B.7 Macroinvertebrate Community

B.7.1 Watershed Assessment

Big Darby Creek Mainstem

Upper Big Darby Creek - Headwaters to Plain City

The aquatic macroinvertebrate community was of very good to exceptional quality in the extreme headwater segment (from RM 83.2 downstream to the confluence of Flat Branch with Big Darby Creek at RM 78.48). All ICI scores in this reach, which ranged from 42 to 56 longitudinally, met the WWH biocriterion, the current designated aquatic life use for this reach, and also met or exceeded the EWH minimum score (i.e., ICI = 42) (Tables B.7.1 and B.7.2). Community quality improved and seemed to be recovering well from the previous ODOT stream work upstream from CR 152 in 1997 at approximately RM 82.6. Total **EPT** [**E**phemeroptera (mayfly), **P**lecoptera (stonefly), **T**richoptera (caddisfly)] taxa, number of sensitive taxa, and total taxa increased and indicated improvements in community quality in the upper Big Darby Creek headwaters downstream to the Flat Branch confluence - RM 78.48 (Figures B.7.1 to B.7.5). In fact, the entire mainstem of Big Darby Creek has demonstrated the ability to support EWH macroinvertebrate communities based on the 2001/2002 sampling results.

The upper Big Darby Creek site, RM 83.2, could also be classified as Coldwater Habitat (CWH). Seven coldwater species out of 26 different species, including the coldwater caddisfly *Diplectrona modesta*, comprised 9.1 percent of the total different species collected. The coldwater community totaled > 11 percent of the macroinvertebrate population collected during the sampling period on the colonizers. The well established riparian buffer consisted of 100 feet of large, mature trees lining both banks ranging from 25% open to a closed canopy undoubtedly contributing to support this fauna.

The CWH component of the macroinvertebrate population at RM 82.5, the next site downstream, had decreased to two taxa. This site was downstream from the ODOT project where stream was relocated and still possessed only limited canopy. The coldwater macroinvertebrates were affected by the lack of a thick mature riparian corridor in this area. Only a 30-40' width of short shrubs and grass lined the streambanks providing very limited shading with 50% to 25% open canopy. Eventually the riparian canopy will expand and vertical shading will increase.

The next downstream site at RM 79.3, with 40 to 100 feet of large trees and increased shading adjacent Big Darby Creek ranging from 50% open to a closed canopy, had three CWH taxa present including the caddisfly *Ceratopsyche slossonae*, but they comprised < 2 percent of the macroinvertebrate community population. With the CW macroinvertebrate taxa showing increased representation further downstream from the ODOT stream segment it is recommended to also designate Big Darby Creek as CWH from the headwaters to RM 78.5 just upstream from the confluence with Flat Branch (RM 78.48) particularly when coupled with the fish community sampling results.

Relative numerical abundance (or density) in Big Darby Creek downstream from the confluences with Flat Branch and Little Darby Creek (Logan Co) at RM 78.3 doubled to >1000 organisms/ft^2 on the artificial substrate samplers. Elevated total suspended solids (TSS), nitrite, TKN, and total phosphorus (TP) concentrations input from Flat Branch which equaled the 75th - 90th percentile of ECBP ecoregion background values and the Flat Branch WWTP which discharged TSS at >95th percentile and nitrites and TP at 90th percentile vs. ECBP background (Table B.3.2) were suspected contributors to the increase in numerical abundance. Low mean diel D.O.s which ranged from 4.29 mg/l to 4.62 mg/l with lows of 3.5 -3.87 mg/) and large nutrients and TSS loads were recorded in Flat Branch in 2001. These Flat Branch inputs and similarly elevated TSS and nutrient loads from Flat Branch WWTP have caused instream D.O. violations of the EWH minimum (i.e., < 5 mg/l) and mean D.O. concentration (i.e., < 6 mg/l) downstream from the confluence at RM 78.4. Elevated concentrations of some metals were also found downstream from the Flat Branch WWTP. Correspondingly, the ICI decreased from 56 upstream to 50 downstream from Flat Branch. Sensitive taxa, total EPT taxa, and total number of taxa declined or remained static at RM 78.3 (Figures B.7.1 to B.7.9). The copper exceedence from Flat Branch and metals inputs from Flat Branch WWTP may have adversely affected community composition. The abnormally large *Hydra* population documented (wtd. ICI= 31.8) was indicative of large amounts of available nutrients /organic matter in the water column (suspended solids with attached algae and/or free suspended algae) downstream from Flat Branch. The moderately intolerant, filter feeding, tanytarsini midge population (*Rheotanytarsus sp.*) (wtd. ICI= 44.0) also doubled and ameliorated somewhat the negative influence of the skewed community composition. High quality water from Little Darby Creek (Logan Co.) (RM 78.34) diluted some the adverse effects to the macroinvertebrate community from the Flat Branch and Flat Branch WWTP inputs.

Big Darby Creek had recovered by North Lewisburg Rd. (RM 76.6) with an ICI of 56. This site yielded normal community abundance (shaded canopy at the site) and the highest number of sensitive taxa collected in the upper watershed including freshwater mussels (Figure B.7.8). Exceptional conditions were documented here with an ICI of 56. Relative density decreased as a result of the shaded canopy at the sampling site. This occurred despite non-point source (NPS) inputs that included extremely high TSS, nitrites, TKN, and TP with values at the 95th and 90th percentile vs. ecoregion background concentrations (Table B.3.2). Decreasing nutrient inputs and sedimentation through widened riparian areas upstream from North Lewisburg Rd. will result in even higher stream quality.

Exceptional community quality persisted, but declined slightly downstream to Milford Center, RM 67.2, as overall the number of sensitive taxa, total EPT, and total taxa decreased. But at RM 67.2, upstream from Milford Center, due to stable and favorable habitat six mussel taxa were collected. This was the highest number of mussel taxa collected in the upper BDC watershed from its headwaters to just upstream from Plain City. Habitat included vegetated side channels and pools with stable gravel bars. The substrates were loose, though in the rocky upstream pools some silt had accumulated and covered over the top surfaces of the rubble and boulders present. Stable banks anchored by trees that limited erosion and improved stream sinuosity had created favorable side pool habitat.

Table B.7.1. Summary of macroinvertebrate data collected from artificial substrates (quantitative sampling) and natural substrates (qualitative sampling) from Big Darby Creek and tributaries sampled in the Big Darby Creek watershed, June - October, 2001. (Aquatic life uses listed are those currently designated in the Ohio Water Quality Standards or the recommended use changes).

Stream River Mile	Drainage Area (mi.^{2})	Rel. Density (#/ft.^{2})	No. Quant. Taxa	No. Qual. Taxa	Total No. Taxa	Qual. EPT[a]	Total EPT	Predominant Organisms	QCTV[b]	ICI[c]	Narrative Evaluation[c]
Big Darby Creek Eastern Corn Belt Plains (ECBP) - (WWH/EWH + CWH Recommended)											
83.2	1.3	385	43	54	77	16	18	6,5	40.7	42[ns]	Very Good
82.5	1.5	298	37	55	69	16	18	6,3,18,5	39.7	46	Exceptional
79.3[R]	5.6	544	49	63	86	17	21	3,38,44,42,43,2,10	39.7	56	Exceptional
Big Darby Creek (ECBP) - (EWH)											
78.3	25.1	1024	48	64	87	19	23	8,3,9,44,43,20	40.9	50	Exceptional
76.5[R]	32.0	415	51	55	82	19	23	2,9,44,6,20,21	39.7	56	Exceptional
69.4	74.0	144	47	52	82	17	22	9,8,43,6,45,1,3	41.8	52	Exceptional
64.4[R]	88.0	285	50	58	80	22	26	9,6,20,28,34	41.0	50	Exceptional
62.9[R]	120	147	35	50	70	13	18	3,42,43,21,26	39.3	42[ns]	Very Good
54.1[R]	136	118	36	61	81	23	25	45,3,9,12,14,10	41.9	42[ns]	Very Good
53.9	136	Mod.-Low	--	75	75	20	20	3,45,9,10,12,14,6,	39.7	E[d]	Exceptional
52.1	150	176	46	58	80	19	24	3,2,45,9,10,11,12	39.7	52	Exceptional
52.0	150	239	34	40	58	13	16	3,45,10,12,9,18	39.1	44[ns]	Very Good
49.7	177	550	40	69	89	18	23	3,45,9,10,21	40.7	56	Exceptional
42.1[R]	240	430	40	58	83	19	25	3,45,2,9,12,8,46,4,	42.3	50	Exceptional
34.2	253	305	47	65	86	26	29	3,2,11,8,14,47,41,	41.2	52	Exceptional
26.9[R]	453	981	45	63	85	20	29	2,40,9,3,10,22,6,1	41.6	54	Exceptional
23.8	498	849	67	72	103	23	29	3,10,14,9,11,6,22,	41.6	46	Exceptional
22.5	505	1571	48	64	86	22	33	5,27,9,3,41,8,6	40.4	56	Exceptional
19.1	512	274	56	77	113	19	27	12,2,3,14,9,10,8,4	42.3	E	Exceptional
13.5[R]	534	1222	52	67	87	17	25	41,3,45,5,27,10	40.4	56	Exceptional
3.2[R]	552	1375	55	73	94	26	33	1,2,8,3,10,47,48,2	42.3	56	Exceptional
Flat Branch (ECBP) - Modified Warmwater Habitat (MWH)											
3.2	3.3	Moderate	--	35	35	8	8	8,3,23,21,34,22	33.8	G	Good
2.2	9.3	Moderate	--	31	31	6	6	3,23,21	33.3	MG	Marg. Good
1.0[RM]	13.8	440	46	36	62	9	16	6,20,21,52,49,42	35.1	50	Exceptional

Continued.

Table B.7.1. Continued.

Stream River Mile	Drainage Area (mi.^{2})	Rel. Density (#/ft.^{2})	No. Quant. Taxa	No. Qual. Taxa	Total No. Taxa	Qual. EPT[a]	Total EPT	Predominant Organisms	QCTV[b]	ICI	Narrative Evaluation[c]
Unnamed Trib. to Flat Branch (RM 1.50) (ECBP) - (Undesignated/MWH Recommended)											
0.1	3.5	Low	--	24	24	4	4	27,21,50	33.2	F	Fair
Little Darby Creek (Logan Co.) (RM 78.34) (ECBP) - (EWH/EWH + CWH Recommended)											
3.5[R]	2.4	345	49	54	72	16	18	2,6,43,5,27,42,44,9	40.8	54	Exceptional
0.4	5.4	873	52	52	83	12	15	2,3,6,20,38,49,42,43,44,9	40.6	50	Exceptional
Unnamed Trib. to Big Darby Creek (RM 74.91) (ECBP) - (Undesig./ EWH Recommended.)											
0.3	3.9	Mod.-Low	--	44	44	14	14	3,45,10,44,9,18,21	41.0	VG	Very Good
Spain Creek (ECBP) - (WWH/WWH + CWH Recommended)											
5.7	3.5	Mod.-Low	--	54	54	11	11	3,45,10,44,9,18,21	35.0	MG[ns]	Marg. Good
Spain Creek (ECBP) - (WWH/EWH +CWH Recommended)											
3.4[R]	6.0	331	40	52	72	15	18	3,6,10,2	40.6	44	Very Good
0.1[R]	9.1	254	46	47	66	12	19	2,3,12,42,43,44	39.3	56	Exceptional
Pleasant Run (ECBP) - (EWH)											
4.1	4.9	Mod.-Low	--	46	46	15	15	9,44,13,4,11	39.1	VG[ns]	Very Good
0.5[R]	9.4	468	59	52	86	19	27	3,2,6,34	37.8	56	Exceptional
U. T. to Big Darby Creek (RM 69.41) (ECBP) - (Undesignated/WWH Recommended)											
0.3	4.6	Moderate	--	40	40	10	10	45,10	37.8	G	Good
Hay Run (ECBP) - (WWH/EWH Recommended)											
0.2	5.8	Mod.-High	--	42	42	11	11	45,11,4	39.3	VG	Very Good
Buck Run (ECBP) - (WWH)											
10.4	5.1	Mod.-Low	--	32	32	6	6	23,26	30.4	MG[ns]	Marg. Good
7.8	9.2	Mod.-Low	--	46	46	9	9	20,27,31	35.1	G	Good
5.0	18.1	High-Mod.	--	48	48	10	10	20,27,26	32.6	MG[ns]	Marg. Good
0.6	29.7	Mod.-Low	--	46	46	7	7	9,29,10,53,26,21,24,22,4	33.3	MG[ns]	Marg. Good

Continued.

Table B.7.1. Continued.

Stream River Mile	Drainage Area (mi.^{2})	Rel. Density (#/ft.^{2})	No. Quant. Taxa	No. Qual. Taxa	Total No. Taxa	Qual. EPT[a]	Total EPT	Predominant Organisms	QCTV[b]	ICI	Narrative Evaluation[c]
Robinson Run (ECBP) - WWH											
5.5A	4.6	Low	--	14	14	2	2	9,29,13,26,51	29.8	VP*	Very Poor
2.1	8.4	High-Mod.	--	30	30	2	2	53,21,34	29.8	F*	Fair
0.8	11.5	High-Mod.	--	51	51	8	8	10,11,22	39.0	MG[ns]	Marg. Good
Sweeney Run (ECBP) - (Undesignated/WWH Recommended)											
0.2	4.0	Mod.-Low	--	28	28	4	4	8,13,54,4,25	26.4	F*	Fair
Sugar Run (ECBP) -(WWH/MWH Recommended)											
7.7	4.3	Mod.-Low	–	21	21	4	4	3,22,26,21,24	32.0	F	Fair
	(ECBP) (WWH)										
6.9	9.5	Mod.-Low	–	46	46	10	10	3,8,6,31,24,21	33.2	MG	Marg. Good
5.5	11.0	Mod.-Low	–	46	46	7	7	3,31,24,8,42	35.0	G	Good
0.5	19.4	Moderate	–	52	52	16	16	3,25,6,31	38.7	VG	Very Good
U. T. to Sugar Run (RM 7.39) (ECBP) - (Undesignated/MWH Recommended)											
0.1	5.0	Mod.-Low	--	35	35	9	9	3,13,26,31	34.4	MG	Marg. Good
Worthington Ditch (ECBP) - (Undesignated/ WWH Recommended)											
0.2	4.4	High-Mod.	--	40	40	9	9	5,55,12,11,26,18,54,4	37.5	MG[ns]	Marg. Good
Ballenger-Jones Ditch (ECBP) - (Undesignated/WWH Recommended)											
0.2	6.0	High-Mod.	--	48	48	19	19	8,11,3,6,26	39.7	E	Exceptional
Yutzy Ditch (ECBP) - (Undesignated/ WWH Recommended)											
0.4	4.3	Mod.-Low	--	34	34	8	8	11,4,6,13	35.9	MG[ns]	Marg. Good
Fitzgerald Ditch (ECBP) - (Undesignated/WWH Recommended)											
0.5	5.1	High-Mod.	--	32	32	7	7	5,3,9,11,21	35.1	MG[ns]	Marg.Good

Continued.

Table B.7.1. Continued.

Stream River Mile	Drainage Area (mi.^{2})	Rel. Density (#/ft.^{2})	No. Quant. Taxa	No. Qual. Taxa	Total No. Taxa	Qual. EPT[a]	Total EPT	Predominant Organisms	QCTV[b]	ICI	Narrative Evaluation[c]
Little Darby Creek (ECBP) - (EWH/EWH+CWH)											
41.2	3.3	Moderate	--	56	56	15	15	3,11,27,13	40.4	VG	Very Good
39.3	12.5	3914	48	66	81	13	15	5,27,3,13	36.8	48	Exceptional
38.8	13.2	1305	56	66	89	16	17	3,5,27,18,21,13	38.1	48	Exceptional
34.6	25.9	516	52	64	90	13	18	3,45,4,22,9,10,26,21	33.9	56	Exceptional
Little Darby Creek (ECBP) - (EWH)											
29.4	70.0	1400	55	54	78	17	24	3,45,11,6,22,9,4,26	39.4	50	Exceptional
24.5	83.0	504	46	85	95	22	25	45,6,22,5,27,9,3,43,42,34	40.4	58	Exceptional
17.0	142	318	36	68	81	17	21	3,45,10,6,28,9	39.3	48	Exceptional
15.4	151	325	48	63	86	21	23	3,5,27,2,45,10,22,4,28	40.9	50	Exceptional
6.4	163	510	43	68	88	16	20	5,2,3,45,10,1	39.7	54	Exceptional
3.8	170	1366	38	68	78	20	21	5,3,2,6,45,27	40.9	52	Exceptional
0.5	176	842	50	60	79	20	27	45,3,8,2,6,10,5,2	41.9	56	Exceptional
Clover Run (ECBP) - (EWH/WWH Recommended)											
0.6	2.0	Mod.-Low	--	47	47	14	14	3,2,5,6,4,38,42	39.7	VG	Very Good
0.2	2.4	Mod.-Low	--	37	37	8	8	3,6,18,13,22	38.3	G	Good
Lake Run (ECBP) (EWH/EWH Deferred)											
0.9	6.0	Mod.-Low	–	38	38	12	12	10,41	38.3	VG	Very Good
Jumping Run (ECBP) (Undesignated/WWH Recommended)											
0.2	2.4	Mod.-Low	–	37	37	8	8	3,6,18,13,22	38.3	G	Good
Treacle Creek (ECBP) - (EWH)											
11.7	5.7	Moderate	--	52	52	11	11	5,27,22,30,6,4,10,13,37	38.1	VG[ns]	Very Good
8.3	10.3	Moderate	--	63	63	17	17	2,5,45,6,10,21,13	41.0	E	Exceptional
6.0	17.0	Mod.-Low	--	59	59	13	13	3,5,27,6,21	38.3	VG[ns]	Very Good
0.7	37.3	Mod.-Low	--	44	44	5	5	27,3,37,22,18,34,21	36.8	MG*	Marg. Good
Howard Run (ECBP) - (EWH)											
0.6	2.6	Mod.-Low	--	46	46	10	10	2,3,45,10	38.1	VG[ns]	Very Good

Continued.

Table B.7.1. Continued

Stream River Mile	Drainage Area (mi.^{2})	Rel. Density (#/ft.^{2})	No. Quant. Taxa	No. Qual. Taxa	Total No. Taxa	Qual. EPT[a]	Total EPT	Predominant Organisms	QCTV[b]	ICI	Narrative Evaluation[c]
Proctor Run (ECBP) - (EWH)											
4.9	3.9	Mod.-Low	--	54	54	13	13	3,44,45,12,9,6,18	40.0	VG[ns]	Very Good
3.2	9.1	High-Low	--	55	55	15	15	4,6,12,9,3,20,45,27,21	39.3	VG[ns]	Very Good
1.7	10.0	Mod.-Low	--	67	67	22	22	2,3,45,6,9	39.7	E	Exceptional
Barron Creek (ECBP) - (EWH/WWH Recommended)											
2.1	4.9	Mod.-Low	--	44	44	8	8	10,53,6,51	32.7	MG[ns]	Marg. Good
0.1	6.3	Mod.-Low	--	39	39	6	6	22,45,34,21	33.3	MG[ns]	Marg. Good
Wamp Ditch (ECBP) - (Undesignated/WWH Recommended)											
0.1	4.8	High-Mod.	--	48	48	9	9	4,26,22,31,10	31.0	MG[ns]	Marg. Good
Spring Fork (ECBP) - (EWH)											
15.8	4.3	Mod.-Low	--	36	36	8	8	5,44,18,24,13	36.2	G*	Good
13.3	8.3	Mod.-Low	--	58	58	13	13	5,3,19,22,18,9	39.3	VG[ns]	Very Good
7.7	19.3	Moderate	--	38	38	11	11	9,6,18,22,31	39.1	G*	Good
Bales Ditch (ECBP) - (WWH Recommended)											
0.4	5.2	Mod.-Low	--	53	53	10	10	4,9,10,12,21,26,13	36.2	G	Good
2.2	1.2	Mod.-Low	--	42	42	7	7	3,18,21	35.9	G	Good
Smith Ditch (Trib. to BDC @ RM 31.69) (ECBP) - EWH (recommended)											
2.1	5.9	Moderate	--	58	58	15	15	5,12,2,10,45,6,18	38.7	E	Exceptional
0.2	6.7	Moderate	--	45	45	11	11	3,5,12,4,6	39.7	E	Exceptional
Hellbranch Run (ECBP) - (WWH)											
9.4	24.8	740	40	36	55	6	9	5,27	33.2	46	Exceptional
7.4	27.9	656	44	39	60	11	17	5,27,8,3	39.4	48	Exceptional
5.7	30.5	Mod.-Low	--	47	47	10	10	5,27	39.0	G	Good
Hellbranch Run (ECBP) - (WWH/EWH Recommended)											
3.7	32.6	349	41	45	69	10	13	3,2,8,5,27,10,9,11	39.2	50	Exceptional
0.9	35.3	270	45	55	80	16	19	3,2,8,9,10	38.3	VG	Very Good
0.5	35.4	Mod.-Low	--	57	57	10	10	3,2,9,8,5,27,10,21,42	38.9	VG	Very Good

Continued.

Table B.7.1. Continued

Stream River Mile	Drainage Area (mi.^{2})	Rel. Density (#/ft.^{2})	No. Quant. Taxa	No. Qual. Taxa	Total No. Taxa	Qual. EPT[a]	Total EPT	Predominant Organisms	QCTV[b]	ICI	Narrative Evaluation[c]
Hamilton Ditch (ECBP) - (MWH)											
3.4	3.4	Mod.-Low	--	42	42	2	2	31,5,11,32	33.9	F	Fair
(ECBP) - (WWH)											
0.5	9.4	707	42	41	61	4	8	5,27,11,13,31,24	32.0	40	Good
Clover Groff Ditch (ECBP) - (MWH)											
4.7	3.8	Mod.-Low	--	19	19	0	0	27,22,33	33.2	VP*	Very Poor
(ECBP) - (WWH)											
0.8	6.7	167	27	30	43	5	6	10,21	39.0	20*	Fair
Springwater Run (ECBP) - WWH											
0.8	1.8	Mod.-Low	--	28	28	3	3	13,3,18	33.2	F*	Fair
U.T. Big Darby Creek (RM 20.20) (ECBP) - (Undesignated/WWH Recommended)											
0.8	4.3	High-Low	--	42	42	9	9	5,45,4,18,10	39.5	G	Good
Greenbrier Creek (ECBP) - WWH											
2.7	4.4	Low	--	32	32	7	7	7,5,12,18,10	39.3	MG[ns]	Marg. Good
Georges Creek (ECBP) - WWH											
0.5	1.2	Low	--	32	32	6	6	9,5,38,43	39.3	MG[ns]	Marg. Good
Lizard Run (ECBP) - (Undesignated/LRW Recommended)											
0.2	1.2	Very Low	--	3	3	0	0	30,13	0.0	VP*	Very Poor

Ecoregion Biocriteria: Eastern Corn Belt Plains	INDEX	WWH	EWH	MWH[e]	LRW
	ICI	**36**	**46**	**22**	**8**

[a] EPT=total Ephemeroptera (mayflies), Plecoptera (stoneflies), & Trichoptera (caddisflies) taxa richness.

[b] Qualitative Community Tolerance Value (QCTV) is derived as the median of the tolerance values calculated for each qualitative taxon present (see discussion in Methods Section).

[c] Qualitative narrative evaluation is based on best professional judgment utilizing sample attributes such as taxa richness, EPT richness, and QCTV score and is used when quantitative data are not available to calculate an Invertebrate Community Index (ICI) score.

[d] Qualitative narrative assessment used in lieu of quantitative score due to lack of requisite current velocity, loss and/or vandalism of artificial substrates.

[e] Modified Warmwater Habitat for channel modified areas.

R Regional reference site
RM Regional modified reference site
* Significant departure from ecoregion biocriterion (>4 ICI units); poor and very poor results are underlined.
ns Nonsignificant departure from ecoregion biocriterion (≤4 ICI units).

Predominant organism code list

1 *Isonychia* mayflies	12 water pennies	23 burrowing mayflies	34 *Argia* damselflies	45 *Neophylax* caddisflies	56 tipulids/cranefly
2 *Chimarra* caddisflies	13 pond (LH) snails	24 various beetles	35 limpet snails	46 *Protoptila* caddisflies	
3 hydropsychid caddisflies	14 moth larvae	25 isopods	36 helgrammites	47 *Ceraclea* caddisflies	
4 snail-cased caddisfly	15 blackflies	26 scuds / shrimp	37 *Sialis* sp	48 *Oecetis* caddisflies	
5 tanytarsini midges	16 aquatic worms	27 midges	38 *Helichus* beetles	49 *Ancyronyx* beetles	
6 flathead mayflies	17 *Tricorythodes*	28 crayfish	39 tabanids	50 freshwater mussels	
7 nonred midges	18 red midges	29 flatworms	40 stoneflies	51*Peltodytes* beetles	
8 baetid mayflies	19 Bryozoa	30 tipulids	41 polycentropids	52 *Berosus* beetles	
9 riffle beetles	20 *Caenis* mayflies	31 corixids	42 *Dubiraphia* beetles	53 hydrobiid snails	
10 river (RH) snails	21 damselflies	32 dragonflies	43 *Macronychus* beetles	54 *Fossaria* snails	
11 cased caddisflies	22 fingernail clams	33 leeches	44 *Optioservus* beetles	55 ephemerellid mayflies	

Table B.7.2. Summary of macroinvertebrate data collected from artificial substrates (quantitative sampling) and natural substrates (qualitative sampling) from Big Darby Creek and tributaries sampled in the Big Darby Creek watershed, June - October, 2002. (Aquatic life uses listed are those currently designated in the Ohio Water Quality Standards or proposed use changes).

Stream River Mile	Drainage Area (mi.^{2})	Rel. Density (#/ft.^{2})	No. Quant. Taxa	No. Qual. Taxa	Total No. Taxa	Qual. EPT[a]	Total EPT	Predominant Organisms	QCTV[b]	ICI[c]	Narrative Evaluation[c]
Big Darby Creek (ECBP) - (EWH)											
67.2	81.0	73 /(Mod.-	31	51	66	18	20	2,1,3,28,10,34,12,9,38,37	41.9	E[d]	Exceptional
66.0	83.0	1104	40	59	73	14	15	5,10,3,45,19,34,21	39.7	40*	Good
38.9	247	297	46	61	83	23	30	3,45,10,8,9	42.3	52	Exceptional
28.6	450	Mod.-High	--	78	78	26	26	10,45,48,17,1	41.9	E	Exceptional
26.1	496	Moderate	--	61	61	21	21	10,3,9,1,23,6,40,28	43.3	E	Exceptional
15.8	529	2032	44	59	68	30	32	3,1,48,8,6,11,10,9,24	43.7	52	Exceptional
15.1	532	1994	46	58	73	22	27	3,11,5,48,8,9,27,17	43.6	54	Exceptional
11.2	537	1740	42	77	88	26	33	3,2,45,4,48,9,1,10,8,50,43,42	42.0	52	Exceptional
8.4	544	1714	50	65	73	26	30	3,1,2,10,8,11,48,5,27,17,55	42.1	52	Exceptional
5.3	550	981	51	52	75	24	29	3,9,2,27,48,17,6,52	42.7	52	Exceptional
Little Darby Creek (ECBP) - (EWH)											
33.2	28.0	219	39	54	67	15	18	9,43,3,22,42,8,5	40.7	54	Exceptional
26.5	72	577	41	68	85	21	25	5,3,8,11,20,31,43,6,42	39.7	52	Exceptional
23.2	89	Moderate	--	75	75	24	24	3,8,9,43,17,20,23,45,4	41.9	E	Exceptional
20.5	98	473	30	58	72	16	21	1,10,45,6,42,3	39.3	48	Exceptional
15.3[R]	151	332	27	56	66	19	21	45,46,6,10,1,5,28	40.7	46	Exceptional
Spring Fork (ECBP) - (EWH)											
10.1	14.6	327	40	41	62	13	20	5,9,44,3,12	41.9	56	Exceptional
3.4	32	754	66	51	85	13	16	5,27,3,8,6,9,43,42,32	39.3	E	Exceptional
3.3	32	65 / Mod.	46	44	66	13	17	3,12,4,6,34,21,9	40.4	56	Exceptional
Hellbranch Run (ECBP) - (WWH)											
0.5	35.4	182/(Mod.-	53	63	78	14	16	56,3,5,48,10,1,49	39.7	VG	Very Good
U. T. to Big Darby Creek (RM 18.41) (ECBP) - (Undesignated/WWH Recommended)											
0.1	3.5	Mod.-	--	43	43	8	8	11,48,6,28,52,31	35.7	G	Good

Continued.

Table B.7.2. Continued.

Stream River Mile	Drainage Area (mi.^{2})	Rel. Density (#/ft.^{2})	No. Quant. Taxa	No. Qual. Taxa	Total No. Taxa	Qual. EPT[a]	Total EPT	Predominant Organisms	QCTV[b]	ICI[c]	Narrative Evaluation[c]
Greenbrier Creek (ECBP) - (WWH)											
1.3	7.0	Moderate	--	40	40	10	10	3,4,6,18,22	39.3	VG	Very Good

Ecoregion Biocriteria: Eastern Corn Belt Plains

INDEX	WWH	EWH	MWH	LRW
ICI	**36**	**46**	**22**	**8**

[a] EPT=total Ephemeroptera (mayflies), Plecoptera (stoneflies), & Trichoptera (caddisflies) taxa richness.

[b] Qualitative Community Tolerance Value (QCTV) is derived as the median of the tolerance values calculated for each qualitative taxon present (see discussion in Methods Section).

[c] Qualitative narrative evaluation is based on best professional judgment utilizing sample attributes such as taxa richness, EPT richness, and QCTV score and is used when quantitative data are not available to calculate an Invertebrate Community Index (ICI) score.

