State of Ohio
Environmental Protection Agency

Division of Surface Water

Appendices to Biological and Water Quality Study of the Muskingum River Tributaries

Muskingum and Morgan Counties, Ohio

OEPA Report DSW/EAS 2009-12-11

December 30, 2009

Ted Strickland, Governor
Chris Korleski, Director

APPENDICES
Biological and Water Quality Study of the Muskingum River Tributaries
2008

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Appendix Table 1. Muskingum Tributaries chemical/physical surface water sampling results, 2008. NA = not analyzed.

		Site Location: **FLAT RUN -SR 60 at trailer park S. of Zanesville** River Mile: 0.3 Storet: 300429					Site Location: **SYCAMORE HOLLOW RUN @ River Road** River Mile: 0.23 Storet: 300430				
		Duplicate A/B					Duplicate A	Duplicate B			
Parameter	Units	6/24/2008	7/8/2008	7/29/2008	8/14/2008	9/24/2008	6/24/2008	6/24/2008	7/8/2008	7/29/2008	8/14/2008
Acidity	mg/L	< 5	< 5/ <5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
Alkalinity	mg/L	44.8	53/ 53.5	48.1	39.7	31.7	44.4	44.7	41.6	55.7	63.9
Aluminum	ug/L	< 200	207/ <200	< 200	< 200	< 200	305	< 200	282	245	< 200
Ammonia	mg/L	0.077	0.066/ 0.065	< 0.05	< 0.05	< 0.05	0.065	0.054	< 0.05	0.066	0.112
Arsenic	ug/L	< 2	< 2/ <2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Barium	ug/L	38	37/ 35	47	58	61	42	41	32	48	57
Cadmium	ug/L	< 0.2	< 0.2/ <0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Calcium	mg/L	57	44/ 41	61	72	79	30	30	19	33	41
Chloride	mg/L	29.2	19.3/ 19.4	30.7	47	44.7	< 5	< 5	< 5	< 5	< 5
Chromium	ug/L	< 2	< 2/ <2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
COD	mg/L	15	< 10/ <10	< 10	< 10	< 10	12	12	< 10	< 10	12
Conductivity	umhos/cm	499	415/ 414	595	686	NA	291	291	208	316	404
Copper	ug/L	< 2	< 2/ <2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Hardness, Total	mg/L	229	176/ 164	247	287	317	124	128	80	140	172
Iron	ug/L	380	590/ 524	79	92	352	340	205	337	513	745
Lead	ug/L	< 2	< 2/ <2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Magnesium	mg/L	21	16/ 15	23	26	29	12	13	8	14	17
Manganese	ug/L	323	351/ 330	197	140	138	1190	1170	287	1670	3010
Mercury	ug/L	< 0.2	< 0.2/ <0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Nickel	ug/L	6.3	5.5/ 5.4	5	4.7	4.7	5.2	5.3	2.8	5.7	5.7
Nitrate+nitrite	mg/L	0.44	0.47/ 0.46	0.43	0.41	0.45	0.16	0.16	0.13	0.1	< 0.1
Nitrite	mg/L	< 0.02	< 0.02/ <0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Potassium	mg/L	3	3/ 3.0	3	4	5	2	2	2	3	3
Selenium	ug/L	< 2	< 2/ <2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Sodium	mg/L	17	13/ 12	21	28	28	7	7	5	8	10
Strontium	ug/L	217	161/ 152	262	309	333	116	116	84	130	184
Sulfate	mg/L	169	109/ 108	210	246	254	80.1	82.4	50.1	88.7	137
TKN	mg/L	< 0.2	< 0.2/ <0.2	0.23	< 0.2	0.21	< 0.2	< 0.2	< 0.2	0.29	< 0.2
Total Dissolved Solids	mg/L	404	324/ 320	422	500	556	194	200	150	212	284
Total Phosphorus	mg/L	< 0.01	0.01/ <0.01	0.019	< 0.01	< 0.01	< 0.01	< 0.01	0.01	0.01	< 0.01
Total Suspended Solids	mg/L	5	7/ 6.0	< 5	< 5	5	< 5	< 5	8	< 5	< 5
Zinc	ug/L	< 10	< 10/ <10	< 10	< 10	10	10	< 10	< 10	< 10	< 10
Field Measurements											
Temperature	°C	19.34	21.38	19.29	20.9	14.52	19.81	19.81	21.41	19.77	18.59
Conductivity	µmhos/cm	585.3	431	587.6	685.2	761.2	322	322	217.3	296.5	400.1
Dissolved Oxygen	mg/L	8.47	7.9	9.83	12.67	11.33	5.8	5.8	7.69	6.58	6.14
D.O. Saturation	%	92.1	89.4	106.7	142.1	111.4	63.6	63.6	87	72.1	65.7
pH	S.U.	7.9	NA	7.44	7.49	7.41	8.18	8.18	NA	6.97	6.96

Appendix Table 1. Continued.

		Site Location: **ISLAND RUN @ Helmic Bridge** River Mile: 3.4 Storet: 300431					Site Location: **S. BRANCH ISLAND RUN adj. TR 193 - Brown Road** River Mile: 0.1 Storet: 300432				
Parameter	Units	6/24/2008	7/8/2008	7/29/2008	8/14/2008	9/24/2008	6/24/2008	7/8/2008	7/29/2008	8/14/2008	9/24/2008
Acidity	mg/L	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
Alkalinity	mg/L	90.3	100	126	122	138	92.2	96	127	121	135
Aluminum	ug/L	484	< 200	< 200	413	< 200	< 200	< 200	< 200	< 200	< 200
Ammonia	mg/L	0.203	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Arsenic	ug/L	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Barium	ug/L	33	30	35	44	62	30	31	35	37	61
Cadmium	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Calcium	mg/L	35	34	42	42	54	33	31	43	35	52
Chloride	mg/L	10.3	9.2	12.1	14.3	27.1	< 5	< 5	14.2	7.4	18
Chromium	ug/L	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
COD	mg/L	15	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Conductivity	umhos/cm	276	251	321	343	440	254	330	334	295	399
Copper	ug/L	2.3	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Hardness, Total	mg/L	120	118	142	146	184	115	110	144	124	179
Iron	ug/L	787	108	142	807	279	110	70	287	155	79
Lead	ug/L	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Magnesium	mg/L	8	8	9	10	12	8	8	9	9	12
Manganese	ug/L	22	10	16	38	40	13	18	19	25	35
Mercury	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Nickel	ug/L	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Nitrate+nitrite	mg/L	0.44	< 0.1	< 0.1	< 0.1	< 0.1	0.11	< 0.1	< 0.1	< 0.1	< 0.1
Nitrite	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Potassium	mg/L	3	2	3	3	4	2	2	3	2	3
Selenium	ug/L	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Sodium	mg/L	9	9	11	13	18	8	7	12	10	16
Strontium	ug/L	157	154	179	206	283	167	161	171	200	250
Sulfate	mg/L	26.4	27.3	29.3	35.9	32.5	22.7	24.1	32.5	26.1	29.6
TKN	mg/L	< 0.2	< 0.2	0.22	< 0.2	0.3	< 0.2	< 0.2	0.34	< 0.2	0.28
Total Dissolved Solids	mg/L	182	174	198	206	242	152	154	186	178	224
Total Phosphorus	mg/L	< 0.01	< 0.01	< 0.01	0.013	0.016	< 0.01	< 0.01	0.017	< 0.01	0.042
Total Suspended Solids	mg/L	6	< 5	< 5	14	6	< 5	< 5	< 5	7	5
Zinc	ug/L	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Field Measurements											
Temperature	°C	21.96	22.5	26.21	21.67	17.12	23.38	22.15	25.01	21.97	15.58
Conductivity	µmhos/cm	307.3	292.2	317.8	338.6	454	282.4	265.7	308.2	292	398.6
Dissolved Oxygen	mg/L	8.52	9.99	9.88	12.84	7.97	7.98	9.12	8.89	15.8	11.56
D.O. Saturation	%	97.5	115.4	122.3	146	82.7	93.8	104.7	107.7	180.7	116.2
pH	S.U.	8.22	NA	8.2	8.05	7.95	8.92	NA	8.13	8	8.05

Appendix Table 1. Continued.

		Site Location: **BIG BOTTOM RUN near mouth (TR 313)** River Mile: 0.2 Storet: 300433					Site Location: **BLUEROCK CREEK at Blue Rock Road** River Mile: 0.8 Storet: 300434				
Parameter	Units	6/24/2008	7/8/2008	7/29/2008			6/24/2008	7/8/2008	7/29/2008	8/14/2008	
Acidity	mg/L	< 5	< 5	< 5			< 5	< 5	< 5	< 5	
Alkalinity	mg/L	127	126	178			97.5	102	144	150	
Aluminum	ug/L	365	< 200	< 200			< 200	< 200	< 200	< 200	
Ammonia	mg/L	< 0.05	< 0.05	< 0.05			< 0.05	< 0.05	< 0.05	< 0.05	
Arsenic	ug/L	< 2	< 2	< 2			< 2	< 2	< 2	< 2	
Barium	ug/L	46	36	51			40	39	47	50	
Cadmium	ug/L	< 0.2	< 0.2	< 0.2			< 0.2	< 0.2	< 0.2	< 0.2	
Calcium	mg/L	50	43	59			39	37	45	48	
Chloride	mg/L	9.6	7.1	8.1			8.7	12.8	12.4	16.5	
Chromium	ug/L	< 2	< 2	< 2			< 2	< 2	< 2	< 2	
COD	mg/L	12	< 10	< 10			< 10	11	< 10	10	
Conductivity	umhos/cm	354	297	407			203	298	338	394	
Copper	ug/L	< 2	< 2	< 2			5.2	< 2	3.8	< 2	
Hardness, Total	mg/L	166	144	197			130	125	149	161	
Iron	ug/L	677	< 50	84			61	86	80	317	
Lead	ug/L	< 2	< 2	< 2			< 2	< 2	< 2	< 2	
Magnesium	mg/L	10	9	12			8	8	9	10	
Manganese	ug/L	34	< 10	10			11	10	10	15	
Mercury	ug/L	< 0.2	< 0.2	< 0.2			< 0.2	< 0.2	< 0.2	< 0.2	
Nickel	ug/L	< 2	< 2	< 2			< 2	< 2	< 2	< 2	
Nitrate+nitrite	mg/L	0.34	0.18	< 0.1			0.1	< 0.1	< 0.1	< 0.1	
Nitrite	mg/L	< 0.02	< 0.02	< 0.02			< 0.02	< 0.02	< 0.02	< 0.02	
Potassium	mg/L	4	3	4			2	2	2	2	
Selenium	ug/L	< 2	< 2	< 2			< 2	< 2	< 2	< 2	
Sodium	mg/L	10	9	10			11	11	12	15	
Strontium	ug/L	176	157	195			157	157	169	197	
Sulfate	mg/L	33.4	31	36.1			30.5	29.3	32	33	
TKN	mg/L	< 0.2	< 0.2	0.44			< 0.2	< 0.2	< 0.2	< 0.2	
Total Dissolved Solids	mg/L	226	198	234			174	182	192	232	
Total Phosphorus	mg/L	< 0.01	0.011	0.03			< 0.01	0.018	0.01	0.014	
Total Suspended Solids	mg/L	< 5	< 5	< 5			< 5	17	< 5	< 5	
Zinc	ug/L	< 10	< 10	< 10			< 10	< 10	< 10	< 10	
Field Measurements											
Temperature	°C	21.65	22.31	23.65			24.28	23.47	23.52	21.65	
Conductivity	µmhos/cm	397	345.6	402.8			322.6	313.5	335.1	399.6	
Dissolved Oxygen	mg/L	6.73	10.59	10.85			8.69	8.22	8.01	6.08	
D.O. Saturation	%	76.6	121.9	128.1			103.9	96.8	94.3	69.1	
pH	S.U.	8.85	NA	8.05			8.93	NA	7.62	7.39	

Appendix Table 1. Continued.

		Site Location: **BACK RUN adj Back Run Road** River Mile: 0.6 Storet: 300435					Site Location: **DRY RIFFLE RUN @ SR 60 near Gaysport** River Mile: 0.2 Storet: 300436				
Parameter	Units	6/24/2008	7/8/2008	7/29/2008	8/14/2008	9/24/2008	6/24/2008	7/8/2008	7/29/2008	8/14/2008	
Acidity	mg/L	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	
Alkalinity	mg/L	92.3	20.7	122	127	128	164	183	218	227	
Aluminum	ug/L	< 200	< 200	< 200	< 200	< 200	< 200	< 200	< 200	< 200	
Ammonia	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	
Arsenic	ug/L	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	
Barium	ug/L	38	35	45	50	57	60	56	67	67	
Cadmium	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	
Calcium	mg/L	34	31	40	44	53	76	70	85	82	
Chloride	mg/L	5.6	< 5	6.2	7.5	10.8	32.7	26.9	34.2	35.9	
Chromium	ug/L	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	
COD	mg/L	< 10	< 10	< 10	23	< 10	12	< 10	< 10	< 10	
Conductivity	umhos/cm	277	188	293	319	368	573	547	612	638	
Copper	ug/L	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	
Hardness, Total	mg/L	122	110	137	155	182	256	241	282	275	
Iron	ug/L	66	< 50	< 50	76	< 50	59	< 50	< 50	111	
Lead	ug/L	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	
Magnesium	mg/L	9	8	9	11	12	16	16	17	17	
Manganese	ug/L	< 10	< 10	12	13	19	12	< 10	11	20	
Mercury	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	
Nickel	ug/L	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	
Nitrate+nitrite	mg/L	< 0.1	0.35	< 0.1	< 0.1	< 0.1	0.13	0.12	< 0.1	< 0.1	
Nitrite	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	
Potassium	mg/L	2	2	2	2	2	2	2	2	2	
Selenium	ug/L	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	
Sodium	mg/L	8	7	8	9	10	22	20	26	29	
Strontium	ug/L	156	144	169	190	214	351	332	376	379	
Sulfate	mg/L	26.5	27.6	29.8	32	32	69.1	65.2	65.1	63	
TKN	mg/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	
Total Dissolved Solids	mg/L	154	134	158	190	210	368	338	360	388	
Total Phosphorus	mg/L	< 0.01	< 0.01	0.012	< 0.01	< 0.01	< 0.01	< 0.01	0.012	0.012	
Total Suspended Solids	mg/L	5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	< 5	
Zinc	ug/L	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	
Field Measurements											
Temperature	°C	18.95	21.2	23.18	19.75	23.89	20.54	22	20.4	20.04	
Conductivity	µmhos/cm	290.5	263.1	293.1	290.8	379.1	629.8	572.9	608.1	655.7	
Dissolved Oxygen	mg/L	8.12	7.91	7.71	10.42	9.55	6.21	7.41	6.32	10.02	
D.O. Saturation	%	87.5	89.1	90.2	114.1	113.3	69.2	84.9	70.1	110.5	
pH	S.U.	8.46	NA	7.51	7.31	7.69	8.77	NA	7.41	7.42	

Appendix Table 1. Continued.

