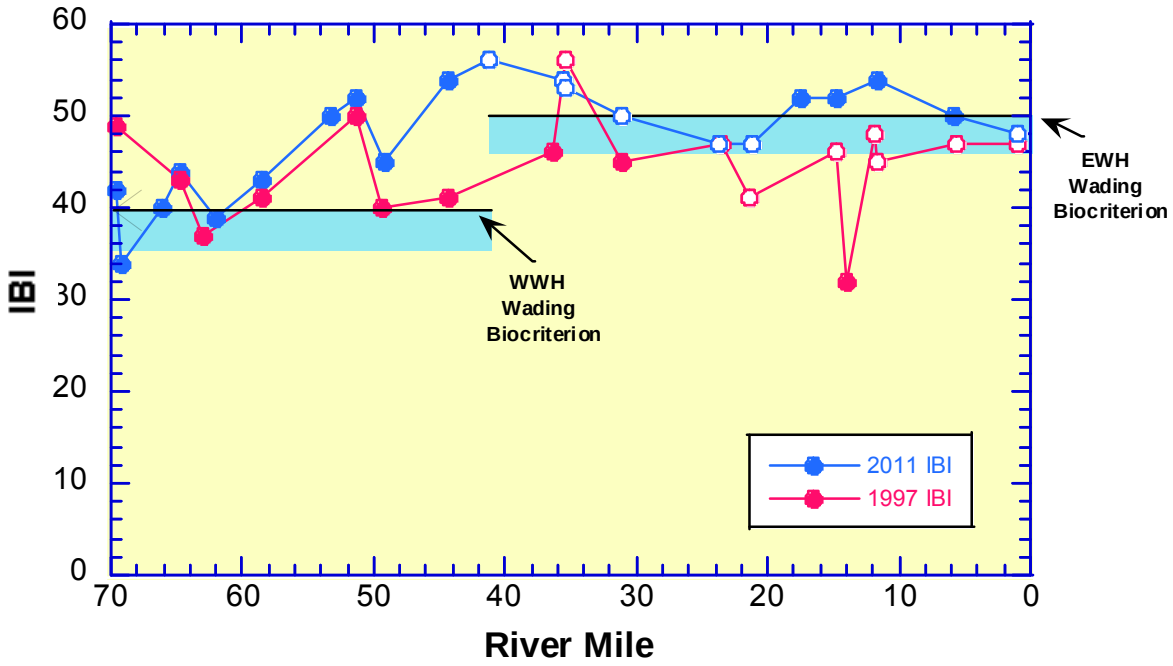


Figure 12. Index of Biotic Integrity (IBI) scoring trends in Deer Creek, 1997 and 2011. Open circles denote locations sampled using the boat electrofishing method.

Table 11. Average IBI and MIwb scores from fourteen similar Deer Creek mainstem sites in the 1997 and 2011.

Year	IBI	MIwb
2011	48.4	9.464
1997	44.7	9.163

An increase in bigeye chub (*Hybopsis amblops*) abundance suggested that improvements made in sediment retention and runoff controls in the Deer Creek watershed have improved water quality. This species is intolerant of silt covered substrates. It can be found in small to moderate sized streams with clean gravel and sand bottoms (Trautman, 1981). Combined totals from all previous fish community surveys from 1987 to 1999 in the Deer Creek watershed produced twenty total bigeye chubs collected from two tributaries, Hay Run and Buskirk Creek. In 2011, 382 bigeye chubs were recorded from five different streams- Deer Creek, Hay Run, Buskirk Creek, Waugh Run, and Dry Run (Appendix 7). The strongest population was in Hay Run at RM 3.8 with 177 individuals caught during one 150 meter sampling event. In contrast, six total bigeye chubs were caught at this location in 1997.

Fish Tissue Contamination

Ohio has been sampling streams annually for sport fish contamination since 1993. Fish are analyzed for contaminants that bioaccumulate in tissue 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 sport fish consumption advisories; 2) to determine attainment with the water quality standards; and 3) to examine trends in fish contaminants over time.

Sport fish consumption 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.