[d] Qualitative narrative assessment used in lieu of quantitative score due to lack of requisite current velocity, loss and/or vandalism of artificial substrates.

[R] Regional reference site

* Significant departure from ecoregion biocriterion (>4 ICI units); poor and very poor results are underlined.

[ns] Nonsignificant departure from ecoregion biocriterion (≤4 ICI units).

Predominant organism code list

1 *Isonychia* mayflies	12 water pennies	23 burrowing mayflies	34 Argia damselflies	45 *Neophylax* caddisflies	56 tipulids/cranefly
2 *Chimarra* caddisflies	13 pond (LH) snails	24 various beetles	35 limpet snails	46 *Protoptila* caddisflies	
3 hydropsychid caddisflies	14 moth larvae	25 isopods	36 helgrammites	47 *Ceraclea* caddisflies	
4 snail-cased caddisfly	15 blackflies	26 scuds / shrimp	37 *Sialis* sp	48 *Oecetis* caddisflies	
5 tanytarsini midges	16 aquatic worms	27 midges	38 *Helichus* beetles	49 *Ancyronyx* beetles	
6 flathead mayflies	17 *Tricorythodes*	28 crayfish	39 tabanids	50 freshwater mussels	
7 nonred midges	18 red midges	29 flatworms	40 stoneflies	51*Peltodytes* beetles	
8 baetid mayflies	19 Bryozoa	30 tipulids	41 polycentropids	52 *Berosus* beetles	
9 riffle beetles	20 *Caenis* mayflies	31 corixids	42 *Dubiraphia* beetles	53 hydrobiid snails	
10 river (RH) snails	21 damselflies	32 dragonflies	43 *Macronychus* beetles	54 *Fossaria* snails	
11 cased caddisflies	22 fingernail clams	33 leeches	44 *Optioservus* beetles	55 ephemerellid mayflies	

Figure B.7.1. Longitudinal trends in the ICI and the estimates ICI score based on the Qualitative Narrative on the mainstem of Big Darby Creek based on sampling conducted in 2001 and 2002.

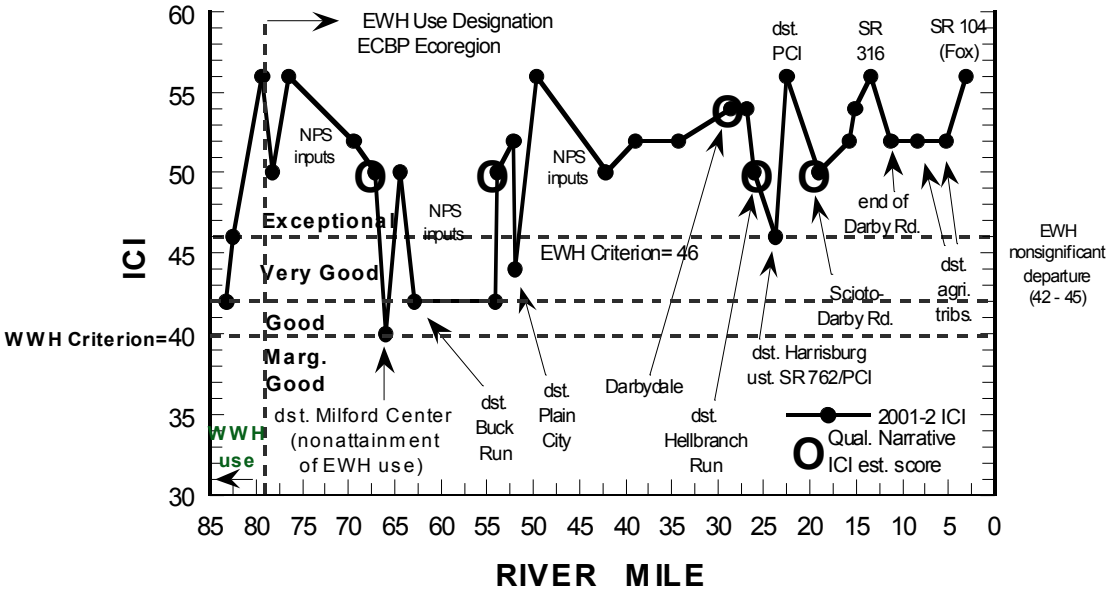


Figure B.7.2. Longitudinal trends in the Total EPT taxa collected from sites on the mainstem of Big Darby Creek in 2001-2002.

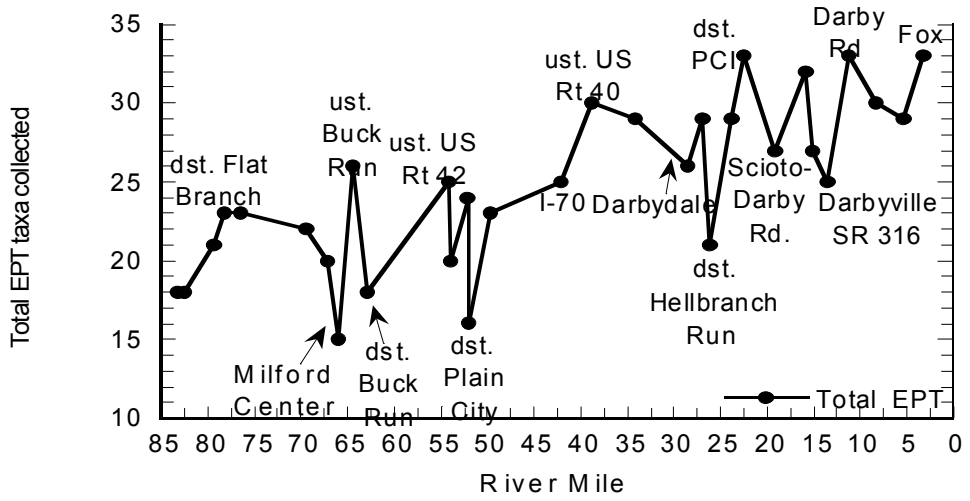


Figure B.7.3. Longitudinal trends in the number of sensitive macroinvertebrate taxa collected from sites on the mainstem of Big Darby Creek in 2001-2002.

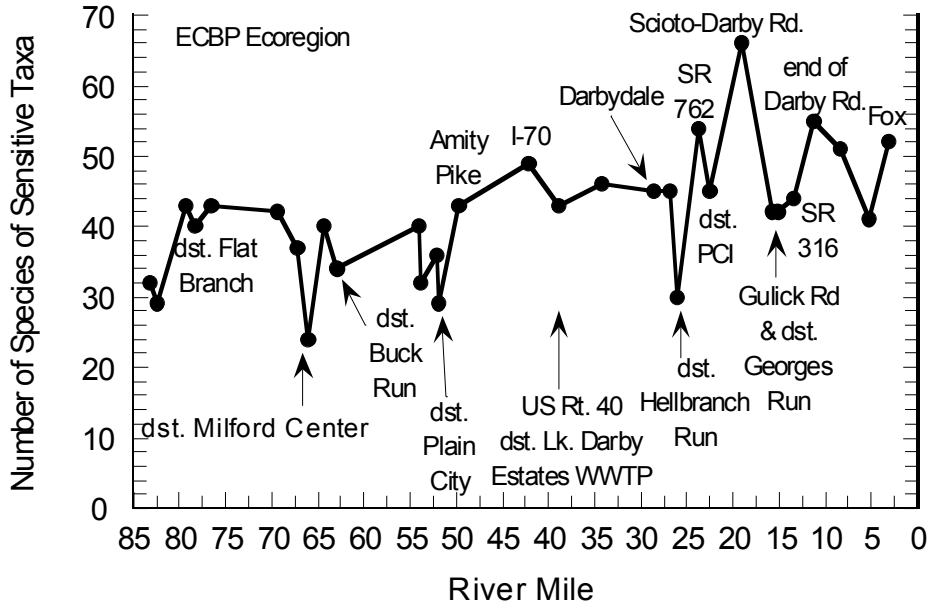


Figure B.7.4. Longitudinal trends in the Invertebrate Community Index and the number of sensitive taxa collected from sites on the mainstem of Big Darby Creek in 2001-2002.

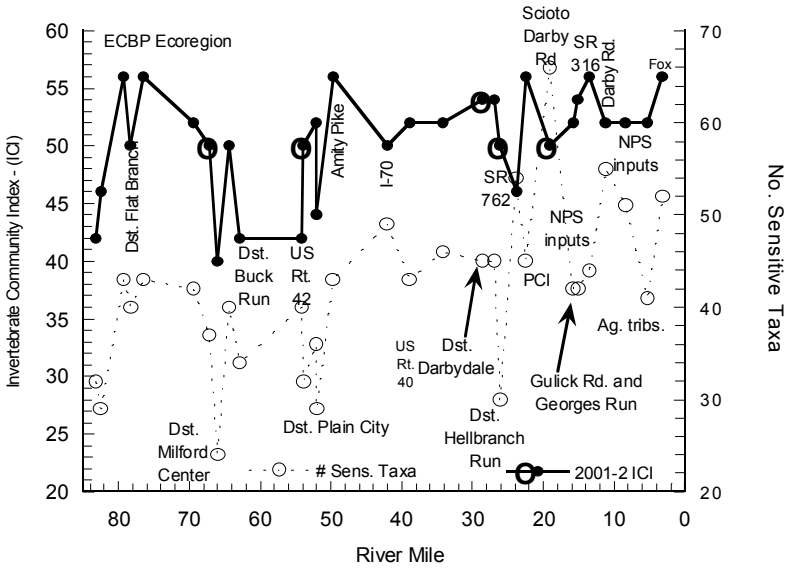


Figure B.7.5. Longitudinal trends in the Invertebrate Community Index and the total number of macroinvertebrate taxa collected from sites on the mainstem of Big Darby Creek in 2001-2002.

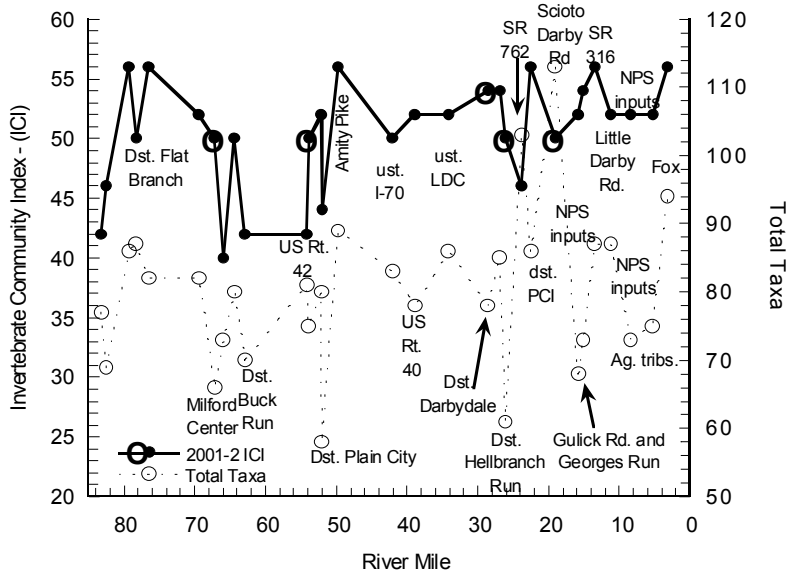


Figure B.7.6. Longitudinal trends in the relative density of macroinvertebrate taxa per sq. ft. in the Big Darby Creek mainstem based on sampling in 2001 and 2002.

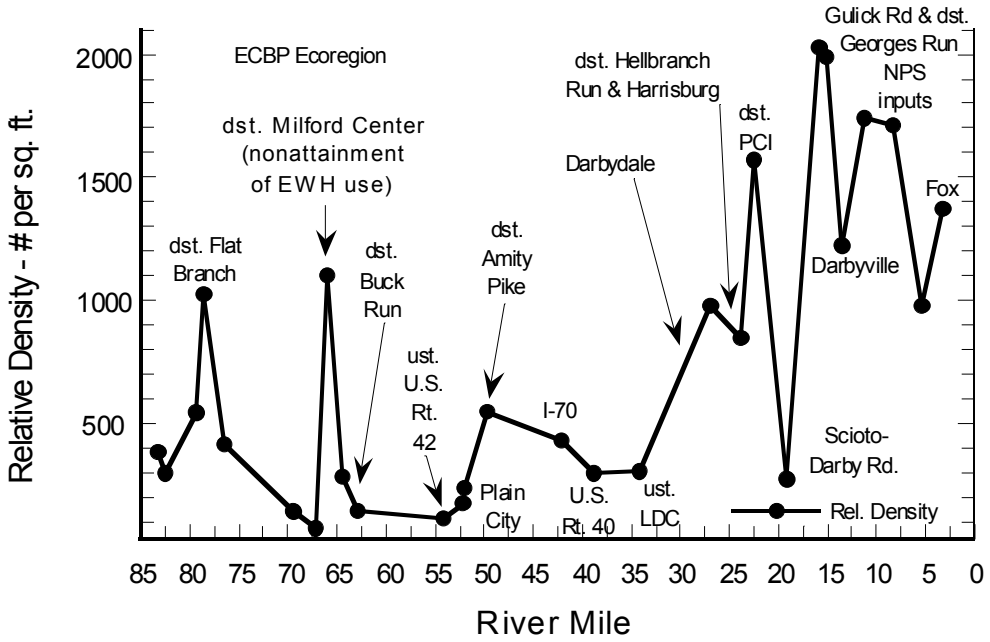


Figure B.7.7. Longitudinal trends in the Invertebrate Community Index and the Relative Abundance (no./sq.ft.) of Macroinvertebrates on the Big Darby Creek mainstem based on sampling conducted in 2001 and 2002.

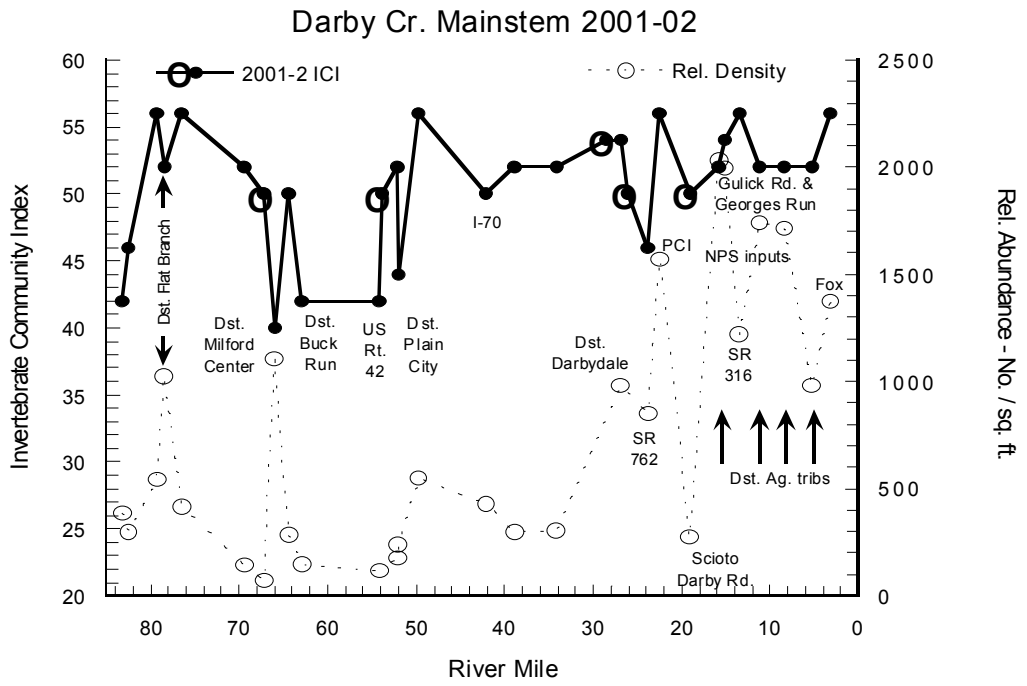


Figure B.7.8. Longitudinal trends in the Invertebrate Community Index and the number of bivalve mussels observed from sites on the mainstem of Big Darby Creek in 2001-2002.

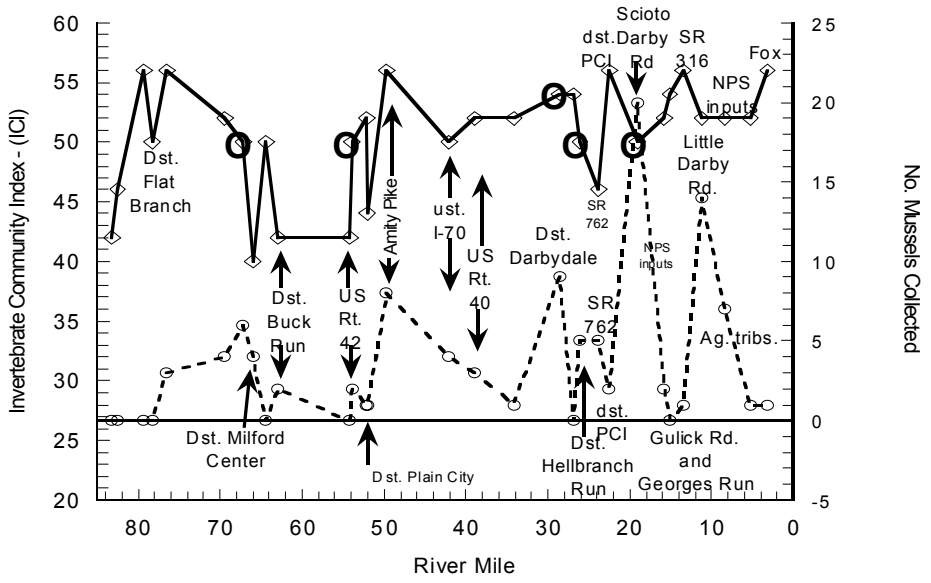
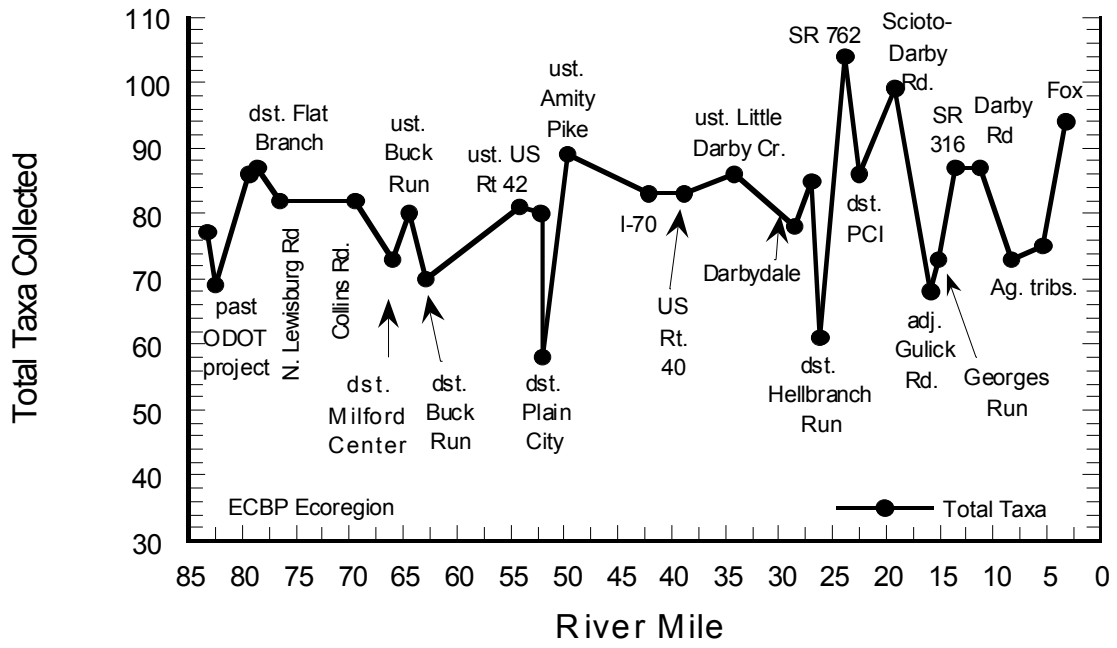


Figure B.7.9. Longitudinal trends in the Total macroinvertebrate taxa collected from sites on the mainstem of Big Darby Creek in 2001-2002.



This site yielded normal community abundance (shaded canopy at the site) and the highest number of sensitive taxa collected in the upper watershed including freshwater mussels (Figure B.7.8). Exceptional conditions were documented at the reference site at North Lewisburg Rd. (RM 76.6) with an ICI of 56. Relative density decreased as a result of the shaded canopy at the sampling site. This occurred despite NPS inputs that included extremely high TSS, nitrites, TKN, and TP with values at the 95th and 90th percentile vs. ecoregion background concentrations (Table B.3.2). Decreasing nutrient inputs and sedimentation through widened riparian areas upstream from North Lewisburg Rd. will result in even higher stream quality.

Exceptional community quality persisted, but declined slightly downstream to Milford Center, RM 67.2, as overall the number of sensitive taxa, total EPT, and total taxa decreased. But at RM 67.2, upstream from Milford Center, due to stable and favorable habitat six mussel taxa were collected. This was the highest number of mussel taxa collected in the upper BDC watershed from its headwaters to just upstream from Plain City. Habitat included vegetated side channels and pools with stable gravel bars. The substrates were loose, though in the rocky upstream pools some silt had accumulated and covered over the top surfaces of the rubble and boulders present. Stable banks anchored by trees that limited erosion and improved stream sinuosity had created favorable side pool habitat.

Recent agricultural and fertilizer spills and kills, and past sewage and storm water inputs from Milford Center impaired the macroinvertebrate community downstream from Milford Center, RM 66.0. The ICI dropped to 40 which did not meet the EWH criterion from an exceptional evaluation upstream from Milford Center at RM 67.2 and an ICI of 52 at RM 69.4. Silted and embedded substrates limited colonization. Only 15 total EPT taxa and 24 sensitive taxa were collected which was the lowest total collected on BDC mainstem. No baetid mayflies were collected. This could suggest short, sporadically toxic conditions emanating from inputs upstream, since flow was adequate. Macroinvertebrate community abundance increased 4- or 5-fold more than the upstream Milford Center site (i.e., to about 1100 organisms/ft^2) in response to increased NPS nutrient inputs. More tolerant filtering or scavenging organisms, like *Hydra* sp., *Physella* sp. and other tolerant snails, and flatworms (wtd. ICI = 26.8), increased to approx. one-fifth of the sampled population in response to these nutrient increases. The spike (*Elliptio dilatata*), plain pocketbook *(Lampsilis cardium*), and the cylindrical papershell (*Anodontoides ferassacianus*) mussels were collected upstream (RM 67.2), but not close downstream to Milford Center (RM 66.1). Mussel diversity decreased some downstream from Milford Center and stayed depressed until U.S. State Route 42 as a result of past spills and kills, silty conditions present and other NPS effects through much of the segment (i.e., nutrient enrichment and lower dissolved oxygen concentrations).

The community recovered to exceptional levels (i.e., ICI = 50) upstream from Streng Rd. and the confluence with Buck Run, RM 64.4. Though still silty in places, habitat quality improved with nice riffle / run / pool complexes with rubble substrates. The total EPT taxa increased from 15 downstream from Milford Center, RM 66.1, to 26 at RM 64.4 which was the highest total in the upper watershed.

Downstream from Buck Run and upstream from St. Rt. 38 at RM 62.9 the silt and nutrient load significantly decreased macroinvertebrate quality. The ICI score declined to 42 at the low end of the EWH range. Aquatic macrophytes, mainly water willow, predominated in areas adjacent to portions of the slow runs and wide pools in this reach of Big Darby Creek. This macrophyte production was partially in response to nutrient inputs from Buck Run [e.g., TKN (1.17 mg/l) and ammonia (0.107 mg/l) at the 95th and 90th percentiles, respectively vs. ECBP background concentrations] and other NPS inputs further upstream (nitrates concentration of 6.30 mg/l at RM 63.8). The riparian corridor was narrower, allowing more sunlight penetration which permitted increased instream production. Diel D.O. readings were below 6 mg/l (~ 5.7 - 5.9 mg/l) during continuous monitoring on 7/04/01 slightly downstream in this reach and at the mouth of Buck Run indicating the potential for D.O. to limit the Big Darby Creek macroinvertebrate community downstream from Buck Run. Substrates and surfaces were quite silty, and all of the factors listed above contributed to significant reductions of total EPT taxa, sensitive taxa, total taxa, and total abundance (Fig. 2-5). Because of silted conditions in the pools and slow runs, only the more silt-tolerant giant floater (*Pyganodon grandis*) and fatmucket (*Lampsilis radiata luteola*) mussels were collected in this reach downstream from Buck Run.

Downstream to U.S. Rt. 42 (RM 54.1) the ICI also scored 42 (very good), though the diversity in the macroinvertebrate community increased (sensitive taxa and total EPT taxa) (Fig. 2-5). Many mayflies and caddisflies were collected only during qualitative sampling because of the low numbers present. The QCTV value of 41.9 was one of the higher values on the BDC mainstem. There was some silt present and more embedded substrates due to accumulated sediment/silt load from upstream, but the riparian area adjacent Big Darby Creek through this reach was much wider allowing for good, stable stream development providing a variety of habitat.

Full recovery to exceptional macroinvertebrate quality was verified from downstream U.S. Rt. 42 (RM 53.9) to upstream from the Plain City WWTP (ICI = 52) and downstream Sweeney Run which drains municipal Plain City (RM 52.1).

The ICI downstream from the Plain City WWTP decreased to 44 which marginally met the EWH biocriterion, but community quality declined significantly (~ 30 percent) amid effluent inputs of excess organic solids, high fecal coliform bacteria exceedences, excessive nutrients (ambient NH_3, nitrates, nitrites, TKN, and TP concentrations > 95th percentile of ECBP background) and low diel D.O. concentrations. Violations of the EWH minimum and mean D.O. criterion (< 5.0 mg/l and 6.0 mg/l, respectively) were recorded downstream from Plain City WWTP. The lowest recorded D.O. readings for 20-22 August 2002 were 4.98, 4.12 and 3.81 mg/l, respectively. The mean D.O. concentrations that were EWH criterion violations were 5.85 mg/l on 8/21 (data range of 4.12-9.09 mg/l) and 4.36 mg/l on 8/22 (data range of 3.81-6.15 mg/l). As a consequence of these stressors, twenty-two fewer macroinvertebrate taxa were collected at RM 52.0 than at the upstream site, and only thirteen qualitative EPT taxa were collected. This was the lowest number of qualitative EPT taxa collected at any of the Big Darby Creek mainstem sample sites.

<u>Middle Big Darby Creek</u> - from Sugar Run to upstream from Little Darby Creek
Recovery to exceptional conditions occurred upstream of Amity Rd. (RM 49.7) with an ICI of 56. Total taxa collected almost doubled with 23 EPT taxa and eight mussel species present including the intolerant fluted shell (*Lasmigona costata*) and plain pocketbook *(Lampsilis cardium*). Qualitative macroinvertebrate sampling occurred on 9/14/01. A fair number of dead mussels were observed on 9/25/01 when electrofishing the same sampling location. A kill may have occurred in the interim or the empty shells may represent downstream movement of dead from a previous upstream kill (e.g., Milford Center). OEPA was notified by Franklin County Metroparks personnel describing a possible kill in this reach. Spills and occasional episodes of low dissolved oxygen have been documented from Plain City and the lower reaches of Sugar Run that would impact Big Darby Creek (i.e., RM 52 -49).

Exceptional Warmwater Habitat performance continued downstream from I-70 to upstream U.S. Rt. 40 at RM 38.9. Abundance decreased, as total load inputs were less through this reach. ICI scores dropped slightly from 56 at Amity Rd. (RM 49.7) to 52 downstream at RM 38.9. Total taxa and sensitive taxa decreased from the I-70 site (RM 42.1) to downstream from the Lake Darby Estates WWTP at U.S. Rt. 40 (RM 38.9), though 30 total EPT taxa were collected.

Mussel diversity decreased from eight near Amity Rd. (RM 49.7) to three at U.S. Rt. 40 (RM 38.9). Previous raw sewage inputs (i.e. from a former campground), poor WWTP performance, and other possible inputs (e.g., quarry discharges, spills and kills, hypolimnetic waters from impoundment, and sedimentation) have kept diversity lower than previously recorded.(Watters and Flaute Myers, 2003). Near U.S. Route 40 the mussel diversity is showing some recent improvements. Upstream from Little Darby Creek in the Franklin county Metropark Exceptional Warmwater Habitat performance was documented with increases in total EPT taxa (RM 34.2)

Big Darby Creek Lower Mainstem - downstream from Little Darby Creek to its mouth Exceptional habitat quality within the Franklin County Metropark property (mean QHEI = 93.5) supported Exceptional Warmwater Habitat biological performance (ICI = 52) from the upstream site (above the confluence) to downstream from the Little Darby Creek confluence and on to Darbydale. Macroinvertebrate sampling immediately downstream from Darbydale (RM 28.6) indicated exceptional conditions despite storm water, wastewater or nutrient-linked inputs with high fecal coliform bacteria concentrations. Nine mussel species, including six observed live species, were collected close to Darbydale (RM 28.6). Nutrient enrichment was evident downstream 1-2 miles from Darbydale and adjacent to Georgesville-Harrisburg Rd. (RM 26.9), as relative abundance increased threefold to about 1000/ft^2. The total EPT taxa collected downstream from Darbydale decreased over twenty percent. No live or fresh-dead mussels were collected/observed downstream in this nutrient-enriched sample site (only old shells) compared to the nine species found at the downstream edge of Darbydale (RM 28.6). A dissolved oxygen sag documented in this enriched segment was a major factor contributing to the decreased macroinvertebrate diversity. At RM 27.7, the mean diel D.O. concentration for August 1, 2001 was measured at 5.77 mg/l - a water quality violation of the EWH mean D.O. criterion of 6.0 mg/liter.