		Site Location: **DUNCAN RUN at River Rd. south of Philo** River Mile: 0.29 Storet: 300483					Site Location: **LITTLE DUNCAN RUN at Duncan Run Rd.** River Mile: 0.06 Storet: 300484				
		Duplic. A/B									
Parameter	Units	6/24/2008	7/8/2008	7/29/2008	8/14/2008	9/24/2008	6/24/2008	7/8/2008	7/29/2008	8/14/2008	9/24/2008
Acidity	mg/L	< 5	< 5	< 5/ <5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
Alkalinity	mg/L	93.8	90.5	120/ 121	125	117	98.1	93.4	132	137	140
Aluminum	ug/L	< 200	< 200	< 200/ <200	< 200	< 200	< 200	< 200	< 200	< 200	< 200
Ammonia	mg/L	NA	< 0.05	< 0.05/ <0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Arsenic	ug/L	< 2	< 2	< 2/ <2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Barium	ug/L	45	38	48/ 48	50	60	42	32	42	40	54
Cadmium	ug/L	< 0.2	< 0.2	< 0.2/ <0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Calcium	mg/L	40	32	42/ 43	40	45	51	35	52	51	73
Chloride	mg/L	8.8	5.6	7.7/ 7.7	8.2	9.9	8.7	5.6	8.4	10.8	18.9
Chromium	ug/L	< 2	< 2	< 2/ <2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
COD	mg/L	NA	14	< 10/ 12	14	< 10	< 10	14	< 10	< 10	< 10
Conductivity	umhos/cm	316	267	317/ 317	308	352	413	316	400	420	537
Copper	ug/L	< 2	< 2	< 2/ <2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Hardness, Total	mg/L	145	117	150/ 153	149	162	189	133	187	189	265
Iron	ug/L	< 50	127	< 50/ <50	76	74	79	78	< 50	< 50	< 50
Lead	ug/L	< 2	< 2	< 2/ <2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Magnesium	mg/L	11	9	11/ 11.0	12	12	15	11	14	15	20
Manganese	ug/L	22	14	31/ 32	74	29	19	19	27	82	119
Mercury	ug/L	< 0.2	< 0.2	< 0.2/ <0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Nickel	ug/L	< 2	< 2	< 2/ <2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Nitrate+nitrite	mg/L	NA	0.37	< 0.1/ <0.1	< 0.1	0.11	0.22	0.19	< 0.1	0.35	< 0.1
Nitrite	mg/L	< 0.02	< 0.02	< 0.02/ <0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Potassium	mg/L	3	3	3/ 3.0	3	3	3	3	3	3	3
Selenium	ug/L	< 2	< 2	< 2/ <2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Sodium	mg/L	9	7	8/ 8.0	9	9	11	8	10	12	15
Strontium	ug/L	150	126	146/ 149	153	186	180	131	166	170	236
Sulfate	mg/L	40.9	31.7	37.1/ 36.7	39.2	34.9	80.3	51.4	64.1	73.5	95
TKN	mg/L	NA	< 0.2	< 0.2/ <0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.26	0.25	< 0.2
Total Dissolved Solids	mg/L	196	168	188/ 180	208	224	258	198	252	278	340
Total Phosphorus	mg/L	NA	< 0.01	0.013/ 0.01	< 0.01	< 0.01	< 0.01	0.01	0.012	0.012	0.012
Total Suspended Solids	mg/L	< 5	5	< 5/ <5	< 5	< 5	< 5	< 5	< 5	< 5	< 5
Zinc	ug/L	< 10	< 10	< 10/ <10	< 10	< 10	< 10	< 10	< 10	< 10	< 10
Field Measurements											
Temperature	°C	21.34	21.67	22.69	20.75	16.32	19.9	21.98	21.73	19.96	17.2
Conductivity	µmhos/cm	345.5	283.7	312.9	330.6	359.9	447.3	327.5	402.4	436.7	558.4
Dissolved Oxygen	mg/L	7.15	8.32	8.85	8.64	3.07	8.55	8.25	8.68	11.11	6.26
D.O. Saturation	%	80.8	94.6	102.6	96.5	31.3	94	94.4	98.9	122.2	65.1
pH	S.U.	8.89	NA	7.42	7.24	6.93	8.91	NA	7.64	7.57	7.58

Appendix Table 1. Continued.

		Site Location: **BRUSH CREEK Adj. SR 555 (ust. Brush Cr. Cem.)** River Mile: 1.0 Storet: 300485					Site Location: **BRUSH CREEK Dst. Turkey Run confluence** River Mile: 4.81 Storet: 300486				
Parameter	Units	6/24/2008	7/8/2008	7/29/2008	8/14/2008	9/24/2008	6/24/2008	7/8/2008	7/29/2008	8/14/2008	9/24/2008
Acidity	mg/L	< 5	< 5	< 5	< 5	< 5	22.3	5.2	24.7	28.1	47.8
Alkalinity	mg/L	10	25.8	14.4	9.9	11.1	< 5	22.4	< 5	< 5	< 5
Aluminum	ug/L	508	267	322	470	< 200	989	540	1090	2130	4000
Ammonia	mg/L	0.05	< 0.05	< 0.05	< 0.05	< 0.05	0.1	0.067	0.11	0.106	0.073
Arsenic	ug/L	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Barium	ug/L	41	32	46	43	48	47	36	48	47	55
Cadmium	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.21	< 0.2	< 0.2	0.25	0.36
Calcium	mg/L	73	50	83	86	119	75	53	79	90	132
Chloride	mg/L	10.3	6.4	11.3	15.6	21.7	10	8.1	10	12	13.6
Chromium	ug/L	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
COD	mg/L	< 10	< 10	< 10	< 10	< 10	< 10	< 10	< 10	18	< 10
Conductivity	umhos/cm	698	500	757	828	1100	762	528	782	913	1290
Copper	ug/L	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	2.8	3.4
Hardness, Total	mg/L	310	215	343	375	499	311	219	333	398	564
Iron	ug/L	461	262	136	170	107	1350	1330	1040	974	1080
Lead	ug/L	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Magnesium	mg/L	31	22	33	39	49	30	21	33	42	57
Manganese	ug/L	1490	1050	1350	1140	1110	2410	1640	2690	3250	4650
Mercury	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Nickel	ug/L	22.4	13.3	19.1	19.5	19	36	20.3	30.2	38.2	46.3
Nitrate+nitrite	mg/L	0.19	0.16	0.16	0.14	< 0.1	0.21	0.13	0.11	0.13	0.1
Nitrite	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Potassium	mg/L	3	2	3	4	4	3	2	3	4	4
Selenium	ug/L	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2	< 2
Sodium	mg/L	28	16	28	42	58	35	20	34	53	75
Strontium	ug/L	352	233	372	479	619	382	258	385	497	677
Sulfate	mg/L	318	211	349	450	509	354	229	377	514	652
TKN	mg/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	0.25	< 0.2	< 0.2	< 0.2
Total Dissolved Solids	mg/L	534	364	572	732	906	606	400	606	816	1050
Total Phosphorus	mg/L	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Total Suspended Solids	mg/L	< 5	< 5	6	< 5	< 5	< 5	< 5	5	< 5	< 5
Zinc	ug/L	21	15	25	23	27	52	39	61	69	106
Field Measurements											
Temperature	°C	19.39	20.41	20.9	20.28	18.01	19.36	20.9	20.27	20.7	17.98
Conductivity	µmhos/cm	773.4	532.6	756.1	914.9	1141	854.3	570.6	778.2	1027.1	1372.8
Dissolved Oxygen	mg/L	8.88	7.97	9.12	12.87	10.66	8.05	8.39	8.97	13.43	7.46
D.O. Saturation	%	96.6	88.5	102.4	142.7	113	87.6	94.1	99.4	150.2	79
pH	S.U.	7.42	NA	6.48	6.9	7.38	6.29	NA	5.24	4.19	3.82

Appendix Table 1. Continued.

		Site Location: **BRUSH CREEK Dst. Goose Run adj. Goose Creek Rd** River Mile: 7.3 Storet: 300487					
Parameter	Units	Duplicate A 6/24/2008	Duplicate B 6/24/2008	7/8/2008	7/29/2008	8/14/2008	9/24/2008
Acidity	mg/L	< 5	< 5	< 5	< 5	< 5	< 5
Alkalinity	mg/L	74.9	72.9	94.1	98.8	85.7	73
Aluminum	ug/L	352	312	< 200	< 200	< 200	< 200
Ammonia	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	0.055	< 0.05
Arsenic	ug/L	< 2	< 2	< 2	< 2	< 2	< 2
Barium	ug/L	47	50	39	53	60	82
Cadmium	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Calcium	mg/L	52	54	42	60	74	114
Chloride	mg/L	12.1	11.7	12.1	12.9	12.3	13.1
Chromium	ug/L	< 2	< 2	< 2	< 2	< 2	< 2
COD	mg/L	< 10	< 10	< 10	< 10	12	< 10
Conductivity	umhos/cm	470	471	379	530	679	945
Copper	ug/L	< 2	< 2	< 2	< 2	< 2	< 2
Hardness, Total	mg/L	192	197	154	220	284	433
Iron	ug/L	699	654	283	500	1390	2440
Lead	ug/L	< 2	< 2	< 2	< 2	< 2	< 2
Magnesium	mg/L	15	15	12	17	24	36
Manganese	ug/L	184	191	107	251	898	965
Mercury	ug/L	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Nickel	ug/L	2.5	2.7	< 2	2.3	5.2	4.7
Nitrate+nitrite	mg/L	0.17	0.18	0.12	< 0.1	< 0.1	< 0.1
Nitrite	mg/L	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Potassium	mg/L	2	2	2	2	3	3
Selenium	ug/L	< 2	< 2	< 2	< 2	< 2	< 2
Sodium	mg/L	23	24	17	26	42	58
Strontium	ug/L	241	246	201	273	359	502
Sulfate	mg/L	127	128	75	162	316	365
TKN	mg/L	< 0.2	< 0.2	0.27	0.33	< 0.2	< 0.2
Total Dissolved Solids	mg/L	322	318	242	382	562	752
Total Phosphorus	mg/L	< 0.01	0.012	0.014	< 0.01	< 0.01	< 0.01
Total Suspended Solids	mg/L	6	6	< 5	5	< 5	< 5
Zinc	ug/L	< 10	< 10	< 10	< 10	< 10	< 10
Field Measurements							
Temperature	°C	19.68	19.68	20.61	20.51	20.58	17.76
Conductivity	µmhos/cm	525	525	410.1	527.8	823	1109.2
Dissolved Oxygen	mg/L	6.91	6.91	7.89	8.16	9.01	5.82
D.O. Saturation	%	75.6	75.6	87.9	90.8	100.5	61.4
pH	S.U.	6.99	6.99	NA	7.3	6.43	6.2

Appendix Table 2. Bacteriological surface water results for Muskingum Tributaries, 2008.

Stream	River Mile	2008 Sampling Dates 6/30	7/9	8/7	8/20	8/28
Muskingum Tributaries Bacteria: **Fecal Coliform**						
Flat Run	0.3	950 JL	2400/ 3900	480 J	810 JL	1600 JL
Sycamore Hollow Run	0.23	550	860 JL	110 JL	20 JL	200 J
Island Run	3.4	750 JL	1700 J,JL	250	80 JL	5700
S. Branch Island Run	0.1	180 JL	1200 J,JL	230	20 JL	8000 JL
Big Bottom Run	0.2	130 JL	940 JL	40 JL	NA	1200 JL
Bluerock Creek	0.8	170 JL	800 JL	200	< 10	690 JL
Back Run	0.6	430	780 JL	50 JL	20 JL	20 JL
Dry Riffle Run	0.2	810 JL	1400 JL	30 JL	10 JL	130 J,JL
Duncan Run	0.29	460	2000	120 J,JL	10 JL	200 J
Little Duncan Run	0.06	380	5000 J,JL	200 J,JL	50 J,JL	270 J
Brush Creek	1.0	NA	1400 JL	160 JL	220	10 JL
Brush Creek	4.81	160 JL	1100 JL	20 JL	70 JL	60 JL
Brush Creek	7.3	340	1600 J,JL	430	80 JL	1200 J,JL
Muskingum Tributaries Bacteria: **E. coli**						
Flat Run	0.3	760	1000 JL/ 1200 JL	210	310	850 JL
Sycamore Hollow Run	0.23	440	450	30 JL	10 JL	110 JL
Island Run	3.4	360	2100	120 JL	110 JL	5200
S. Branch Island Run	0.1	80 JL	710	130 JL	< 10	3400
Big Bottom Run	0.2	100 JL	620	10 JL	NA	370
Bluerock Creek	0.8	80 JL	580	70 JL	< 10	180 JL
Back Run	0.6	120 JL	420	10 JL	< 10	10 JL
Dry Riffle Run	0.2	560	550	30 JL	10 JL	60 JL
Duncan Run	0.29	280	720	120 JL	< 10	230
Little Duncan Run	0.06	200	1700 JL	170 J,JL	40 JL	80 JL
Brush Creek	1.0	NA	1300 JL	70 JL	200	< 10
Brush Creek	4.81	130 JL	2100	40 JL	40 JL	30 JL
Brush Creek	7.3	160 JL	800 JL	370	80 JL	890 JL

J - The analyte was positively identified, the associated numerical value is estimated.