The minimum data requirement for issuing a fish advisory is 3 samples of a single species from within the past 10 years. For this study, Deer Creek and Deer Creek Lake were sampled and both met sampling requirements. For Deer Creek, channel catfish and white crappie are both in the two meals per week advisory category due to mercury contamination; common carp, smallmouth bass, and spotted bass are in the one meal per week advisory category due to mercury contamination. For Deer Creek Lake, common carp, largemouth bass, and white crappie are in the two meals per week advisory category due to mercury contamination. For all other species, the statewide advisories apply, which are: two meals a week for sunfish (e.g., bluegill) and yellow perch, one meal a week for most other fish, and one meal a month for flathead catfish 23" and over.

For a listing of fish tissue data collected from Deer Creek and Deer Creek Lake in support of the advisory program, and how the data compare to advisory thresholds, see Table 12.

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 the Human Health Fish Contaminants section in the latest Integrated Water Quality Monitoring and Assessment Report for further details of this conversion (http://epa.ohio.gov/dsw/tmdl/OhioIntegratedReport.aspx).

In order to be considered in attainment of the Ohio Water Quality Standards (WQS) criteria, the sport fish caught within a HUC12 must have a weighted average concentration of the geometric means for all species below 1.0 mg/kg for mercury, and below 0.054 mg/kg for PCBs. With few exceptions, these two pollutant parameters are the only ones which bioaccumulate at high enough concentrations in fish tissue to trigger WQS criteria violations. For fish tissue data to be adequate to assess the Human Health (Fish Contaminants) use in a HUC12, at least two samples from fish in trophic levels 3 and 4 are needed. Of the five HUC12s in Deer Creek

where fish tissue was collected, three met that data requirement. The three HUC12s that were evaluated for Human Health (Fish Contaminants) use attainment were Richmond Ditch-Deer Creek (05060002 01 02), Turkey Run-Deer Creek (05060002 01 06), and Town of Mount Sterling-Deer Creek (05060002 02 04). For the purpose of this report, Deer Creek Lake was evaluated for attainment separately from the stream HUC12 data. Concentrations of mercury and PCBs and the associated attainment status are listed in Table 12.

Table 12. Attainment status of HUC12s with lakes for the Human Health (Fish Contaminants) use.

HUC12 or Lake	Mercury (mg/kg)	PCBs (mg/kg)	Attainment
05060002 01 02	0.069	Not detected	Full attainment
05060002 01 06	0.081	Not detected	Full attainment
05060002 02 04	0.113	Not detected	Full attainment
Deer Creek Lake	0.065	Not detected	Full attainment

All three HUC12s for which status of the Human Health (Fish Contaminants) use was determined were in full attainment of the use, as was Deer Creek Lake.

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 to air and/or surface water.

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

Fish tissue had previously been collected from Deer Creek Lake in 1994 and in Deer Creek in 1996. No PCBs were detected in fish from Deer Creek Lake in any sampling year. Mercury increased slightly between 1994 and 2005/2011, from 0.051 mg/kg in 1994 to 0.065 mg/kg in 2005/2011. This increase in mercury corresponded to an increase in fish size in Deer Creek Lake, from an average of 320 mm in 1994 to 414 mm in 2005/2011. Since mercury concentrations increase with increasing fish length, the increase in mercury between the two sampling events is likely attributable to the increase in average fish size.

The stretches of Deer Creek that were sampled for fish tissue in 1996 approximately line up with those sampled in 2011. In 1996, fish tissue was sampled upstream from Green Lane at RM 65.9, to upstream from State Route 104 at RM 1.2. In 2011, fish tissue was sampled from State Route 38 at RM 64.7, to State Route 104 at RM 1.05. In Deer Creek, PCBs were found in two fish samples in 1996, both from RM 1.2. In 2011, no PCBs were found in any fish samples from Deer Creek, including from RM 1.05. Both concentrations of mercury and fish size were almost identical in 1996 and 2011, with average mercury concentrations in fish in 1996 at 0.109 mg/kg and an average fish length of 373 mm, and average mercury concentrations in fish in 2011 at 0.106 mg/kg and an average fish length of 369 mm.