Exceptional habitat (QHEI = 94.5) downstream from Hellbranch Run (RM 26.1) ameliorated much of the effects of Hellbranch Run inputs. Stable habitat supported five mussel species in this reach, including the intolerant plain pocketbook (*Lampsilis cardium*) and wavy-rayed lampmussel (*Lampsilis fasciola*) - an Ohio Species of Concern (ODNR, 2002). Macroinvertebrate community performance did decrease slightly but was still evaluated as exceptional. These were areas of sediment accumulation.

Upstream from St. Rt. 762 and the PCI WWTP the macroinvertebrate community marginally met the EWH criterion with an ICI of 46 at RM 23.8. The exceptional macroinvertebrate community assemblage was quite diverse with a total of 103 taxa collected (2nd highest total in the survey). The lower exceptional score resulted from the relatively high percentage of the moderately intolerant *Elimia* river snails which comprised about 25 percent of the collected sample (i.e., over 1400 individuals) and unbalanced the community percentage metrics. Relative density was similar to the upstream sites at about 850 organisms/ft^2. There was more sediment, silt and sand present here than upstream from agricultural NPS inputs, but the broken bedrock slabs and scattered boulders mixed with smaller substrates and good flow created a variety of available macrohabitats. The undersides of slab bedrock pieces were protected from

some silt and sand accumulation. A very similar mussel community to upstream utilized these habitats, upstream from St. Rt. 762 at RM 23.8.

Downstream from the PCI WWTP at RM 22.5 the ICI increased to 56. The macroinvertebrate community was dominated by mayflies (*Isonychia*, baetids, *Stenonema pulchellum*, and *Tricorythodes sp*.), caddisflies (*Cheumatopsyche* and *Polycentropus sp*.), and Tanytarsini midges. Total EPT taxa increased to 33. Nutrient inputs from the PCI WWTP which were at median ECBP background concentrations increased macroinvertebrate density to about 1600/ft.^{2}, but it seemed to be good quality effluent based on the biology. Several unsewered areas and small package WWTPs are scheduled to tie into the PCI WWTP by 2005. These will include the Derby area, the Clark's Lake WWTP, and several local Mobile Home Parks. These actions will eliminate many localized problem areas in the lower watershed. This will, however, increase the importance of continuously operating the PCI WWTP to yield high quality effluent to protect endangered and sensitive biological communities downstream.

Continuous D.O. monitors downstream from the PCI WWTP indicated relatively small D.O. swings. Night D.O. concentrations stayed above 6.0 mg/l downstream to Scioto Darby Rd. (RM 18.9). There were, however, very low D.O. concentrations (i.e., < 1.0 mg/l) on 20-22 Aug. 2002 in the Clark's Lake Tributary (RM 20.2) with some higher concentration of nutrients (NH3 and nitrite at the 95th percentile and TKN and TP at the 90th percentile of ECBP background) and additional inputs from Foxlair MHP WWTP. Drought conditions in 2002 lead to interstitial flow in the Clark's Lake Tributary. This stream appears to be normally a losing stream with deep perennial pools found in its lower reach. Although stream flow is probably reaching Big Darby Creek through interstitial or ground water flow, high water events would probably flush inputs into Big Darby Creek and affect instream biota in Big Darby Creek downstream from its confluence at RM 20.2. Both the Clark's Lake WWTP and the Foxlair MHP WWTP will be diverted to PCI for wastewater treatment in 2003, eliminating these wastewater source inputs through this reach. This will definitely benefit the biological communities downstream in Big Darby Creek, possibly allowing for recovery of some sensitive or endangered organisms downstream from these tributaries.

Big Darby Creek fully lived up to its reputation for biodiversity at Scioto Darby Rd (RM 19.1). The 113 taxa collected was the highest total of any site in the 2001 survey area. Instream habitat at this location included an extensive island/bar complex with multiple side channels. Twenty mussel taxa were collected (including many intolerant species and one Ohio Species of Concern - the wavy-rayed lampmussel (*Lampsilis fasciola*). The federally endangered species once found infrequently in this reach, the northern riffleshell mussel *(Epioblasma torolusa rangiana*) was not collected here during this survey. Downstream from the Scioto Darby bridge at RMs 18.45 and 18.1 the night time D.O. concentrations dropped to about 5.5 to 5.6 mg/l for extended periods on 10-11 July 2002. The mean daily D.O. concentrations stayed just above the required minimum (of 6.0 mg/l) at 6.03 and 6.01 mg/l during this continuous monitoring in July 2002. Decreased inputs of nutrients from eliminated unsewered inputs, reduced agricultural NPS inputs and reduced organic enrichment from WWTPs diverted to the PCI

WWTP should result in improved instream conditions in this reach upstream and downstream from Scioto Darby Rd.

Potential sources of nutrient inputs to Big Darby Creek near Gulick Rd. (RM 15.8) include: agricultural NPS inputs; Greenbrier Creek at RM 16.75 (TSS, nitrates and TP at 75th percentile vs. ECBP ecoregion), and from small tributaries to Big Darby Creek (RM 18.41, RM 18.18, & RM 15.85). Relative abundance increased 600 percent to 2000 organisms/ft.^{2} from the upstream site at Scioto Darby Road. Filter feeding macroinvertebrates were the predominant taxa (i.e., hydropsychid caddisflies and *Rheotanytarsus* and *Polypedilum* midges) and nutrient enriched conditions were evident. Algal strands and dense plant/algal mats covered the rocky substrates. Dissolved oxygen ranging from <6 mg/l. at night to 12 mg/l in the afternoon was recorded with continuous D.O. monitors on 10-12 September 2002 at RM 15.7.

Through these lower reaches the riparian width varied with property owner. Nutrient inputs occurred directly from agricultural fields or through delivery via small tributaries to Big Darby Creek. A levee impinged on river right at RM 15.8, Gulick Rd.. There was no canopy cover and a large gravel bar and side channel. There was no surface flow, just interstitial flow in the side pool during the summer of 2002. Erosion was evident against the levee on the right and the opposite bank behind the bar at high flows. Embedded conditions were present. All of these factors decreased diversity substantially from 113 total taxa upstream to 68 total taxa in the reach at RM 15.8. Mussel taxa counts decreased to two observed taxa, although a lot of old shells were present. Changes in stable mussel habitat areas (flow increases and erosion of unstable banks) and low dissolved oxygen from excess plant respiration/decay have contributed to this decline. Low exceptional scores still met the criterion (ICI = 52).

Similar conditions were present downstream from Georges Run at RM 15.1. Another unnamed tributary to Big Darby Creek discharged at RM 15.50. Much of this reach was leveed with riprap placed along the denuded shaped banks. Other areas had narrowed riparian widths with more open canopy adjacent to the Big Darby Creek mainstem. More silt was present in the slow runs and pools and had accumulated on the substrates. Macroinvertebrate community abundance was still high (~ 2000 organisms/ ft.^{2}), though there were less caddisflies and more Tanytarsini midges. Large amounts of fixed and suspended algae carpeted the margins and portions of the runs. Dissolved oxygen had even larger swings from 12.5 mg/l in the afternoon to 5.5 mg/l at night. Eroding leveed areas with little stream margin habitat and embedded conditions continued to limit the mussel population through these reaches.

The reach downstream to St. Rt. 316, Darbyville, generally had more slow run / pool habitat where larger substrates were covered with unstable spongy gravel/sand deposits and also covered with silt and muck in pools and some margins. Where there was stronger flow a more diverse community was present. The range in diel D.O. concentrations was still wide, though slightly less, varying from about 11 mg/l to 5.3 mg/l dissolved oxygen. Relative community abundance decreased to about 1200 organisms/ft.^{2} with most areas generally having a little more intact riparian corridor (and likely less NPS nutrient inputs). The percentage of mayflies in the community and the total taxa increased, and subsequently the ICI increased to 56.

At RM 11.2 (lane off Darby Rd.), stable habitat adjacent to portions of the stream with areas of wider riparian corridors offset any nutrient enriching inputs from upstream (Darbyville and downstream, including Lizard Run during high flow events). Riffle and run substrates were a little spongy in this segment as some silt and sand was mixed within the gravel/small cobble substrates. Side gravel bars with water willow and side channels and other side pools protected by downed trees or protruding banks (with trees holding the banks) were present yielding more diverse instream habitat. The macroinvertebrate community was predominated by filtering hydropsychid caddisflies, baetid and *Isonychia* mayflies. The 33 total EPT taxa collected here tied for the highest number of EPT taxa collected in the Big Darby Creek mainstem survey. This also was the location of largest live population of mussels observed largely due to more optimum mussel habitat here. Species observed included the intolerant Fluted shell (*Lasmigona costata*), buckhorn (*Tritogonia verrucosa*), deertoe (*Truncilla truncata*), plain pocketbook (*Lampsilis cardium*), and an Ohio species of concern, the wavy-rayed lampmussel (*Lampsilis fasciola*). There was also a live washboard mussel (*Megalonais nervosa*), an Ohio endangered species, observed and tentatively identified. Dissolved oxygen fluctuations were less variable ranging between < 10 mg/l and about 5.7 mg/l. Diversity did not appear to have been negatively impacted by this dissolved oxygen regime. Steps need to be taken to ensure that the dissolved oxygen minimums do not decline any further. One strategy to protect the diversity of this reach of Big Darby Creek is to protect or enhance the riparian buffer upstream which would tend to limit sediment loss from farm fields, reduce nutrient inputs and minimize the loss of habitat from bank erosion.

At RM 8.4 just downstream from a small agricultural tributary (RM 8.5) a similar macroinvertebrate community (i.e., ~ 1700 organisms/ft.^{2} and ICI = 52) was present with similar nutrient enrichment. Total taxa declined modestly. Seven bivalve taxa were observed here. However, most were found near the opposite bank out of the area of influence of the tributary inputs. Tributary nutrient inputs could be decreased to further improve community quality and decrease nutrient enrichment and low nighttime dissolved oxygen concentrations.

Further downstream narrow or nonexistent riparian corridors combined with high flows result in erosion to unstable banks and/or bedload movement which destabilizes habitat and substrates. These unstable conditions decreased mussel habitat further. Diel dissolved oxygen swings increased modestly downstream from RM 8.5 and RM 5.4 with the minimum D.O.s slightly lower (i.e., ~ 5.5 mg/l). Dissolved oxygen in deeper pools may be at risk through these lower reaches of Big Darby Creek (RMS ~ 8.5 to 5). The ICI score at RM 5.4 downstream from the agricultural tributary at RM 5.86 was also a 52. The decline in macroinvertebrate density (i.e., to about 1000 organisms/ft.^{2}) suggests some decline in nutrient enrichment.

Diversity increased to 33 total EPT taxa and 94 total taxa at St. Rt. 104 (RM 3.2). The ICI also increased to 56 as a result of the exceptional riffle habitat (i.e., boulder/cobble with smaller sand substrates and fast flow). Some erosion of the banks were evident particularly at outside bends. Riparian density and width needs to be increased to protect against bank erosion and decrease diel D.O. swings (> 17 mg/l to 7 mg/l recorded 20-22 Aug. 2002) during summer conditions. Side pools or glides contained more silt and sediment than in past with some areas being quite

soft and unconsolidated. Sedimentation and/or erosion during high flows is a concern in the lower reaches of Big Darby Creek where riparian areas were too narrow or of inadequate density. Unstable habitat will continue to limit mussel populations in the lower portion of Big Darby Creek mainstem until storm water flows are controlled.

Big Darby Creek Upper Tributaries - Flat Branch to Sweeney Run

Flat Branch (02-223) (RM 78.48) (MWH)

Flat Branch was a channelized stream with excess nutrients (i.e., TP, TKN, nitrite and NH_3) and sediment / suspended solids (TSS) present. Upstream (RM 3.2 - good quality) there was some recovery of instream development with some small, rocky riffles present resulting from slumpage. However, agricultural fields along river left allowed sedimentation, nutrient runoff and excess algal production as a result of the open canopy. This was confirmed by high instream temp. (28.1^{o} C), highly elevated E. coli (42,000 colonies/100 ml.) and fecal coliform (22,000 colonies/100 ml.) counts found. Lots of baetid mayflies and hydropsychid caddisflies were present in the small refuge riffles (including the intolerant *Acerpenna pygmaeus* mayfly) and good numbers of burrowing mayflies in the clay bottom which predominated the shallow pools or glides.

The water in Flat Branch at RM 2.2 was a whitish-green color. This site was downstream from an unnamed tributary draining large portions of Honda. The channel was still deeply incised, but some small willows and other small trees were growing along the banks. However, the stream margin was primarily vegetated with grass. The stream channel has some root mats, and limited hard substrates on the stream bottom. Small rocky substrates were embedded in the top of the clay bottom substrates. Some banks had slumped which increased the erosional bed load. The EPT taxa total and the tanytarsini midge population decreased at this site to a marginally good condition, but which still met the MWH biocriterion. An acutely toxic concentration of copper (81 ug/l) was documented here, and instream bacterial counts were elevated.

Habitat in Flat Branch upstream from the old SR 33 bridge possessed similar riparian habitat to other upstream portions of the subwatershed with an open canopy and a largely brushy/weed riparian corridor. The upland habitat quality adjacent to Flat Branch at the downstream site (RM 1.0) improved with the riparian corridor widening to 40-50 feet of mature trees. The instream habitat features still reflected modified conditions and less than optimal substrates (i.e., gravels and fine silt/clays with scattered embedded rubble with some woody debris present). The ICI at RM 1.0 scored a 50 and indicated exceptional quality based on the organisms collected from the artificial substrate colonizer sample. EPT taxa richness increased significantly from the six collected upstream to the sixteen recorded at this site. Nutrient concentrations and bacteria counts were still elevated at the mouth of Flat Branch and consequently increased loadings to Big Darby Creek. However, contributions could have been higher. Diel dissolved oxygen measured in 2002 and macroinvertebrate density (440/ ft.^{2}) measured at RM 1.0 were more moderate due to shading and other factors resulting from the wooded corridor. Low dissolved oxygen measurements in Big Darby Creek downstream from

the confluence with Flat Branch were partially the result of Flat Branch nutrients, algae and TSS inputs.

Unnamed Tributary to Flat Branch (02-365) (RM 1.50) (Undesignated/MWH)
This unnamed tributary to Flat Branch consisted of a short channelized watercourse that drained the reservoir adjacent to the TRE automotive testing facility. Slow flow coupled with substrates of fine clays, silt and rotted detritus yielded very turbid conditions. The shoreline was largely unprotected except for weeds and grass with some slumped or cracked falling banks. Elevated nutrients (i.e., TSS, nitrite, TKN, and TP at 75th - 90th percentile vs. ECBP background) and an open canopy resulted in excess primary production. Numerous waterfowl, particularly Canada geese, inhabited the channel and shore line of this tributary and the reservoir upstream contributing to the nutrient enrichment problem. Algal mats, aquatic vegetation, and suspended algae were very common. Small runs, riffles and some rocky substrates were found towards the mouth of this tributary, though there was a large accumulation of silt and clays on the rocky substrates limiting colonization and being delivered to Flat Branch. The giant floater (*Pyganodon grandis*), a bivalve compatible with silty and slow pooled conditions, was present in large numbers. The macroinvertebrate community here, with few EPT taxa collected and generally a tolerant community, was fair quality but still attained the MWH biocriterion ($\geq$22).

Little Darby Creek (02-251) (RM 78.34) (Logan Co.) (Undesignated/EWH Recommended)
Little Darby Creek in it's headwaters was a high quality stream (ICI = 54 and 50). Both sites have been used as ecoregional reference sites as a result of their relatively undisturbed condition and high water resource quality. Total taxa collected at the RM 3.5 and 0.4 sites was 72 and 83, respectively, which included several intolerant mayflies and caddisflies. Little Darby Creek could be characterized as having clear water with good riffle/run/pool development and predominantly rubble substrates with smaller substrates in its pools. Some woody debris was present in the stream channel with fairly good habitat along it's margins including undercut banks. Even in this small subbasin, some NPS nutrients and *E. coli* were elevated (i.e., TSS, nitrite, TKN, and TP sometimes were at > 90th percentile). Additionally one grab water sample had a toxic copper concentration of 46 ug/l. While these elevated nutrient concentrations may have increased loadings to the mainstem of Big Darby Creek the relatively higher instream dissolved oxygen concentrations and lower water temperatures in Little Darby Creek probably improved water quality in Big Darby Creek when compared to inputs from Flat Branch. Some channelization occurred after sampling in 2002 which will adversely impact water resource quality in the future.

Unnamed Tributary to Big Darby Creek (02-361) (RM 74.91) (Undesignated/EWH Recommended)
There was a very good macroinvertebrate community present in this unnamed tributary to Big Darby Creek though there was evidence of some unstable habitat. Along one side the banks were eroding and collapsing where the riparian corridor was too narrow and destabilized during high flow. Siltation was a problem. The stream was observed to run dark brown after a morning

rainfall. Instream evidence of this problem included partial embeddedness in the riffles and runs with silt deposition in pools. Nutrient, bacteria, and silt inputs (nitrates and TP at >90th percentile and TSS at >75th percentile vs. ECBP background) could be reduced to this tributary and to Big Darby Creek if the riparian corridor was widened and the tile delivery slowed or decreased. One possibility would be to change the delivery to the riparian corridor instead of direct delivery to the stream channel.

Spain Creek (02-222) (RM 72.01) (WWH/WWH+CWH Recommended Hdwtrs to RM 5.0) (WWH/EWH+CWH Recommended RM 5.0 to mouth)
Spain Creek marginally met the WWH biocriterion downstream from Mingo - North Lewisburg Rd. (RM 5.7) with a marginally good quality community. Unrestricted cattle access upstream and past channelization allowed increased nutrient, waste, bacteria, sand, and silt inputs to upper Spain Creek (i.e., nitrite at 90th percentile and TSS at **205 mg/l** was at >95th percentile vs. ECBP background). These sources adversely affected the macroinvertebrate community as evidenced by the predominance of tolerant limpet snails, planorbid and *Physella* snails, besides common Hydropsychid caddisflies. There were also four different leech species collected. The stream channel was characterized as a "U-shaped" channel with sandy riffles from slumped banks with some rubble perched on top which was very unstable and of variable quality.

Downstream near Gilbert Rd. (RM 3.4) the habitat stabilized with solid, small rubble and coarse gravel riffles present. Eighteen total EPT and 72 total taxa were collected with a large increase of sensitive or cool water taxa (38 here compared to eleven upstream, including the mayfly *Diphetor hageni* (I) , the stonefly *Stenonema vicarium* (MI), caddisflies *Chimarra aterrima* (MI) and *Ceratopsyche slossonae* (CW/MI), and the cool water midge Polypedilum aviceps (MI)). The EWH biocriterion proposed for the remainder of Spain Creek was marginally met with an ICI of 44 (nonsignificant departure from the criterion of 46). Hydropsychid caddisflies were not on the colonizers due to slow current velocity at the end of the colonization period, even though they were one of the predominant organisms on the natural stream substrates. Several hydropsychid metrics should, in normal flow, have scored higher and indicated the potential for an even higher ICI score. High TSS from non-point sources upstream and local construction inputs, elevated *E. coli* counts, and an elevated ammonia concentration (0.208 mg/l at >95th percentile vs. ECBP background) indicated sporadic stress to the macroinvertebrate community.

Macroinvertebrate quality near the mouth of Spain Creek, downstream from the North Lewisburg WWTP, was still exceptional (i.e., ICI = 56) and greatly exceeded the EWH biocriterion. There was a more balanced macroinvertebrate community with many sensitive organisms present (including the intolerant mayflies *Acerpenna pygmaeus* and *Diphetor hageni*, the sensitive midges *Tvetenia bavarica gr.*, *Corynoneura spp*. and *Thienemanniella lobapodema*, and the fatmucket (*Lampsilis radiata luteola*) and the squawfoot (now named the creeper - Strophitus undulatus undulatus) mussels (MI). Some nutrient inputs increased downstream from the effluent, as TP, nitrite, and NH_3 concentrations sometimes exceeded the 90th -95th percentile of ECBP background concentration. Bacterial concentrations were still elevated. Shading from the tree canopy prevented negative effects from excess nutrient

enrichment. The overall water quality inputs from Spain Creek positively influenced Big Darby Creek water quality, as full attainment in Big Darby Creek occurred downstream from the Spain Creek confluence near Collins Road (RM 69.4).

Pleasant Run (02-221) (RM 72.01) (EWH)

Pleasant Run at Dunn Rd. (RM 4.1) was a previously channelized stream with wide, shallow, slow runs connected by gravel/sand riffles. It was obviously ground water influenced with cool water temperatures. Some marl encrustations had covered the larger substrates present. Water quality appeared very good with fifteen EPT taxa present, though there seemed to have been some algal die off based on the predominance of the tolerant *Physella* snails along with sensitive, cased caddisflies *Helicopsyche borealis* and *Neophylax sp.*. The riparian corridor was narrow, but intact amidst agricultural fields. Elevated bacterial concentrations were evident here. One live unionid mussel was observed but not identified.

Near the mouth and upstream from Middleburg-Plain City Rd. (RM 0.5), the macroinvertebrate sample at this ecoregion reference site indicated exceptional water quality with an ICI of 56. The total EPT taxa almost doubled to 27 and a very diverse community (86 total taxa) was present including midges which were under-represented upstream. Fresh shells of the sensitive Wabash pigtoe (*Fusconaia flava*), fatmucket (*Lampsilis radiata luteola*), and slippershell mussel (*Alasmidonta viridis* whose hosts include sculpins and johnny darters) were collected. There were rubble substrates consistently in lotic areas and lots of woody debris instream with wide riparian areas (30' to > 100') of larger trees shading most of the stream channel. Consequently most nutrient concentrations were below the median ECBP background concentrations, and bacteria counts had decreased slightly from upstream values. Pleasant Run was judged to significantly contribute to the exceptional conditions found downstream from its confluence (RM 72.01) in Big Darby Creek.

Unnamed Tributary to Big Darby Creek (02-360) (RM 69.4) (Undesignated/WWH Recommended)

This unnamed tributary to Big Darby Creek met the recommended WWH biocriterion. A good macroinvertebrate community was present in this stream. The sensitive, cased caddisfly Neophylax sp. and the river snail, Elimia sp., predominated, but this community lacked diversity and had a much higher percentage of tolerant organisms such as planorbid snails, leeches, and flatworms. A few elevated bacterial counts were also recorded. This groundwater-fed stream (temp. = 62° F) has been channelized and, therefore, has more silt in the streambed. The wooded riparian corridor was patchy in distribution with the balance a grass filter strip. The narrow woods remaining, though incomplete, did help shade, keep water temperatures lower and limited excess algal productivity to the small open canopy areas. Nutrient inputs (nitrate, nitrite, TKN, and TP at >75th to >95th percentile vs. ECBP background conditions) from adjacent agricultural areas were elevated, including TSS (lesser degree), and contributed to algal production and some silt accumulation in Big Darby Creek downstream from its confluence.

Hay Run (02-220) (RM 67.6) (WWH/EWH Recommended)
Hay Run was a small, unshaded, modified stream in its upper reaches, but the sample site near the mouth (RM 0.2) exhibited a very good macroinvertebrate community and marginally met the EWH biocriterion. This groundwater-fed stream (temp. = 13.1° C or 56° F at the time of sampling) contained rocky substrates with decent base flows. All of the predominant and common organisms in the riffle and pool habitats were sensitive taxa (including the cased caddisflies *Neophylax sp.* (I) and *Helicopsyche borealis* (MI) and the moderately intolerant mayfly *Isonychia sp.*). Where there was some unshaded stream channel (usually closed canopy) a significant amount of algal and periphyton growth was present. Macroinvertebrate densities were moderate to high and also indicated nutrient enrichment (nitrate and nitrite concentrations ranged from > 75th percentile to > 95th percentile vs. ECBP background). *E. coli* concentrations were similarly elevated. Hay Run inputs into Big Darby Creek contributed to the enrichment found upstream from Milford Center. Decreased NPS nutrient inputs into Hay Run via wider riparian corridor (and hopefully more filtered runoff) would improve community quality here and downstream in Big Darby Creek below Hay Run.

Buck Run (02-209) (RM 63.74) (WWH)
The Buck Run headwaters (5 mi.^{2}) sampled at Allen Center-Pottersburg Rd. (RM 10.4) was mostly a pooled reach with soft clay bottoms that was turbid brown (high TSS at 75th to >95th percentile vs. ECBP background). There were also short reaches of constricted slow runs with woody debris and small sand/rubble riffles. The canopy was mostly open (75 percent) with one bank short grass and the other bank small trees. The moderately intolerant burrowing mayfly, *Hexagenia limbata*, was predominant in the macroinvertebrate community in the pools. Six EPT taxa were collected and this upper reach was evaluated as marginally good meeting the WWH biocriterion.

Lotic habitat improved near St. Rt. 245 (RM 7.8) with increased rocky substrates and a stable riffle present. Some substrates were embedded with silt deposition noticed in the pools and on rocks along the stream margin. Caenis mayflies were predominant in the run, and hydropsychid caddisflies, isopods, riffle beetles, and baetid mayflies were the common organisms collected in the riffle. The midges collected in the pools were mainly the tolerant midges *Chironomus decorus* and *Dicrotendipes simpsoni*, but sensitive midges were present in the run and riffle (the moderately intolerant *Corynoneura n. sp. 1*, *Microtendipes pedellus gr.*, and *Tanytarsus sp.*). This segment with improved habitat yielded a marginally good macroinvertebrate community (nine EPT taxa), but there were some indications of stress. A violation of the WWH Dissolved Oxygen minimum WQS (3.69 mg/l) was recorded here. Ammonia and nitrite (>95th percentile vs. ECBP background) were at potentially chronically toxic concentrations, and TSS and other nutrient parameters were also very elevated at times (> 90th percentile vs. ECBP background).

Near Milford - Amrine Rd. (RM 5.0) Buck Run was a wide, modified slow run/pool with unstable, steep, incised, collapsing banks (of grass/weeds) where slumpage had created a slow run. Rocky cobble and rubble were common stream substrates with adjacent pockets of silt, sand, and/or detritus. This reach was a sediment sink. Heavy silt and silty algae had accumulated $\geq$ 1 inch deep on the parent substrates. A dissolved oxygen concentration of 3.52

mg/l was documented here. EPT taxa collected at RM 5.0 were comparable those collected at RM 7.8 with increased populations of Tanytarsini midges and the rare midge *Paratendipes sp. 1*. However, the lower quality habitat limited the community quality (only 9 of the 48 taxa were sensitive organisms). The community sampled at this site was characterized as marginally good. Riparian restoration and bank stabilization would greatly increase habitat quality by reducing erosion, siltation, algal production, and allowing for improved stream riffle/run/pool development.

Near its mouth Buck Run (RM 0.6) was still a fairly sluggish stream with extensive and fairly deep pools. The giant floater mussel, *Pyganodon grandis*, which favors this type of habitat was collected here. Despite good habitat there were not many mayflies, and the total EPT taxa decreased from upstream. Riffle beetles, flatworms, and fingernail clams were predominant in the various habitats. The macroinvertebrate community was evaluated as marginally good. Excess nutrients, *E. coli* (still elevated but not to the levels of upstream sites) and TSS were still present, despite uptake and filtering by the extensive beds of aquatic macrophytes. and contributed to increased loadings in Big Darby Creek. The ICI in Big Darby Creek decreased significantly from the 50 found upstream to 42^{ns} at RM 62.9 which only marginally met the EWH biocriterion. Overall, riparian habitat improvements, livestock setbacks and exclusion, and widening of the greenbelt corridor surrounding Buck Run would improve the biological community and decrease silt, nutrient, and TSS inputs downstream into Big Darby Creek.

Robinson Run (02-207) (RM 53.69) (WWH)

Robinson Run near Hawn Rd. at RM 5.5 (4.6 $mi.^2$ drainage) was of very poor quality with low EPT totals and low total taxa. This channelized, open canopy, ditched stream was enriched with lots of algae and periphyton on rocks along the margin and near the surface. Substrate size ranged from boulders in the runs and pools to silt from slumped banks that accumulated in depositional areas with rubble and coarse gravel predominant overall. No midges were collected and the only mayfly taxa collected was the moderately tolerant (MT) *Callibaetis sp.*. Almost all of the cranefly pupae and all of the hydroptilid caddisfly cases collected in the riffle had hatched and were empty. Decayed, blackish anaerobic scum on the rock surfaces indicated low dissolved oxygen conditions had undoubtedly limited the macroinvertebrate community quality. Pools were almost devoid of life except for tolerant lunged pond snails *Physella sp.* and scuds at low densities. Low dissolved oxygen was the likely culprit for this community suppression. Riparian growth would be a good first step to help the stream water quality of Robinson Run in this upper reach.

Fair water quality conditions existed near St. Rt. 736 (RM 2.1). There were high numbers of moderately intolerant hydrobiid snails present probably from nutrient enrichment and variable dissolved oxygen concentration with other organisms limited (only two EPT taxa collected and at least one-third of the community tolerant organisms). Pooled areas had substrates that revealed anaerobic black stains on their sides and bottoms. These substrates yielded very few organisms. Low diel dissolved oxygen concentrations were likely based on the lack of common community organisms in expected habitats. No mayflies nor pupated or larval hydropsychid caddisflies were collected on rocks in the narrow shallow runs which had had more flow earlier.

Agricultural NPS run-off was still a significant stressor, as well as the discharge from the small WWTP upstream (i.e., Darby Meadows WWTP at RM 5.23). Ammonia, nitrate, nitrite, and TKN were elevated with some concentrations exceeding the > 90th and/or > 95th percentile versus ECBP background conditions. Despite the point source and NPS inputs better riparian conditions with increased shading and slightly lower temperatures allowed the macroinvertebrate community quality to improve slightly to fair conditions compared to very poor upstream.