JL - The reported result is estimated. It has been computed using a colony count that is not within the acceptable count range.

< - Less than detection limit; NA - Not analyzed

Two values in one box indicate duplicate samples.

Table 3. Qualitative Habitat Evaluation Index (QHEI) scores and physical attributes for fish sampling sites in Muskingum River Tributaries, 2009.

River Mile	QHEI	Habitat Rating	WWH Attributes: No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Substrates	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low-Normal Overall Embeddedness	Max. Depth >40 cm	Low-Normal Riffle Embeddedness	**Total WWH Attributes**	MWH Attributes – *High Influence*: Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/ No Cover	Max. Depth <40 cm (WD,HW sites)	**Total High Influence Attributes**	MWH Attributes – *Moderate Influence*: Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1-2 Cover Types	Intermittent & Poor Pools	No Fast Current	High/Mod. Overall Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	**Total Moderate Influence Attributes**	**(MWH H.I.+1)/ (WWH+1) Ratio**	**(MWH M.I.+1)/ (WWH+1) Ratio**
Island Run (17-090)																																	
3.4	**72.0**	Excellent	■		■	■	■	■		■	■	■	8				◆		1									●				1	0.22	0.33
South Branch Island Run (17-091)																																	
0.1	**69.0**	Good	■	■		■	■			■		■	6				◆	◆	2									●				1	0.43	0.57
Big Bottom Run (17-092)																																	
0.2	**59.5**	Good	■	■				■	■		■	■	6			◆	◆		2		●			●					●	●		4	0.43	1.00
Bluerock Creek (17-095)																																	
0.8	**72.5**	Excellent	■	■		■	■	■	■	■	■	■	9						0		●											1	0.10	0.20
Little Bluerock Creek (17-096)																																	
0.1	**69.0**	Good	■	■		■	■	■	■	■		■	8			◆		◆	2					●								1	0.33	0.44
Back Run (17-097)																																	
0.7	**69.5**	Good	■	■		■	■	■	■		■		7				◆		1						●				●	●		3	0.25	0.63
Dry Riffle Run (17-099)																																	
0.2	**73.0**	Excellent	■	■		■	■	■	■		■		7				◆		1										●	●		2	0.25	0.50
Duncan Run (17-911)																																	
0.3	**65.0**	Good	■	■			■		■	■	■	■	7				◆		1					●	●							2	0.25	0.50
Little Duncan Run (17-912)																																	
0.1	**59.0**	Good	■	■			■		■	■		■	6				◆	◆	2						●							1	0.43	0.57
Brush Creek (17-914)																																	
7.3	**73.5**	Excellent	■	■		■	■	■		■	■		7				◆		1									●		●		2	0.25	0.50
4.8	**75.0**	Excellent	■			■	■	■			■		5						0		●							●	●	●		4	0.17	0.83
1.2	**52.5**	Fair	■	■					■	■	■	■	6				◆		1		●			●	●	●						4	0.29	0.86
Baughman Run (17-915)																																	
0.1	**73.0**	Excellent	■	■		■	■	■		■	■	■	8						0									●				1	0.11	0.22
Turkey Run (17-916)																																	
0.1	**56.5**	Good		■	■		■			■		■	5				◆	◆	2	●				●				●		●		4	0.50	1.17
Goose Run (17-917)																																	
0.1	**68.0**	Good	■	■		■	■	■			■		6						0									●	●	●		3	0.14	0.57
Sycamore Hollow Run (17-133)																																	
0.2	**53.5**	Fair	■	■			■			■		■	5				◆	◆	2					●				●				2	0.50	0.83
Flat Run (17-135)																																	
0.3	**61.0**	Good		■		■	■	■		■	■	■	7				◆		1	●	●							●	●	●		5	0.25	0.88

Key QHEI Components

Appendix Table 4. Fish species and abundance for each sampling location in the Muskingum River Tributaries study area, 2009.

River Code: **17-090**	Stream: **Island Run**	Sample Date: **2008**
River Mile: **3.40**	Location:	Date Range: 07/15/2008
Time Fished: 4680 sec	Drainage: 10.8 sq mi	
Dist Fished: 0.20 km	Basin: Muskingum River No of Passes: 1	Sampler Type: E

Species Name / ODNR status	IBI Grp	Feed Guild	Breed Guild	Tol	# of Fish	Relative Number	% by Number	Relative Weight	% by Weight	Ave(gm) Weight
White Sucker	W	O	S	T	83	124.50	8.80			
Western Blacknose Dace	N	G	S	T	62	93.00	6.57			
Creek Chub	N	G	N	T	130	195.00	13.79			
South. Redbelly Dace	N	H	S		55	82.50	5.83			
Silverjaw Minnow	N	I	M		52	78.00	5.51			
Bluntnose Minnow	N	O	C	T	184	276.00	19.51			
Central Stoneroller	N	H	N		345	517.50	36.59			
Green Sunfish	S	I	C	T	1	1.50	0.11			
Fantail Darter	D	I	C		31	46.50	3.29			
Mile Total					943	1,414.50				
Number of Species					9					
Number of Hybrids					0					

River Code: **17-091**	Stream: **South Branch Island Run**	Sample Date: **2008**
River Mile: **0.10**	Location:	Date Range: 07/15/2008
Time Fished: 2520 sec	Drainage: 4.9 sq mi	
Dist Fished: 0.20 km	Basin: Muskingum River No of Passes: 1	Sampler Type: E

Species Name / ODNR status	IBI Grp	Feed Guild	Breed Guild	Tol	# of Fish	Relative Number	% by Number	Relative Weight	% by Weight	Ave(gm) Weight
White Sucker	W	O	S	T	4	6.00	1.13			
Western Blacknose Dace	N	G	S	T	44	66.00	12.43			
Creek Chub	N	G	N	T	133	199.50	37.57			
South. Redbelly Dace	N	H	S		66	99.00	18.64			
Silverjaw Minnow	N	I	M		9	13.50	2.54			
Bluntnose Minnow	N	O	C	T	18	27.00	5.08			
Central Stoneroller	N	H	N		70	105.00	19.77			
Fantail Darter	D	I	C		10	15.00	2.82			
Mile Total					354	531.00				
Number of Species					8					
Number of Hybrids					0					

River Code: **17-092**	Stream: **Big Bottom Run**	Sample Date: **2008**
River Mile: **0.20**	Location: upst. Old River Rd.	Date Range: 06/16/2008
Time Fished: 1500 sec	Drainage: 4.2 sq mi	
Dist Fished: 0.15 km	Basin: Muskingum River No of Passes: 1	Sampler Type: E

Species Name / ODNR status	IBI Grp	Feed Guild	Breed Guild	Tol	# of Fish	Relative Number	% by Number	Relative Weight	% by Weight	Ave(gm) Weight
White Sucker	W	O	S	T	5	10.00	5.81			
Western Blacknose Dace	N	G	S	T	7	14.00	8.14			
Creek Chub	N	G	N	T	48	96.00	55.81			
South. Redbelly Dace	N	H	S		1	2.00	1.16			
Sand Shiner	N	I	M	M	4	8.00	4.65			
Bluntnose Minnow	N	O	C	T	8	16.00	9.30			
Central Stoneroller	N	H	N		11	22.00	12.79			
Fantail Darter	D	I	C		2	4.00	2.33			
Mile Total					86	172.00				
Number of Species					8					
Number of Hybrids					0					

River Code: **17-095**	Stream: **Bluerock Creek**	Sample Date: **2008**
River Mile: **0.80**	Location: North River Rd.	Date Range: 07/24/2008
Time Fished: 2700 sec	Drainage: 9.5 sq mi	
Dist Fished: 0.20 km	Basin: Muskingum River No of Passes: 1	Sampler Type: E

Species Name / ODNR status	IBI Grp	Feed Guild	Breed Guild	Tol	# of Fish	Relative Number	% by Number	Relative Weight	% by Weight	Ave(gm) Weight
Northern Hog Sucker	R	I	S	M	7	10.50	1.00			
White Sucker	W	O	S	T	18	27.00	2.57			
Western Blacknose Dace	N	G	S	T	35	52.50	5.00			
Creek Chub	N	G	N	T	105	157.50	15.00			
South. Redbelly Dace	N	H	S		15	22.50	2.14			
Silver Shiner	N	I	S	I	1	1.50	0.14			
Rosyface Shiner	N	I	S	I	31	46.50	4.43			
Striped Shiner	N	I	S		79	118.50	11.29			
Spotfin Shiner	N	I	M		25	37.50	3.57			
Sand Shiner	N	I	M	M	26	39.00	3.71			
Silverjaw Minnow	N	I	M		17	25.50	2.43			
Bluntnose Minnow	N	O	C	T	138	207.00	19.71			
Central Stoneroller	N	H	N		159	238.50	22.71			
Largemouth Bass	F	C	C		1	1.50	0.14			
Green Sunfish	S	I	C	T	17	25.50	2.43			
Bluegill Sunfish	S	I	C	P	2	3.00	0.29			
Johnny Darter	D	I	C		2	3.00	0.29			
Banded Darter	D	I	S	I	3	4.50	0.43			
Rainbow Darter	D	I	S	M	8	12.00	1.14			
Fantail Darter	D	I	C		11	16.50	1.57			
Mile Total					700	1,050.00				
Number of Species					20					
Number of Hybrids					0					

River Code: **17-096**	Stream: **Little Bluerock Creek**	Sample Date: **2008**
River Mile: **0.10**	Location:	Date Range: 07/09/2008
Time Fished: 1896 sec	Drainage: 2.7 sq mi	
Dist Fished: 0.15 km	Basin: Muskingum River No of Passes: 1	Sampler Type: E

Species Name / ODNR status	IBI Grp	Feed Guild	Breed Guild	Tol	# of Fish	Relative Number	% by Number	Relative Weight	% by Weight	Ave(gm) Weight
White Sucker	W	O	S	T	9	18.00	1.82			
Western Blacknose Dace	N	G	S	T	64	128.00	12.96			
Creek Chub	N	G	N	T	121	242.00	24.49			
South. Redbelly Dace	N	H	S		116	232.00	23.48			
Redside Dace	N	I	S	I	1	2.00	0.20			
Striped Shiner	N	I	S		11	22.00	2.23			
Spotfin Shiner	N	I	M		13	26.00	2.63			
Bluntnose Minnow	N	O	C	T	2	4.00	0.40			
Central Stoneroller	N	H	N		92	184.00	18.62			
Largemouth Bass	F	C	C		1	2.00	0.20			
Green Sunfish	S	I	C	T	1	2.00	0.20			
Bluegill Sunfish	S	I	C	P	2	4.00	0.40			
Orangethroat Darter	D	I	S		18	36.00	3.64			
Fantail Darter	D	I	C		43	86.00	8.70			
	Mile Total				494	988.00				
	Number of Species				14					
	Number of Hybrids				0					

River Code: **17-097**	Stream: **Back Run**	Sample Date: **2008**
River Mile: **0.70**	Location: dst. Back Run Rd.	Date Range: 06/16/2008
Time Fished: 2100 sec	Drainage: 2.7 sq mi	
Dist Fished: 0.15 km	Basin: Muskingum River No of Passes: 1	Sampler Type: E

Species Name / ODNR status	IBI Grp	Feed Guild	Breed Guild	Tol	# of Fish	Relative Number	% by Number	Relative Weight	% by Weight	Ave(gm) Weight
Western Blacknose Dace	N	G	S	T	73	146.00	15.90			
Creek Chub	N	G	N	T	139	278.00	30.28			
South. Redbelly Dace	N	H	S		247	494.00	53.81			
Mile Total					459	918.00				
Number of Species					3					
Number of Hybrids					0					

River Code: **17-099**	Stream: **Dry Riffle Run**	Sample Date: **2008**
River Mile: **0.20**	Location: upst. St. Rt. 60	Date Range: 06/16/2008
Time Fished: 2700 sec	Drainage: 4.2 sq mi	
Dist Fished: 0.15 km	Basin: Muskingum River No of Passes: 1	Sampler Type: E

Species Name / ODNR status	IBI Grp	Feed Guild	Breed Guild	Tol	# of Fish	Relative Number	% by Number	Relative Weight	% by Weight	Ave(gm) Weight
Golden Redhorse	R	I	S	M	1	2.00	0.43			
Northern Hog Sucker	R	I	S	M	1	2.00	0.43			
White Sucker	W	O	S	T	22	44.00	9.48			
Western Blacknose Dace	N	G	S	T	4	8.00	1.72			
Creek Chub	N	G	N	T	34	68.00	14.66			
Striped Shiner	N	I	S		10	20.00	4.31			
Spotfin Shiner	N	I	M		3	6.00	1.29			
Sand Shiner	N	I	M	M	33	66.00	14.22			
Silverjaw Minnow	N	I	M		8	16.00	3.45			
Bluntnose Minnow	N	O	C	T	52	104.00	22.41			
Central Stoneroller	N	H	N		43	86.00	18.53			
Green Sunfish	S	I	C	T	4	8.00	1.72			
Bluegill Sunfish	S	I	C	P	14	28.00	6.03			
Green Sf X Bluegill Sf					1	2.00	0.43			
Fantail Darter	D	I	C		2	4.00	0.86			
	Mile Total				232	464.00				
	Number of Species				14					
	Number of Hybrids				1					

River Code: **17-133**	Stream: **Sycamore Hollow Run**	Sample Date: **2008**
River Mile: **0.20**	Location:	Date Range: 07/08/2008
Time Fished: 1158 sec	Drainage: 1.5 sq mi	
Dist Fished: 0.15 km	Basin: Muskingum River No of Passes: 1	Sampler Type: E

Species Name / ODNR status	IBI Grp	Feed Guild	Breed Guild	Tol	# of Fish	Relative Number	% by Number	Relative Weight	% by Weight	Ave(gm) Weight
White Sucker	W	O	S	T	3	6.00	2.19			
Western Blacknose Dace	N	G	S	T	15	30.00	10.95			
Creek Chub	N	G	N	T	85	170.00	62.04			
South. Redbelly Dace	N	H	S		9	18.00	6.57			
Central Stoneroller	N	H	N		4	8.00	2.92			
Green Sunfish	S	I	C	T	21	42.00	15.33			
Mile Total					137	274.00				
Number of Species					6					
Number of Hybrids					0					