Lakes Sampling

Inland Lakes – Madison Lake and Deer Creek Lake (2011-2012)

Methods

Inland lakes are an integral part of watersheds in Ohio and throughout the United States. Natural lakes act as a sink where excess nutrients, sediments and other pollutants are deposited and assimilated into the lake ecosystem. The fate of these pollutants is variable and complex depending on the assimilative capacity of the lake and the food web within.

Certain pollutants will adhere to suspended sediments and eventually fall out where they will either accumulate or become available again, prompted by certain chemical reactions (oxidation) at the substrate interface. Many times this re-suspension involves nutrients that are made available for primary production. These nutrients may be considered beneficial in a nutrient limited water body (oligotrophy or mesotrophy). In other instances, this re-suspension of immediately available nutrients may push the lake into nutrient overdrive and under certain circumstances may result in nuisance or even toxic algal blooms. Even further, some pollutants can bio-accumulate and become a health hazard to fish-eating predators and humans.

Ohio is dominated by artificial reservoirs that are essentially dammed rivers and streams used mainly for flood control and drinking water purposes. Generally speaking, Ohio reservoirs or impoundments are different than natural lakes, with shorter retention times and unstable or inconsistent stratification. However, these impoundments possess certain characteristics and can sustain biological communities that are representative of natural lakes. The biological communities and physical habitats in reservoirs are much different than those found in Ohio's rivers and streams, so inland lakes and reservoirs cannot be assessed as such.

Ohio EPA has implemented a sampling strategy that focuses on evaluating chemical conditions near the surface and physical conditions in the water column of inland lakes. Physical profile measurements are summarized either for the entire water column or the epilimnion depending on thermal stratification. The sampling target consists of an even distribution of a total of ten sampling events divided over a two-year period and collected during the index period of May 1 – September 30. Key parameters used to determine the attainment status of lakes include chlorophyll a, ammonia, dissolved oxygen, pH, total dissolved solids and various metals. Other parameters used to evaluate the degree of support or non-support included secchi depth, total phosphorus and total nitrogen. Details of the sampling protocol are outlined in Appendix 1 of the Ohio EPA Surface Water Field Sampling Manual, available on Ohio EPA's web page at; http://www.epa.ohio.gov/portals/35/inland_lakes/Lake_Sampling_Procedures.pdf

Water Quality Standards for the Protection of Aquatic Life in Lakes

Presently, lakes in Ohio are designated as Exceptional Warmwater Habitat (EWH) with respect to the aquatic life habitat use designation. Revisions to Ohio's WQS that would change the aquatic life use from EWH to Lake Habitat (LH) were proposed for adoption in December, 2011, but were subsequently withdrawn. A future rulemaking is anticipated but the timeframe is unknown. A primary reason for this revision is that in Ohio, a set of biological criteria applies to rivers and streams, whereas no biocriteria apply to lakes. The numeric chemical criteria to protect the LH use will remain the same as the criteria to protect the EWH use that currently applies to lakes, with a suite of nutrient criteria added. A set of numeric criteria that applies to all surface waters for the protection of aquatic life, regardless of specific use designation, also apply to inland lakes and are referred to as "base aquatic life use criteria" in the proposed WQS rules. The base aquatic life use criteria will be the same aquatic life numeric criteria that currently apply to lakes. Examples include various metals such as copper, lead, and cadmium as well as organic chemicals such as benzene and phenol. Specific details concerning the

progress of revisions to Ohio's Water Quality Standards involving the proposed Lake Habitat aquatic life use and associated criteria can be found at the following Ohio EPA web site as information becomes available: http://www.epa.ohio.gov/dsw/rules/draftrules.aspx. Details of the proposed use designation, draft criteria and assessment methodology are previewed in the Ohio EPA 2012 Integrated Water Quality Monitoring and Assessment Report, available on Ohio EPAs web page at; http://epa.ohio.gov/dsw/tmdl/OhioIntegratedReport.aspx

Results

Both Madison Lake and Deer Creek Lake were sampled 6 times during 2011 and 5 times during 2012, with Deer Creek Lake having 2 locations - one near the dam and another at the upstream end of the lake (L1 and L2, respectively). According to the 2012 Integrated Report, both lakes are considered "impoundments" and are located in the ECBP ecoregion with respect to the proposed tiered LH criteria (Table 15). Madison Lake was unstratified during all 11 sampling events due to its shallow nature while Deer Creek Lake exhibited inconsistent stratification, as described above, during the 2011 and 2012 sampling season at both L1 and L2.