The downstream site on Robinson Run at U.S. Rt. 42 (RM 0.8) was still nutrient enriched. Macroinvertebrate community composition had improved with moderate to high community density. Habitat quality had also improved with good development within a largely intact wooded riparian corridor. There were > 70 cm. deep pools with undercut banks held by trees with submerged roots. Rocky substrates were common with some silt deposition also. Some embeddedness with silt and/or sand in riffles and runs were a symptom of TSS bedload (> 90percentile vs. ECBP background) and storm water flashiness primarily from upstream agricultural areas and possibly some urban storm runoff. Bacterial concentrations were elevated here and upstream. High densities of *Elimia* snails (MI) were noted here and predominated in all habitats. Fingernail clams and hydroptilid (pursed) caddisflies were also prominent in the riffle and run, respectively. Eight EPT taxa were collected, including the moderately intolerant *Chimarra obscura* and *Pycnopsyche* caddisflies and indicated better conditions. However, facultative flatworms, craneflies, scuds, and alderflies were common in the riffle and run habitats indicating variable conditions. This site was marginally good meeting minimum WWH expectations. Decreasing the NPS inputs would stabilize and improve macroinvertebrate community quality, decrease nutrient enrichment, and decrease nutrient and sediment loadings into the pooled reach of Big Darby Creek upstream from Plain City where biological scores had decreased slightly. The TSS (partially from siltation), total phosphorus, and nitrogenous compounds currently were mostly >75th percentile to >90th percentile vs. ECBP background range.

<u>Sweeney Run</u> (02-357) (RM 52.11) (Undesignated/WWH Recommended)
Sweeney Run was affected by agricultural runoff, storm water runoff and other inputs from Plain City (i.e., nitrates, nitrites and TSS were very elevated as well as fecal coliform counts > 12,500 counts/100 ml. and E. coli at 7,000 counts/100 ml). Both tolerant and sensitive organisms (*Neophylax* sp. (I) and (MI) *Helicopsyche borealis*) were collected at RM 0.2. The macroinvertebrate community was judged to be fair based on the low number of EPT taxa collected (4) and that the majority of the prominent organisms were tolerant. Sanitary sewer work in 1998 to decrease leakage to storm sewers decreased some sewage inputs to Sweeney Run. Work on the storm sewers in 1997 in a portion of Plain City, which now discharges to Big Darby Creek in Mc Kitrick Park, also decreased some NPS inputs to Sweeny Run. Additional samples in Sweeney Run (chemical and biological) are warranted to determine water quality upstream from Plain City and help locate elevated fecal coliform and/or *E. coli* sources to determine whether agricultural NPS inputs from upstream of Plain City or municipal/county related (e.g., sewage from on-lot septic systems with storm water connections), storm water runoff (i.e., possibly runoff from manure at fair), spills, and/or other sources were the cause of

the problem). An additional source of stress to Sweeney Run is the mosquito fogging program which occurs annually in Plain City and which could periodically be affecting the macroinvertebrate communities.

Big Darby Creek Middle Tributaries - Sugar Run to upstream from Little Darby Creek

Sugar Run (02-206) (RM 50.92) (WWH/MWH Recommended)

The channelized upper reaches of Sugar Run, are currently designated WWH. Local habitat quality and biological sampling results resulted in a recommendation for this segment to be re-designated as MWH. The fair macroinvertebrate community documented at RM 7.7 met the MWH biocriterion (i.e., $\geq$ 22). Very slow current flow contained within grass-covered and slumping banks characterized this stream reach. Murky green water with lots of algae were evidence of the nutrient enriched condition of the waters. High TSS, TKN, nitrates, and TP were measured at $\geq$90th percentile and/or $\geq$ 95th percentile of ECBP ecoregion background concentrations. Depressed nighttime dissolved oxygen concentrations resulting from algal respiration from agricultural NPS runoff, and golf course runoff likely has also hindered community quality.

Somewhat improved water quality conditions were found downstream at Taylor Rd. (RM 6.9) with ten qualitative EPT taxa collected (including the intolerant mayfly *Leucrocuta sp.* and the moderately intolerant mayflies of the genera *Centroptilum* and *Procloeon*). In contrast only four EPT taxa were found upstream. Also, the number of taxa collected at RM 6.9 more than doubled to 46 despite it being only a marginally good quality community. The canopy was open with the riparian zone consisting of a 50 ft wide strip of grass and weeds along both banks. The primary land use in the area was row crop agriculture. Siltation and runoff from adjacent land has colored the water column brown and turbid. Low dissolved oxygen concentrations were documented periodically with lows reaching 2.88 mg/l at RM 7.0. A violation of minimum the MWH D.O. criterion occurs when concentrations are $\leq$ 3.0 mg/l. Nutrient NPS inputs were similar or higher compared to upstream with increased NH_3 and nitrate concentrations. Despite these adverse factors, live paper pondshell mussels (*Utterbackia embecillus*) were observed within this reach. Increased woody riparian growth would improve quality by shading the stream thus decreasing stream temperatures, decreasing algal production, increasing water and nutrient absorption, decreasing silt delivery, and stabilize the stream banks.

Better habitat was found at RM 5.5. This sampling site was in the WWH designated reach. The 60 ft. wide woody riparian buffer upstream from U.S. Rt. 42 fostered more natural conditions and yielded good community quality. Hydropsychid caddisflies in the riffle and baetid mayflies in the slow run were predominant due to better habitat along with corixids and beetles. Overall community quality increased slightly. However, low flows, elevated nutrients, bacterial inputs, and embedded substrate conditions were likely the limiting factors to even greater community quality improvements.

Near the mouth of Sugar Run habitat quality improved. Many more sensitive mayflies, caddisflies, and midges were collected (like the mayfly *Nixe sp.* with weighted ICI = 47.2 and

the midge *Rheotanytarsus pellucidus* with a weighted ICI of 46.3) near Cemetery Pike at RM 0.5. Sixteen total EPT taxa, including an intolerant stonefly from the *Neoperla clymene complex*, resulted in an aggregate of 52 total taxa. The very good community present here was directly related to increased habitat quality, reduced silt, lowered nutrients concentrations, and more consistent dissolved oxygen concentrations. Sugar Run water quality inputs into Big Darby Creek do add some NPS loadings in the form of excess nutrients and sediment to the BDC mainstem. Sugar Run nutrient inputs (TSS, nitrates, nitrites, TKN and TP) measured from the 75th to the 95th percentile compared to ECBP background concentrations and were higher than upstream inputs from Robinson Run into Big Darby Creek upstream from Plain City. A measured total phosphorus concentration of 0.58 mg/l at RM 0.5 represented an especially high NPS concentration. However, nutrient concentrations discharged from Sugar Run into Big Darby Creek were much lower than nutrient concentrations measured downstream from the Plain City WWTP discharge. Big Darby Creek ICI scores did show recovery downstream from the confluence with Sugar Run at Amity Pike in comparison to ICI scores closer to the Plain City WWTP. Any decrease in nutrients and sediment discharged from Sugar Run associated with habitat improvements in the upper watershed would greatly improve Big Darby Creek water quality and protect vital biological communities downstream from Plain City.

Unnamed Tributary to Sugar Run (02-358) (RM 7.39) (Undesignated/MWH Recommended)

This tributary was a channelized, shallow and mostly pooled stream with very low flow and slow current due to its gradient and modified channel. The banks were mostly grass or lined with rip rap. Some areas had slumped banks. Modified Warmwater Habitat is the recommended aquatic life use for this currently undesignated stream. The macroinvertebrate community was of marginally good quality with nine EPT taxa collected. Three sensitive mayfly taxa and one midge taxa were collected. Despite poor riffle quality, hydropsychid caddisflies along with freshwater shrimp and also intolerant *Physella* snails were predominant in the riffle/run area. Delivery of excess nutrients to this tributary as a result of the limited riparian corridor and adjacent agricultural fields has led to excess nutrients and mats of algae being exported to Sugar Run.

Worthington Ditch (02-356) (RM 50.62) (Undesignated/WWH Recommended)

Worthington Ditch was sampled at RM 0.2, downstream from Plain City - Georgesville Rd./ St. Rt. 142 contained a marginally good community in its lower reaches. Large concentrations of algae in the pools and high populations of Tanytarsini midges and blackflies in the riffles indicated nutrient enriched conditions instream. Nutrient concentrations mostly exceeded the > 75th percentile but nitrate concentrations also exceeded the 95th percentile ECBP background concentrations. Nine EPT taxa were collected, including some sensitive organisms. Moderately intolerant (MI) caddisflies (e.g., *Chimarra aterrima*), the intolerant stonefly *Agnetina capitata complex*, and MI midges *Paratrichocladius sp.* and *Paratanytarsus n. sp. 1*, which are also cold water taxa, were some of the sensitive taxa collected in the macroinvertebrate community in lower Worthington Ditch. Groundwater influx and shading from a modest amount of wooded riparian vegetation in the lower reach downstream from St. Rt. 142 has yielded cooler instream water temperatures and ameliorated some of the effects

from nutrient enrichment introduced to the channelized open stream segment further upstream. Increasing the grass and/or wooded riparian buffer upstream from St. Rt. 142 would improve water quality of Worthington Ditch and the water quality being delivered to Big Darby Creek at RM 50.62.

Ballenger-Jones Ditch (02-355) (RM 49.68) (Undesignated/WWH Recommended)
Ballenger-Jones Ditch water quality was higher than that found in Worthington Ditch despite having similar nutrient concentrations to Worthington Ditch. The agricultural land use upstream gave way to a 300 to 400 yard long grassy, slightly treed and partly shaded, meandering reach that allowed for natural processing of nutrients and WWTP wastewater and permitted lower water temperatures than found in the open canopy conditions further upstream. Downstream from St. Rt. 142 there was a fairly stable natural bed through the woods leading to Big Darby Creek (RM 49.68). An exceptional macroinvertebrate community was evident with 19 EPT taxa collected. Many sensitive taxa including baetid mayflies, hydropsychid and cased caddisflies, stenonemid mayflies, and freshwater shrimp were predominant in the riffles, pools, or runs. Allowing more trees upstream in the grassy area and increasing the extent of the stream canopy would further benefit Ballenger-Jones Ditch stream quality. This would also benefit the critical receiving reach of the Big Darby Creek mainstem. After sampling in 2001 the channel was modified in the lower wooded section of this stream.

Yutzy Ditch (02-364) (RM 47.1) (Undesignated/WWH Recommended)
Yutzy Ditch was of marginally good quality at the site near St. Rt. 142 , RM 0.4, and met the recommended WWH aquatic life use biocriterion. There was still some slight flow and groundwater recharge or supplemental interstitial flow and modest canopy in the lower reach that moderated water temperatures (~ 70° F). A more natural stream channel was present approximately 400-500 yards upstream from St. Rt. 142 with riffles and functional pools comprised of predominately rocky substrates. This pattern continued downstream to the mouth (confluence with BDC @ RM 47.1). Further upstream the stream was conventionally channelized and quite deeply entrenched. A short segment upstream from the sampled reach was petitioned and maintained by the Madison County Engineer's Office. Nitrate, TKN, and TP concentrations were very elevated from upstream inputs ($\geq$ 75th percentile to $\geq$ 95th percentile vs. ECBP background). At the sample site near St. Rt. 142 there were eight EPT taxa collected including sensitive mayflies and caddisflies. Moderately intolerant water pennies (beetle larvae), *Helichus sp.* beetles, and tanytarsini midges *Rheotanytarsus sp.* and *Rheotanytarsus n. sp. 1* (also a coolwater taxa) were present. Various sensitive or more adaptive cased caddisflies and stenonemid mayflies were predominant in the riffles and pools, and tolerant *Physella* snails in the more variable margin habitat. Additional sampling should be conducted further upstream prior to recommending an aquatic life use for the upper portions of Yutzy Ditch.

Fitzgerald Ditch (02-272) (RM 44.96) (Undesignated/WWH Recommended)
Fitzgerald Ditch, a direct tributary to BDC at RM 44.96, receives effluent from the Canaan Community MHP WWTP upstream from the sampling site near St. Rt. 142. Nutrient

enrichment was evident at RM 0.5 with algal mats present on the mostly rubble and coarse gravel substrates. There were high to moderate densities of filtering hydropsychid caddisflies, larval and adult riffle beetles, and *Rheotanytarsus sp.* midges with *Polypedilum* midges very common in the riffles or runs. Ammonia (0.215 mg/l), nitrate (11.4 mg/l), TKN, and TP (1.48 mg/l) were > 90th percentile to > 95th percentile versus ECBP background. *E. coli* and fecal coliform bacteria concentrations were very elevated in at least one sampling in 2001 (4400 and 6000/100 ml., respectively), and a slight antiseptic odor (possibly chlorine) was present. These chemical inputs, particularly NH_3 and possibly chlorine, could be related to the lack of mayflies collected at RM 0.5 (only one baetid mayfly and no stenonemid mayflies). The community overall was determined to be marginally good and attained the recommended WWH aquatic life use (nonsignificant departure).

Little Darby Creek - Mainstem

Sixteen sites were sampled in the Little Darby Creek mainstem and all but two colonizers were recovered. All sites met the established and recommended EWH biocriterion scores at each site (Table B.7.1). There were differences in exceptional quality through different reaches of Little Darby Creek. There was a range of fifteen to 27 EPT taxa, 28 to 46 sensitive taxa, and zero to twelve mussels collected per sampled site. Different highlights, variables, and challenges to stream community quality will be discussed in the following narratives.

At its headwaters Little Darby Creek was a very good to exceptional quality coolwater stream (temperature ~ 56° F) with the coolwater hydropsychid caddisfly *Ceratopsyche slossonae* and coldwater cased caddisfly *Glossosoma sp.* predominant in the riffle with the coldwater mayfly *Baetis tricaudatus* the most common mayfly collected. The very good community marginally met the recommended EWH biocriterion (nonsignificant departure). There were fifteen EPT taxa, six to seven coldwater taxa, and a total of 28 sensitive taxa collected downstream from Allison Rd. (RM 41.2). Adjacent and connected to the creek was a wetland / seep complex with noticeable cool, groundwater recharge. There were some negatives as a fair number of blackflies and *Physella* snails were present. Upstream was an open pasture area that could be a source of past NPS inputs. Past NPS sedimentation had caused some riffle embeddedness and it appeared that recreational vehicles were exacerbating the problem at the time of collection.

The next sample site was downstream of St. Rt. 29 where Little Darby Creek winds southeast and east through the south edge of Mechanicsburg. The site was downstream from the Clover Run confluence and just downstream from a fertilizer / feed distributor storage facility and an open pasture with cows in the stream. The macroinvertebrate community population indicated excess nutrient enrichment with high to moderate population densities of filtering midges and hydropsychid caddisflies in the riffles and runs. Relative density increased approximately 800 percent to approximately 4000/ft.^{2}. The nutrient loading to this area needs to be reduced

(Figure B.7.10). The qual. EPT taxa collected decreased, and the QCTV dropped significantly from 40.4 upstream to 36.8 at RM 39.3 (Figures B.7.11 and B.7.12). This resulted from a shift to more tolerant midges (like *Cricotopus C. bicinctus*) and larger populations of aquatic worms and *Physella* snails. There were some slumped and caved-in banks in the open pasture area. The stream bed was spongy where banks were destabilized by cattle. There were consistently elevated *E. coli* counts. Cattle were not fenced out of Little Darby Creek upstream from the sample site at RM 39.3. Sedimentation from destabilized banks rendered some rocky bottom substrates unusable for colonization. Coarse substrates in depositional and margin areas were covered with silt. The cooler water temperatures instream (~ 52° F) ameliorated some of these problems with this site yielding an ICI of 48, which met the EWH biocriterion. Increased bank stabilization, cattle exclusion and more dense streambank canopy cover upstream on Little Darby Creek mainstem and on Clover Run would decrease the NPS erosional sedimentation/siltation and nutrient inputs from various sources.

Figure B.7.10. Longitudinal trend in the Relative Density of Macroinvertebrates in Little Darby Creek based on samples collected in 2001 and 2002.

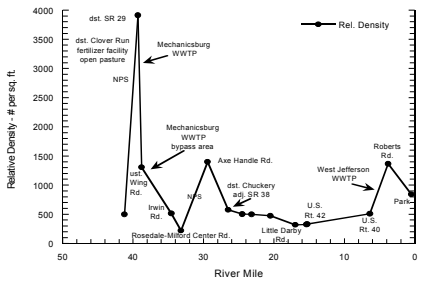


Figure B.7.11. Longitudinal trend in the QCTV in Little Darby Creek based on samples collected in 2001 and 2002.

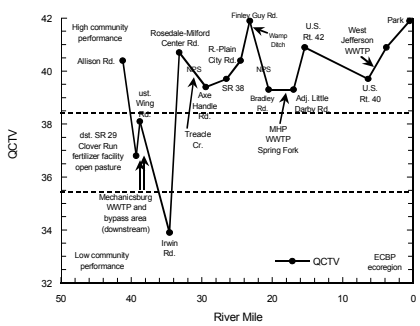
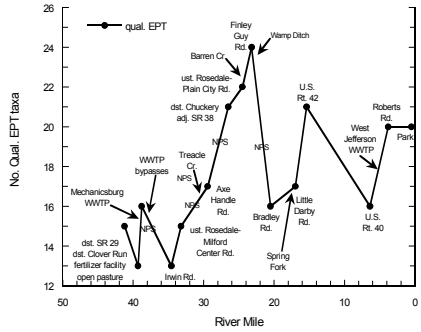


Figure B.7.12. Longitudinal trend in the number of Qual EPT taxa in Little Darby Creek based on samples collected in 2001 and 2002.



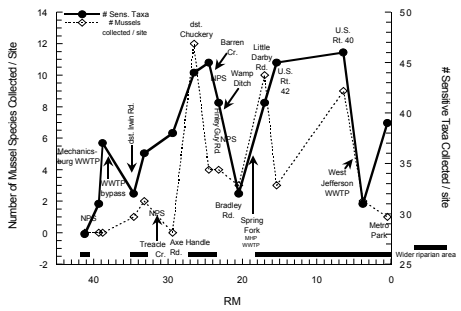
The next sampled reach was upstream from Wing Road (RM 38.8). The sampled location, where the colonizer was placed, was downstream from the Mechanicsburg WWTP, but upstream from the WWTP bypass which was closer to Wing Rd. The stream here was more defined with a narrower channel and good riffle/run complexes. Good riparian cover existed on

the north bank, but Little Darby Creek flowed through the edge of an open pasture where *E. coli* concentrations were equal to or greater than upstream NPS sources. The south banks were trampled and destabilized from cattle. This resulted in silt and sediment mixed in with the bottom rocky substrates. The macroinvertebrate community collected was still of very good to exceptional quality, with the number of sensitive taxa increased compared to upstream (Figure B.7.14). Intolerant taxa collected included the mayflies *Pseudocloeon frondale*, *Diphetor hageni*, and the midge *Tvetenia discoloripes group*. However, some of the pool and margin community was predominated by the tolerant *Physella* snails, *Chironomus decorus gr.* midges, and silt-resistant limpet snails due to the wastewater and NPS inputs. A couple of the pools sampled were adjacent to or downstream from the WWTP bypass outfall. Nutrient enriched conditions continued with nutrients $\geq 75^{th}$ percentile vs. ECBP background, but the relative abundance decreased to approximately 1300/ft.^{2} (Figure B.7.10). Four coolwater taxa, including caddisflies *Glossosoma sp.* and *Ceratopsyche slossonae*, were still present, and the cooler water temperature assisted in ameliorating water quality impacts from wastewater and NPS inputs. Based on the coldwater taxa collected here and further upstream the CWH aquatic life use designation was recommended from the headwaters to upstream from Lake Run (RM 37.0). Based on the pool sampling downstream where the Mechanicsburg WWTP bypass was located, there was the likelihood that the macroinvertebrate community downstream from Wing Rd. might have been more impacted than upstream above the WWTP bypass. The fish results downstream from Wing Rd. indicated further impact.

The macroinvertebrate community quality downstream from Irwin Rd. (RM 34.6) was improved with an ICI of 56 (Figure B.7.14). This was attributed to the distance of the site from the Mechanicsburg WWTP and periodic WWTP bypass discharges and natural stream assimilative processes. The relative density has decreased toward baseline conditions (Figure B.7.10). Large increases in the proportion of baetid mayflies and decreases in the total numbers of tolerant (T) midges and aquatic oligochaete worms fueled the increases in the ICI score. There was still room for improvement in community quality, as the ratio of very tolerant and tolerant organisms present (i.e., organic tolerant midges, leeches, worms, and snails) outnumbered the intolerant (I) taxa present by a seven-to-three margin, though their numbers were much lower than upstream. The number of sensitive and qualitative EPT taxa collected was slightly lower, and the total EPT taxa was still less than twenty (Figures B.7.12 and B.7.14). The QCTV was correspondingly lower (Figure B.7.11). Possible reason(s) could have been: 1) habitat restrictions with less riffle habitat in the recovering channelized reach; or 2) periodic short-term minor impacts from the Mechanicsburg WWTP bypasses; or 3) chronic dairy waste spills near the county line and/or from other residual periodic NPS inputs (i.e., upstream sedimentation from erosion in open pastures). Improved quality was such that moderately intolerant giant floater mussels, *Pyganodon grandis*, were present at this location. Improvement to Mechanicsburg WWTP and the elimination of raw wastewater bypasses and other NPS inputs with increased riparian corridor width and density will definitely further improve water quality conditions downstream from Mechanicsburg.

The reach of Little Darby Creek upstream from Rosedale - Milford Center Rd. (RM 33.2) possessed a more continuous, mature woody riparian corridor that began downstream from a

Figure B.7.13. Longitudinal trends in the number of mussel species collected per site and the number of sensitive taxa collected in Little Darby Creek in 2001 and 2002.



tree farm at Irwin Rd. The south bank was virtually continuous with trees with riparian widths greater than 50 feet. The north bank had at least one very thin section where the eroding outside bank abutted against the agricultural crop field with maybe one foot of weeds, but most of the north bank riparian corridor was approximately 35 to 50 feet wide. Little Darby Creek in this reach had not recovered from past channelization. There were small sand and gravel riffles or riffles composed largely of sticks and woody debris. Moderately deep, short runs converged into mostly deep pools that had accumulated some sand and silt. Within this reach of more stable habitat and lessened NPS inputs, a density of about 220 organisms/ ft.^{2} was collected (Figure B.7.10). An ICI of 54 was scored here similar to the upstream value meeting the EWH biocriterion. The QCTV value improved dramatically (i.e., to 40.7).

There were more sensitive organisms collected with less tolerant taxa observed (Figures B.7.14 and B.7.15). Unique sensitive organisms collected included the mayflies *Diphetor hageni*, *Stenonema vicarium* and *S. terminatum*, and the cased caddisflies *Oecetis persimilis* and *Triaenodes ignitus*. Two mussel taxa, the Threeridge (*Amblema plicata plicata*) and the Wabash pigtoe (*Fusconaia flava*), were observed in this reach and were present where more stable and wider riparian habitat was found (Tables B.7.1 and B.7.2). Mussels, and sensitive

Figure B.7.14. Longitudinal trends in the number of sensitive species collected in Little Darby Creek in 2001 and 2002.

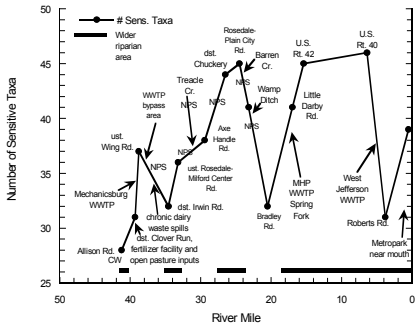
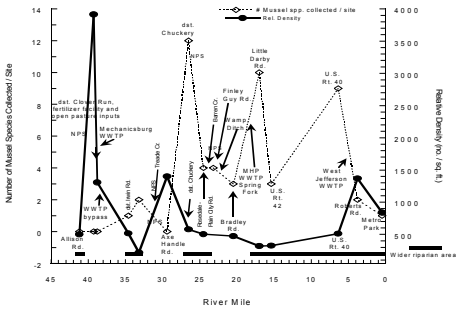


Figure B.7.15. Longitudinal trends in the number of mussel species collected per site and the relative density of macroinvertebrates collected in Little Darby Creek in 2001 and 2002.



taxa in general, also seem to have higher diversity where wider, mature, and more stable riparian areas were adjacent to Little Darby Creek and where there were no point source inputs or tributary NPS inputs that elevated silt and nutrient concentrations (Figures B.7.14 and B.7.15). Conversely, communities in good riparian areas usually have low baseline or decreasing relative community abundance correlated to limited inputs, shaded conditions, and lower temperatures. Wider riparian corridors adjacent to Little Darby Creek and its tributaries would limit sediment and nutrient inputs into the system and be more protective of sensitive organisms.

Downstream from Rosedale - Milford Center Rd.(aka Bates Rd. in Union County), no riparian buffer was present adjacent to Little Darby Creek as a result of an open pasture. Banks were broken down and devoid of vegetation. Sedimentation resulting from the free access of livestock to the stream channel had degraded instream quality (Figure B.7.16). Similar livestock agricultural practices were observed adjacent to Treacle Creek near Irwin and upstream from Winget Rd. (covered bridge) that yielded denuded, slumped, or false banks and excess silt or sediment inputs. Violations of the minimum EWH D.O. concentration (i.e., < 5 mg/l) in Treacle Creek were recorded at Winget Rd. during continuous monitoring on 9/13/01. Related NPS nutrient inputs from livestock and rowcrop cultivation were evident downstream in Little Darby Creek, as TSS, ammonia, nitrate, and nitrite concentrations instream at the Axe Handle Rd. site (at RM 29.5) were elevated to $\geq 75^{th}$ percentile or $\geq 90^{th}$ percentile compared to ECBP background conditions. Patterns in the macroinvertebrate community confirmed nutrient enriched conditions with 1400 organisms/ft.^{2} (Figure B.7.10). Filtering organisms (i.e., caddisflies and *Corbicula* clams) and scrapers or grazers (i.e., riffle beetles and *Stenacron sp.* mayflies) predominated in the riffles and runs. The shallower, more aerated pool downstream from the fast, oxygenated riffle reach had good diversity but low density. In this short aerated reach the ICI scored a 50 and met the EWH biocriterion. The pool upstream from the riffle at the bridge, a long pooled reach, was much siltier with more depositional sediments and contained fewer organisms with more limited diversity. No unionid mussels were collected here (Figure B.7.15). During sampling, black-green solids, perhaps rotting fresh hay or grass, were suspended in the water and floated downstream. These solids contributed to the oxygen demand further lowering instream dissolved oxygen concentrations.

Figure B.7.16. Landuse downstream from Bates Rd., RM 33.2, in Little Darby Creek, 2001.

Continuous monitoring just upstream from the riffle in the flowing water at Axe Handle Rd. revealed critically low D.O. concentrations. On 13 September 2001, the dissolved oxygen concentration dropped to $\leq$ 6.00 mg/l from 3:00-10:00 AM with a mean concentration during

that time of 5.66 mg/l. With D.O. concentrations in the pool depths undoubtedly being even lower, these night time D.O. values contributed to chronically impact the macroinvertebrate community in this vicinity. However, large reaches of Little Darby Creek in this portion of the watershed possessed similar physical characteristics and would be expected to react similarly. Reducing sedimentation, TSS, fecal bacteria, and nutrient inputs in the mainstem upstream and in Treacle Creek will improve water quality in Little Darby Creek through this reach and protect downstream resources.

Downstream to Chuckery the riparian corridor was of mixed quality. This segment possessed some largely open canopy as well as partial canopy with some unprotected banks. Excess sedimentation, nutrient enrichment and associated fluctuating or periodic low D.O. concentrations are a distinct possibility unless upstream and adjacent sedimentation and nutrient inputs are reduced coupled with an expanded shaded stream canopy which would reduce excessive algal productivity.

It is critical that the sediment/silt load contributed to this reach (i.e., from downstream from Rosedale - Milford Center Rd.[AKA Bates Rd. in Union County] to downstream Chuckery - which includes Treacle Creek and its tributaries) be reduced significantly in order to protect one of the last strongholds in the Darby watershed of the federally endangered clubshell mussel, *Pleurobema clava*, which occurs downstream from Chuckery.

Downstream from Chuckery and adjacent to St. Rt. 38 the Little Darby Creek mainstem was sampled at RM 26.5. One of the more stable, wider riparian corridors that exists in the upper mainstem continues downstream to Rosedale - Plain City Road. A very diverse community was found which utilized all of the available stable substrates. Slow, sandy run habitat was a prominent habitat with scattered shallow rocky and stick riffles in shallower areas. Permanent sand/gravel bars, formed behind or adjacent to sunken logs, yielded live mussel colonies. Scattered silt deposition in pools limited the macroinvertebrate community in those habitats. Clay bottom substrates were exposed near some banks. The ICI of 52 which met the EWH biocriterion confirmed the assessment of this exceptional and diverse macroinvertebrate community. There were 25 total EPT taxa and 85 total taxa collected which represented a significant increase from upstream (Table B.7.1). The relative abundance decreased to a more normal amount of 577 organisms/ft.^{2} because of the decreased nutrient inputs resulting from filtering by the riparian corridor and shading by the canopy (Tables B.7.1 and B.7.2). The increase in sensitive organisms collected was strongly linked to the very diverse mussel community present (Figures B.7.13, B.7.14 and B.7.15). Twelve mussel species were recorded, including live kidneyshell (*Ptychobranchus fasciolaris*), spike (*Elliptio dilatata*), and Wabash pigtoe (*Fusconaia flava*). The most rare mussel collected here was a fresh dead specimen of the federally endangered clubshell mussel (*Pleurobema clava*). Its habitat requirement include loose well-aerated sand and gravel substrates in riffles and runs free from silt which allow interstitial flow and oxygen regeneration to deeper substrates, since it burrows well below the surface (Watters, 1993). Sandy substrates that predominate in this reach, the wider and mature riparian corridor and groundwater recharge to Little Darby Creek are significant factors in why the clubshell mussel has survived here (Figure A.2 glacial geology map). Limiting siltation and

sedimentation from erosion or runoff from upstream sources is vital to the protection of this unique mussel's habitat. Increasing canopy cover adjacent Little Darby Creek upstream would decrease instream temperatures and algal production and keep baseline D.O. concentrations higher to protect the more intolerant organisms in the macroinvertebrate community.