River Code: **17-135**	Stream: **Flat Run**	Sample Date: **2008**
River Mile: **0.30**	Location:	Date Range: 07/08/2008
Time Fished: 1800 sec	Drainage: 5.0 sq mi	
Dist Fished: 0.15 km	Basin: Muskingum River No of Passes: 1	Sampler Type: E

Species Name / ODNR status	IBI Grp	Feed Guild	Breed Guild	Tol	# of Fish	Relative Number	% by Number	Relative Weight	% by Weight	Ave(gm) Weight
Golden Redhorse	R	I	S	M	1	2.00	0.09			
White Sucker	W	O	S	T	1	2.00	0.09			
Western Blacknose Dace	N	G	S	T	2	4.00	0.18			
Creek Chub	N	G	N	T	40	80.00	3.68			
Emerald Shiner	N	I	M		750	1,500.00	69.06			
Striped Shiner	N	I	S		1	2.00	0.09			
Spotfin Shiner	N	I	M		4	8.00	0.37			
Sand Shiner	N	I	M	M	210	420.00	19.34			
Bluntnose Minnow	N	O	C	T	6	12.00	0.55			
Central Stoneroller	N	H	N		55	110.00	5.06			
Rock Bass	S	C	C		1	2.00	0.09			
Green Sunfish	S	I	C	T	9	18.00	0.83			
Bluegill Sunfish	S	I	C	P	2	4.00	0.18			
Orangethroat Darter	D	I	S		1	2.00	0.09			
Fantail Darter	D	I	C		3	6.00	0.28			
Mile Total					1,086	2,172.00				
Number of Species					15					
Number of Hybrids					0					

River Code: **17-911**	Stream: **Duncan Run**	Sample Date: **2008**
River Mile: **0.30**	Location:	Date Range: 07/08/2008
Time Fished: 1189 sec	Drainage: 7.3 sq mi	
Dist Fished: 0.15 km	Basin: Muskingum River No of Passes: 1	Sampler Type: E

Species Name / ODNR status	IBI Grp	Feed Guild	Breed Guild	Tol	# of Fish	Relative Number	% by Number	Relative Weight	% by Weight	Ave(gm) Weight
White Sucker	W	O	S	T	1	2.00	0.53			
Western Blacknose Dace	N	G	S	T	15	30.00	8.02			
Creek Chub	N	G	N	T	31	62.00	16.58			
Silver Shiner	N	I	S	I	7	14.00	3.74			
Spotfin Shiner	N	I	M		16	32.00	8.56			
Sand Shiner	N	I	M	M	63	126.00	33.69			
Silverjaw Minnow	N	I	M		2	4.00	1.07			
Bluntnose Minnow	N	O	C	T	39	78.00	20.86			
Central Stoneroller	N	H	N		8	16.00	4.28			
Bluegill Sunfish	S	I	C	P	1	2.00	0.53			
Hybrid X Sunfish					1	2.00	0.53			
Johnny Darter	D	I	C		3	6.00	1.60			
Mile Total					187	374.00				
Number of Species					11					
Number of Hybrids					1					

River Code: **17-912**	Stream: **Little Duncan Run**	Sample Date: **2008**
River Mile: **0.10**	Location:	Date Range: 07/08/2008
Time Fished: 963 sec	Drainage: 2.8 sq mi	
Dist Fished: 0.15 km	Basin: Muskingum River No of Passes: 1	Sampler Type: E

Species Name / ODNR status	IBI Grp	Feed Guild	Breed Guild	Tol	# of Fish	Relative Number	% by Number	Relative Weight	% by Weight	Ave(gm) Weight
White Sucker	W	O	S	T	3	6.00	0.63			
Western Blacknose Dace	N	G	S	T	92	184.00	19.33			
Creek Chub	N	G	N	T	152	304.00	31.93			
South. Redbelly Dace	N	H	S		53	106.00	11.13			
Striped Shiner	N	I	S		20	40.00	4.20			
Spotfin Shiner	N	I	M		13	26.00	2.73			
Sand Shiner	N	I	M	M	1	2.00	0.21			
Silverjaw Minnow	N	I	M		12	24.00	2.52			
Bluntnose Minnow	N	O	C	T	6	12.00	1.26			
Central Stoneroller	N	H	N		62	124.00	13.03			
Largemouth Bass	F	C	C		2	4.00	0.42			
Green Sunfish	S	I	C	T	1	2.00	0.21			
Bluegill Sunfish	S	I	C	P	1	2.00	0.21			
Johnny Darter	D	I	C		4	8.00	0.84			
Orangethroat Darter	D	I	S		7	14.00	1.47			
Fantail Darter	D	I	C		47	94.00	9.87			
	Mile Total				476	952.00				
	Number of Species				16					
	Number of Hybrids				0					

River Code: **17-914**	Stream: **Brush Creek**	Sample Date: **2008**
River Mile: **7.30**	Location:	Date Range: 07/15/2008
Time Fished: 2700 sec	Drainage: 6.2 sq mi	
Dist Fished: 0.20 km	Basin: Muskingum River No of Passes: 1	Sampler Type: E

Species Name / ODNR status	IBI Grp	Feed Guild	Breed Guild	Tol	# of Fish	Relative Number	% by Number	Relative Weight	% by Weight	Ave(gm) Weight
White Sucker	W	O	S	T	117	175.50	24.12			
Western Blacknose Dace	N	G	S	T	36	54.00	7.42			
Creek Chub	N	G	N	T	157	235.50	32.37			
South. Redbelly Dace	N	H	S		48	72.00	9.90			
Bluntnose Minnow	N	O	C	T	52	78.00	10.72			
Central Stoneroller	N	H	N		31	46.50	6.39			
Spotted Bass	F	C	C		2	3.00	0.41			
Green Sunfish	S	I	C	T	9	13.50	1.86			
Fantail Darter	D	I	C		33	49.50	6.80			
	Mile Total				485	727.50				
	Number of Species				9					
	Number of Hybrids				0					

River Code: **17-914**	Stream: **Brush Creek**	Sample Date: **2008**
River Mile: **4.80**	Location:	Date Range: 07/24/2008
Time Fished: 2340 sec	Drainage: 15.9 sq mi	
Dist Fished: 0.15 km	Basin: Muskingum River No of Passes: 1	Sampler Type: E

Species Name / ODNR status	IBI Grp	Feed Guild	Breed Guild	Tol	# of Fish	Relative Number	% by Number	Relative Weight	% by Weight	Ave(gm) Weight
White Sucker	W	O	S	T	3	6.00	3.90			
Creek Chub	N	G	N	T	53	106.00	68.83			
Black Bullhead		I	C	P	1	2.00	1.30			
Green Sunfish	S	I	C	T	3	6.00	3.90			
Bluegill Sunfish	S	I	C	P	17	34.00	22.08			
Mile Total					77	154.00				
Number of Species					5					
Number of Hybrids					0					

River Code: **17-914**	Stream: **Brush Creek**	Sample Date: **2008**
River Mile: **1.20**	Location: adj. St. Rt. 555	Date Range: 07/08/2008
Time Fished: 895 sec	Drainage: 24.0 sq mi	
Dist Fished: 0.20 km	Basin: Muskingum River No of Passes: 1	Sampler Type: D

Species Name / ODNR status	IBI Grp	Feed Guild	Breed Guild	Tol	# of Fish	Relative Number	% by Number	Relative Weight	% by Weight	Ave(gm) Weight
White Sucker	W	O	S	T	4	6.00	2.42	0.14	5.53	24.00
Goldfish	G	O	M	T	1	1.50	0.61	0.03	1.00	17.00
Creek Chub	N	G	N	T	106	159.00	64.24	1.99	76.53	12.53
Striped Shiner	N	I	S		17	25.50	10.30	0.09	3.53	3.63
Sand Shiner	N	I	M	M	10	15.00	6.06	0.03	1.27	2.20
Bluntnose Minnow	N	O	C	T	1	1.50	0.61	0.00	0.08	1.00
Central Stoneroller	N	H	N		1	1.50	0.61	0.02	0.81	14.00
Black Bullhead		I	C	P	1	1.50	0.61	0.04	1.34	23.00
Rock Bass	S	C	C		1	1.50	0.61	0.03	1.11	19.00
Largemouth Bass	F	C	C		1	1.50	0.61	0.01	0.46	8.00
Green Sunfish	S	I	C	T	8	12.00	4.85	0.14	5.26	11.38
Bluegill Sunfish	S	I	C	P	14	21.00	8.48	0.08	3.15	3.92
Mile Total					165	247.50		2.60		
Number of Species					12					
Number of Hybrids					0					

River Code: **17-915**	Stream: **Baughman Run**	Sample Date: **2008**
River Mile: **0.10**	Location:	Date Range: 08/15/2008
Time Fished: 1200 sec	Drainage: 2.2 sq mi	
Dist Fished: 0.15 km	Basin: Muskingum River No of Passes: 1	Sampler Type: E

Species Name / ODNR status	IBI Grp	Feed Guild	Breed Guild	Tol	# of Fish	Relative Number	% by Number	Relative Weight	% by Weight	Ave(gm) Weight
White Sucker	W	O	S	T	1	2.00	2.70			
Creek Chub	N	G	N	T	35	70.00	94.59			
Bluegill Sunfish	S	I	C	P	1	2.00	2.70			
Mile Total					37	74.00				
Number of Species					3					
Number of Hybrids					0					

River Code: **17-916**	Stream: **Turkey Run**	Sample Date: **2008**
River Mile: **0.10**	Location:	Date Range: 07/09/2008
Time Fished: 2335 sec	Drainage: 2.1 sq mi	Thru: 08/15/2008
Dist Fished: 0.30 km	Basin: Muskingum River No of Passes: 2	Sampler Type: E

Species Name / ODNR status	IBI Grp	Feed Guild	Breed Guild	Tol	# of Fish	Relative Number	% by Number	Relative Weight	% by Weight	Ave(gm) Weight
Creek Chub	N	G	N	T	7	7.00	20.00			
Green Sunfish	S	I	C	T	18	18.00	51.43			
Bluegill Sunfish	S	I	C	P	9	9.00	25.71			
Green Sf X Bluegill Sf					1	1.00	2.86			
No Fish					0	0.00	0.00			
Mile Total					35	35.00				
Number of Species					3					
Number of Hybrids					1					

River Code: **17-917**	Stream: **Goose Run**	Sample Date: **2008**
River Mile: **0.10**	Location:	Date Range: 08/15/2008
Time Fished: 1500 sec	Drainage: 2.0 sq mi	
Dist Fished: 0.15 km	Basin: Muskingum River No of Passes: 1	Sampler Type: E

Species Name / ODNR status	IBI Grp	Feed Guild	Breed Guild	Tol	# of Fish	Relative Number	% by Number	Relative Weight	% by Weight	Ave(gm) Weight
White Sucker	W	O	S	T	5	10.00	1.35			
Western Blacknose Dace	N	G	S	T	66	132.00	17.84			
Creek Chub	N	G	N	T	153	306.00	41.35			
South. Redbelly Dace	N	H	S		97	194.00	26.22			
Central Stoneroller	N	H	N		12	24.00	3.24			
Green Sunfish	S	I	C	T	7	14.00	1.89			
Fantail Darter	D	I	C		30	60.00	8.11			
Mile Total					370	740.00				
Number of Species					7					
Number of Hybrids					0					

Appendix Table 5. Fish Index of Biotic Integrity (IBI) scores and metrics for sites in the Muskingum River tributaries, 2008.

River Mile	Type	Date	Drainage area (sq mi)	Number of: Total species	Minnow species	Headwater species	Sensitive species	Darter & Sculpin species	Simple Lithophils	Percent of Individuals: Tolerant fishes	Omni-vores	Pioneering fishes	Insect-ivores	DELT anomalies	Rel.No. minus tolerants /(0.3km)	IBI
Island Run - (17-090)																
Year: 2008																
3.40	E	07/15/2008	10.8	9(3)	6(3)	3(3)	0(1)	1(1)	3(1)	49(3)	28(3)	39(3)	9(1)	0.0(5)	725(3)	30
S. Br. Island Run - (17-091)																
Year: 2008																
0.10	E	07/15/2008	4.9	8(3)	6(5)	3(3)	0(1)	1(1)	3(3)	56(3)	6(5)	45(3)	5(1)	0.0(5)	233(3)	36
Big Bottom Run - (17-092)																
Year: 2008																
0.20	E	06/16/2008	4.2	8(3)	6(5)	3(3)	1(1)	1(1)	3(3)	79(1)	15(3)	65(1)	7(1)	0.0(5)	36(1) *	28
Blue Rock Creek - (17-095)																
Year: 2008																
0.80	E	07/24/2008	9.5	20(5)	11(5)	3(3)	6(5)	4(5)	9(5)	45(3)	22(3)	40(3)	33(3)	0.0(5)	581(3)	48
L. Blue Rock Creek - (17-096)																
Year: 2008																
0.10	E	07/09/2008	2.7	14(5)	8(5)	4(5)	1(1)	2(3)	6(5)	40(3)	2(5)	29(5)	18(3)	0.0(5)	594(5)	50
Back Run - (17-097)																
Year: 2008																
0.70	E	06/16/2008	2.7	3(1)	3(3)	2(3)	0(1)	0(1)	2(3)	46(3)	0(5)	30(3)	0(1)	0.0(5)	494(5)	34
Dry Riffle Run - (17-099)																
Year: 2008																
0.20	E	06/16/2008	4.2	14(5)	8(5)	2(3)	3(3)	1(1)	5(5)	50(3)	32(1)	42(3)	33(3)	0.0(5)	232(3)	40
Sycamore Hollow Run - (17-133)																
Year: 2008																
0.20	E	07/08/2008	1.5	6(3)	4(3)	2(3)	0(1)	0(1)	3(5)	91(1)	2(5)	77(1)	15(3)	0.0(5)	26(1)	32
Flat Run - (17-135)																
Year: 2008																
0.30	E	07/08/2008	5.0	15(5)	8(5)	2(3)	2(1)	2(3)	5(5)	5(5)	1(5)	5(5)	90(5)	0.0(5)	2056(5)	52

♦ - IBI is low end adjusted.