Examination of the base aquatic life parameters revealed no impairment since all metals were below their respective criteria in all samples. However, the sampling results during 2011 and 2012 revealed impairment of the proposed Lake Habitat use for both Madison Lake and Deer Creek Lake since one or more of the key tiered LH parameters exceeded the criteria. In addition, both Deer Creek Lake and Madison Lake would be on a "watch list" for nutrient enrichment since all three nutrient parameters exceeded the proposed Lake Habitat OMZA criteria (Tables 14, 15 and 16).

One public beach is maintained by the Ohio Department of Natural Resources during the recreational season at each lake. The Bathing Waters recreation use was evaluated by measuring levels of *E. coli* bacteria at the beach. In Deer Creek Lake, colony counts ranged from below detection to 700 cfu/100 ml and the geometric mean calculated from 11 samples collected over two years was 11.54 cfu/100 ml. Similarly, the Madison Lake beach geometric mean for *E. coli* was 18.36, ranging from below detection to 60 cfu/100 ml. Based on information collected during these two survey years, the Bathing Waters recreation use for both reservoirs was met.

Sediment samples were collected from the L-1 site at both Deer Creek Lake and Madison Lake on 10/16/2012 and analyzed for metals, nutrients, semi-volatile organics, insecticides and polychlorinated biphenyls (PCBs). No organic compounds, insecticides or PCB constituents were detected in the samples, thus a tabular presentation is not necessary. Sediment metal results from Deer Creek Lake and Madison Lake are listed in Table 13 and Table 14, respectively. Results were compared against Sediment Reference Values (SRVs) for the ECBP ecoregion and the MacDonald probable effect concentration (PEC) as a means of determining the likelihood of toxicity to benthic organisms.

Discussion

Madison and Deer Creek lakes are the main basins in the Deer Creek drainage system evaluated for human and aquatic life uses as described above. The assessment of these two lakes is, in essence, another instrument in Ohio EPA's toolbox that can assist in determining the overall health of the Deer Creek basin. Madison Lake is influenced largely by activities affecting the watershed below Choctaw Lake and by unsewered homes surrounding the lake. Deer Creek Lake receives most of its impact from Deer Creek below Madison Lake, and from Oak Run and Bradford Creek to the west, and Glade Run to the east.

Both Madison Lake and Deer Creek Lake revealed indications of nutrient enrichment from the tributaries feeding them. Nutrient or organic enrichment contributed to aquatic life use impairment found at three (3) of the four (4) non-attaining sites on the Deer Creek mainstem.

Enrichment sources in these tributaries include agricultural activities such as livestock operations and row crop production, failing home sewage treatment systems and wastewater treatment plants. One CAFO unit in the Bradford Creek drainage has demonstrated violations of manure applications and undoubtedly contributes to the nutrient load affecting Deer Creek Lake. Several permitted sludge application fields are located upstream from both lakes with potential to run off into the tributaries that feed them. Another potential, but undocumented source is over-application of lawn fertilizers from homeowners throughout the Deer Creek basin.

Both lakes are considered impaired using Ohio EPA's current lake assessment methods. Historically, the nutrient (phosphorus and nitrogen) overload has not resulted in significant algal blooms or fish kills. Deer Creek Lake water column temperatures at L1 were roughly the same between the two years; however, 2011 was a very wet summer as compared to the dry 2012 summer. During 2011, L1 managed to set up a weak thermocline on two separate occasions; whereas during 2012, L1 established a summertime two-tiered stratification with little or no metalimnion Table 17). Dissolved oxygen dropped significantly at the 4-5 meter depth during the heat of the summer both years. Thus far, fish have managed to escape adverse effects by avoiding the oxygen deficient zone in Deer Creek Lake. Madison Lake is very shallow and turbulent, and appears to remain well-mixed. However, Madison Lake also experienced average water column D O concentrations below the WQS criterion on two occasions during an unusually hot summer in 2012, triggering impairment for dissolved oxygen (Table 16).