The macroinvertebrate community at Rosedale - Plain City Rd. was located at the downstream end of this fairly lengthy and mostly contiguous wooded riparian area. Two small tributaries from the west draining agricultural fields as well as the adjacent agricultural fields had added nutrients to the system. Elevated TSS and TP concentrations were collected at $\geq 75^{th}$ percentile level while ammonia (0.11 mg/l) and nitrate (6.04 mg/l) were found to be $\geq 90^{th}$ percentile to $\geq 95^{th}$ percentile, respectively, compared to the ECBP background levels. These nutrient concentrations and TSS were all higher than those recorded at Axe Handle Road. Algal growth inhibited by the shaded conditions permitted the relative community abundance to decrease to 577 organisms/ft.^{2}. The exceptional macroinvertebrate community present scored a 58 (out of a 60 maximum) was the highest recorded during the survey (Table B7.1 and Figure B.7.14). The highest number of qual. taxa (85) and total taxa (95) were recorded here at RM 24.5 (Table B.7.1). The 25 total EPT taxa and 45 sensitive organisms collected approached the highest totals collected in the Little Darby Creek basin. Furthermore, all sites with many sensitive taxa (i.e., 44 to 46) were linked to wide, contiguous woody riparian corridors. This condition promotes habitat stability, increased shading, reduced nutrient inputs and lower mean temperatures) (Figures B.7.14 and B.7.15). A good mussel community was present with many fresh dead Threeridge (*Amblema plicata plicata*), and a live Wabash pigtoe (*Fusconaia flava*) was identified which yielded a site total of 4 bivalve species. Mussel community diversity was probably under represented at this sampling site. Overcast conditions and the thick canopy limited visibility more than usual reducing sampling effectiveness. The habitat upstream consisted of aerated, loose sand predominant in the runs and riffles with coarser substrates also present. This reach, representative of prime clubshell mussel habitat, was similar to upstream at RM 26.5 but with more larger substrates available for colonization and greater diversity of other macroinvertebrates. The temperatures were cooler here at Rosedale - Plain City Rd. than upstream (i.e., 65° to 75° F) This was attributed the extensive riparian canopy which also resulted in a more stable dissolved oxygen regime. Solidifying the riparian corridor and limiting TSS, reducing silt present in some pools, and lowering nutrient inputs through improved riparian habitat in tributaries with adjacent agricultural fields will insure continued exceptional community quality and protect vital habitat throughout this reach.

Just downstream from the Rosedale - Plain City Rd. bridge adjacent to the mouth of Barron Creek previous open pasturing had permitted livestock to trample and break down the banks which eroded further during higher flows. They are now fenced out of the stream. It is recommended that the narrow and limited riparian corridor and areas of open canopy downstream be converted to a wider woody riparian buffer to protect and improve Little Darby Creek stream water quality through this reach and to reduce biological isolation by connecting areas of greater biological diversity.

Downstream from Barron Creek and upstream from Finley Guy Rd. the silt load was observed to be heavy in depositional areas and along the margins away from the current. Riffle embeddedness increased at the next sample site, RM 23.2. An unusual phenomena was observed at this site. Travertine had encrusted the rocky substrates. The macroinvertebrate community was exceptional with similar EPT and sensitive taxa including some new taxa (Figures B.7.12 and B.7.14). Despite some embeddedness and encrusting of the surface that had limited some bottom substrate colonization, an intolerant stonefly (*Agnetina capitata complex*), the cased caddisfly *Protoptila sp.* (I), and the moderately intolerant *Anthopotamus sp.* mayfly were new taxa collected. Similar mussel taxa to upstream (i.e., 4) were collected including three live species: threeridge *(Amblema plicata plicata*), spike (*Elliptio dilatata*), and the kidneyshell (*Ptychobranchus fasciolaris*). All mussel taxa collected were species that need well oxygenated, flowing current and resided in the riffle or run habitats. No pool species were collected where heavier silt deposition had occurred. Again, areas of narrow and limited riparian corridor habitat and open canopy are recommended to be shifted to wider wooded riparian buffers to protect and improve Little Darby Creek stream water quality through this reach and downstream.

A slightly less exceptional quality community was collected downstream at Bradley Rd. (RM 20.5). The ICI recorded here was 48 (Table B.7.1 and Figure B.7.14). Qual. EPT taxa and sensitive taxa declined from upstream (Tables B.7.1 and B.7.2). The mixed patchwork of unprotected banks, some thin and some wide riparian corridor reaches left the mainstem less stable and more vulnerable to increased erosion during higher wet weather flows. As a result, silt contributed to riffle embeddedness. Also, the calcification encrusting the rocky substrates had converted the streambed into a hardened concrete-like surface in the main riffle area. More colonization occurred in the slow run and shallow riffle areas winding through the water willow beds. Sediment was deposited on the top of substrates in pools, but areas with protected bottom surfaces were colonized with higher quality organisms like stenonemid mayflies and *Neophylax* caddisflies. Mussel taxa observed were similar but the diversity decreased compared to sites upstream (Figure B.7.15). Allowing woody vegetation to fill in riparian corridor gaps, increasing riparian width, and stabilizing unprotected banks will improve water quality through this reach. These remedial actions will decrease water temperatures, which was 78° F at sampling, by increased shading, will decrease sedimentation, and will diminish substrate smothering, hardening, or embeddedness which will increase bottom substrate microhabitats.

Spring Fork joined Little Darby Creek upstream from the Little Darby Rd. ford at RM 17.4. Elevated N and P concentrations (>75th and/or 90th percentile versus ECBP background) with algal production (in open canopy) and low night time D.O.s just barely above the EWH minimum 5 mg/l were recorded at Lafayette Plain City Road (8/02). Also elevated fecal coliform and *E. coli* bacteria were recorded there more numerously than upstream with possible NPS livestock input and human inputs (i.e., Greentree MHP WWTP). Numerous continuing water quality violations for TSS, fecal coliform, CBOD and dissolved oxygen have been documented by Ohio EPA.

The macroinvertebrate community in Little Darby Creek scored an ICI of 48 downstream from Spring Fork at Little Darby Rd. at RM 17.0 (Figure B.7.14 and Table B.7.1). Upstream toward the ford the bottom substrates were less hardened consisting mostly of rubble and some coarse gravel interspersed with sand. Downstream of the ford some of the rubble was covered with concretions with interspersed sand, and some hardening or embeddedness in the bottom substrates had occurred. The riparian corridor upstream on the Little Darby Creek mainstem was more intact through this reach than further upstream (i.e., above the last site upstream from Bradley Rd.). As a result of the extended distance from the nearest point source (i.e., the Green Meadows MHP) and the amount of the riparian cover along the Little Darby Creek mainstem, the relative abundance at this site was the lowest at 318 organisms/ft.^{2} (Tables B.7.1 and B.7.2). With the more intact vegetated corridor, increases in quality or diversity were expected. Mussel diversity and the number of sensitive taxa collected in this reach increased significantly as well as the total number of taxa collected (Figures B.7.13, B.7.14 and B.7.15). A higher quality community was present. Ten live mussel taxa were collected in Little Darby Creek in this stream reach (Figure B.7.13). The federally endangered Clubshell mussel (*Pleurobema clava*) was observed in low numbers. Also the wavy-rayed lampmussel, *Lampsilis fasciola*, an Ohio Species of Concern, was collected in this reach. The lack of cooperation from local landowners in providing access to lower Spring Fork hobbled efforts to fully assess environmental conditions there and immediately downstream from the confluence in Little Darby Creek. The ability to sample and monitor lower Spring Fork is necessary to accurately assess the impact of the Green Meadows MHP WWTP to biological communities in Spring Fork and Little Darby Creek. Better knowledge of water resource quality will better protect endangered or very sensitive organisms that have low populations in Little Darby Creek. Conditions that would favor protection of these organisms include a good riparian stream corridor with high quality water and aerated, non-silty, unembedded sandy substrates. Therefore, point source and NPS inputs upstream in Spring Fork need to be minimized.

The reference site near U.S. Rt. 42 (RM 15.4) had increases in EPT and total taxa and, therefore, in the quality in the macroinvertebrate community (Figures B.7.12 and B.7.14). The ICI scored a 50 despite less than adequate flow velocities when retrieved in 2001. The main current had moved to the edge of colonizer. The QCTV value had also increased significantly (Figure B.7.12 and Table B.7.1). A similar ICI score was recorded just downstream in 2002 at RM 15.3. The riparian corridor was uniformly wide, and additional NPS inputs were minimal through this reach to U. S. Rt. 42. Ambient chemical concentrations were similar or less than upstream. Ammonia was not detected and TSS values were reduced.

Downstream from U.S. Rt. 40 and several small WWTPs and Fisher Cast Steel and upstream from the West Jefferson WWTP, the macroinvertebrate community was exceptional with an ICI of 54 at RM 6.4 (Table B.7.1). Excellent habitat development was evident in this stream reach with islands, gravel bars, side channels, water willow in margins and run edges, and big pools. The 46 sensitive taxa collected here was the highest total at any site and reflective of the excellent habitat. Predominant sensitive taxa included *Rheotanytarsus* midges (MI), *Isonychia* (MI), *Stenonema pulchellum* (MI) and *S. mediopunctatum* (I) mayflies, and *Chimarra obscura* (MI) and *Neophylax* (I) caddisflies. Some sensitive mussels observed were the intolerant wavy-

rayed lampmussel (*Lampsilis fasciola*) and plain pocketbook (*L. cardium*) and the moderately intolerant rainbow (*Villosa iris*) and spike mussels (*Elliptio dilatata*). Habitat protection, a limit to municipal inputs and storm water controls upstream and adjacent to West Jefferson are needed to protect this reach of Little Darby Creek upstream from the West Jefferson WWTP.

Downstream from the West Jefferson WWTP near Roberts Rd. (RM 3.8) an exceptional macroinvertebrate community was still present with an ICI of 52, but the community was nutrient enriched (~ 1400 organisms/ft.^{2}) at almost three times the relative density found upstream. Filtering *Rheotanytarsus* midges accounted for over 45% of the community with greater than 3000 organisms collected (Tables B.7.1 and B.7.2 and Figure B.7.10). There was some foam on the water surface downstream from the riffle. An antiseptic odor from the treated wastewater effluent was also observed. The community quality had decreased significantly from upstream due to periodic solids and overflow problems from the wastewater treatment plant. The number of qualitative and sensitive organisms downstream from West Jefferson WWTP decreased significantly (from 23 to 33 %, respectively). Furthermore, only two mussel taxa were collected downstream from West Jefferson WWTP - a 78 percent reduction in mussel diversity which indicated some water quality instability and episodic impacts (Figures B.7.13 and B.7.15). Plant and infrastructure improvements are needed to improve WWTP quality, decrease nutrient inputs, and protect downstream biological integrity and diversity below West Jefferson WWTP and further downstream into the park property and Big Darby Creek.

Downstream in the Battelle-Darby Metropark near the mouth at RM 0.5 an ICI of 56 and a decrease in relative density (i.e., to 842 organisms/ft.^{2}) indicated recovery from most West Jefferson municipal inputs (Table B.7.1 and Figure B.7.10). The QCTV value of 41.9 and the significant increase in sensitive taxa further confirmed the higher quality exceptional community present (Tables B.7.1 and B.7.2 and Figure B.7.14). The lower number of mussels in this reach could be due to the relative short time since dam removal and/or substrate movements, stability or quality. Mussel colonization in this lower reach also might be a slower process due to possible contamination from long-term deposition within the previous dam pool that has not yet been flushed downstream (Figure B.7.15).

Little Darby Creek Tributaries

Clover Run (02-218) (RM 39.8) (EWH/WWH Recommended)

Clover Run water quality was very good at the Maple Grove Cemetery (RM 0.6). Some intact wooded riparian areas on nearby hills and surrounding the cemetery positively influenced water quality. High quality sensitive organisms predominated in the riffle, run and margin habitats. The EPT taxa total collected here was similar to the most upstream Little Darby Creek site which had a similar drainage area. A couple of coolwater taxa were still present despite some open canopy areas adjacent to row crop agriculture further upstream. Elevated fecal coliform and E. coli bacteria counts were detected, but nutrient inputs were mostly at median background levels. Small amounts of sediment had accumulated at this site. The flashy nature of the stream had resulted in some bank erosion. Some of the sediment may also have come from upstream.

If a wider riparian buffer was allowed to become established which would decrease TP and silt Clover Run would improve to even higher quality.

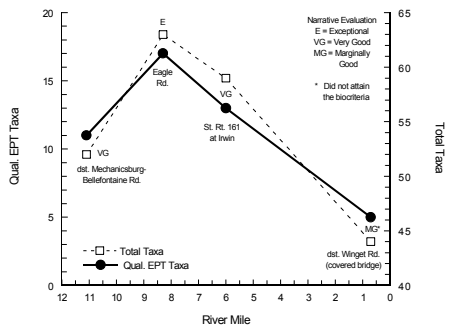
Lake Run (02-216) (RM 36.9) (EWH/EWH Deferred)
Lake Run was a small, rocky, cooler (~ 60º F) stream that drained into Little Darby Creek at RM 36.9 (6 mi.^{2} drainage). A nice riparian corridor was present downstream from St. Rt. 4 (RM 0.9) and a short distance upstream. Above that short upstream reach a golf course was built adjacent to both sides of the stream. Some clayey sediment had accumulated in the pools and on rocky substrates in other areas from post-construction NPS sedimentation. Attached benthic growth was present on the rocks, but the density of the macroinvertebrate community did not indicate enriched conditions. All nutrient inputs were at median levels except for elevated bacteria concentrations and ammonia, which was >75th percentile to >90 percentile concentration vs. ECBP background. The highest number of *Pycnopsyche* caddisfly cases were observed. However, all were empty, and all of the *Neophylax sp.* cases observed or collected had already hatched and were empty also. Twelve EPT taxa were collected in this EWH deferred stream which was determined to still be of very good quality despite the excess sediment present. Further improvements in community quality should occur as the sediments contributed by the construction activities are flushed or stabilized.

Jumping Run (02-217) ((RM 3.9) (EWH/WWH Recommended)
Jumping Run was a small headwater stream (i.e., 2.4 mi.^{2} drainage) that emptied into Lake Run at RM 3.00 north of Mechanicsburg. The sample site downstream from St. Rt. 559 (RM 0.2), mainly consisted of pools with bottoms of unconsolidated sediments and some detritus from agricultural sources. Included in this segment was a rocky riffle comprised of cobble, smaller substrates along with some woody debris. A decent forest corridor downstream ameliorated some upstream NPS inputs (i.e., sediment or some nutrients). Cooler temperatures (66º F) probably helped to maintain instream D.O. based on the macroinvertebrate community present. Eight EPT taxa and 37 total taxa were collected. Jumping Run met the biocriterion for its recommended WWH aquatic life use.

Treacle Creek (02-213) (RM31.3) (EWH)
Treacle Creek downstream from Mechanicsburg-Bellefontaine Rd. at RM 11.7 was still in very good quality condition despite siltation from open pasturage upstream and streamside row crop agriculture that encroached on the riparian buffer along one shoreline. Several spots on the bank were filled with riprap where the bank had become destabilized and erosion had occurred. Due to these factors a layer of silt 1/4 to 1/3 inch thick covered rock surfaces in the pools and slow runs. Cooler instream water temperatures (i.e., 53º F), a mostly covered canopy, and a variety of substrate and margin habitat types somewhat counterbalanced the impact of silt. At least one-third of the 52 taxa observed were sensitive, but the diversity of baetid mayflies and stoneflies were limited or not collected. When some action is taken to decrease or eliminate sediment inputs, this stream reach that marginally met the EWH biocriterion should improve greatly.

Community quality improved at Eagle Road (RM 8.3) to exceptional despite some embeddedness in the riffles and runs upstream from the bridge. The source of the sedimentation was from further upstream. Siltation in the downstream pools was from recently completed bridge work. There was a wider riparian corridor at this site with nice development upstream. Downstream portions of this site was recovering from historical channelization. This site was more diverse with sensitive *Chimarra aterrima* caddisflies, *Rheotanytarsus sp.* midges, *Neophylax sp.* caddisflies, *Elimia sp.* snails, and facultative stenonemid mayflies predominant in the riffle/run/pool complexes. The highest total taxa and EPT taxa in Treacle Creek were collected in this reach (Figure B.7.17). Control of sediment was still an important issue.

Figure B.7.17. Longitudinal trends in Qual EPT taxa and total macroinvertebrate taxa found in Treacle Creek in 2001.



Near Irwin Rd. (RM 6.0) the macroinvertebrate community decreased to very good which still marginally met the EWH biocriterion. However, open pastures upstream had caused bank instability from riparian corridor loss or elimination, erosion, and siltation and deposition in pools and runs. Therefore, there were primarily smaller substrates present. Downstream there was a reach with deep channelized pools where agricultural crop land was directly adjacent to the right bank. However, the narrow riparian corridor that formerly stabilized the right bank had recently been removed as evidenced by slash and trees lying in the channelized pool. There were elevated *E. coli* counts as high as 2300 colonies /100 ml. The highest TSS concentration collected (134 mg/l) was a full order of magnitude higher than upstream and greater than the 95th percentile versus ECBP background conditions. Nitrates and TKN concentrations were also very elevated (>75th percentile compare to ECBP background). As a consequence the number of EPT taxa decreased by about 25 percent and the QCTV decreased significantly to a similar value as the RM 11.7 site which was also narratively scored as very good (Table B.7.2). Leaving a decent riparian buffer and fencing out livestock will decrease significantly the nutrient and sediment inputs and improve water and community quality.

The biological performance downstream from Winget Rd. and the covered bridge (RM 0.8) did meet the biological criterion. Treacle Creek upstream was inhabited by cattle in open pastures with no buffers and slumped and eroding banks. The channel downstream was flanked by 20 to 35 feet of more mature wooded riparian buffer with row crop agriculture beyond. Instream there was still some entrenchment in the previously widened channel. The solid substrates have a thick layer of silt and solids with embeddedness common. Woody debris was the primary hard substrate still available, as the bottom substrates were of medium to soft consistency (i.e., clay to silts). A less sensitive macroinvertebrate assemblage persisted in this reach which was affected by NPS inputs of sedimentation, excess nutrients, and low minimum diel D.O.

violations. Fecal coliform and E. coli counts >10400 colonies/100 ml., and ammonia, nitrate, TSS, nitrite, and TKN were above the 75th or 90th percentile compared to ECBP background values. Only five EPT taxa were collected here with 30 percent fewer taxa overall than the highest quality sampled site. The midge community was predominated by more facultative species like *Polypedilum flavum* and *Tribelos* spp. and also more tolerant taxa like *P. (P.) illinoense*. Increased NH_3 and other nitrogenous compounds were documented at this site. Some high quality coolwater midges (*Paratanytarsus n. sp. 1*, *Micropsectra sp.*, and *Parametriocnemus sp.*) were still present in the 54º F water. Other sensitive organisms, like moderately intolerant *Chimarra* and *Ceratopsyche* caddisflies and giant floater mussels (*Pyganodon grandis*), were still present because of the available canopy shaded a good portion of Treacle Creek and the cooler water temperatures in concert ameliorated some of the NPS impacts. The marginally good macroinvertebrate community present needed decreases in sedimentation and the other NPS-related nutrient inputs mentioned above to allow an improved community to flourish and meet the EWH biocriterion.

Howard Run (02-215) (RM 5.4) (EWH)

Howard Run at McMahill Rd. (RM 0.6) was a small stream partially recovered from past channelization. It has developed fairly good meanders upstream as a consequence of the good gradient present. A fair amount of peat and filamentous algae was present on the coarse substrates with some dark silt covering the bottom. Shrubs (10 ft.) and grass (25 ft. wide) comprised the thin riparian corridor. Siltation lowered quality modestly, but sensitive organisms were still predominant in the riffle, run and pool habitats (i.e., *Chimarra obscura* (MI) and *Neophylax sp.* caddisflies and the river snail *Elimia sp.*). Cooler water and largely closed canopy helped to lessen the impacts from NPS inputs. The macroinvertebrate community very marginally met the EWH biocriterion. Reducing siltation, widening the woody riparian corridor and permitting natural recovery from past channelization would improve the benthic community quality of Howard Run. These steps in turn would also reduce sedimentation and nutrient inputs to Treacle Creek (present sampled concentrations for nitrate were >90th percentile and TKN at >75th percentile versus ECBP background conditions).

Proctor Run (02-214) (RM 3.69) (EWH)

Proctor Run was sampled at three locations. Upstream at Park Rd. (RM 4.9) coarse substrates in riffles and runs were covered with a fairly uniform layer of fine dark brown silt. The short segment between the bridges may have been modified in the past. The water quality was still very good despite some issues with the resident macroinvertebrate community marginally meeting the EWH biological criterion. High quality sensitive organisms, like *Neophylax* and *Chimarra aterrima* caddisflies and *Stenonema vicarium* and *Diphetor hageni* mayflies, were among the predominant or common taxa in the sampled habitats. Raw sewage from septic tanks just upstream of the riffle lowered the macroinvertebrate community performance. Elevated TSS, ammonia, and TP concentrations were observed here exceeding the 75th and 90th percentile vs. ECBP background. Flatworms and blackflies were present in the riffles and runs with a low density of tolerant *Chironomus (C.) decorus* in the downstream pool. Tolerant *Physella* and *Helisoma* snails were the organisms predominant in the margins.

Near St. Rt. 559 (RM 3.2) Proctor Run was primarily a channelized grass-lined stream with mostly pea gravel and sandy substrates. The water was clear with a fairly good gradient forming occasional riffles. The upstream riffle had large amounts of rubble and consequently many more organisms. In fact, the high riffle density of macroinvertebrates and the greatly increased filamentous algal growth present indicated slight nutrient enrichment with many nutrient parameters at median to >75th percentile vs. ECBP background. The riparian width was still at least 25 feet or greater, but the sand and sediment bedload had increased. The source of the very high fecal coliform bacteria counts (i.e., >40,000/100 ml.) measured here could have been agricultural runoff and/or from failing septic systems. The macroinvertebrate community was very similar in quality to upstream despite the open canopy. The very good community marginally met the EWH biocriterion.

At McMahill Rd. (RM 1.7) this wooded stream reach was in exceptional condition. Due to closed canopy and a 40 - 150 ft. riparian corridor NPS nutrient inputs were minimized and ambient nutrient concentrations were at the median background concentrations. Proctor Run at this location was a picturesque, small to medium sized stream with coarse substrates. There were 22 mayfly and caddisfly taxa collected. Primarily sensitive benthic organisms were predominant or common in most habitats. Sensitive predominant organisms included *Chimarra aterrima* and *Neophylax sp.* (I) caddisflies and *Stenonema vicarium* and *S. mediopunctatum* (I) mayflies. A rare midge, *Eukiefferiella brehmi gr.*, was also collected among the high quality midge community present. Upstream community quality in Proctor Run could improve to exceptional quality if buffer protections and failing septic systems were improved.

Barron Creek (02-212) (RM 24.4) (EWH/WWH Recommended)

Barron Creek at RM 2.1 was a cool groundwater recharged stream (~ 60° F) that flows through an area of intensive row crop agricultural land use. Past channelization in the upper reach had occurred. The canopy was open with groomed grass buffer strips. Excess NPS nutrient inputs caused enrichment with gross algal production and a large biomass of aquatic macrophytes present. Substrates in the bottom of shallow pools were black and with little oxygen content from accumulated decayed detritus. In portions of the stream with open canopy all organisms were observed in areas with flow primarily on top of rocky substrates in the upper pools and upper margin edges (grasses). Other areas were not inhabited. Tolerant hydrobiid and planorbid snails and leeches were common at low densities in the open canopy pools. In contrast, under the bridge there was a better quality community in the shaded canopy, as the flow and cooler water temperatures provided a more amenable environment. Eight EPT taxa were collected in this soft shaded reach, including Pycnopsyche sp. and an intolerant stonefly, *Agnetina capitata complex*. The river snail, *Elimia sp.*, was the predominant macroinvertebrate in the riffle and rocky pools of this small refuge area. The cool groundwater recharge to Barron Creek ameliorated more severe impacts to the open canopy area of the stream which comprised most of the stream near Rosedale - Plain City Road. Barron Creek could harbor a higher quality macroinvertebrate community with a wooded riparian buffer. This canopy would provide essential shading and absorb some NPS runoff nutrients to reduce primary production which would significantly reduce the decaying algal/aquatic decaying biomass. This would have the

consequence of raising D.O. concentrations and protecting the resident macroinvertebrate communities.

Barron Creek near the mouth (RM 0.1) was impacted by livestock in an open pasture. Unvegetated banks had collapsed and a large amount of silt covered the rocky substrates and lowered water quality conditions at the stream bottom. TSS was recorded here as high as 48 mg/l (>90th percentile compared to ECBP background), and other NPS nutrient inputs, including nitrites, NH3, TKN, P, from upstream row crop agriculture and/or livestock inputs were >75th percentile to >90th percentile compared to ECBP background conditions. Cattle waste was present instream, as the fecal bacteria concentrations had counts as high as 60,000 and 80,000 / 100 mls.. Despite the turbid and silty conditions enough quality benthic organisms were still present and predominant in the slow run/pool sampled, that the narrative evaluation was marginally good. Fencing out livestock and stabilizing banks with a widened woody riparian corridor would improve water quality and biological diversity in lower Barron Creek and downstream below the confluence at RM 24.4 in a pivotal and environmentally sensitive reach of Little Darby Creek.

Wamp Ditch (02-363) (RM23.0) (Undesignated./MWH Recommended)
Wamp Ditch was sampled near the mouth downstream from Vogelsburg Rd. (RM 0.1) Upper Wamp Ditch drains primarily agricultural land and flowed through a 1/4 - mile long partially groomed, grass buffer (30-50 yards wide) into and through a small open pasture into Little Darby Creek at RM 23.0. There was evidence of nutrient enrichment. Pool bottoms were blackish with rotting algal detritus which precluded the use of the bottom substrates by the macroinvertebrate community. However, decent macroinvertebrate community diversity was still present on the available rocky substrates. Several higher quality cased caddisflies were collected yielding a total of nine EPT taxa. The snail-cased caddisfly *Helicopsyche borealis*, the river snail *Elimia sp.*, water pennies, and fingernail clams were either predominant or common in the riffle and runs. Scuds and corixids were also predominant, and the high densities of all of these organisms collected at all sampled habitats indicated nutrient enriched conditions. Despite the agricultural NPS influences the stream still yielded a marginally good community. Cooler water temperatures (61° F) from groundwater recharge lessened some enrichment effects. Decreasing NPS nutrient inputs and increasing shading adjacent to the stream would reduce algal production and would stabilize diel D.O. concentrations in the pool bottoms. This would allow for higher water quality instream and increased biological diversity. Higher quality water with lower nutrients and algal inputs and more stable dissolved oxygen concentrations would then flow into this sensitive area of Little Darby Creek.

Spring Fork (02-211) (RM 17.46) (EWH)
Spring Fork was sampled at five locations to more fully assess this confirmed EWH tributary of Little Darby Creek. Access at a historically sampled site at Lafayette - Plain City Rd. was denied, so the lower two miles were not re-assessed based on recent data.

Spring Fork upstream from Wren Rd. (RM 15.8) was of good quality but did not meet the EWH biocriterion. The lack of more caddisfly and dipteran diversity (low taxa totals) and a less

sensitive community present pointed toward lowered quality (Figures B.7.18 and B.7.19). Only eight EPT taxa were collected. NPS nutrient inputs had occurred as the parameters, from TSS (21 mg/l) to TKN (1.06 mg/l) and TP (0.15 mg/l) ranged from >75th percentile to >90th percentile compared to ECBP background conditions. Other evidence also indicated NPS nutrient inputs. Fecal coliform and E. coli counts were elevated. Tolerant *Physella* snails or facultative taxa, like *Stictochironomus sp.* midges, were predominant or common in the runs, pools and margin and also indicated a community of warmwater quality. Other tolerant taxa collected included leeches and more tolerant dragonflies. The QCTV (36.2) was lower than the value typically associated with an exceptional macroinvertebrate community.

Spring Fork community quality improved downstream near State Route 29 (RM 13.3). Increased community diversity and quality (13 EPT taxa and 58 total taxa) was present, as the number of sensitive taxa collected doubled (Figures B.7.18 and B.7.19). A few sensitive taxa collected included the intolerant mayfly *Pseudocloeon frondale*, the Cylindrical Papershell mussel (*Anodontoides ferussacianus*), *Ceratopsyche C. morosa gr.* caddisflies, and several moderately intolerant midges (e.g., *Tvetenia bavarica*, *Nilotanypus fimbriatus*, and the cool water *Parametriocnemus sp.*). There were increased densities of filterers with facultative taxa predominant and increased periphyton, present in response to similar continued NPS inputs upstream. A more consistent and wider woody riparian buffer upstream would help limit nutrient inputs, lower instream water temperatures, and better protect water quality.

Figure B.7.18. Longitudinal trends in the Invertebrate Community Index and the number of Sensitive Taxa collected in Spring Fork in 2001.