* - < 200 Total individuals in sample

** - < 50 Total individuals in sample

● - One or more species excluded from IBI calculation.

Appendix Table 5. Continued.

River Mile	Type	Date	Drainage area (sq mi)	Number of: Total species	Minnow species	Headwater species	Sensitive species	Darter & Sculpin species	Simple Lithophils	Percent of Individuals: Tolerant fishes	Omni-vores	Pioneering fishes	Insect-ivores	DELT anomalies	Rel.No. minus tolerants /(0.3km)	IBI
Duncan Run - (17-911)																
Year: 2008																
0.30	E	07/08/2008	7.3	11(3)	8(5)	1(1)	2(1)	1(1)	3(3)	46(3)	21(3)	40(3)	49(5)	0.0(5)	202(3)	36
L. Duncan Run - (17-912)																
Year: 2008																
0.10	E	07/08/2008	2.8	16(5)	9(5)	3(3)	1(1)	3(5)	5(5)	53(3)	2(5)	38(3)	22(3)	0.0(5)	444(5)	48
Brush Creek - (17-914)																
Year: 2008																
7.30	E	07/15/2008	6.2	9(3)	5(3)	3(3)	0(1)	1(1)	3(3)	76(1)	35(1)	45(3)	9(1)	0.0(5)	171(3)	28
4.80	E	07/24/2008	15.9	5(1)	1(1)	0(1)	0(1)	0(1)	1(1)	77(1)	4(5)	73(1)	27(3)	0.0(5)	36(1) *	22
Baughman Run - (17-915)																
Year: 2008																
0.10	E	08/15/2008	2.2	3(1)	1(1)	0(1)	0(1)	0(1)	1(1)	97(1)	3(5)	95(1)	3(1)	0.0(5)	2(1) *	20
Turkey Run - (17-916)																
Year: 2008																
0.10	E	07/09/2008	2.1	3(1)	1(1)	0(1)	0(1)	0(1)	0(1)	71(1)	0(5)	71(1)	77(5)	0.0(5)	20(1) *	24
0.10	E	08/15/2008	2.1	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0(1)	0.0(1)	0(1) * *	12
Goose Run - (17-917)																
Year: 2008																
0.10	E	08/15/2008	2.0	7(3)	4(3)	3(3)	0(1)	1(3)	3(3)	62(1)	1(5)	43(3)	10(1)	0.0(5)	278(5)	36

♦ - IBI is low end adjusted.

* - < 200 Total individuals in sample

** - < 50 Total individuals in sample

● - One or more species excluded from IBI calculation.

River Mile	Type	Date	Drainage area (sq mi)	Number of: Total species	Sunfish species	Sucker species	Intolerant species	Darter species	Percent of Individuals: Simple Lithophils	Tolerant fishes	Omni-vores	Top carnivores	Insect-ivores	DELT anomalies	Rel.No. minus tolerants /(0.3km)	IBI	Modified Iwb
Brush Creek - (17914)																	
Year: 2008																	
1.20	D	07/08/2008	24	11(3)	3(3)	1(1)	0(1)	0(1)	13(1)	73(1)	4(5)	1.2(3)	30(3)	0.0(5)	68(1)	28	3.9

na - Qualitative data, Modified Iwb not applicable.

♦ - IBI is low end adjusted.

* - < 200 Total individuals in sample

** - < 50 Total individuals in sample

● - One or more species excluded from IBI calculation.

Appendix Table 6. Macroinvertebrate results for each sampling location in the Muskingum River Tributaries study area, 2009.

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Site: Island Run

Collection Date: 07/09/2008 River Code: 17-090 RM: 3.60

Taxa Code	Taxa	Quant/Qual
03600	*Oligochaeta*	+
08260	*Orconectes (Crokerinus) sanbornii sanbornii*	+
11014	*Acentrella turbida*	+
11120	*Baetis flavistriga*	+
11150	*Pseudocloeon propinquum*	+
11250	*Centroptilum sp (w/o hindwing pads)*	+
11651	*Procloeon sp (w/o hindwing pads)*	+
13400	*Stenacron sp*	+
13521	*Stenonema femoratum*	+
13590	*Maccaffertium vicarium*	+
15000	*Paraleptophlebia sp*	+
17200	*Caenis sp*	+
22300	*Argia sp*	+
23909	*Boyeria vinosa*	+
33100	*Leuctra sp*	+
34130	*Acroneuria frisoni*	+
34300	*Neoperla clymene complex*	+
44501	*Corixidae*	+
48610	*Nigronia fasciatus*	+
52200	*Cheumatopsyche sp*	+
52315	*Diplectrona modesta*	+
60900	*Peltodytes sp*	+
63300	*Hydroporini*	+
65501	*Hydrophilidae*	+
67500	*Laccobius sp*	+
68075	*Psephenus herricki*	+
68130	*Helichus sp*	+
68700	*Dubiraphia sp*	+
69400	*Stenelmis sp*	+
71500	*Ormosia sp*	+
71700	*Pilaria sp*	+
72340	*Dixella sp*	+
74100	*Simulium sp*	+
77120	*Ablabesmyia mallochi*	+
78500	*Paramerina fragilis*	+
80420	*Cricotopus (C.) bicinctus*	+
84450	*Polypedilum (Uresipedilum) flavum*	+
84470	*Polypedilum (P.) illinoense*	+
84750	*Stictochironomus sp*	+
85501	*Paratanytarsus n.sp 1*	+
85818	*Tanytarsus glabrescens group sp 4*	+
95100	*Physella sp*	+

Taxa Code	Taxa	Quant/Qual

No. Quantitative Taxa: 0 Total Taxa: 42

No. Qualitative Taxa: 42 ICI:

Number of Organisms: 0 Qual EPT: 15

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Site: South Branch Island Run

Collection Date: 07/09/2008 River Code: 17-091 RM: 0.10

Taxa Code	Taxa	Quant/Qual
07860	*Cambarus (Puncticambarus) robustus*	+
08260	*Orconectes (Crokerinus) sanbornii sanbornii*	+
11018	*Acerpenna macdunnoughi*	+
11120	*Baetis flavistriga*	+
11125	*Pseudocloeon frondale*	+
11250	*Centroptilum sp (w/o hindwing pads)*	+
11651	*Procloeon sp (w/o hindwing pads)*	+
13000	*Leucrocuta sp*	+
13100	*Nixe sp*	+
13521	*Stenonema femoratum*	+
13590	*Maccaffertium vicarium*	+
15000	*Paraleptophlebia sp*	+
17200	*Caenis sp*	+
23909	*Boyeria vinosa*	+
34130	*Acroneuria frisoni*	+
34300	*Neoperla clymene complex*	+
34500	*Perlesta placida complex*	+
50315	*Chimarra obscura*	+
52200	*Cheumatopsyche sp*	+
52530	*Hydropsyche depravata group*	+
52540	*Hydropsyche dicantha*	+
60900	*Peltodytes sp*	+
63900	*Laccophilus sp*	+
68025	*Ectopria sp*	+
68075	*Psephenus herricki*	+
68130	*Helichus sp*	+
69400	*Stenelmis sp*	+
74100	*Simulium sp*	+
77500	*Conchapelopia sp*	+
80310	*Cardiocladius obscurus*	+
80420	*Cricotopus (C.) bicinctus*	+
84315	*Phaenopsectra flavipes*	+
84450	*Polypedilum (Uresipedilum) flavum*	+
84460	*Polypedilum (P.) fallax group*	+
84750	*Stictochironomus sp*	+
96900	*Ferrissia sp*	+

Taxa Code	Taxa	Quant/Qual

No. Quantitative Taxa: 0 Total Taxa: 36

No. Qualitative Taxa: 36 ICI:

Number of Organisms: 0 Qual EPT: 18

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Site: Big Bottom Run
upst. Old River Rd.

Collection Date: 06/16/2008 River Code: 17-092 RM: 0.20

Taxa Code	Taxa	Quant/Qual
07820	*Cambarus (Cambarus) sp A*	+
07860	*Cambarus (Puncticambarus) robustus*	+
11120	*Baetis flavistriga*	+
13100	*Nixe sp*	+
13521	*Stenonema femoratum*	+
13590	*Maccaffertium vicarium*	+
15000	*Paraleptophlebia sp*	+
21200	*Calopteryx sp*	+
33100	*Leuctra sp*	+
34120	*Acroneuria carolinensis*	+
34130	*Acroneuria frisoni*	+
34200	*Eccoptura xanthenes*	+
48610	*Nigronia fasciatus*	+
51600	*Polycentropus sp*	+
52200	*Cheumatopsyche sp*	+
52530	*Hydropsyche depravata group*	+
57400	*Neophylax sp*	+
63300	*Hydroporini*	+
63700	*Ilybius sp*	+
68025	*Ectopria sp*	+
68075	*Psephenus herricki*	+
68130	*Helichus sp*	+
74100	*Simulium sp*	+
84430	*Polypedilum (P.) albicorne*	+
95100	*Physella sp*	+

Taxa Code	Taxa	Quant/Qual

No. Quantitative Taxa: 0 Total Taxa: 25
No. Qualitative Taxa: 25 ICI:
Number of Organisms: 0 Qual EPT: 13

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Site: Bluerock Creek

Collection Date: 07/08/2008 River Code: 17-095 RM: 0.70

Taxa Code	Taxa	Quant/Qual
03600	*Oligochaeta*	+
08260	*Orconectes (Crokerinus) sanbornii sanbornii*	+
11014	*Acentrella turbida*	+
11119	*Plauditus dubius or P. virilis*	+
11120	*Baetis flavistriga*	+
11125	*Pseudocloeon frondale*	+
11250	*Centroptilum sp (w/o hindwing pads)*	+
11430	*Diphetor hageni*	+
11651	*Procloeon sp (w/o hindwing pads)*	+
13100	*Nixe sp*	+
13400	*Stenacron sp*	+
13521	*Stenonema femoratum*	+
13561	*Maccaffertium pulchellum*	+
13590	*Maccaffertium vicarium*	+
15000	*Paraleptophlebia sp*	+
16700	*Tricorythodes sp*	+
17200	*Caenis sp*	+
22001	*Coenagrionidae*	+
23909	*Boyeria vinosa*	+
27307	*Epitheca (Epicordulia) princeps*	+
33100	*Leuctra sp*	+
34130	*Acroneuria frisoni*	+
34300	*Neoperla clymene complex*	+
34500	*Perlesta placida complex*	+
36200	*Haploperla brevis*	+
51400	*Nyctiophylax sp*	+
51600	*Polycentropus sp*	+
52200	*Cheumatopsyche sp*	+
57900	*Pycnopsyche sp*	+
63300	*Hydroporini*	+
68075	*Psephenus herricki*	+
68130	*Helichus sp*	+
68707	*Dubiraphia quadrinotata*	+
69400	*Stenelmis sp*	+
70700	*Dicranota sp*	+
71100	*Hexatoma sp*	+
71900	*Tipula sp*	+
71910	*Tipula abdominalis*	+
74100	*Simulium sp*	+
77750	*Hayesomyia senata or Thienemannimyia norena*	+
77800	*Helopelopia sp*	+
80420	*Cricotopus (C.) bicinctus*	+
80430	*Cricotopus (C.) tremulus group*	+
80440	*Cricotopus (C.) trifascia*	+
81825	*Rheocricotopus (Psilocricotopus) robacki*	+
82141	*Thienemanniella xena*	+
83040	*Dicrotendipes neomodestus*	+
83840	*Microtendipes pedellus group*	+
84440	*Polypedilum (Uresipedilum) aviceps*	+
84450	*Polypedilum (Uresipedilum) flavum*	+
84612	*Saetheria tylus*	+
85400	*Micropsectra sp*	+
85625	*Rheotanytarsus sp*	+
85802	*Tanytarsus curticornis*	+
85821	*Tanytarsus glabrescens group sp 7*	+
95100	*Physella sp*	+
96900	*Ferrissia sp*	+

No. Quantitative Taxa: 0 Total Taxa: 57

No. Qualitative Taxa: 57 ICI:

Number of Organisms: 0 Qual EPT: 24

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Site: Little Bluerock Creek

Collection Date: 07/09/2008 River Code: 17-096 RM: 0.07

Taxa Code	Taxa	Quant/Qual
07860	*Cambarus (Puncticambarus) robustus*	+
08260	*Orconectes (Crokerinus) sanbornii sanbornii*	+
11014	*Acentrella turbida*	+
11120	*Baetis flavistriga*	+
11150	*Pseudocloeon propinquum*	+
13521	*Stenonema femoratum*	+
13590	*Maccaffertium vicarium*	+
15000	*Paraleptophlebia sp*	+
16700	*Tricorythodes sp*	+
33100	*Leuctra sp*	+
34130	*Acroneuria frisoni*	+
34500	*Perlesta placida complex*	+
45300	*Sigara sp*	+
52001	*Hydropsychidae*	+
52200	*Cheumatopsyche sp*	+
67100	*Hydrobius sp*	+
68075	*Psephenus herricki*	+
68130	*Helichus sp*	+
71100	*Hexatoma sp*	+
72340	*Dixella sp*	+
74100	*Simulium sp*	+
77800	*Helopelopia sp*	+
80355	*Corynoneura sp 5*	+
80430	*Cricotopus (C.) tremulus group*	+
84750	*Stictochironomus sp*	+
95100	*Physella sp*	+

Taxa Code	Taxa	Quant/Qual

No. Quantitative Taxa: 0 Total Taxa: 26

No. Qualitative Taxa: 26 ICI:

Number of Organisms: 0 Qual EPT: 12

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Site: Back Run

Collection Date: 06/16/2008 River Code: 17-097 RM: 1.00

Taxa Code	Taxa	Quant/Qual	Taxa Code	Taxa	Quant/Qual
07860	*Cambarus (Puncticambarus) robustus*	+			
11120	*Baetis flavistriga*	+			
11430	*Diphetor hageni*	+			
11650	*Procloeon sp (w/ hindwing pads)*	+			
13100	*Nixe sp*	+			
13400	*Stenacron sp*	+			
13521	*Stenonema femoratum*	+			
15000	*Paraleptophlebia sp*	+			
18630	*Ephemera varia*	+			
21200	*Calopteryx sp*	+			
27001	*Corduliidae*	+			
33100	*Leuctra sp*	+			
34001	*Perlidae*	+			
34500	*Perlesta placida complex*	+			
45900	*Notonecta sp*	+			
51600	*Polycentropus sp*	+			
52200	*Cheumatopsyche sp*	+			
52530	*Hydropsyche depravata group*	+			
68130	*Helichus sp*	+			
72700	*Anopheles sp*	+			
74100	*Simulium sp*	+			
77500	*Conchapelopia sp*	+			
80370	*Corynoneura lobata*	+			
82200	*Tvetenia bavarica group*	+			
84315	*Phaenopsectra flavipes*	+			
84440	*Polypedilum (Uresipedilum) aviceps*	+			
85800	*Tanytarsus sp*	+			

No. Quantitative Taxa: 0 Total Taxa: 27

No. Qualitative Taxa: 27 ICI:

Number of Organisms: 0 Qual EPT: 14

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Site: Dry Riffle Run

Collection Date: 06/16/2008 River Code: 17-099 RM: 0.10

Taxa Code	Taxa	Quant/Qual
01801	*Turbellaria*	+
07860	*Cambarus (Puncticambarus) robustus*	+
08260	*Orconectes (Crokerinus) sanbornii sanbornii*	+
11250	*Centroptilum sp (w/o hindwing pads)*	+
13400	*Stenacron sp*	+
13521	*Stenonema femoratum*	+
15000	*Paraleptophlebia sp*	+
16200	*Eurylophella sp*	+
17200	*Caenis sp*	+
18619	*Ephemera simulans*	+
21200	*Calopteryx sp*	+
34500	*Perlesta placida complex*	+
57400	*Neophylax sp*	+
57900	*Pycnopsyche sp*	+
60900	*Peltodytes sp*	+
61400	*Agabus sp*	+
63300	*Hydroporini*	+
68075	*Psephenus herricki*	+
68130	*Helichus sp*	+
69400	*Stenelmis sp*	+
71900	*Tipula sp*	+
81231	*Nanocladius (N.) crassicornus or N. (N.) "rectinervis"*	+
83840	*Microtendipes pedellus group*	+
84300	*Phaenopsectra obediens group*	+
84440	*Polypedilum (Uresipedilum) aviceps*	+
84750	*Stictochironomus sp*	+

Taxa Code	Taxa	Quant/Qual

No. Quantitative Taxa: 0 Total Taxa: 26

No. Qualitative Taxa: 26 ICI:

Number of Organisms: 0 Qual EPT: 10

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Site: Sycamore Hollow Run

Collection Date: 07/08/2008 River Code: 17-133 RM: 0.30

Taxa Code	Taxa	Quant/Qual
03600	*Oligochaeta*	+
07860	*Cambarus (Puncticambarus) robustus*	+
08260	*Orconectes (Crokerinus) sanbornii sanbornii*	+
11125	*Pseudocloeon frondale*	+
11250	*Centroptilum sp (w/o hindwing pads)*	+
11430	*Diphetor hageni*	+
13100	*Nixe sp*	+
13400	*Stenacron sp*	+
13590	*Maccaffertium vicarium*	+
15000	*Paraleptophlebia sp*	+
18600	*Ephemera sp*	+
33100	*Leuctra sp*	+
34130	*Acroneuria frisoni*	+
34500	*Perlesta placida complex*	+
36200	*Haploperla brevis*	+
48610	*Nigronia fasciatus*	+
51600	*Polycentropus sp*	+
52200	*Cheumatopsyche sp*	+
52315	*Diplectrona modesta*	+
57400	*Neophylax sp*	+
57900	*Pycnopsyche sp*	+
63300	*Hydroporini*	+
68130	*Helichus sp*	+
69400	*Stenelmis sp*	+
71100	*Hexatoma sp*	+
71200	*Limnophila sp*	+
71900	*Tipula sp*	+
74100	*Simulium sp*	+
79400	*Zavrelimyia sp*	+
84440	*Polypedilum (Uresipedilum) aviceps*	+
85800	*Tanytarsus sp*	+

Taxa Code	Taxa	Quant/Qual

No. Quantitative Taxa: 0 Total Taxa: 31

No. Qualitative Taxa: 31 ICI:

Number of Organisms: 0 Qual EPT: 17

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Site: Flat Run

Collection Date: 07/21/2008 River Code: 17-135 RM: 0.30

Taxa Code	Taxa	Quant/Qual
03301	*Plumatellidae*	+
07801	*Cambarus (C.) sp*	+
08260	*Orconectes (Crokerinus) sanbornii sanbornii*	+
11120	*Baetis flavistriga*	+
11130	*Baetis intercalaris*	+
11150	*Pseudocloeon propinquum*	+
15000	*Paraleptophlebia sp*	+
15501	*Ephemerellidae*	+
17200	*Caenis sp*	+
22001	*Coenagrionidae*	+
23909	*Boyeria vinosa*	+
43570	*Neoplea sp*	+
48600	*Nigronia sp*	+
51600	*Polycentropus sp*	+
52200	*Cheumatopsyche sp*	+
52315	*Diplectrona modesta*	+
52430	*Ceratopsyche morosa group*	+
52530	*Hydropsyche depravata group*	+
68130	*Helichus sp*	+
71100	*Hexatoma sp*	+
74100	*Simulium sp*	+
77120	*Ablabesmyia mallochi*	+
77800	*Helopelopia sp*	+
80204	*Brillia flavifrons group*	+
80420	*Cricotopus (C.) bicinctus*	+
80430	*Cricotopus (C.) tremulus group*	+
81650	*Parametriocnemus sp*	+
82820	*Cryptochironomus sp*	+
84440	*Polypedilum (Uresipedilum) aviceps*	+
84450	*Polypedilum (Uresipedilum) flavum*	+
84470	*Polypedilum (P.) illinoense*	+
85501	*Paratanytarsus n.sp 1*	+
85625	*Rheotanytarsus sp*	+
85800	*Tanytarsus sp*	+
85840	*Tanytarsus sepp*	+
93900	*Elimia sp*	+

Taxa Code	Taxa	Quant/Qual

No. Quantitative Taxa: 0 Total Taxa: 36

No. Qualitative Taxa: 36 ICI:

Number of Organisms: 0 Qual EPT: 11

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Site: Duncan Run

Collection Date: 07/08/2008 River Code: 17-911 RM: 0.30

Taxa Code	Taxa	Quant/Qual
03600	*Oligochaeta*	+
07701	*Cambaridae*	+
11120	*Baetis flavistriga*	+
13400	*Stenacron sp*	+
13521	*Stenonema femoratum*	+
13590	*Maccaffertium vicarium*	+
16200	*Eurylophella sp*	+
17200	*Caenis sp*	+
23909	*Boyeria vinosa*	+
33100	*Leuctra sp*	+
34500	*Perlesta placida complex*	+
48620	*Nigronia serricornis*	+
52200	*Cheumatopsyche sp*	+
52530	*Hydropsyche depravata group*	+
63300	*Hydroporini*	+
63900	*Laccophilus sp*	+
68130	*Helichus sp*	+
68708	*Dubiraphia vittata group*	+
69400	*Stenelmis sp*	+
74100	*Simulium sp*	+
82900	*Demicryptochironomus sp*	+
84440	*Polypedilum (Uresipedilum) aviceps*	+
84750	*Stictochironomus sp*	+
85500	*Paratanytarsus sp*	+

Taxa Code	Taxa	Quant/Qual

No. Quantitative Taxa: 0 Total Taxa: 24

No. Qualitative Taxa: 24 ICI:

Number of Organisms: 0 Qual EPT: 10

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Site: Little Duncan Run

Collection Date: 07/08/2008 River Code: 17-912 RM: 0.06

Taxa Code	Taxa	Quant/Qual
03600	*Oligochaeta*	+
07860	*Cambarus (Puncticambarus) robustus*	+
11014	*Acentrella turbida*	+
11018	*Acerpenna macdunnoughi*	+
11020	*Acerpenna pygmaea*	+
11130	*Baetis intercalaris*	+
11250	*Centroptilum sp (w/o hindwing pads)*	+
13400	*Stenacron sp*	+
13590	*Maccaffertium vicarium*	+
14950	*Leptophlebia sp or Paraleptophlebia sp*	+
17200	*Caenis sp*	+
22001	*Coenagrionidae*	+
23600	*Aeshna sp*	+
23909	*Boyeria vinosa*	+
25510	*Stylogomphus albistylus*	+
33100	*Leuctra sp*	+
34200	*Eccoptura xanthenes*	+
34500	*Perlesta placida complex*	+
51600	*Polycentropus sp*	+
52200	*Cheumatopsyche sp*	+
52315	*Diplectrona modesta*	+
52450	*Ceratopsyche sparna*	+
52530	*Hydropsyche depravata group*	+
60900	*Peltodytes sp*	+
63300	*Hydroporini*	+
68130	*Helichus sp*	+
69400	*Stenelmis sp*	+
70600	*Antocha sp*	+
71100	*Hexatoma sp*	+
71800	*Pseudolimnophila sp*	+
71900	*Tipula sp*	+
74100	*Simulium sp*	+
77800	*Helopelopia sp*	+
81650	*Parametriocnemus sp*	+
81811	*Rheocricotopus (R.) eminellobus*	+
82820	*Cryptochironomus sp*	+
84440	*Polypedilum (Uresipedilum) aviceps*	+
84450	*Polypedilum (Uresipedilum) flavum*	+
84750	*Stictochironomus sp*	+
95100	*Physella sp*	+
96120	*Menetus (Micromenetus) dilatatus*	+
96900	*Ferrissia sp*	+

Taxa Code	Taxa	Quant/Qual

No. Quantitative Taxa: 0 Total Taxa: 42

No. Qualitative Taxa: 42 ICI:

Number of Organisms: 0 Qual EPT: 17

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Site: Brush Creek

Collection Date: 07/10/2008 River Code: 17-914 RM: 7.30

Taxa Code	Taxa	Quant/Qual
06201	*Hyalella azteca*	+
07860	*Cambarus (Puncticambarus) robustus*	+
08260	*Orconectes (Crokerinus) sanbornii sanbornii*	+
11014	*Acentrella turbida*	+
11120	*Baetis flavistriga*	+
11125	*Pseudocloeon frondale*	+
11245	*Centroptilum sp*	+
11651	*Procloeon sp (w/o hindwing pads)*	+
13521	*Stenonema femoratum*	+
13590	*Maccaffertium vicarium*	+
15000	*Paraleptophlebia sp*	+
17200	*Caenis sp*	+
21200	*Calopteryx sp*	+
23900	*Boyeria sp*	+
23909	*Boyeria vinosa*	+
33100	*Leuctra sp*	+
34500	*Perlesta placida complex*	+
47600	*Sialis sp*	+
52200	*Cheumatopsyche sp*	+
52530	*Hydropsyche depravata group*	+
57400	*Neophylax sp*	+
63300	*Hydroporini*	+
67100	*Hydrobius sp*	+
68130	*Helichus sp*	+
69400	*Stenelmis sp*	+
71100	*Hexatoma sp*	+
74100	*Simulium sp*	+
77100	*Ablabesmyia sp*	+
79400	*Zavrelimyia sp*	+
81690	*Paratrichocladius sp*	+
83840	*Microtendipes pedellus group*	+
84460	*Polypedilum (P.) fallax group*	+
84470	*Polypedilum (P.) illinoense*	+
84750	*Stictochironomus sp*	+
86200	*Tabanus sp*	+
95100	*Physella sp*	+

Taxa Code	Taxa	Quant/Qual

No. Quantitative Taxa: 0 Total Taxa: 36

No. Qualitative Taxa: 36 ICI:

Number of Organisms: 0 Qual EPT: 14

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Site: Brush Creek

Collection Date: 07/21/2008 River Code: 17-914 RM: 4.90

Taxa Code	Taxa	Quant/Qual
07860	*Cambarus (Puncticambarus) robustus*	+
08200	*Orconectes sp*	+
17200	*Caenis sp*	+
21200	*Calopteryx sp*	+
21700	*Lestes sp*	+
22001	*Coenagrionidae*	+
23600	*Aeshna sp*	+
47600	*Sialis sp*	+
52315	*Diplectrona modesta*	+
52530	*Hydropsyche depravata group*	+
68130	*Helichus sp*	+
84750	*Stictochironomus sp*	+

Taxa Code	Taxa	Quant/Qual

No. Quantitative Taxa: 0 Total Taxa: 12

No. Qualitative Taxa: 12 ICI:

Number of Organisms: 0 Qual EPT: 3

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Site: Brush Creek
adj. St. Rt. 555

Collection Date: 08/19/2008 River Code: 17-914 RM: 1.20

Taxa Code	Taxa	Quant/Qual
01801	*Turbellaria*	+
03600	*Oligochaeta*	20
07701	*Cambaridae*	+
11001	*Baetidae*	+
21200	*Calopteryx sp*	+
23600	*Aeshna sp*	+
33100	*Leuctra sp*	+
47600	*Sialis sp*	6 +
48620	*Nigronia serricornis*	1
51400	*Nyctiophylax sp*	5
52200	*Cheumatopsyche sp*	+
52315	*Diplectrona modesta*	+
52530	*Hydropsyche depravata group*	+
59500	*Oecetis sp*	+
63300	*Hydroporini*	+
68700	*Dubiraphia sp*	1
71900	*Tipula sp*	+
74501	*Ceratopogonidae*	4
77120	*Ablabesmyia mallochi*	14
77500	*Conchapelopia sp*	17
77750	*Hayesomyia senata or Thienemannimyia norena*	4
78655	*Procladius (Holotanypus) sp*	11
79400	*Zavrelimyia sp*	17
80370	*Corynoneura lobata*	2
82121	*Thienemanniella lobapodema*	1
82700	*Chironomus sp*	4
82820	*Cryptochironomus sp*	10
83900	*Nilothauma sp*	3
84210	*Paratendipes albimanus or P. duplicatus*	29
84300	*Phaenopsectra obediens group*	66
84302	*Phaenopsectra punctipes*	7
84315	*Phaenopsectra flavipes*	7
84430	*Polypedilum (P.) albicorne*	4
84460	*Polypedilum (P.) fallax group*	11 +
84520	*Polypedilum (Tripodura) halterale group*	4
84540	*Polypedilum (Tripodura) scalaenum group*	21
84750	*Stictochironomus sp*	3
84800	*Tribelos jucundum*	50
85500	*Paratanytarsus sp*	1
85615	*Rheotanytarsus pellucidus*	1
85800	*Tanytarsus sp*	4
85821	*Tanytarsus glabrescens group sp 7*	3
87540	*Hemerodromia sp*	2