Sediment metals concentrations (Tables 11 and 12) were within expected ranges, with one exception. Cadmium was slightly above the SRV (1.02 mg/kg) at Deer Creek Lake L-1 (Table 13). When compared to the Mac Donald PEC, the cadmium concentration was well below the benchmark. Sources of metal contamination are numerous including industrial metal finishing, urban or road run-off, land application run-off, WWTPs, WTPs, and pesticides. Nevertheless, metal toxicity does not appear to be problematic for the two lakes assessed in this report.

Table 13. Sediment metals results from Deer Creek Lake L-1 on 10/16/2012.

Metal	2012 Sediment Results (Sediment Reference Values [SRV] for ECBP ecoregion) mg/kg	Consensus Based Probable Effect Concentration (PEC) mg/kg
Arsenic	13.0 (18.8)	33.0
Cadmium	**1.02** (0.92)	4.98
Chromium	18.5 (40.0)	111.0
Copper	28.8 (34.0)	149.0
Iron (%)	33700 (33000)	N/A
Lead	21.0 (47)*	128.0
Mangenese	592 (780)	N/A
Mercury	<0.051 (0.12)	1.06
Nickel	30.8 (42.0)	48.6
Zinc	135.0 (160)	459.0

Table 14. Sediment metals results from Madison Lake L-1 on 10/16/2012.

Metal	2012 Sediment Results (Sediment Reference Values [SRV] by Ohio Ecoregion) mg/kg	Consensus Based Probable Effect Concentration (PEC) mg/kg
Arsenic	10.2 (18.8)	33.0
Cadmium	0.90 (0.92)	4.98
Chromium	15.1 (40.0)	111.0
Copper	24.1 (34.0)	149.0
Iron (%)	24800 (33000)	N/A
Lead	18.0 (47)*	128.0
Mangenese	519 (780)	N/A
Mercury	<0.054 (0.12)	1.06
Nickel	23.3 (42.0)	48.6
Zinc	110.0 (160)	459.0

Table 15. Proposed Lake Habitat use criteria. Note: All criteria are outside mixing zone averages unless specified differently. Note - As of the finalization of this report, the proposed Lake Habitat use and these criteria have not been adopted into the Ohio Water Quality Standards and all discussion of such use and criteria in this report should be considered as examples of how the adopted use and criteria would be applied.

Parameter Lake type	Form[1]	Units[2]	Statewide criteria	Ecoregional criteria				
				ECBP	EOLP	HELP	IP	WAP
Ammonia	T	mg/l	Table 43-4	--	--	--	--	--
Chlorophyll a[3]								
Dugout lakes	T	µg/l	6.0	--	--	--	--	--
Impoundments	T	µg/l	--	14.0	14.0	14.0	14.0	6.2
Natural lakes	T	µg/l	14.0	--	--	--	--	--
Upground reservoirs	T	µg/l	6.0	--	--	--	--	--
Dissolved oxygen[4] All lake types	T	mg/l	5.0 OMZM 6.0 OMZA	--	--	--	--	--
Nitrogen (T-N)[3]								
Dugout lakes	T	µg/l	450	--	--	--	--	--
Impoundments	T	µg/l	--	930	740	930	688	350
Natural lakes	T	µg/l	638	--	--	--	--	--
Upground reservoirs	T	µg/l	1,225	--	--	--	--	--
pH								
All lake types	--	s.u.	A	--	--	--	--	--
Phosphorus (T-P)[3]								
Dugout lakes	T	µg/l	18	--	--	--	--	--
Impoundments	T	µg/l	--	34	34	34	34	14
Natural lakes	T	µg/l	34	--	--	--	--	--
Upground reservoirs	T	µg/l	18	--	--	--	--	--
Secchi disk transparency[5]								
Dugout lakes	--	m	2.60	--	--	--	--	--
Impoundments	--	m	--	1.19	1.19	1.19	1.19	2.16
Natural lakes	--	m	1.19	--	--	--	--	--
Upground reservoirs	--	m	2.60	--	--	--	--	--
Temperature								
All lake types	--	--	B	--	--	--	--	--

1 T = total.

2 m = meters; mg/l = milligrams per liter (parts per million); µg/l = micrograms per liter (parts per billion); s.u. = standard units.