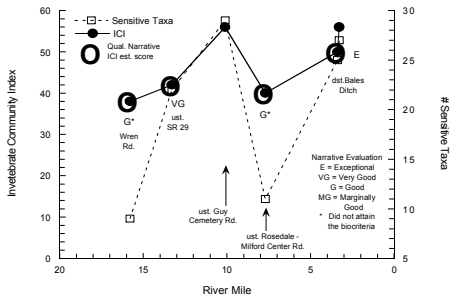
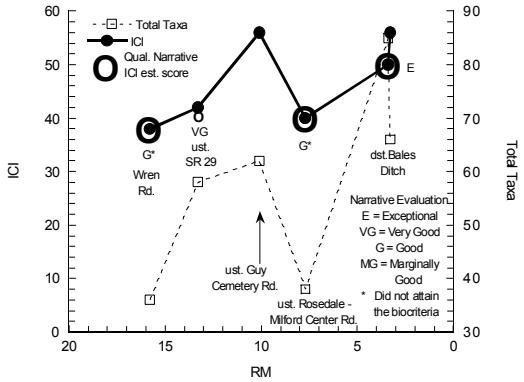


Figure B.7.19. Longitudinal trends in the Invertebrate Community Index and the total number of taxa collected in Spring Fork in 2001.



Good but intermittent riparian corridor present along Spring Fork upstream from Guy Cemetery Rd. was sufficient quality to still support an exceptional warmwater macroinvertebrate community. The ICI at RM 10.1 was 56 with a high quality community present. Where the stream buffer was limited, increased high flow storm water inputs had caused erosion through destabilized banks and increased the sediment/sand bedload. The accumulation sand and silt in the margin, runs, and pools had covered some of the rocky substrates and decreased habitat

quality. Where the permanent, stable rocky substrates were present and not covered or embedded by silt or sand, there was a diverse sensitive community present. Failing to connect woody riparian buffers will continue to allow erosion, sedimentation, and nutrient inputs to destabilize Spring Fork habitat.

A decrease in total taxa and the number of sensitive organisms present occurred downstream in Spring Fork near Rosedale - Milford Center Rd. (RM 7.7) (Figures B.7.18 and B.7.19). The baetid mayfly population decreased from upstream. There was some decent riparian area on the left bank for a short distance upstream from the sampled area, but the channel was choked with sediment. Upstream right was a hay field and/or an open pasture. Row crop agriculture was adjacent to the left bank upstream. NPS nutrient and sediment inputs were increased in this reach, as nitrate (5.06 mg/l) and other parameter concentrations were greater than the 75th percentile to >90th percentile compared to background. TSS was at the highest measured concentration (32 mg/l) in Spring Fork at this site. Also an *E. coli* concentration of 58,000/100ml. was measured and indicated manure inputs. Only eleven EPT taxa were collected compared to 20 total EPT taxa upstream. The number of sensitive and total taxa collected decreased, as the inhabitable areas on wood and rock substrates that were not embedded by sediment was very limited. Also all of the caddisfly cases were empty. Quality conditions apparently worsened in late summer and triggered a complete hatch. Facultative organisms, such as riffle beetles, the red midge *Stictochironomus sp.*, fingernail clams, corixids and *Stenacron* or *Stenonema femoratum* mayflies were predominant in all sampled habitats. This community structure indicated good, but not exceptional community quality. Decreased sedimentation and increased bank stabilization via exclusion of livestock with riparian corridor widening would be recommended actions for improving Spring Fork water quality and to attain the EWH biocriterion in this reach.

Downstream from Bales Ditch there was an exceptional community present at RM 3.4 and RM 3.3. The previous year to sampling (2001) a beaver pond had still impounded Spring Fork here and was breeched by high flows the next year. The treed riparian corridor on the east bank was removed to prevent the reestablishment of the impoundment. So the stream channel was not quite as defined at RM 3.4, and a second set of colonizers were set downstream in the more defined channel. Similar results were observed, as the macroinvertebrate community at RM 3.4 was narratively assessed as exceptional, and the sample at RM 3.3 scored an exceptional ICI of 56. There was some increase in density (754 organisms/ft.^{2}). Also aquatic macrophytes covered most margins and filled the slow run channel. Sediment from upstream NPS inputs (i.e., erosion and runoff from agriculture fields) had accumulated in the impoundment area and had caused some embeddedness. Silt deposition had also covered the tops of most rock substrates and most of the aquatic macrophytes present. Some high flow scouring and erosion had already occurred where the adjacent woody riparian corridor had been removed. The reestablishment of a consistent wooded riparian corridor in this lower section of Spring Fork would protect against erosion, shade the stream, and absorb and limit the impacts of nutrient inputs and siltation which, if unchecked, could destabilize the exceptional Spring Fork water quality.

Downstream from Green Meadows MHP WWTP there was a violation or near violation of the mean instream D.O. concentration on 22 August 2002 at Lafayette - Plain City Rd. (RM 0.75). Numerous elevated fecal bacteria concentrations were recorded, and all nutrient parameters, especially ammonia (not recorded elsewhere in Spring Fork) were elevated overall to the highest collective concentrations observed in Spring Fork (>75th or >90th percentile compared to ECBP background conditions). This indicated nutrient enrichment and associated low diel D.O. concentrations, as the accumulated algal biomass decayed. Numerous violations of dissolved oxygen, TSS, cBOD, and fecal coliform bacteria have continued to be documented (M. Gallaway, personal communication - 11/21/2003). The biological conditions were not assessed in this reach as planned, because access was denied. Due to the sensitivity of lower Spring Fork and the vitally important habitat in Little Darby Creek immediately below the confluence at RM 17.4, it is imperative to adequately sample downstream from Green Meadows MHP to assess its potential impact to Spring Fork and Little Darby Creek and protect downstream habitat and water quality.

Bales Ditch (02-362) (RM3.64) (Undesignated/ WWH Recommended)

Bales Ditch at Rosedale - Milford Center Rd. (RM 0.4) was a small cooler (62° F) tributary to Spring Fork that drained an area west of Plumwood and emptied into Spring Fork at RM 3.64. Despite some past channelization, the good macroinvertebrate community present in this partially recovered stream met the WWH biocriterion. There was a decent riparian corridor of grass - lined banks for 20-30 feet with some small trees and bushes for greater than 30 yards on both banks. Algal accumulation on the rocky substrates with some black organic detritus present in some pools confirmed NPS nutrient inputs upstream (i.e., nitrate at 8.28 mg/l which was >95th percentile with other nitrogenous parameters at >75th percentile compared to ECBP background conditions). Ten EPT taxa and 53 total taxa were collected with mostly sensitive organisms predominant in the riffles and pools (*Helicopsyche borealis* caddisflies, *Elimia* snails, water pennies, and riffle beetles including *Optioservus fastiditus*). Other high quality taxa collected included a small *Leptophlebia* / *Paraleptophlebia* mayfly, the caddisfly *Chimarra obscura*, and several moderately intolerant midges. Preserving and strengthening the riparian corridor upstream will keep and improve the macroinvertebrate community quality in Bales Ditch and improve the water quality input into Spring Fork.

Hellbranch Run and Tributaries

Hellbranch Run (02-204) (RM 26.1) (WWH)

Hellbranch Run, formed at the confluence of Hamilton Ditch and Clover Groff Ditch, was sampled at six sites, and the scores ranged from good to an exceptional score of 50. The upstream sample site was two miles below the confluence and well downstream from Alton Rd. at RM 9.4. There was a fairly good woody riparian corridor adjacent to both banks, but siltation from upstream sources still was affecting substrates. There was some algal production and slight enrichment from elevated nutrients (i.e., TKN and TP at >90th percentile and all other nutrient parameters were >75th percentile vs. ECBP background). The moderately intolerant tanytarsini midges were predominant *(Rheotanytarsus sp.*, *R. pellucidus*, and *Tanytarsus*

glabrescens group Type 7 midges) in the riffle, run and pool habitats. The tanytarsini midges together comprised over 50 percent of the total benthic organisms collected with a combined weighted average ICI of about 44. Besides the predominant *Rheotanytarsus* and *Tanytarsus* midges, there was also good mayfly and caddisfly colonization, and the actual ICI scored at this site was a 46 (exceptional). This score occurred despite an increased *Hydra* and flatworm population (artifact of the more open, pooled conditions upstream, excess nutrients and the subsequent presence of suspended and settled solids of algae and some other organic solids). Decreased upstream NPS siltation inputs and more riparian shading further upstream would further benefit stream quality and allow diversity to increase.

The Hellbranch Run macroinvertebrate community improved near Kunz Rd. at RM 7.4. Silt embeddedness was still an issue, but the habitat overall had improved. The nutrient inputs were decreased from upstream concentrations to median levels (compared to ECBP background conditions). Seventeen EPT taxa were collected, and nearly 42 percent of all taxa found were categorized as sensitive (i.e., moderately intolerant or intolerant). Tanytarsini midges, *Baetis* mayflies, and *Cheumatopsyche sp.* caddisflies were predominant with good density and diversity of other mayflies present (the common *Stenacron sp.* and the intolerant baetid mayfly *Acerpenna pygmaea* to the less represented *Stenonema pulchellum* (MI) and intolerant *S. exiguum*). A decrease in NPS silt inputs via storm water and/or unprotected banks eroding and wider riparian corridors would allow even greater diversity and quality in this reach of Hellbranch Run.

Hellbranch Run macroinvertebrate community quality decreased to good downstream from Oakhurst Knolls WWTP (RM 5.7) and adjacent to the golf course. Only TKN and TP concentrations were consistently >75th percentile with one TP spike of 0.307 mg/l, which was likely linked to post-storm water runoff, that was >95th percentile compared to ECBP background conditions. The *E. coli* bacteria counts were elevated and at higher values than other Hellbranch Run sample sites. The number of sensitive organisms significantly decreased compared to the previous upstream sample site. This was the only benthic invertebrate site that did not at least marginally attain the Exceptional Warmwater Habitat criterion. Periodic inflow and infiltration issues need addressed and resolved at the Oakhurst WWTP to prevent possible bypasses/spills of partially treated or untreated waste. Nutrient runoff from the golf facility could also be affecting the macroinvertebrate community downstream, and care needs to be taken when applications of nutrients or herbicides/pesticides might occur (e.g., upcoming weather conditions) to prevent runoff into Hellbranch Run.

Better developed riffles with large rubble and boulder substrates were present downstream from Beatty Rd. (RM 3.7) with *Chimarra* and Hydropsychid caddisflies, Baetid mayflies, *Caenis* mayflies and Tanytarsini midges predominant. *Elimia* snails, riffle beetles, and hydroptilid caddisflies were also predominant in the run or other habitats. The highest ICI score of 50 was recorded here. Sixty-two percent of the collected taxa were sensitive organisms. The density in this reach was less due to decreased nutrient inputs with most parameters at median levels compared to ECBP background conditions and decreased algal production from the more mature, treed, riparian corridor that shaded Hellbranch Run from an almost complete stream

canopy. Algal production had occurred where direct sunlight was still prevalent coloring the water greenish-brown. Some siltation was still evident and the observed embedded substrate conditions reduced the abundance of stenonemid mayflies with very few collected. Continued efforts to decrease NPS sediment and nutrient inputs should permit even greater water quality and biological diversification.

Downstream from Lambert Rd. (RM 0.9) a diverse macroinvertebrate community was collected with 16 qual. EPT taxa and 80 total taxa collected. *Chimarra* and hydropsychid caddisflies, baetid mayflies, riffle beetles and *Elimia* river snails were the predominant organisms in this very good or *marginally exceptional* community. Unfortunately additional siltation had caused more embeddedness and some soft depositional substrates in pool bottoms and along some margins. Chemical inputs had caused more suspended algae and attached algal matter in the runs. Possible sources include a small school WWTP upstream and/or adjacent agricultural fields. The excessive number of snails yielded an imbalanced or skewed community. With reductions in sediment inputs and wider riparian partitions to capture runoff constituents, the less abundant, sensitive, benthic organisms present will become more populous with reduced chronic stressors. More intolerant stenonemid mayflies should appear with less siltation and embeddedness.

Hellbranch Run downstream from the Timberlake Subdivision WWTP toward the mouth (RM 0.5) was sampled in 2001. This WWTP has a history of poor plant management and no plant maintenance. Highly elevated NH_3 , TP, and TKN concentrations were recorded downstream along with minimum low D.O. violations. A very good macroinvertebrate community was observed that was lower in EPT taxa and overall diversity. Stenonemid mayflies were not found, and leptocerid caddisflies were less abundant. Algal production had decreased some but the substrates were highly embedded from accumulated silt.

Another colonizer was set at RM 0.5 in 2002 because it was lost in 2001. Due possibly to increased scrutiny on the WWTP operations, the macroinvertebrate community quality appeared slightly better but was still categorized as Very Good. The number of EPT taxa and sensitive taxa had increased, including *Stenonema exiguum* (I) and (MI) *S. pulchellum* and several sensitive midges. Also, three mussel taxa were noted in this lower reach: the Wabash Pigtoe (*Fusconaia flava*), the creeper (*Strophitus undulatus*), and the rainbow mussel (*Villosa iris iris*). With the Timberlake Subdivision WWTP tying into a regional WWTP by 2005, improvement to a solidly exceptional macroinvertebrate community downstream would likely occur soon after tie-in had occurred. Sediment accumulation along with nutrient inputs would still be the biggest detriment to deal with in the lower Hellbranch Run.

Clover Groff Ditch (02-245) (RM 11.19) (WWH)

Clover Groff Ditch, the eastern tributary contiguous with Hilliard and metropolitan Columbus, was sampled at Roberts Rd. (RM 4.7). Accumulated sediment trapped in the modified, entrenched channel covered most rocky substrates and neutralized most of the habitat, and gray septic storm water inputs from the adjacent suburban area collectively caused enriched conditions that were likely periodically toxic. The Modified Warmwater Habitat biocriterion

was not met, as poor macroinvertebrate community performance was documented. The poor quality community present had no mayflies or caddisflies, and approximately 37 percent of the taxa collected were tolerant to various negative effects. Numerous elevated fecal bacterial counts were measured, and NPS parameters like ammonia (**0.278** mg/l), nitrite (0.05 mg/l) and TP (**0.912** mg/l) were greater than the 90th or the 95th percentile compared to ECBP background conditions. These same parameters and also TKN had consistently exceeded the 75th percentile of ECBP background conditions. Predominant organisms were increased numbers of filtering midges *Polypedilum flavum* and *Glyptotendipes (G.) sp.* and fingernail clams which inferred enriched conditions. Leeches, tolerant of periodic low dissolved oxygen, were common in all habitats and was one of the predominant pool organisms. Steps to hold, slow down and/or treat NPS municipal storm water runoff should be considered to improve the quality of Clover Groff Ditch. Decreased upstream sedimentation would allow flushing and utilization by the macroinvertebrate community of some of the rocky or firm substrates present in the bottom substrates but currently buried or covered.

Clover Groff Ditch sampled downstream near U.S. Rt. 40 at RM 0.8 scored an ICI of 20. This biological score did not attain the WWH biocriterion, though the macroinvertebrate community quality was much improved with six EPT taxa and more sensitive taxa present. Embedded natural substrates was one factor that limited the population diversity and size. The lower population density collected (167/ft.^{2}) was expected given the more closed riparian corridor and canopy upstream from the sample site. Other possible adverse inputs affecting this downstream macroinvertebrate community were: upstream inputs from discharges (i.e., Cypress Wesleyan School WWTP at RM 1.30 which had poor plant maintenance and discharge flows double of plant capacity, failing on-site septic systems discharges, and NPS nutrient inputs. Some elevated *E. coli* concentrations indicated the presence of some form of organic waste inputs. The highest recorded NH_3 and TP concentrations were still >90th percentile vs. ECBP background, and all nutrient parameters including ammonia, nitrite, TKN, and TP were commonly >75th percentile compared to ECBP background conditions. With orders for the Cypress School discharge to be connected to the city of Columbus sanitary sewer and upstream construction slowing, any riparian corridor widening and reductions in sedimentation would allow improvements in water quality and in the macroinvertebrate community.

Hamilton Ditch (02-259) (RM 11.19)

Hamilton Ditch, the more rural western tributary forming Hellbranch Run, was sampled upstream from Walker Rd., at RM 3.4. Upstream influences were agriculture with a portion of the stream adjacent to some single lot homes. More building of subdivisions is ongoing a couple of miles upstream from Walker Rd. The stream segment sampled was channelized in the past and was still mostly straight and entrenched typical of a Modified Warmwater Habitat Stream segment. The slow current combined with the physical limitations of entrenched channels resulted in trapped sediment. So the channel substrates were partially embedded with silt/sediment decreasing the available rocky or hard substrates. There still was some cobble, a little rubble, and some wood with some smaller gravel usually covered in silt. Values of **140** mg/l and **96** mg/l **TSS** were among the highest, if not the highest concentrations collected during the survey (>95th percentile or higher compared to ECBP background conditions). A

small area with collapsed banks formed a faster riffle area, and *Rheotanytarsus sp.* midges and hydropsychid caddisflies were resident there. This indicated some potential if natural stream development could occur. Some *Oecetis* pupae were attached to larger cobble or rubble in the run where larger rocky substrates were not affected by accumulated sediment. These were the only two EPT taxa collected, and only four organisms present were categorized as moderately intolerant. Predominant organisms were water boatmen, *Rheotanytarsus sp.* midges, *Oecetis* caddisflies, and dragonflies. Tolerant organisms, though, comprised 33 percent of the taxa collected in response to the extremely elevated agricultural and municipal NPS chemical inputs. Ammonia (**0.40** mg/l), TKN (**1.61** mg/l), and TP (**0.443** mg/l) had concentrations that exceeded the 95th percentile, and all of the other common nutrient parameter measurements except nitrate exceeded the 90th or the 75th percentile compared to ECBP background conditions. The fair macroinvertebrate performance met the MWH biocriterion, but by decreasing the NPS sediment, organic, and chemical inputs and allowing some natural stream development Hamilton Ditch water quality could greatly improve.

At RM 0.5 Hamilton Ditch upstream from U.S. Rt. 40 attained the WWH biocriterion with an ICI score of 40. There was eight EPT taxa collected including a stonefly, and the midge community had fairly good diversity. Attainment occurred despite a low gradient, pool and slow run habitat (lack of riffles) with silt and clay substrates that was prevalent in that reach. Slow current had likely reduced mayfly and caddisfly colonization. Predominant organisms in the "riffles" and runs from qualitative sampling were tanytarsini midges and other midges, and the stick-cased Leptocerid caddisfly *Mystacides sepulchralis*. The number of tolerant and facultative organisms like oligochaete worms, isopods, and *Physella* snails will decrease with decreased NPS inputs upstream. The nutrient parameters were lower than upstream but still very elevated (NH_3, TKN, and TP) to the 90th percentile vs. ECBP background conditions in some nutrient parameters.

Lower Big Darby Creek Tributaries (downstream from Little Darby Creek to the mouth)

Smith Ditch (02-353) (RM 31.69) (Undesignated/WWH Recommended)

Smith Ditch, a tributary to Big Darby Creek that enters downstream from the Little Darby Creek confluence, was sampled near Georgesville-Wrightsville Rd. at **RM 2.1**. There was an exceptional macroinvertebrate community present with the high quality habitat supporting a diverse, sensitive community. Cobble and boulders were present with deep pools ($\geq$ 80 cm) along with smaller substrates. All habitats were predominated by sensitive organisms which included *Chimarra* and *Neophylax* caddisflies, water pennies, Tanytarsini midges, and *Elimia* river snails. Almost forty percent of the macroinvertebrate taxa collected were species classified as sensitive organisms. Minimizing NPS inputs (elevated TP, fecal bacteria counts) will keep Smith Ditch a high quality, exceptional stream.

Smith Ditch near the mouth and downstream from Biggert Rd. (**RM 0.2**) was not quite as diverse due to some embeddedness from NPS sedimentation, but an exceptional community was still present. Moderate to high diversity was observed in the riffle and run habitats. The QCTV of 39.7 was improved compared to upstream and appropriate for an exceptional

community. *Chimarra aterrima* and *Helicopsyche borealis* caddisflies and *Rheotanytarsus pellucidus* midges were among the predominant organisms with good numbers of mayflies present. The intolerant baetid mayfly *Diphetor hageni* and moderately intolerant *Stenonema vicarium* mayfly were also collected, as well as a high quality midge community. Notable midge taxa included the intolerant *Stempellinella n. sp. nr. flavidula*, the cold water midge *Paratanytarsus n. sp. 1*, and the MI midge of the *Tvetenia bavarica group*. A decrease in upstream NPS sedimentation and flashy storm water inputs will keep Smith Ditch at a very high quality and continue to contribute high quality water to Big Darby Creek.

Gay Run (02-298) (RM 26.48) (Undesignated/WWH Recommended)
Gay Run was sampled downstream from Boyd Rd. (RM 0.2) near the mouth. A fairly nice riparian corridor was present which served to protect the varied instream habitats. There was a good quality macroinvertebrate community present, and the WWH biocriterion was met. The common *Cheumatopsyche sp.* caddisflies were predominant in the riffles and slow runs with *Chimarra aterrima* caddisflies and Stenonemid mayflies common. Facultative red midges *Stictochironomus sp.* were predominant in the pools. Eight total EPT taxa were collected, and several of those caddisflies (hydroptilid and leptocerid cased caddisflies) and *Stenonema femoratum* mayflies were commonly found in some or all sampled habitats.

Springwater Run (02-203) (RM 24.0) (WWH)
Springwater Run was sampled near U. S. Rt. 62 (RM 0.8) to assess the biological community and any impacts from the small town of Harrisburg. Elevated fecal bacteria counts and nutrient runoff {i.e., nitrate, TKN, and TP ranging from >75th to >90th percentile (TP = 0.22 mg/l)} yielded nutrient enriched conditions with mats of algae coating the stream bed. Only three to four caddisfly and mayfly taxa were collected. The 28 total taxa found was relatively low. Tolerant Physella snails were among the predominant organisms in all habitats present. The abundance of tolerant snails and low diversity yielded a fair macroinvertebrate community which did not meet the recommended WWH biological criterion. Harrisburg is currently unsewered with septic tank leachate reaching the stream. Ways to sewer this community and tie it into the PCI WWTP are currently being investigated. This should greatly reduce nutrient and waste inputs to Springwater Run. Increasing shading along Springwater Run by allowing growth of trees would also reduce instream water temperatures at least 4 to 5° C, limit algal production, and stabilize dissolved oxygen concentrations.

Unnamed Tributary to Big Darby Creek (aka Clarks Lake Outlet) (02-270) (RM 20.2) (Undesignated/WWH Recommended)
The tributary to Big Darby Creek at RM 20.20, also known as the Clarks Lake Outlet, was sampled at Harrisburg - Darbyville Rd. (RM 0.8) to assess the impact of the Clark Lake subdivision WWTP on stream resource quality and to determine the appropriate aquatic life use designation. There were definitely fecal bacteria inputs. Nutrient inputs were also highly elevated. Some ammonia (0.529 mg/l) and nitrite (0.228 mg/l) concentrations were >95th percentile, and TKN (1.16 mg/l) and TP (0.216 mg/l) concentrations were >90th percentile compared to ECBP background conditions. Other nitrite, TKN, and TP values were still

elevated above the 75th percentile versus ECBP background conditions. As a result of these nutrient inputs and suspended algal production, the filtering Tanytarsini midges were predominant in the riffles and runs. The high density of these organisms in the riffles indicated some nutrient enrichment. Other predominant organisms included *Helicopsyche borealis*, the facultative red midge *Stictochironomus sp.*, and *Elimia* river snails. (*Neophylax* caddisfly cases were abundant, but all were empty, possibly from some stressor.) Overall though, the nine EPT taxa documented, and the 42 total taxa collected indicated good community quality and diversity despite the nutrient inputs. Waste treatment systems at Clark's Lake will be tied into sewers delivering wastes to the PCI Regional WWTP. This decrease in nutrient and waste inputs will allow improvements in water quality in this tributary and in turn higher water quality into Big Darby Creek in a vitally important reach based on its biodiversity and number of rare species.

Unnamed Tributary to Big Darby Creek (02-366) (RM 18.41) (Undesignated/WWH Recommended)

The Unnamed tributary to Big Darby Creek was sampled near its mouth. The small, permanently-flowing stream with cool groundwater recharge (17.2° C) was recovering from past channelization near the mouth. Small trees had regrown and were present down in the entrenched channel and caused development with shallow pool formations with meanders in the bottom substrates in response to permanent structure. There were mostly sand and silt substrates, but where higher gradient occurred coarse gravel, cobble and wood were some of the larger riffle substrates present. Where stable substrates were present, good diversity was also present. Forty three total taxa including a fairly diverse midge community and 8 EPT taxa (including the intolerant *Neoperla clymene complex* stonefly) indicated the presence of a good quality macroinvertebrate community. The accumulated sediment in BDC at the tributary mouth was from NPS sedimentation into Big Darby Creek and the erosion of the exposed, unstable unprotected banks at the mouth. The banks of the lower tributary and at the mouth need more woody growth to stabilize them and stop further erosion.

Greenbrier Creek (02-202) (RM16.75) (WWH)

Greenbrier Creek at Mt. Sterling - Commercial Point Rd. (RM 2.7) marginally attained the WWH biocriterion. Potential sources of stress upstream included agriculture NPS run-off and the unsewered village of Derby. The mostly closed riparian corridor and the considerable distance from those inputs permitted instream recovery to take place and some sensitive benthic organisms to be collected. However, only seven EPT taxa were found with no baetid mayflies present. There was some embeddedness and elevated nutrient inputs from NPS sources upstream (e.g., storm water, sedimentation, septic, and agricultural inputs). Nitrate {(7.57 mg/l) and TP (0.216 mg/l) were highly elevated (>90th and >95th percentile with most other parameters >75th percentile compared to ECBP background conditions)}. The low D.O. violation (3.07 mg/l) could have been related to decaying grass dumped into the stream. The filtering midges, *Rheotanytarsus* sp. and *Polypedilum flavum* midges were predominant in the riffle in response to the nutrient inputs noted above and subsequent suspended algal particles. A mixture of sensitive and facultative organisms (i.e., water pennies, red midges, *Stenonemid* mayflies, and damselflies) were predominant in the other habitats and were indicative of a

marginally good quality community. The sewer project sending waste from unsewered Derby to the PCI Regional WWTP within the next two years will decrease nutrient inputs and should improve downstream biological performance in Greenbrier Creek.

Greenbrier Creek was also sampled upstream from Burro Lane (RM 1.3) and upstream from the unnamed headwater trib. (at RM 1.2) adjacent to Burro Lane in 2002. Good habitat quality upstream in the reach supported a very good macroinvertebrate community. Most NPS nutrient inputs were less than upstream but some (i.e., TSS, nitrate, and TP) were still greater than the 75th percentile versus ECBP background. The number of sensitive taxa, EPT taxa, and total taxa increased when compared to upstream. Some sensitive taxa collected included the mayfly *Stenonema vicarium*, the MI midge *Nilotanypus fimbriatus*, and *Chimarra obscura*, and *Helicopsyche borealis* caddisflies. Decreasing sedimentation and widening the riparian corridor would further protect Greenbrier Creek and further improve water quality. It should be noted that a good number of salamanders were present here in the edges of rocky margin habitats.

Greenbrier Creek was sampled at RM 1.1 in 2001 below the unnamed tributary and adjacent to Burro Lane. The macroinvertebrate community was poorer than the site sampled at RM 1.3 upstream. The stream bottom was hardened and looked scoured with a very limited macroinvertebrate community present. From here downstream the channel was dry (sampled in 2001, a drought year, and site was down in floodplain where infiltration/interstitial flow apparently began to occur - a "losing stream"). Upstream in the tributary some stream channelization had recently occurred with sediment runoff a consequence. Also there were open burro pastures with some bare slopes upstream that had likely contributed to bank instability, erosion and silt/sediment loads downstream which would cause hardened substrate conditions. These conditions were not present in 2002. The burros were gone which permitted the grass to re-establish on the slopes and no further stream manipulations had been conducted. Also with normal precipitation the lower portion of Greenbrier Creek was free flowing. The pool sampled in 2001 at this site had been dry prior to sampling due to drought and subsurface flow and had only refilled from a recent rain (it had rained heavily 1-2 days prior to sampling), permitting only a pioneering community to re-establish. Regardless, sampling in 2002 documented that any impacts from 2001 were temporary and the 2002 sampling at RM 1.3 indicated very good quality conditions.

Georges Creek (02-201) (RM 16.75) (WWH)

The sample site in Georges Creek at RM 0.5 was in a habitat-limited reach due to past channelization and diked conditions. There were small trees in the riparian area adjacent to the diked portion of Georges Creek. Six caddisfly taxa were collected, including the moderately intolerant *Chimarra aterrima* and the cold water caddisfly *Diplectrona modesta*. No mayflies were observed though. Other sensitive taxa present included water pennies, *Helichus*, and *Macronychus glabratus* beetles, *Helicopsyche borealis* caddisflies, and the predominant *Rheotanytarsus* sp. midges. The QCTV was 39.3 which is usually indicative of good biological performance. The marginally good macroinvertebrate community performance marginally met the WWH biocriterion. Upstream at London Rd. some stream "maintenance" had occurred with the substrates pushed around and out of the stream channel. This coincided with the fish

sampling location. The channel had been excavated and debris piled on the banks adjacent to London Rd.

Lizard Run (02-273) (RM 12.93) (Undesignated/LRW)

Lizard Run was sampled at Main St./London Northern Rd. (**RM 0.2**) in Darbyville. During sampling (2001 drought year) the stream was completely dry except for a small pool under the bridge. An extremely limited aquatic community was present (three taxa). Lizard Run seemed to be mostly a flashy storm water conveyance (hard-packed bottom) to Big Darby Creek (at RM 12.93). The site was likely also where the stream, when flowing, would sink into the floodplain and become a "losing stream". Until sampling further upstream to confirm an alternate use designation, a Limited Resource Water Use designation was recommended.