Taxa Code	Taxa	Quant/Qual

No. Quantitative Taxa: 31 Total Taxa: 43
No. Qualitative Taxa: 14 ICI: **22**
Number of Organisms: 333 Qual EPT: 6

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Site: Baughman Run

Collection Date: 08/06/2008 River Code: 17-915 RM: 0.10

Taxa Code	Taxa	Quant/Qual
03600	*Oligochaeta*	+
07701	*Cambaridae*	+
51600	*Polycentropus sp*	+
52200	*Cheumatopsyche sp*	+
52315	*Diplectrona modesta*	+
52530	*Hydropsyche depravata group*	+
63300	*Hydroporini*	+
77750	*Hayesomyia senata or Thienemannimyia norena*	+
78601	*Pentaneura Type 1*	+
82141	*Thienemanniella xena*	+
84315	*Phaenopsectra flavipes*	+
84430	*Polypedilum (P.) albicorne*	+
84470	*Polypedilum (P.) illinoense*	+
85615	*Rheotanytarsus pellucidus*	+
85625	*Rheotanytarsus sp*	+
85821	*Tanytarsus glabrescens group sp 7*	+
85840	*Tanytarsus sepp*	+

Taxa Code	Taxa	Quant/Qual

No. Quantitative Taxa: 0 Total Taxa: 17

No. Qualitative Taxa: 17 ICI:

Number of Organisms: 0 Qual EPT: 4

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Site: Turkey Run

Collection Date: 07/21/2008 River Code: 17-916 RM: 0.05

Taxa Code	Taxa	Quant/Qual
07880	*Cambarus (Tubericambarus) thomai*	+
22001	*Coenagrionidae*	+
23909	*Boyeria vinosa*	+
45300	*Sigara sp*	+
45900	*Notonecta sp*	+
47600	*Sialis sp*	+
60900	*Peltodytes sp*	+
61400	*Agabus sp*	+
63300	*Hydroporini*	+
63900	*Laccophilus sp*	+
64100	*Matus sp*	+
71900	*Tipula sp*	+
84430	*Polypedilum (P.) albicorne*	+
85400	*Micropsectra sp*	+

Taxa Code	Taxa	Quant/Qual

No. Quantitative Taxa: 0 Total Taxa: 14

No. Qualitative Taxa: 14 ICI:

Number of Organisms: 0 Qual EPT: 0

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Site: Goose Run

Collection Date: 07/30/2008 River Code: 17-917 RM: 0.10

Taxa Code	Taxa	Quant/Qual
07820	*Cambarus (Cambarus) sp A*	+
08260	*Orconectes (Crokerinus) sanbornii sanbornii*	+
11014	*Acentrella turbida*	+
11120	*Baetis flavistriga*	+
11250	*Centroptilum sp (w/o hindwing pads)*	+
11430	*Diphetor hageni*	+
11650	*Procloeon sp (w/ hindwing pads)*	+
11651	*Procloeon sp (w/o hindwing pads)*	+
13521	*Stenonema femoratum*	+
13590	*Maccaffertium vicarium*	+
17200	*Caenis sp*	+
21200	*Calopteryx sp*	+
22001	*Coenagrionidae*	+
23909	*Boyeria vinosa*	+
33100	*Leuctra sp*	+
52200	*Cheumatopsyche sp*	+
52530	*Hydropsyche depravata group*	+
63300	*Hydroporini*	+
63900	*Laccophilus sp*	+
67700	*Paracymus sp*	+
68130	*Helichus sp*	+
69400	*Stenelmis sp*	+
71100	*Hexatoma sp*	+
72700	*Anopheles sp*	+
74100	*Simulium sp*	+
80410	*Cricotopus (C.) sp*	+
80420	*Cricotopus (C.) bicinctus*	+
95100	*Physella sp*	+

Taxa Code	Taxa	Quant/Qual

No. Quantitative Taxa: 0 Total Taxa: 28

No. Qualitative Taxa: 28 ICI:

Number of Organisms: 0 Qual EPT: 12

Appendix Table 7. Methods, Biosurvey Background Information, and Notice to Users

METHODS

All chemical, physical, and biological field, EPA laboratory, data processing, and data analysis methods and procedures adhere to those specified in the Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (Ohio Environmental Protection Agency 2006a), Manual of Laboratory Operating Procedures, Volumes I-IV (Ohio EPA 2002), Biological Criteria for the Protection of Aquatic Life, Volumes II-III (Ohio Environmental Protection Agency 1987b, 1989a, 1989b) including the 2006 updates, and the Qualitative Habitat Evaluation Index (QHEI); Rationale, Methods, and Application (Rankin 1989) for habitat assessment.

Determining Use Attainment

Use attainment status is a term describing the degree to which environmental indicators are either above or below criteria specified by the Ohio Water Quality Standards (WQS; Ohio Administrative Code 3745-1). Assessing aquatic use attainment status involves a primary reliance on the Ohio EPA biological criteria (OAC 3745-1-07; Table 7-15). These are confined to ambient assessments and apply to rivers and streams outside of mixing zones. Numerical biological criteria are based on multimetric biological indices including the Index of Biotic Integrity (IBI) and modified Index of Well-Being (MIwb), indices measuring the response of the fish community, and the Invertebrate Community Index (ICI), which indicates the response of the macroinvertebrate community. Three attainment status results are possible at each sampling location - full, partial, or non-attainment. Full attainment means that all of the applicable indices meet the biocriteria. Partial attainment means that one or more of the applicable indices fails to meet the biocriteria. Non-attainment means that none of the applicable indices meet the biocriteria or one of the organism groups reflects poor or very poor performance. An aquatic life use attainment table (Table 1) is constructed based on the sampling results and is arranged from upstream to downstream and includes the sampling locations indicated by river mile, the applicable biological indices, the use attainment status (*i.e.,* full, partial, or non), the Qualitative Habitat Evaluation Index (QHEI), and a sampling location description. All biological results were compared to WWH or EWH biocriteria for the Western Allegheny Plateau ecoregion.

Stream Habitat Evaluation

Physical habitat is evaluated using the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA for streams and rivers in Ohio (Rankin 1989, 1995). Various attributes of the available habitat are scored based on their overall importance to the establishment of viable, diverse aquatic faunas. Evaluations of type and quality of substrate, amount of instream cover, channel morphology, extent of riparian canopy, pool and riffle development and quality, and stream gradient are among the metrics used to evaluate the characteristics of a stream segment, not just the characteristics of a single sampling site. As such, individual sites may have much poorer physical habitat due to a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. QHEI scores from hundreds of segments around the state have indicated that values higher than 60 were generally conducive to the establishment of warmwater faunas while those which scored in excess of 75-80 often typify habitat conditions which have the ability to support exceptional faunas.

Surface Water Assessment

Surface water samples were collected 3-5 times from each location from the upper 12 inches of water over the course of the field sampling season. Collected water was preserved using appropriate methods, as outlined in Parts II and III of the Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (Ohio EPA 2006a). Bacteriological samples were collected four to five times at each location. Bacteriological samples were collected directly from the stream into sterilized polyethylene containers, cooled to 4°C, and transported to the Ohio EPA laboratory for analysis within 6 hours of sample collection. All samples were analyzed for fecal coliform and *E. coli* bacteria using U.S.EPA approved methods. Surface water samples were evaluated using comparisons to Ohio Water Quality Standards criteria, reference conditions, or published literature.

Macroinvertebrate Community Assessment

Macroinvertebrates were collected qualitatively from the natural habitats at each sampling location. This sampling effort consisted of an inventory of all observed macroinvertebrate taxa from the natural multihabitats at each site with no attempt to quantify populations other than notations on the predominance of specific taxa or taxa groups within major macrohabitat types (e.g., riffle, run, pool, margin). Detailed discussion of macroinvertebrate field and laboratory procedures is contained in Biological Criteria for the Protection of Aquatic Life: Volume III, Standardized Biological Field Sampling and Laboratory Methods for Assessing Fish and Macroinvertebrate Communities (Ohio EPA 1989a), including the 2006 update.

Fish Community Assessment

Fish were sampled once or twice (Turkey Run only) at each site using pulsed DC electrofishing wading or headwater methods. Electrofishing sampling distances ranged between 150 and 200 meters. Fish were processed in the field, and included identifying each individual to species, counting, weighing (wading site only), and recording any external abnormalities. Discussion of the fish community assessment methodology used in this report is contained in Biological Criteria for the Protection of Aquatic Life: Volume III, Standardized Biological Field Sampling and Laboratory Methods for Assessing Fish and Macroinvertebrate Communities (Ohio EPA 1989a).

Field Instrument Calibration

Field instruments are calibrated using manufacturer recommended procedures along with procedures noted in the Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (2006a) and Biological Criteria for the Protection of Aquatic Life, Volume III (1989b). pH, conductivity, and dissolved oxygen meters were calibrated daily before the start of field work. Laser rangefinders, used to measure sampling distance, were calibrated once at the Groveport Field Facility prior to summer field sampling activities. Fish weighing scales were checked against certified weights once per week during the field season. Calibration of pH, conductivity, dissolved oxygen, fish weighing scales, and laser rangefinders were recorded in a logbook maintained by Ohio EPA, Ecological Assessment Section and Southeast District Office.

Causal Associations

Using the results, conclusions, and recommendations of this report requires an understanding of the methodology used to determine the use attainment status and assigning probable causes and sources of impairment. The identification of impairment in rivers and streams is straightforward - the numerical biological criteria are used to judge aquatic life use attainment and impairment (partial and non-attainment). The rationale for using the biological criteria, within a weight of evidence framework, has been extensively discussed elsewhere (Karr *et al.* 1986; Karr 1991; Ohio EPA 1987a,b; Yoder 1989; Miner and Borton 1991; Yoder 1991; Yoder 1995). Describing the causes and sources associated with observed impairments relies on an interpretation of multiple lines of evidence including water chemistry data, sediment data, habitat data, effluent data, land use data, and biological results (Yoder and Rankin 1995). Thus the assignment of principal causes and sources of impairment in this report represent the association of impairments (based on response indicators) with stressor and exposure indicators. The reliability of the identification of probable causes and sources is increased where many such prior associations have been identified, or have been experimentally or statistically linked together. The ultimate measure of success in water resource management is the restoration of lost or damaged ecosystem attributes including aquatic community structure and function. While there have been criticisms of misapplying the metaphor of ecosystem “health” compared to human patient “health” (Suter 1993), in this document we are referring to the process for evaluating biological integrity and causes or sources associated with observed impairments, not whether human health and ecosystem health are analogous concepts.

NOTICE TO USERS

Ohio EPA incorporated biological criteria into the Ohio Water Quality Standards (WQS; Ohio Administrative Code 3745-1) regulations in February 1990 (effective May 1990). These criteria consist of numeric values for the Index of Biotic Integrity (IBI) and Modified Index of Well-Being (MIwb), both of which are based on fish assemblage data, and the Invertebrate Community Index (ICI), which is based on macroinvertebrate assemblage data. Criteria for each index are specified for each of Ohio's five ecoregions (as described by Omernik 1987), and are further organized by organism group, index, site type, and aquatic life use designation. These criteria, along with the existing chemical and whole effluent toxicity evaluation methods and criteria, figure prominently in the monitoring and assessment of Ohio's surface water resources.

The following documents support the use of biological criteria by outlining the rationale for using biological information, the methods by which the biocriteria were derived and calculated, the field methods by which sampling must be conducted, and the process for evaluating results:

Ohio Environmental Protection Agency. 1987a. Biological criteria for the protection of aquatic life: Volume I. The role of biological data in water quality assessment. Div. Water Qual. Monit. & Assess., Surface Water Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1987b. Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters. Div. Water Qual. Monit. & Assess., Surface Water Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1989b. Addendum to Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters. Div. Water Qual. Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Ohio Environmental Protection Agency. 1989c. Biological criteria for the protection of aquatic life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Div. Water Quality Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Ohio Environmental Protection Agency. 1990. The use of biological criteria in the Ohio EPA surface water monitoring and assessment program. Div. Water Qual. Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Ohio Environmental Protection Agency. 2006a. 2006 updates to Biological Criteria for the Protection of Aquatic Life: Volume II and Volume II Addendum. Users manual for biological field assessment of Ohio surface waters. Div. of Surface Water, Ecol. Assess. Sect., Columbus, Ohio.

Ohio Environmental Protection Agency. 2006b. 2006 updates to Biological Criteria for the Protection of Aquatic Life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Div. of Surface Water, Ecol. Assess. Sect., Columbus, Ohio.

Ohio Environmental Protection Agency. 2006c. Methods for assessing habitat in flowing waters: Using the Qualitative Habitat Evaluation Index (QHEI). Ohio EPA Tech. Bull. EAS/2006-06-1. Div. of Surface Water, Ecol. Assess. Sect., Columbus, Ohio.

Rankin, E.T. 1989. The qualitative habitat evaluation index (QHEI): rationale, methods, and application. Div. Water Qual. Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

In addition to the preceding guidance documents, the following publications by the Ohio EPA should also be consulted as they present supplemental information and analyses used by the Ohio EPA to implement the biological criteria.

DeShon, J.D. 1995. Development and application of the invertebrate community index (ICI), pp. 217-243. in W.S. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Risk-based Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Rankin, E. T. 1995. The use of habitat assessments in water resource management programs, pp. 181-208. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. and E.T. Rankin. 1995. Biological criteria program development and implementation in Ohio, pp. 109-144. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. and E.T. Rankin. 1995. Biological response signatures and the area of degradation value: new tools for interpreting multimetric data, pp. 263-286. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. 1995. Policy issues and management applications for biological criteria, pp. 327-344. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. and E.T. Rankin. 1995. The role of biological criteria in water quality monitoring, assessment, and regulation. Environmental Regulation in Ohio: How to Cope With the Regulatory Jungle. Inst. of Business Law, Santa Monica, CA. 54 pp.