3 These criteria apply as lake medians from May through October in the epilimnion of stratified lakes and throughout the water column in unstratified lakes.

4 For dissolved oxygen, OMZM means outside mixing zone minimum and OMZA means outside mixing zone minimum twenty-four-hour average. The dissolved oxygen criteria apply in the epilimnion of stratified lakes and throughout the water column in unstratified lakes.

5 These criteria apply as minimum values from May through October.

A pH is to be 6.5-9.0, with no change within that range attributable to human-induced conditions.

B At no time shall the water temperature exceed the average or maximum temperature that would occur if there were no temperature change attributable to human activities.

Table 16. Assessment of lake data collected from Madison Lake, 2011 and 2012, using the proposed Lake Habitat aquatic life use and associated criteria. Note - As of the finalization of this report, the proposed Lake Habitat use and these criteria have not been adopted into the Ohio Water Quality Standards and the assessments provided in this table should be considered as examples of how the adopted use and criteria would be applied.

Proposed Lake Habitat Aquatic Life Use							
Parameter	Secchi depth (m)	Chlorophyll a (µg/l)	Total Nitrogen (µg/l)	Total Phosphorus (µg/l)	D.O. (mg/l)	pH	NH3 (mg/l)
Proposed Criteria	1.19 minimum	14 median	930 median	34 median	6.0	6.5-9.0	pH & temperature dependent
6-01-2011	0.37	112.0	1760.0	32.0	12.54	8.75	<
6-15-2011	0.38	48.0	4110.0	86.0	7.85	8.02	0.080
6-30-2011	0.35	56.8	3130.0	54.0	10.56	8.37	<
7-13-2011	0.27	70.4	900.0	79.0	9.14	8.07	<
8-11-2011	0.31	135.0	980.0	78.0	9.98	8.49	<
9-20-2011	0.35	61.1	750.0	75.0	8.34	8.42	<
6-14-2012	0.29	11.3	160.0	89.0	11.85	8.41	<
6-28-2012	0.25	84.4	750.0	84.0	5.95	8.01	<
7-25-2012	0.28	50.3	1230.0	95.0	6.37	8.17	<
8-08-2012	0.28	95.4	1470.0	125.0	7.82	8.11	<
8-30-2012	0.23	116.0	1630.0	623.0	5.34	8.25	<
Median values of proposed Lake Habitat criteria and number of samples exceeding the base aquatic life OMZA criterion. (% Exceeded)	0.29	70.4	1230.0	84.0	2 of 11 (18%)	0 of 11 (0%)	0 of 11 (0%)
Narrative[1]	Watch List	Non-support	Watch List	Watch List	Non-support	Support	Support

[1] – Narrative descriptions include; 'Non-support' which indicates the proposed LH use in not supported, 'Watch List' values will be factored into the prioritization process for the lake to receive additional monitoring, and 'Support' which indicates the proposed LH use is supported.

Table 17. Assessment of lake data collected from Deer Creek Reservoir L-1, 2011 and 2012, using the proposed Lake Habitat aquatic life use and associated criteria. Note - As of the finalization of this report, the proposed Lake Habitat use and these criteria have not been adopted into the Ohio Water Quality Standards and the assessments provided in this table should be considered as examples of how the adopted use and criteria would be applied.