B.7.2 Changes in Biological Community Performance: Macroinvertebrate Communities

Big Darby Creek Mainstem: 1977 to 2001-02

Big Darby Creek has been surveyed numerous times since 1979 by the OEPA with one sample prior to that time, in 1977. Despite some taxonomic differences that would improve earlier scores marginally, the 1979 survey data revealed poorer instream biological community performance in some segments particularly in the upper portion which were associated with point sources or unsewered communities. There were consistently higher percentages of dipteran taxa and tolerant organisms which indicated greater contributions of wastewater. One segment with lowered community performance extended from downstream of the then unsewered Village of Milford Center (~ RM 66) to Ranco, Inc. near Plain City (~ RM 53). The other area of fair macroinvertebrate community performance was also associated with point source dischargers. This segment extended from approximately U.S. Rt. 40 (RM 40.6) downstream to RM 36. Point source dischargers immediately upstream from this impacted segment included Olen Corporation, Camp Wissalohican (an unsewered community at the time), Battelle Memorial Institute, Camp Ken-Jockety and immediately upstream Lake Darby Estates WWTP and the Greentree MHP. A small WWTP at Darby Dan Farms contributed directly to the segment. All sites downstream from the Little Darby Creek confluence to the lowest sampling site in the Big Darby Creek mainstem either met or marginally met the EWH biocriterion in 1979 (Figure B.7.2.1).

The 1986-1988 data indicated decreased community quality in response to pollutants associated with growth and development in the upper watershed particularly in the area affected by development associated with Honda, Flat Branch and North Lewisburg. Some issues that affected the macroinvertebrate community in the late 1980s were also evident downstream from Buck Run, near Ranco, U.S. Rt. 42, and Robinson Run (Figure B.7.2.1). The Plain City WWTP and nonpoint source issues from Buck Run still impacted macroinvertebrate community quality during the 2001/2 water quality survey.

Macroinvertebrate sampling results from 1990-1993 revealed that WWTP upgrades and subsequent improved wastewater treatment had facilitated improvements in macroinvertebrate community performance in the upper Big Darby Creek watershed. This included segments upstream from Plain City and from upstream from I-70 to downstream from U.S. Rt. 40. The upgraded Lake Darby Estates WWTP, which is situated just upstream from Rt. 40, has experienced improved effluent quality for the past ten years as a result of improved and relatively consistent plant operation. However, some larger rain events have hydraulically overloaded the WWTP resulting in episodes of poorer effluent quality. This has resulted in ICI scores from 1990-93 ranging from 50 to 34 in different sample years (Figure B.7.2.2). Samples near Harrisburg, Orient, and downstream from the PCI WWTP showed some improvements but also some inconsistencies (i.e., ICI range of 42 to 56) with storm water inputs and wastewater overflows after rain events that negatively affected the community quality.

The 1997 sampling recorded the effects of the ODOT project that relocated the upper Big Darby Creek mainstem, as scores at RM 82.5 and RM 81.5 were decreased. At RM 82.5 in 2002 the ICI of 46 indicated recovery to exceptional conditions, though the riparian tree canopy was still immature and more open conditions were still present (Figure B.7.2.3).

Figure B.7.2.1. Longitudinal and temporal trends in the Invertebrate Community Index based on sampling conducted in the Big Darby Creek mainstem in 1979 and 2001.

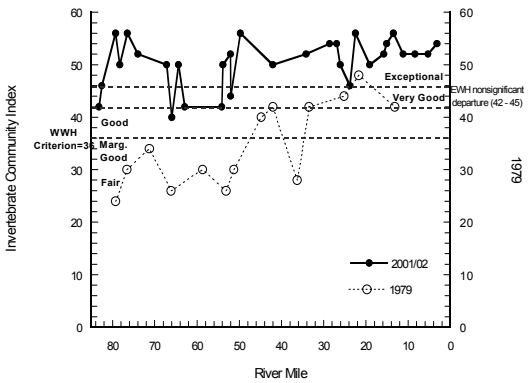


Figure B.7.2.2. Longitudinal and temporal trends in the Invertebrate Community Index based on sampling conducted in the Big Darby Creek mainstem in 1979, 1986/88, 1990-93 and 2001/02.

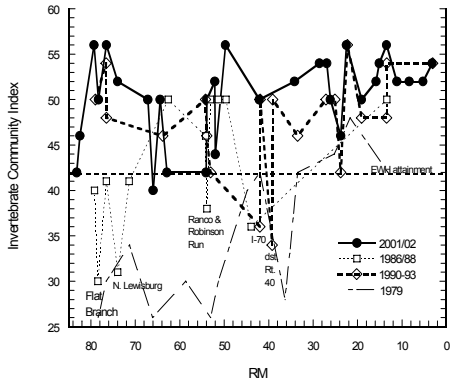
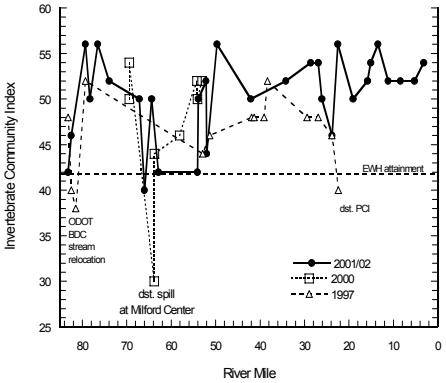


Figure B.7.2.3. Longitudinal and temporal trends in the Invertebrate Community Index based on sampling conducted in the Big Darby Creek mainstem in 1997, 2000, and 2001/02.



Downstream from the Pickaway Correctional Institute WWTP in 1997 the ICI was 40. Plant improvements were ordered by the Director of the Ohio EPA through Director's Final Findings and Orders (DFFOs) to ensure compliance with the Clean Water Act's general water quality criteria normally referred to as "Free Froms" (OAC 3745 -1 - 04) and total suspended solids (TSS) limits. Additionally the PCI WWTP will be expanded to accommodate the connection of package WWTPs with operational problems and unsewered areas. More consistent operation at the WWTP in recent years have resulted in improvements in stream quality downstream from the discharge with an ICI of 56 recorded in 2001 (Figure B.7.2.3).

The eliminations of these WWTPs and local unsewered areas should benefit stream quality downstream from Harrisburg to Scioto Darby Rd.

The 2000 samples were collected in response to a large release of organic material that was discharged from an agricultural supply company in Milford Center (~ RM 66) that killed a large percentage of fish, insects and mussels residing in a segment extending five miles downstream from the spill. Fair quality conditions were observed at RM 63.8 soon after the spill passed downstream. Other sites downstream were sampled prior to the plume of the spill reaching that location. Follow-up samples collected in late summer indicated significant recovery had occurred. However, the vast majority of the bivalve mussel community was killed. Some mussels did survive and were observed through the sampled reach in September 2000. Sensitive benthic organisms like burrowing mayflies, *Lype sp.* and polycentropid caddisflies were also severely degraded. This site still had not recovered by 2002 (i.e., ICI of 40 at RM 66.0) (Figure B.7.2.3).

Major upgrades and improvements have occurred, are ongoing, or planned for many WWTPs (e.g., PCI, Plain City, West Jefferson, Mechanicsburg- pending). Also new regional plants (Darbydale and PCI) will soon begin accepting wastewater from currently poorly functioning small WWTPs (e.g., Oak Hills MHP and Foxlair MHP) and provide service to the unsewered communities, like Darbydale, Derby, and Harrisburg. The elimination of inadequately treated or untreated domestic sewage, particularly between RM 34 and RM 19, should improve water quality significantly in a very sensitive reach of Big Darby Creek. Widely adopted storm water controls would assist in stabilizing downstream habitat which is strongly suspected as a contributing factor towards the decline of bivalve molluscs and other habitat sensitive species.

Flat Branch (02-223) (RM 78.48) (MWH): 1988 - 2001
The Flat Branch macroinvertebrate community showed improvement towards the mouth in 2001 compared to 1988 and 1997 surveys. More stabilization in the subwatershed (i.e., less construction and NPS inputs) allowed increased diversity in the macroinvertebrate community. There still were increased nutrients and TSS, though that affected Big Darby Creek water quality in 2001 downstream from the confluence (i.e., low dissolved oxygen concentrations).

Little Darby Creek (02-251) (RM 78.48) (Undesignated/ EWH Recommended):1988-2001
All of the samples over the years in Little Darby Creek (Logan County) met the EWH biocriterion except for the 1988 sample which was evaluated as good. The upper site in 2001 at RM 3.5 (ICI of 54) ranked higher than the 1997 upstream sample at RM 3.7 of 44 which was marginally exceptional. The riparian corridor in 2001 along a majority of the stream had been continuous and relatively wide and, therefore, supported greater diversity. However, a portion of the stream was channelized after the 2001 sample which likely affected community quality for some distance. High quality water from Little Darby Creek (Logan Co.) Probably helped ameliorate some of the water quality impacts from Flat Branch on Big Darby Creek.

Spain Creek (02-222) ((RM 74.3) (WWH): 1988 - 2001
The 1988 survey indicated good conditions at RMs 2.6 and 0.1 despite only primary treatment at the North Lewisburg WWTP at that time. Secondary treatment was installed at the North Lewisburg WWTP in the next few years. Although the WWTP still had problems, treatment did improve through the 1990s. In the upper subwatershed (i.e., RM 5.7) in 2001, near non point sources (i.e., historic channelization and cattle in open pastures), there were sludge and solids present in the stream bottom. Despite these stressors, community quality was marginally good, meeting the recommended WWH biocriterion. The sites at RMs 3.4 and 0.1 in 2001 reflected the improved conditions and supported the recommended EWH biocriterion for the middle and lower reaches. Full capacity of the approximately 0.2 MGD WWTP is projected to be reached by 2010, so care and attention is needed with plant operation, redesign and storm water controls to protect the exceptional biological community downstream in Spain Creek and in Big Darby Creek.

Pleasant Run (02-221) (RM 72.01) (EWH): 1998 - 2001
All sites met or marginally met the EWH biocriterion in 1988, 1997 and 2001. The ICI score in 2001 of 56 at RM 0.5 improved from the1988 survey and was similar to the 1997 survey.

Buck Run (02-209) (RM63.74) (WWH): 1990 and 2001
Buck Run samples near the mouth in 1990 indicated excess nutrient enrichment and sedimentation with large numbers of the moderately tolerant *Glyptotendipes sp.* and other filtering midges indicative of excess algal production. Buck Run samples in 2001 indicated marginal attainment of the WWH biological criterion despite the same issues including an absence of streamside habitat which caused erosion, nutrient runoff, TSS and sedimentation. Dealing with some of these habitat related issues would greatly improve the quality of Buck Run and decrease the negative inputs into Big Darby Creek.

Robinson Run (02-207) (RM53.69) (WWH): 1992 and 2001
Robinson Run near the mouth had similar diversity between the 1992 and the 2001 sample. A slight improvement at RM 0.8 could be related to sealing a landfill leak near Ranco, although some landfill issues are still present. Upstream agricultural non-point inputs and a small WWTP input still affected the upstream macroinvertebrate community.

Sugar Run (02-206) (RM50.92) (WWH): 1990 - 2001
Stream quality has improved, particularly between RM 8 and RM 3, since 1992 and 1995 (Figure B.7.2.4). Possible factors include the closing of the landfill upstream and the stabilization of the land surface in the upper watershed. Construction adjacent to Sugar Run and its tributaries and the channel manipulation/straightening through the industrial area has been completed or diminished. Some unsanctioned stream manipulation has continued to occur sporadically in the Sugar Run subbasin, hence similar quality (VG) macroinvertebrate communities were observed at the RM 0.5 site in 1995 and 2001. No improvement has occurred. Open pastures bracketing St. Rt. 161 and associated erosion and sedimentation from broken and destabilized stream banks were still affecting downstream quality. The exceptional score at RM 6.9 in 1990 indicated

higher water quality potential from RM 7.0 downstream if the streamside habitat is allowed to stabilize the banks and the channel is not manipulated. Spills have continued to occur in the subwatershed and have contributed to perturbations in water resource quality.

Little Darby Creek (02-210) (RM 34.1) (EWH): 1979 to 2001-02

There have been some improvements made at Mechanicsburg WWTP since the early 1990s. This was reflected in the significantly improved ICI scores at Irwin Rd in 1996 (Figure B.7.2.5). Also a long-term dairy spill area that had sporadically discharged into Little Darby Creek near the Champaign - Madison County line (~ RM 37) was stopped and resolved (~ 1998-9) which could also be related to the measured improvements. The Mechanicsburg WWTP bypasses or overflows, a longstanding problem, were still occurring as recently as 2000. The 2001 macroinvertebrate sample site was downstream from the WWTP discharge but was upstream from the bypass location which was sealed in December 2001, so only the fish site at Wing Rd. evaluated the effects of any possible bypasses. More improvements in the collection system and waste treatment in Mechanicsburg are mandated to occur in the near future, and with their completion and the elimination of bypasses stream quality should improve further in upper Little Darby Creek.

Figure B.7.2.4. Longitudinal and temporal trends in the Invertebrate Community Index in Sugar Run based on samples collected in 1990, 1992, 1995 and 2001.

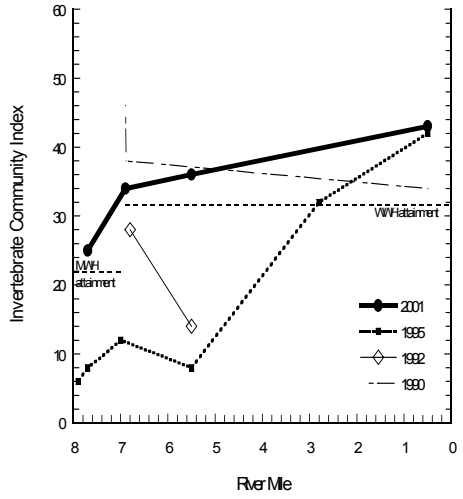
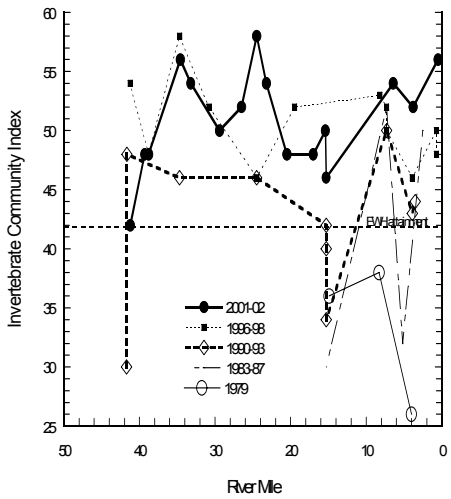


Figure B.7.2.5. Longitudinal and temporal trends in the Invertebrate Community Index in Little Darby Creek based on samples collected in 1979, 1983-87, 1990-93, 1996-98 and 2001-02.



Some improvements upstream from U.S. Rt. 42 (i.e., wide woody riparian area upstream) allowed scores to improve from those recorded in the early 1990s. The sag in community quality downstream from West Jefferson WWTP (~ RM 4) has decreased over time but has not been eliminated. Ongoing improvements at the West Jefferson WWTP and its municipal collection system, when finished, will improve final effluent quality and should eliminate losses of solids from the WWTP.

The two reaches that showed the largest relative declines in the current data were downstream from Rosedale-Milford Center Rd. to near Axe Handle Rd. and from downstream of Rosedale-Plain City Rd. to Bradley Rd. These declines were related to habitat and NPS inputs. Inadequate woody riparian width, excess nutrients, periodic lower diel D.O.s and sedimentation contributed to the declines observed. There was also a significant decrease in sensitive taxa (i.e., EPT taxa down 33 percent and mussel taxa decreased 78 percent) collected downstream from West Jefferson WWTP compared to the highly diverse macroinvertebrate community documented upstream. These decreases were due to excess nutrient enrichment, possible periodic decreases in diel D.O., and plant operation problems. The West Jefferson WWTP experiences periodic release of solids and overflows.

The collapse and removal of the dam near the mouth of Little Darby Creek has allowed the re-invasion of lower Little Darby Creek by many species long cutoff from that portion of the watershed. This has been reflected in the improvements in biological performance since 1996-98.

Treacle Creek (02-213) (RM 31.3) (EWH): 1992 - 2001
Treacle Creek was sampled in three different years at RM 0.7 and twice at RM 8.3. The upstream site evaluations both met the EWH biocriterion with similar ICIs - likely related to the lack of change in habitat and cool groundwater inputs present there. The downstream site at RM 0.7, where sedimentation and nutrients from open pastures upstream were still concerns, did not met the EWH biological standard in 1992 or in 2001. The 1997 ICI of 42 at RM 0.7 marginally met the EWH biocriterion which confirmed the potential and the appropriateness of the designated use.

Proctor Run (02-214) (RM 3.69) (EWH): 1992 - 2001
Proctor Run in 2001 at the downstream sampling site (RM 1.6/1.7) had improved slightly from 1992 with an increased exceptional score, number of EPT taxa, and greater diversity. The riparian corridor here in the lower reach was wider than previously which could account for the slight improvements.

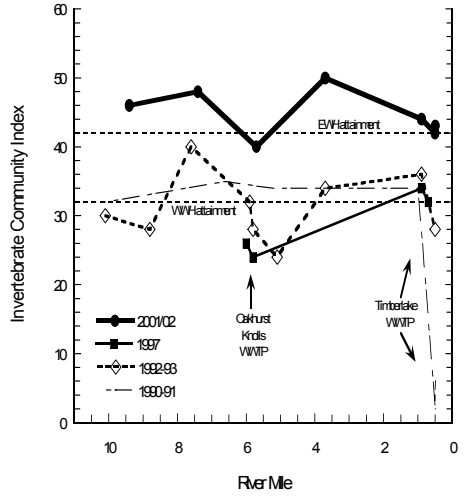
Spring Fork (02-211) (RM 17.46) (EWH): 1992 - 2002
Spring Fork sites were sampled in 1992 and 2001/02. Macroinvertebrate communities did not meet the EWH biocriterion upstream from Wren Rd. and near Rosedale - Milford Center Rd. (RM 7.7) in either 1992 and 2001. Both reaches were affected by nutrient runoff and sedimentation from row crop agriculture and/or open pastures. The lower portions of Spring

Fork met the EWH biocriterion, although the recent status of the lower mile of Spring Fork was not assessed. The reluctance of the resident landowner to grant permission to sample Spring Fork has resulted in the Green Meadows MHP WWTP not being adequately evaluated for its impact on resident aquatic communities in Spring Fork and its receiving stream, Little Darby Creek.

Hellbranch Run (02-204) (RM 26.1) (WWH): 1990 - 2001/02

Hellbranch Run has improved compared to earlier surveys and easily attained the WWH biocriterion throughout its length in the 2001-02 survey (Figure B.7.2.6). Downstream from the Oakhurst Knolls WWTP was the only site that did not at least marginally attain the EWH biocriterion in the latest survey.

Figure B.7.2.6. Longitudinal and temporal trends in the Invertebrate Community Index in Hellbranch Run based on samples collected in 1990-91, 1992-93, 1997, and 2001/02.



Downstream from the Timberlake WWTP and Oakhurst Knolls WWTP were the worst problem areas historically in Hellbranch Run based 1990-97 surveys. The upper portion near Alton Rd. was of fair quality during the 1992-93 sampling due to upstream influences, channelization and sedimentation. The Timberlake WWTP is under Director's Findings and Orders to close operations and connect to regional facility by 2005. Water quality in lower Hellbranch Run should significantly improve and benefit Big Darby Creek downstream of the confluence. Follow-up monitoring of Hellbranch Run should be conducted to determine the effectiveness of these environmental improvement efforts and to determine the appropriateness of the current designated aquatic life. The lower four miles of Hellbranch Run currently would be in partial attainment of the EWH aquatic life use due to fish community scores being less than EWH biocriteria at RM 0.5. It would take very little improvement in biological performance to push it into total compliance.

Hamilton Ditch (02-259) (RM 11.19) (MWH): 1991 - 2001

Hamilton Ditch upstream near Walker Rd (RM 3.4) has improved into the fair range and currently meets the Modified Warmwater Habitat biocriterion. The ICI of 40 upstream from U.S. Rt. 40 (Broad St.) also met the recommended WWH biocriterion for the lower reach of Hamilton Ditch. The historically deepened and straightened channel of Hamilton Ditch prevents the expulsion of sediment bedload into the floodplain or the development of normal riffle, pool and run complexes. Fair community performance, largely due to its sediment load, soft bottom

substrates, and a lack of natural stream development, persisted near the mouth (RM 0.3) from the 1992 through the 1997 survey years. The fair quality found at Feder Rd. in 1991 (RM 2.1) resulted from the siltation associated from construction of residential developments inputs adjacent and upstream. Deposits of grayish black solids from on-lot septic systems also contributed to the depressed macroinvertebrate community.

Habitat will continue to challenge the biological community quality until natural channel functioning is restored (i.e., varied depths, different habitats, and sediment-expelling capability). Future suburban development needs to incorporate adequate storm water BMPs in order for Hamilton Ditch water quality to improve. Stream development and sinuosity within a functioning floodplain with an intact riparian buffer are needed for a more natural Hamilton Ditch. Decreases in sediment and nutrient loads in Hamilton Ditch will allow for more community quality improvements downstream in Hellbranch Run.

Clover Groff Ditch (02-245) (RM 11.19): 1991 - 2001

The proximity of Clover Groff Ditch to the growing community of Hilliard results in poorer biological communities than documented in Hamilton Ditch. Residential development had already adversely affected stream quality in 1991. At RM 2.5 upstream from Feder Rd. extremely high numbers of oligochaetes (i.e., ~ 20,000 individuals), flatworms, leeches, and tolerant midges largely comprised the community present. The resultant ICI was a 10 (poor). In 2001 further upstream at Roberts Rd. (RM 4.7) storm water runoff and other residential inputs including septic tank leachate and unconsolidated sediment had caused very poor community quality to persist. Community quality downstream near U.S. Rt. 40 (Broad St.) was similar in 1992 and 2001 in the ICI range of 18 to 20. The Cypress School package WWTP is under Director's Findings and Orders to connect into Columbus sewers. Suburban storm water treatment, possibly through wetlands and better stream development (sinuosity) with a functioning floodplain to expel the excess sediment built up from construction runoff should help improve the quality of Clover Groff Ditch.

B.7.3 Drainage Area Comparisons: Macroinvertebrate Communities

Drainage Area Range: 1.2 - 2.6 mi^2

Four of the ten sites with drainage areas <2 mi.^{2} were currently designated or recommended to be designated Exceptional Warmwater Habitat (EWH). All met applicable criteria because cool groundwater from the bouldered and hummocky moraine fields into these headwater streams supported exceptional communities and ameliorated slight deficiencies in habitat quality. These sites had QHEIs ranging from 55 to 71.5 with some sites having thinner than desired riparian widths, sedimentation, and NPS agricultural inputs. These included Little Darby Creek (Logan County) at RM 78.34, Howard Run, and the two most upstream Big Darby Creek sites. Clover Run, whose source originates in the same geologic type area also marginally met the EWH biocriterion, despite some unstable banks, excess sedimentation, and nutrient inputs. Clover Run is currently designated WWH due to lower fish community performance (Figure B.7.3.1).

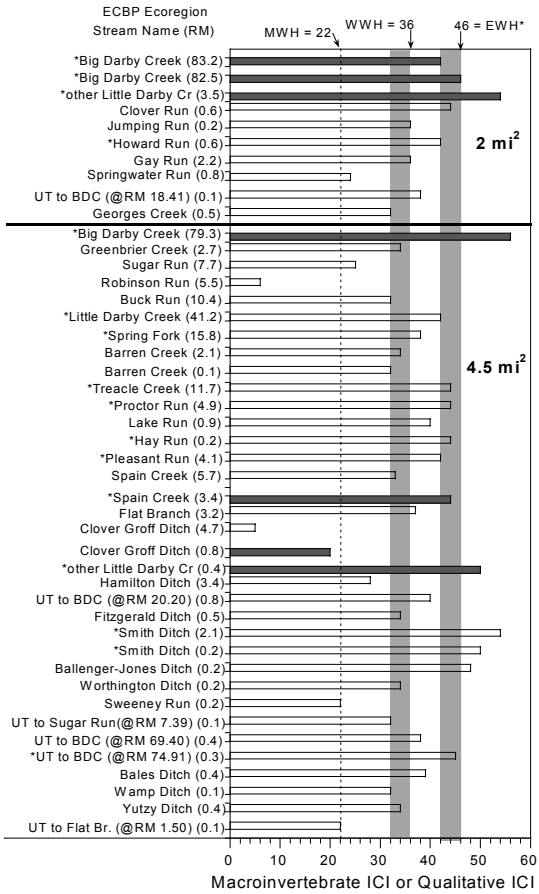


Figure B.7.3.1. Drainage area relationships (<2mi^2 and 4.5mi^2) in the Invertebrate Community Index at sites sampled in the Big Darby Creek watershed, 2001.

Of the six 2 mi.^{2} drainage area WWH sites, the one non-attaining site had problems with storm water inputs of nutrients and silt. Impacts from these stressors were exacerbated by the site's open canopy which caused excessive algal production. All six sites had increased sedimentation from reduced riparian widths which resulted in NPS runoff and eroding and unstable banks. Disturbed habitat in or around the streambed can naturally recover if left alone. Such was the case with Georges Creek and the unnamed tributary to Big Darby Creek (RM 18.41), as there had been some recovery from channelization. Georges Creek was altered after sampling.

Drainage Area Range: 3.3-6.7mi^2

Twelve of the thirty-five sites in this drainage area range were categorized as EWH streams. All twelve sites have their source in end moraines with hummocky till substrates (i.e., the western portion of the Big Darby Creek basin) that contribute cool groundwater which minimizes the effects of bacterial inputs, some sedimentation and NPS agricultural inputs. Habitat quality was

generally higher in these EWH streams with six of the twelve sites having QHEIs greater than 70. All sites meeting the criterion yielded at least eleven EPT taxa (i.e., 11-17 taxa). The one non-attaining macroinvertebrate site was at Spring Fork (i.e., RM 15.8) with eight EPT taxa, a greater predominance of tolerant taxa, and reduced diversity. Excess sedimentation, elevated TSS, and high nitrogen and phosphorus inputs were enough to reduce the community performance to the good range. An unnamed, small stream whose confluence to Big Darby Creek was at RM 69.40 scored only a good macroinvertebrate performance (recommended WWH) because of the cumulative negative effects of past channelization, sedimentation, and nutrients inputs. This was in contrast to a fairly similar unnamed tributary to Big Darby Creek (RM 74.91) which was designated EWH and met the criterion. A less complete woody riparian corridor protecting the stream at RM 69.40 compared to the unnamed tributary at RM 74.91 was likely the difference in the macroinvertebrate quality, as there were more effects from NPS storm water runoff. An interesting and important observation was that the four EWH streams that had lower nutrient inputs (i.e., near median ECBP concentrations or with a few samples greater) had more, wider, and/or intact contiguous woody riparian corridors (i.e., Big Darby Creek - RM 79.3, Little Darby Creek - RM 41.2, Pleasant Run - RM 4.1, and Smith Ditch - RMs 2.1 and 0.2) than the other sites.

Five sites in this drainage area range were Modified Warmwater Habitat stream locations. The non-attaining site (i.e., Clover Groff Ditch at RM 4.7) was affected by residential storm water runoff and excess siltation that contributed to the very poor community performance. The two sites with higher performance had at least some shading and, therefore, comparatively cooler stream temperatures (i.e., Hamilton Ditch - RM 3.4 and the unnamed tributary to Sugar Run - RM 0.1). Two sites that just met the MWH minimum, Sugar Run at RM 7.7 and the unnamed tributary to Flat Branch - RM 0.1, contended with excess silt and nutrient enriched conditions coupled with algal accumulation.

Eighteen of the thirty five 4.5 mi.^{2} sites were designated WWH with four (22%) not meeting the WWH biocriterion. Three of those four did not meet the biocriterion due to residential storm water runoff, spills, and/or accumulated wastewater inputs. Sweeney Run was influenced by inputs from Plain City, and Springwater Run was sampled adjacent to Harrisburg. Clover Groff Ditch (RM 0.8) had several dischargers upstream including a periodically overburdened school WWTP upstream. This WWTP is scheduled to be tied into municipal sewers and the discharge eliminated. The fourth site, Robinson Run (RM 5.5), was affected by excess agricultural inputs, high algal accumulation resulting from an open canopy and nutrients, and periodic low dissolved oxygen conditions. Fifty percent of the sampled WWH sites only marginally met the WWH biocriterion with ICIs ranging from 32-34. These sites generally were hampered by lack of riparian corridor upstream and excess sediment and nutrient accumulation from agricultural NPS inputs.

Drainage Area Range: 7.0 - 13.2mi^2

Sixteen sites were sampled with approximately a 9 mi.^{2} drainage area. There were eight EWH sites, six WWH sites, and two MWH sites within this drainage area range (Figure B.7.3.2). All eight EWH streams sampled have their source in end moraines with hummocky till substrates

(western portion of Big Darby Cr. basin) that contribute cool groundwater which minimized the effects of bacterial inputs, some sedimentation and NPS agricultural inputs. All eight EWH sites met or marginally met the EWH biocriterion. All four sites with higher community performance (i.e., in the range of ICIs = 54-56) had wider and more continuous riparian corridors ranging in width from 30 feet to greater than 150 feet at and upstream from the sample sites (i.e., Spain Creek at RM 0.1, Pleasant Run at RM 0.5, Treacle Cr. at Rm 8.3, and Proctor Run at RM 1.7). This factor kept NPS nutrient inputs to near the median ECBP concentrations or less. The shaded canopy also decreased algal production and allowed for more instream assimilation. Spain Creek, for example, did have higher nutrient concentrations at RM 0.1 due to upstream cattle and WWTP inputs, but the community density on the colonizer was still low at 254 organisms/ft.^{2} due to the shaded conditions. There was also the highest number of EPT taxa collected at these sites compared to others sampled in these respective streams. Mussels were observed at three of these four EWH sites, and the number of sensitive taxa observed was the highest or close to it compared to each respective streams. The two with slightly less total sensitive taxa were Spain Creek at RM 0.1 resulting from WWTP inputs and Treacle Creek at RM RM 8.3 which was impacted by bridge construction prior to sampling.