Yoder, C.O. and M.A. Smith. 1999. Using fish assemblages in a State biological assessment and criteria program: essential concepts and considerations, pp. 17-63. in T. Simon (ed.). Assessing the Sustainability and Biological Integrity of Water Resources Using Fish Communities. CRC Press, Boca Raton, FL.

These documents and this report may be obtained by writing to:

Ohio EPA, Division of Surface Water
Ecological Assessment Section
4675 Homer Ohio Lane
Groveport, Ohio 43125
(614) 836-8786

or

http://www.epa.ohio.gov/dsw/document_index/psdindx.aspx

BIOSURVEY BACKGROUND INFORMATION

What is a Biological and Water Quality Survey?

A biological and water quality survey, or "biosurvey", is an interdisciplinary monitoring effort coordinated on a waterbody specific or watershed scale. This effort may involve a relatively simple setting focusing on one or two small streams, one or two principal stressors, and a handful of sampling sites or a much more complex effort including entire drainage basins, multiple and overlapping stressors, and tens of sites. Each year Ohio EPA conducts biosurveys in 4-5 watersheds study areas with an aggregate total of 250-300 sampling sites.

The Ohio EPA employs biological, chemical, and physical monitoring and assessment techniques in biosurveys in order to meet three major objectives: 1) determine the extent to which use designations assigned in the Ohio Water Quality Standards (WQS) are either attained or not attained; 2) determine if use designations assigned to a given water body are appropriate and attainable; and 3) determine if any changes in key ambient biological, chemical, or physical indicators have taken place over time, particularly before and after the implementation of point source pollution controls or best management practices. The data gathered by a biosurvey is processed, evaluated, and synthesized in a biological and water quality report. Each biological and water quality study contains a summary of major findings and recommendations for revisions to WQS, future monitoring needs, or other actions which may be needed to resolve existing impairment of designated uses. While the principal focus of a biosurvey is on the status of aquatic life uses, the status of other uses such as recreation and water supply, as well as human health concerns, are also addressed.

The findings and conclusions of a biological and water quality study may factor into regulatory actions taken by Ohio EPA (*e.g.,* NPDES permits, Director's Orders, the Ohio Water Quality Standards [OAC 3745-1], Water Quality Permit Support Documents [WQPSDs]), and are eventually incorporated into State Water Quality Management Plans, the Ohio Nonpoint Source Assessment, and the biennial Integrated Water Quality Monitoring and Assessment Report (305[b] and 303[d]).

Hierarchy of Indicators

A carefully conceived ambient monitoring approach, using cost-effective indicators consisting of ecological, chemical, and toxicological measures, can ensure that all relevant pollution sources are judged objectively on the basis of environmental results. Ohio EPA relies on a tiered approach in attempting to link the results of administrative activities with true environmental measures. This integrated approach includes a hierarchical continuum from administrative to true environmental indicators (Figure 1). The six "levels" of indicators include: 1) actions taken by regulatory agencies (permitting, enforcement, grants); 2) responses by the regulated community (treatment works, pollution prevention); 3) changes in discharged quantities (pollutant loadings); 4) changes in ambient conditions (water quality, habitat); 5) changes in uptake and/or assimilation (tissue contamination, biomarkers, wasteload allocation); and, 6) changes in health, ecology, or other effects (ecological condition, pathogens). In this process the results of administrative activities (levels 1 and 2) can be linked to efforts to improve water quality (levels 3, 4, and 5) which should translate into the environmental "results" (level 6). Thus, the aggregate effect of billions of dollars spent on water pollution control since the early 1970s can now be determined with quantifiable measures of environmental condition. Superimposed on this hierarchy is the concept of stressor, exposure, and response indicators. *Stressor* indicators generally include activities which have the potential to degrade the aquatic environment such as pollutant discharges (permitted and unpermitted), land use effects, and habitat modifications. *Exposure* indicators are those which measure the effects of stressors and can include whole effluent toxicity tests, tissue residues, and biomarkers, each of which provides evidence of biological exposure to a stressor or bioaccumulative agent. *Response* indicators are generally composite measures of the cumulative effects of stress and exposure and include the more direct measures of community and population response that are represented here by the biological indices which comprise Ohio's biological criteria. Other response indicators could include target assemblages, *i.e.,* rare, threatened, endangered, special status, and

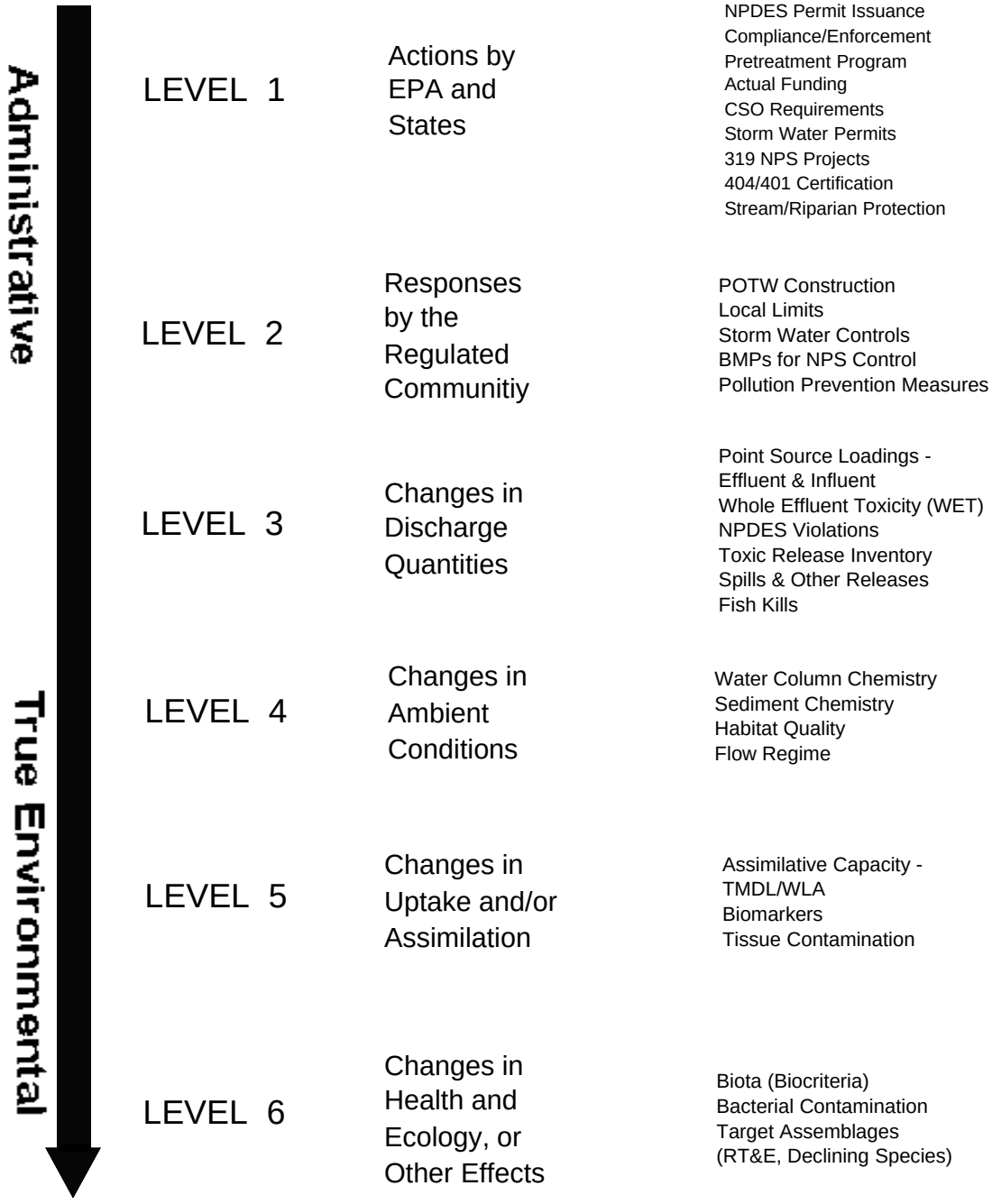

Figure 1. Hierarchy of administrative and environmental indicators which can be used for water quality management activities such as monitoring and assessment, reporting, and the evaluation of overall program effectiveness. This is patterned after a model developed by the U.S. EPA.

declining species or bacterial levels which serve as surrogates for the recreation uses. These indicators represent the essential technical elements for watershed-based management approaches. The key, however, is to use the different indicators *within* the roles which are most appropriate for each.

Describing the causes and sources associated with observed impairments revealed by the biological criteria and linking this with pollution sources involves an interpretation of multiple lines of evidence including water chemistry data, sediment data, habitat data, effluent data, biomonitoring results, land use data, and biological response signatures within the biological data itself. Thus the assignment of principal causes and sources of impairment represents the association of impairments (defined by response indicators) with stressor and exposure indicators. The principal reporting venue for this process on a watershed or subbasin scale is a biological and water quality report. These reports then provide the foundation for aggregated assessments such as the Integrated Water Quality Monitoring and Assessment Report (305[b] and 303[d]), the Ohio Nonpoint Source Assessment, and other technical bulletins.

Ohio Water Quality Standards: Designated Aquatic Life Use
The Ohio Water Quality Standards (WQS; Ohio Administrative Code 3745-1) consist of designated uses and chemical, physical, and biological criteria designed to represent measurable properties of the environment that are consistent with the goals specified by each use designation. Use designations consist of two broad groups, aquatic life and non-aquatic life uses. In applications of the Ohio WQS to the management of water resource issues in Ohio's rivers and streams, the aquatic life use criteria frequently result in the most stringent protection and restoration requirements, hence their emphasis in biological and water quality reports. Also, an emphasis on protecting for aquatic life generally results in water quality suitable for all uses. The five different aquatic life uses currently defined in the Ohio WQS are described as follows:

1) *Warmwater Habitat (WWH)* - this use designation defines the "typical" warmwater assemblage of aquatic organisms for Ohio rivers and streams; *this use represents the principal restoration target for the majority of water resource management efforts in Ohio.*

2) *Exceptional Warmwater Habitat (EWH)* - this use designation is reserved for waters which support "unusual and exceptional" assemblages of aquatic organisms which are characterized by a high diversity of species, particularly those which are highly intolerant and/or rare, threatened, endangered, or special status (*i.e.,* declining species); *this designation represents a protection goal for water resource management efforts dealing with Ohio's best water resources.*

3) *Coldwater Habitat (CWH)* - this use is intended for waters which support assemblages of cold water organisms and/or those which are stocked with salmonids with the intent of providing a put-and-take fishery on a year round basis which is further sanctioned by the Ohio DNR, Division of Wildlife; this use should not be confused with the Seasonal Salmonid Habitat (SSH) use which applies to the Lake Erie tributaries which support periodic "runs" of salmonids during the spring, summer, and/or fall.

4) *Modified Warmwater Habitat (MWH)* - this use applies to streams and rivers which have been subjected to extensive, maintained, and essentially permanent hydromodifications such that the biocriteria for the WWH use are not attainable *and where the activities have been sanctioned by state or federal law;* the representative aquatic assemblages are generally composed of species which are tolerant to low dissolved oxygen, silt, nutrient enrichment, and poor quality habitat.

5) *Limited Resource Water (LRW)* - this use applies to small streams (usually <3 mi^2 drainage area) and other water courses which have been irretrievably altered to the extent that no appreciable assemblage of aquatic life can be supported; such waterways generally include small streams in extensively urbanized areas, those which lie in watersheds with extensive drainage modifications, those which completely lack water on a recurring annual basis (*i.e.,* true ephemeral streams), or other irretrievably altered waterways.

Chemical, physical, and/or biological criteria are generally assigned to each use designation in accordance with the broad goals defined by each. As such the system of use designations employed in the Ohio WQS constitutes a "tiered" approach in that varying and graduated levels of protection are

provided by each. This hierarchy is especially apparent for parameters such as dissolved oxygen, ammonia-nitrogen, temperature, and the biological criteria. For other parameters such as heavy metals, the technology to construct an equally graduated set of criteria has been lacking, thus the same water quality criteria may apply to two or three different use designations.

Ohio Water Quality Standards: Non-Aquatic Life Uses

In addition to assessing the appropriateness and status of aquatic life uses, each biological and water quality survey also addresses non-aquatic life uses such as recreation, water supply, and human health concerns as appropriate. The recreation uses most applicable to rivers and streams are the Primary Contact Recreation (PCR) and Secondary Contact Recreation (SCR) uses. The criterion for designating the PCR use can be having a water depth of at least one meter over an area of at least 100 square feet or, lacking this, where frequent human contact is a reasonable expectation. If a water body does not meet either criterion, the SCR use applies. The attainment status of PCR and SCR is determined using bacterial indicators (*e.g.,* fecal coliform, *E. coli)* and the criteria for each are specified in the Ohio WQS.

Attainment of recreation uses are evaluated based on monitored bacteria levels. The Ohio Water Quality Standards state that all waters should be free from any public health nuisance associated with raw or poorly treated sewage (Administrative Code 3745-1-04, Part F). Additional criteria (Administrative Code 3745-1-07) apply to waters that are designated as suitable for full body contact such as swimming (PCR- primary contact recreation) or for partial body contact such as wading (SCR- secondary contact recreation). These standards were developed to protect human health, because even though fecal coliform bacteria are relatively harmless in most cases, their presence indicates that the water has been contaminated with fecal matter.

Water supply uses include Public Water Supply (PWS), Agricultural Water Supply (AWS), and Industrial Water Supply (IWS). Public Water Supplies are simply defined as segments within 500 yards of a potable water supply or food processing industry intake. The AWS and IWS use designations generally apply to all waters unless it can be clearly shown that they are not applicable. An example of this would be an urban area where livestock watering or pasturing does not take place, thus the AWS use would not apply. Chemical criteria are specified in the Ohio WQS for each use and attainment status is based primarily on chemical-specific indicators. Human health concerns are additionally addressed with fish tissue data, but any consumption advisories are issued by the Ohio Department of Health.