Proposed Lake Habitat Aquatic Life Use							
Parameter	Secchi depth (m)	Chlorophyll a (µg/l)	Total Nitrogen (µg/l)	Total Phosphorus (µg/l)	D.O. (mg/l)	pH	NH3 (mg/l)
Proposed Criteria	1.19 minimum	14 median	930 median	34 median	6.0	6.5-9.0	pH & temperature dependent
6-01-2011	**1.15**	26.0	3060.0	89.0	10.02	8.73	<
6-15-2011	**0.75**	26.2	2860.0	37.0	**3.41**	7.62	0.195
6-27-2011	**0.86**	34.5	2890.0	40.0	**5.97**	8.08	<
7-12-2011	1.23	32.9	2400.0	20.0	8.70	8.69	<
8-10-2011	**0.72**	55.0	1400.0	59.0	6.90	8.68	<
9-22-2011	**0.83**	48.3	870.0	53.0	**5.60**	8.05	0.137
6-12-2012	**0.98**	88.0	4080.0	76.0	12.93	**9.20**	<
6-26-2012	**0.92**	29.3	3150.0	56.0	6.55	8.46	<
7-25-2012	**0.75**	95.7	1190.0	50.0	**4.04**	8.34	0.070
8-07-2012	**0.57**	47.3	600.0	40.0	**3.74**	8.28	<
8-28-2012	**0.59**	42.8	700.0	36.0	**4.92**	8.52	<
Median values of proposed Lake Habitat criteria and number of samples exceeding the base aquatic life OMZA criterion. (% Exceeded)	0.83	42.8	2400.0	50.0	6 of 11 (55%)	1 of 11 (9%)	0 of 11 (0%)
Narrative[1]	Watch List	Non-support	Watch List	Watch List	Non-support	Support	Support

[1] – Narrative descriptions include; 'Non-support' which indicates the proposed LH use in not supported, 'Watch List' values will be factored into the prioritization process for the lake to receive additional monitoring, and 'Support' which indicates the proposed LH use is supported.

Table 18. Assessment of lake data collected from Deer Creek Reservoir L-2, 2011 and 2012, using the proposed Lake Habitat aquatic life use and associated criteria. Note - As of the finalization of this report, the proposed Lake Habitat use and these criteria have not been adopted into the Ohio Water Quality Standards and the assessments provided in this table should be considered as examples of how the adopted use and criteria would be applied.

Proposed Lake Habitat Aquatic Life Use							
Parameter	Secchi depth (m)	Chlorophyll a (µg/l)	Total Nitrogen (µg/l)	Total Phosphorus (µg/l)	D.O. (mg/l)	pH	NH3 (mg/l)
Proposed Criteria	1.19 minimum	14 median	930 median	34 median	6.0	6.5-9.0	pH & temperature dependent
6-01-2011	1.54	10.7	3140.0	72.0	9.90	8.72	0.054
6-15-2011	0.55	48.5	3140.0	52.0	9.48	8.82	<
6-27-2011	0.83	71.9	3380.0	60.0	10.56	8.74	<
7-12-2011	0.72	46.8	2300.0	41.0	7.47	8.42	<
8-10-2011	0.52	55.1	1260.0	72.0	7.13	8.43	<
9-22-2011	0.65	40.2	1140.0	61.0	6.85	8.39	0.147
6-12-2012	0.90	72.6	3980.0	59.0	11.78	9.16	<
6-26-2012	0.55	45.4	2870.0	60.0	7.94	8.62	<
7-25-2012	0.45	39.9	1150.0	60.0	6.18	8.41	0.11
8-07-2012	0.46	55.7	0110.0	50.0	6.04	8.88	<
8-28-2012	0.50	40.9	0580.0	48.0	5.47	8.41	<
Median values of proposed Lake Habitat criteria and number of samples exceeding the base aquatic life OMZA criterion. (% Exceeded)	0.55	46.8	2300.0	60.0	1 of 11 (9%)	1 of 11 (9%)	0 of 11 (0%)
Narrative[1]	Watch List	Non-support	Watch List	Watch List	Support	Support	Support

[1] – Narrative descriptions include; 'Non-support' which indicates the proposed LH use in not supported, 'Watch List' values will be factored into the prioritization process for the lake to receive additional monitoring, and 'Support' which indicates the proposed LH use is supported.

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