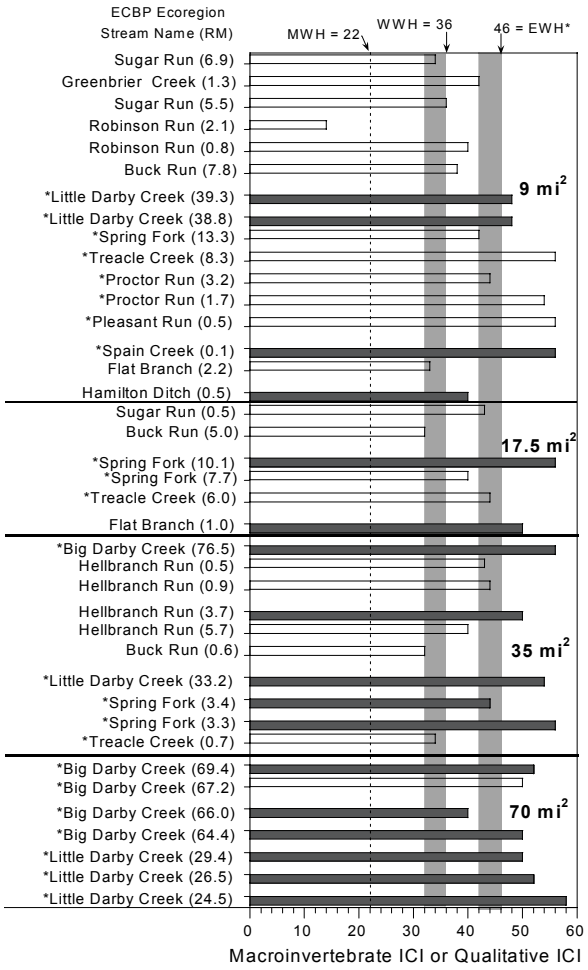


Figure B.7.3.2. Drainage area relationships (larger drainage areas) in the Invertebrate Community Index at sites sampled in the Big Darby Creek watershed, 2001.

Seven of the eight WWH or MWH sites met their respective biocriterion. The WWH site that did not meet was Robinson Run at RM 2.1. Elevated nutrient inputs from agricultural NPS inputs and a small WWTP discharge caused nutrient enriched conditions and periodic low dissolved oxygen concentrations. The impacts were lessened due to the riparian corridor (i.e., 5-7 feet of grass/weeds adjacent with 15-20 feet of small trees). The sites within this drainage area range tended to be more biologically stable and better able to withstand the occasional perturbation.

Drainage Area Range: 14.0 - 19.4mi^2

Only one of six sites in this drainage area range did not attain its designated use - the EWH-designated Spring Fork at RM 7.7. Community performance was only in the good range. This was due to a myriad of negative inputs that stemmed from having a one-sided riparian corridor with destabilized banks opposite from a hay field / open pasture. Stressors impacting instream biological community performance included buried natural substrates, excess sedimentation, manure, and excess nutrient inputs, and higher water temperatures (i.e., 76.5º F) resulting from the open pasture and lack of canopy along one bank. These factors have led to lower D.O. concentrations and lowered overall instream water quality.

Buck Run at RM 5.0 marginally met the WWH biocriterion (MG) due to unstable banks and gross erosion and sedimentation resulting from a lack of a stabilizing woody riparian buffer adjacent to the stream in this former open pasture. Available large rocky substrates permitted some benthic colonization. At this drainage area range a reasonable wooded riparian corridor around a naturally meandering stream appears to limit nutrient inputs and siltation and permits aquatic communities to meet their potential.

Drainage Area Range: 28.0 - 37.3mi^2

Streams in this drainage area range are able accommodate some exposure to stressors and still maintain biological performance within the range of expectations. However, some of the more sensitive taxa including some of the intolerant mayflies, caddisflies, mussels and midges may be may be eliminated from the catch. WWH sites on Hellbranch Run and Buck Run, though attaining, had to contend with inadequate riparian corridors upstream that contributed to continued sediment bedload movement downstream. Buck Run at RM 0.6 only marginally met the WWH biocriterion with low numbers of sensitive taxa due to the sedimentation and nutrient inputs that pervaded most of the stream. A low number of eight to nine sensitive taxa were present in Buck Run from the RM 7.8 site downstream to RM 0.6. In contrast, the highest number of sensitive taxa were collected at 35 mi.^{2} sampling sites at Big Darby Creek (RM 76.5) and Little Darby Creek (RM 33.2) with 43 and 36 taxa, respectively.

Similarly the open pasture conditions upstream from the Treacle Creek sampled site (RM 0.7) and inadequate bank protection which yielded erosion, slumped banks, and sediment bedload downstream coupled with nutrient enrichment and periodic low dissolved oxygen concentrations resulted in the number of sensitive taxa declining from a high of 29 at Eagle Rd. (RM 8.3) to only thirteen at RM 0.7. Adverse effects noted upstream accumulated and were significant enough to result in not meeting the EWH biocriterion at RM 0.7.

In contrast to Buck Run, as habitat improved in Hellbranch Run and negative NPS inputs diminished, the number of sensitive taxa increased. Lower Hellbranch Run sites, with QHEIs of about 84, had 20 to 33 sensitive taxa present. All Hellbranch Run sites exhibited marginally exceptional performance except for the site at RM 5.7, which was affected by a nearby golf course and WWTP inputs, which yielded 14 sensitive taxa, the lowest total in the subbasin. Instream biological performance in Hellbranch Run will improve when consistent riparian and

storm water protections are in place and effluent inputs have been reduced through planned WWTP closures and tie-ins to regional WWTPs or sewer lines.

Drainage Area Range: 70.0 - 88.0mi^2

These larger wadable streams demonstrated exceptional biological performance barring any catastrophic impacts, such as the 2000 spill in Milford Center, or large constant inputs such as large dischargers which could acutely or chronically affect macroinvertebrate community performance. The site downstream from Milford Center at RM 66.0 one year after the large spill still did not meet the EWH biocriterion. There was only one-third the number of sensitive taxa and 25 to 40 percent lower EPT taxa totals when compared to the other six sites within this drainage area range. The two sites with the narrowest overall riparian widths (i.e., Big Darby Creek at RM 64.4 and Little Darby Creek at 26.5) yielded no mussels. Mussels were present at sites where at least one side of the riparian corridor equaled 50 feet. Also, two of the three sites with the narrower riparian widths (i.e., Big Darby Creek at RM 66.0 and Little Darby Creek at RM 29.4) had the highest community densities (i.e., 1100 to 1400/ft.^{2}) indicating nutrient enriched benthic communities. The two other sites on Little Darby Creek (i.e., RMs 26.4 and 24.5) in this drainage area range and which were also downstream from RM 29.4 had much wider riparian corridors (i.e., >50 ft. to 100 ft.). They also had community densities 50 percent less - a function of lower nutrient inputs and shaded canopy conditions. The wider riparian corridor along Big Darby Creek and Little Darby Creek at this drainage area range buffers the biological communities and helps protect against large or continuing impact events.

B.7.4 Trends in Unionid Mussel Communities

The Big Darby Creek watershed has been widely acclaimed for its diverse unionid mussel fauna (Watters, 1994). Surveys since 1986 have shown a general decline in species diversity throughout the watershed. Thirty percent of the species that have been observed in recent surveys are now found in very few locations and in low abundance (Watters 1998, Tetzloff 2000, Watters and Myers Flaute 2003). Aggregating the efforts of several groups and individuals that have surveyed the watershed between 2000 and 2002 yielded a cumulative total of 35 mussel species that are still present in the watershed (Table B.7.4.1). However, five previously collected mussel species were not found. Missing species included two special interest species, one Ohio threatened species, and one species considered endangered in Ohio (Table B.7.4.1).

Several interesting conclusions can be drawn from data presented in Watters and Myers Flaute (2003). Lower mussel diversity coincided with lowered Index of Biotic Integrity scores which is based on fish community attributes (Table B.7.4.2). Lower mussel diversity also was found in stream segments with low habitat quality as evaluated by the Qualitative Habitat Evaluation Index (Table B.7.4.2). Factors also contributing to these correlations, many of which are interrelated, included toxic impacts (which includes the impacts from spills), sedimentation/siltation, substrate embeddedness, lack of riparian corridor width, lack of stream shading from decreased canopy cover, bank destabilization, and nutrient inputs causing excess algal production and low nighttime dissolved oxygen concentrations.

Although the Invertebrate Community Index (ICI) measures the relative quality of the macroinvertebrate community, it did not correlate well with shifts in bivalve species richness (Figure B.7.8, Table B.7.1). This difference may be explained by the difference in response of aquatic insects (the main component of the ICI) versus bivalve molluscs to environmental perturbations. Unionid mussels, due to their filter feeding and sedentary life history, are frequently the most sensitive component of the aquatic environment and are the first to succumb to environmental perturbations. Due to their reliance on fish hosts to repopulate impacted areas and the long period of time that it takes for them to reach a size where they are large enough to be detected and identified by most current sampling procedures, it is also, therefore, generally a long time before live specimens are detected in previously impacted areas. Most other benthic macroinvertebrates, on the other hand, are quick to repopulate impacted areas due to their ability to re-invade through downstream drift and aerial routes.

The strongest spatial correlation in the historical mussel data was decreased mussel diversity in areas immediately downstream from dischargers (See Appendix C.3, Mussel Species Richness Maps). Evaluation of point source dischargers was the major focus of these earlier surveys in contrast to more recent surveys which had a broader focus. Areas showing lowered bivalve mussel diversity coincided with historical chemical sampling locations with elevated BOD5, ammonia, TKN, or nitrates present and the metals lead, zinc, copper and cadmium, parameters normally associated with point source dischargers (Appendix C.3, Mussel Species Richness Maps). Metals, such as copper and zinc, though previously bound can be released into solution through a combination of various chemical reactions (Burton et al., 1992). Besides contributing

to cumulative toxicity, these metals, which impact gills and decrease oxygen-carrying capacity in fish, could possibly be affecting mussels similarly (Sorenson, 1991). Additionally elevated chlorides, sulfates, higher conductivity, hardness and pH were also found downstream from point source dischargers in areas with decreased mussel diversity. Elevated pHs can be important since they can result in toxic microenvironments from increasing concentrations from un-ionized ammonia (USEPA, 1979, Thurston et al., 1974). Sulfates have been used in WWTP processes and chlorine stabilization (Merck Index, 1989) (See Appendix C.3, Mussel Species Richness Maps).

Bivalve distribution maps compared against maps detailing average chemical parameter concentration roughly by decade revealed impacts in the middle reaches in the 1980s (i.e., in the vicinity of Plain City and West Jefferson, and in the segment from upstream of I-70 to downstream from U.S. Rt. 40 downstream from package WWTPs and campgrounds) (Appendix C.3, Mussel Species Richness Maps). Impacts were also seen in the 1980s in the lower reaches of Big Darby Creek downstream from dischargers and associated with elevated BOD, low dissolved oxygen ammonia, and metals. These dischargers included the PCI WWTP and several small developments (mostly MHPs).

Table B.7.4.1. Unionid Mussel Distribution documented in surveys conducted in the Big Darby Creek Watershed during 1986, 1990, 1996, and 2000-2002[a].

Taxon	Common Name	Status	*1986*	*1990*	*1996*	*2000-2002*
Ligumia recta	**Black Sandshell**		X	X		X
Pleurobema clava	**Clubshell**	FE	X	X	X	X
Lasmigona compressa	**Creek Heelsplitter**	OSC	X	X	X	
Anodontoides ferussacianus	**Cylindrical Papershell**		X	X	X	X
Truncilla truncata	**Deertoe**	OSC	X			X
Elliptio crassidens	**Elephant Ear**	OE	X			X
Alasmidonta marginata	**Elktoe**	OSC	X	X	X	X
Lampsilis radiata luteola	**Fat Mucket**		X	X	X	X
Truncilla donaciformis	**Fawnsfoot**	OT	X	X	X	
Lasmigona costata	**Fluted-shell**		X	X	X	X
Leptodea fragilis	**Fragile Papershell**		X	X	X	X
Pyganodon grandis	**Giant Floater**		X	X	X	X
Ptychobranchus fasciolaris	**Kidneyshell**	OSC	X	X	X	X
Toxolasma parvus	**Lilliput**		X	X	X	X
Quadrula quadrula	**Mapleleaf**		X	X	X	X
Epioblasma rangiana	**Northern Riffleshell**	FE	X	X	X	X
Utterbackia imbecilis	**Paper Pondshell**		X	X	X	X
Quadrula pustulosa	**Pimpleback**		X	X	X	X
Potamilis alatus	**Pink Heelsplitter**		X	X		X
Potamilis ohiensis	**Pink Papershell**		X	X	X	X

Continued.

Table B.7.4.1. Continued

Taxon	Common Name	Status	*1986*	*1990*	*1996*	*2000-2002*
Tritogonia verrucosa	**Pistolgrip**		X	X	X	X
Lampsilis cardium	**Plain Pocketbook**		X	X	X	X
Uniomerus tetralasmus	**Pondhorn**	OT	X	X		
Cyclonaias tuberculata	**Purple Wartyback**	OSC	X	X	X	X
Quadrula cylindrica	**Rabbitsfoot**	OE	X	X	X	X
Villosa iris	**Rainbow**		X	X	X	X
Villosa fabalis	**Rayed Bean**	OE	X	X	X	
Obovaria subrotunda	**Round Hickorynut**		X	X	X	X
Pleurobema sintoxia	**Round Pigtoe**	OSC	X	X	X	X
Simpsonaias ambigua	**Salamander mussel**	OSC	X	X		
Alasmidonta viridis	**Slippershell**		X	X	X	X
Epioblasma triquetra	**Snuffbox**	OE	X	X	X	X
Elliptio dilatata	**Spike**		X	X	X	X
Strophitus undulatus	**Sqawfoot/Creeper**		X	X	X	X
Amblema plicata	**Threeridge**		X	X	X	X
Fusconaia flava	**Wabash Pigtoe**		X	X	X	X
Megalonaias nervosa	**Washboard**	OE	X	X		X
Lampsilis fasciola	**Wavy-rayed Lampmussel**	OSC	X	X	X	X
Lasmigona complanata	**White Heelsplitter**		X	X	X	X
Pleurobema cordatum	**Ohio Pigtoe**	OE				X
		Total	39	37	32	35

[a] - (adapted from Watters, 1998)

A similar comparison using data from the 1990s revealed losses in mussel diversity in upper Big Darby Creek around Flat Branch and in the middle reaches within and downstream from Plain City. Decreased mussel diversity in Little Darby Creek was found immediately downstream from the Mechanicsburg and West Jefferson WWTPs. Hellbranch Run had reduced mussel diversity which was associated with residential growth. Some of these same affected areas were also noted in Watters (1994).

Nutrient enrichment (i.e., high concentrations of N and P) and associated nighttime dissolved oxygen sags were documented in the 1990s (Appendix C.3, Mussel Species Richness Maps). High afternoon dissolved oxygen measurements confirmed nutrient enrichment. Lower dissolved oxygen readings may have been recorded during morning data collections or under clouded conditions. Dissolved oxygen sags with levels falling to very low concentrations can occur in pooled areas downstream from the supersaturated sites. In suspect stream reaches where low dissolved oxygen levels were recorded during previous surveys or observed during the present survey, additional continuous D.O. data monitoring was conducted.

Any relationships between low dissolved oxygen concentrations and decreased mussel diversity along with other supporting data is presented in Table B.7.4.2.

Table B.7.4.2. Stream segments with correlations between low dissolved oxygen concentrations and lowered fish community scores and bivalve mollusc diversity.

Stream reach	D.O. data	Other supporting data
BDC dst. Flat Br. WWTP & dst. Flat Br. confluence	6 hrs D.O. < EWH min with low of 4.4 mg/l 15 of 24 hours < min. ave. D.O. of 6.0 mg/l	Low fish IBI of 37.3 (2001)
BDC dst. Plain City & Sugar Run (RM 51.6 - 49.5)	D.O. < mean and min. D.O. (Low of 3.9 mg/l) D.O. < EWH min. (Low of 4.5 mg/l)	Low fish IBI / MIwb of 43 & 8.78-8.3, resp.(2001)
BDC dst. Darbydale (RM 27.7) dst. in pooled reach	12 hrs. D.O.< EWH min with low of 4.9 mg/l 17 of 24 hrs. < min. ave. D.O. of 6.0 mg/l	No fish sampled in this particular reach
BDC dst. Scioto Darby Rd pooled reach (RM 18.45)	13 hrs. < EWH mean of 6.0 mg/l with range of 5.4-5.9 mg/l	Total numbers of mussels noted decreased with time
Dst. U.T. to BDC dst. Scioto Darby Rd (@ RM 18.41) pooled reach (18.1)	12-13 hrs. < EWH mean of 6.0 mg/l with range of 5.4-5.9 mg/l	Sediment and some nutrients input
U.T. to BDC (@ RM 20.2)	D.O.< 1.0 mg/l D.O. (~ 36 hrs.) Directors Findings and Orders for Foxlair to tie into PCI WWTP has been filed	Foxlair MHP with poor effluent (high NH_3), periodic pulsed discharge via flushes of storm water in trib. (local toxicity at low flows); discharge trib. in area of Northern Riffleshell Mussel habitat reach (FE)
BDC adj. Gulick Rd. (RM 15-16) dst. U.T. to BDC (@ RM15.50)	~ 4 hrs. < EWH mean of 6 mg/l supersaturated conditions to high of ~ 12 mg/l down to ~ 5.7 mg/l - open canopy and nutrients	Only one species found (Tetzloff, 2000) two species (OEPA, 2002) 3 total specimens - only fresh dead
BDC dst. Georges Run (RM 14.8)	11 to 14 hrs < EWH mean of 6 mg/l with range of 5.4-5.9 mg/l & a daytime high of 12.5 mg/l nutrients input and limited canopy (mostly open) with higher stream temperatures / density >2000 org.(macroinvertebrates) / $ft.^2$	RM 15 - 14 no mussels collected (Tetzloff, 2000 or OEPA, 2002) - other factors were concrete rip rap on one eroded bank, little aquatic plants / shallows, more pooled
BDC near & dst. SR 316 (Darbyville) RM 13.5 / 12.9	RM 13.5 high >12mg/l D.O. (low of 5.2 mg/l) RM 12.9 9 hrs < EWH mean with low range of 5.4-5.9 mg/l) algae, enriched, ~ 1990 org. / $ft.^2$	RM 14-13 five total spp. found with only 7 total found (Tetzloff, 2000) unstable spongy substrates

Continued

Stream reach	D.O. data	Other supporting data
BDC dst. U.T. to BDC (@ RM 8.5) RM 7.9	9 hrs. < EWH mean of 6 mg/l D.O. (low of 5.7-5.9 mg/l) and high of ~ 10 mg/l 1714/ft.^{2} lots of algae in tributary - very enriched	RM 8-7 only one mussel species collected (one record) loss of riparian, eroded banks, unstable habitat or embedded substrates
BDC dst. SR 104 (RM	Supersaturated daytime D.O. > 17 mg/l, indicated nutrient enrichment so low nighttime D.O. threatens pooled reaches further downstream.	RM 3-2 only 3 species and five total individuals (all fresh dead not any live specimens) (Tetzloff, 2000) lots of silt below Fox riffle and soft substrates
Treacle Cr. RM 0.8	D.O. < EWH minimum of 5.0 mg/l (4.8 mg/l)	Didn't meet EWH in 1997- fish IBI and MIwb were 41 and 8.1, respectively (G to MG) and impacts from cattle of sediment/siltation and unstable banks and lack of canopy in open pasture area (only one sp. in wooded reach dst. that can handle some silt

Mussel species richness has generally declined in most reaches through time (Watters et al., 2003). Statistically significant decreases in mussel richness diversity occurred in 36% (i.e., 15 of 42) of the long-term sampled reaches and approximately 60% (i.e., 25 of 42) indicated non-statistically significant decreases or variable mussel species richness totals over time (minimum of four different samples through time and $R^2 > 0.50$). Less than five percent (i.e., 2 of 42) of the reaches showed statistically significant increases (Table B.7.4.3).

An effort was made to determine the causes and sources of statistically significant declines in unionid mussel diversity. All currently available data including historical data and that resulting from more recent surveys was evaluated and the causes of the impacts were catalogued for stream locations showing statistically significant decreases in mussel taxa richness (Table B.7.4.3).

Table B.7.4.3. Probable causes of declines in unionid mussel species richness.

Reaches with Statistically Significant Decreasing Mussel Taxa Richness (r^2>0.5)	Probable Causes of Declines
Big Darby Creek RM 66 - 63.8 (64.5-64.3) (dst. Milford Center)	A) Spills (grain storage(molasses)) / acutely low D.O. B) Embeddedness from NPS sedimentation (silt) C) Nutrient enrichment (6.30 mg/l nitrates > 95th %ile ECBP background) local potential effects from nitrite D) Sediment phosphorus (1420 mg/kg) >LEL and high sediment ammonia (68 mg/kg)
Big Darby Creek RM 54.1 (to RM 53.9) (pooled reach at and ust. and dst. SR 42	A) Significant drop due to historical metals (Ranco) (1960-1970s) sedimentation/ silt with elevated metals (Al,As,Ba,Cr,Mn,Hg,Zn) with Total Organic Carbon and Phosphorus (1670 mg/kg) > LEL (Persaud et al., 1993) and TSS > 75th %ile C) Embeddedness from the silt (NPS inputs - cattle & agri. upst.) D) Nutrient enrichment / low diel D.O. (N > 75th %ile, P > 95th %ile, P=1.75 mg/l) E) Spills in the area and upstream F) Sediment metals and sediment ammonia (52 mg/kg)
Big Darby Creek RM 51.5 - 51.3 (dst. Plain City upst. from Cemetary Pike (pooled / slow run reach)	A) BOD / suspended solids caused likely periodic chronic lower D.O. conc. B) Nutrient enrichment w' respiration and degradation added to low D.O. C) Some silt accumulation D) Spills in the Plain City area
Big Darby Creek RM 41.1 - 40.6 (dst. I-70 & dst. High Free Pike)	A) Raw effluent discharge / periodic toxic discharges 1970s camp ground converted to permanent homes with septic vaults and raw sewage. Legal proceedings & actions in 1996 led to WWTP installed & running in 2000 (Wissolohican Sanitary Sewer Dist.) B) Quarry discharges? C) Spills in the area
Big Darby Creek RM 39.5- 38.9 (dst. Darby Estates WWTP)	A) Historical impacts from NPDES discharge - lead, zinc, nitrites, and nitrates, BOD, solids, contributed to low D.O.s B) Sedimentation from NPS runoff C) Some historical spills
Big Darby Creek RM 3.2 (dst. SR 104)	A) Siltation B) Unstable substrates C) Substrate bedloads D) Sediment phosphorus (1700 mg/kg >LEL) and ammonia (83 mg/kg) and possibly metals

Continued

Reaches with Statistically Significant Decreasing Mussel Taxa Richness (r^2>0.5)	Probable Causes of Declines
Little Darby Creek RM 27.0 - 26.7 (dst. Chuckery)	A) Sedimentation from open pasture upstream, destabilized banks (erosion) B) Nutrient enrichment / low diel D.O. via agri. / livestock NPS inputs and large percentage of open canopy & woody riparian corridor immediately adjacent stream banks in the reach upst. NW of SR 161 (Union Co.) **OEPA sample at RM 26.5 was far enough downstream in the stable mature wooded canopy corridor that the habitat and nutrient impacts from upstream are buffered (12 mussel taxa collected).
Little Darby Creek RM 24.5 (dst. Rosedale-Plain City Rd.)	A) Sedimentation (NPS inputs - agri. and cattle inputs) B) Destabilized banks / lack stable wooded riparian corridor /canopy C) Hardened substrates or embeddedness
Little Darby Creek RM 17.9 -17.6	A) Lack of stable habitat upstream - partial riparian corridor with siltation and nutrients from upst. NPS inputs - cattle and crop agriculture with some embeddedness (some open pasture) B) Possible lower diel D.O. from NPS inputs
Little Darby Creek RM 17.6 -16.8	A) Inputs from Green Meadows MHP into Spring Fork and to LDC (@ RM 17.4) (past & present potentially toxic inputs with periodic low D.O.s (violations: TSS, fecal coliform bacteria, CBOD, & D.O. ($\leq$2.1-1.1 mg/l) very likely issues with ammonia B) Lack of stable habitat upstream - partial riparian corridor with siltation and nutrients from upst. NPS inputs - cattle and crop agriculture with some embeddedness (some open pasture) C) Localized cementing of the bottom substrates (consequence of nutrient enrichment/ high pH and calcium carbonate precipitation). D) Possible lower nighttime D.O. from NPS inputs
Treacle Creek RM 11.9 - 11.6 (near Mechanisburg - Bellefontaine Rd.)	A) Excess siltation from open pasture upstream and NPS agri. near with narrow, limited, inadequate riparian buffer width B) Ammonia (0.76mg/l) and nitrite > 95th %ile of ECBP background ** Mussel richness decreased from 2 (highest at first sample) to 0
Treacle Creek RM 8.3 (Eagle Rd.)	A) Sedimentation (silt) and embeddedness with black anaerobic conditions on bottom substrates in run B) Low D.O. conc. in bottom substrates (silt & nutrients from NPS runoff -nitrates >75th %ile & TP >95th %ile) - algae/low D.O. ** From one mussel to no live or fresh dead collected (older mussel specimens were observed, so more taxa also lost earlier)

Continued

Reaches with Statistically Significant Decreasing Mussel Taxa Richness (r^2>0.5)	Probable Causes of Declines
Hellbranch Run RM 10.4 - 9.9 (Alton Rd.)	A) Siltation and modified reach (sediment accumulation) ** Two species decreased to one species (both more common)
Sugar Run RM 0.7 - 0.4	A) Siltation/sedimentation and high TSS via erosion from unstable banks (open pasture upst.); sediment TOC and phosphorus >LEL (Persuad et al., 1993) B) High nutrients from upstream NPS inputs contributing to some enrichment, possible low D.O. or other effects (nitrite) here and dst. in BDC below confluence (N>90th %ile & P>95th %ile) C) Spills historically upstream

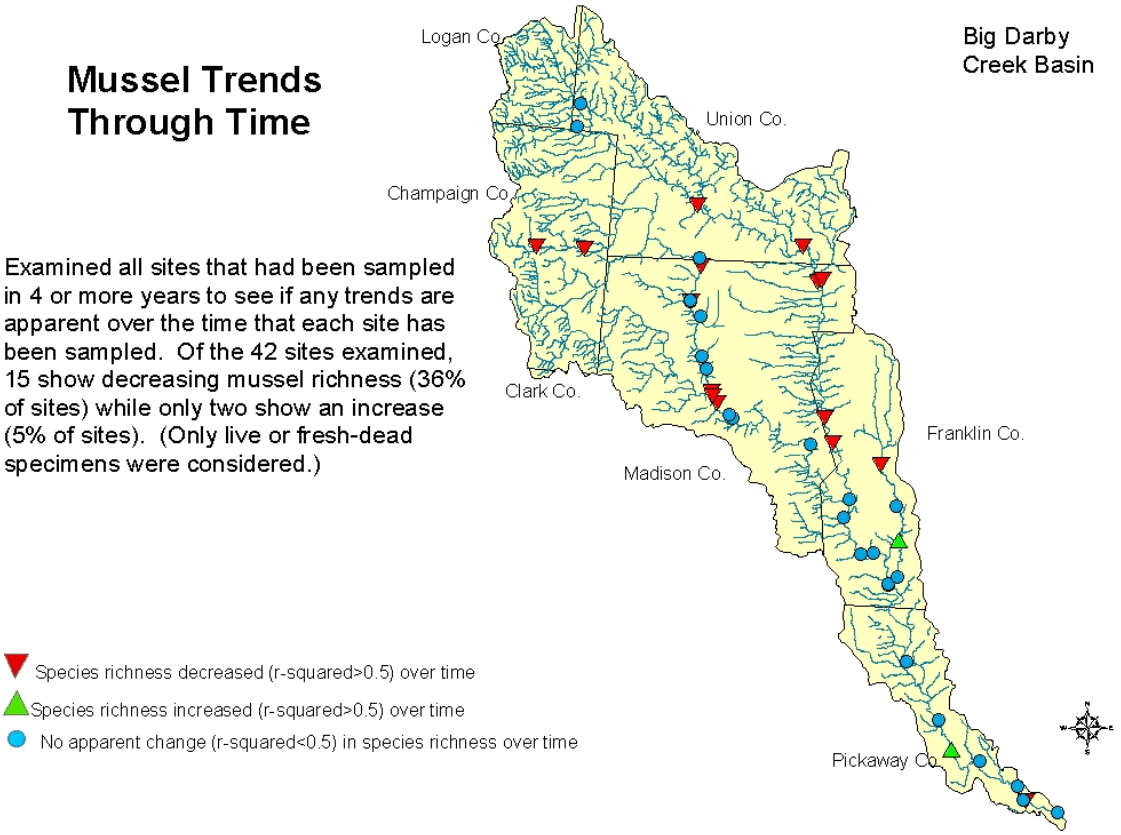
The two stream segments within the Big Darby Creek watershed that showed statistically significant increases in mussel diversity (though further examination indicated non-statistical significance (Watters and Flaute Myers, 2003) had an increasingly rare commodity - stable habitat. Hellbranch Run near Beatty Rd. (RM 3.8) had more stable and better defined riffle complexes with less silt than upstream reaches, which were choked with silt and buried riffles (Figure B.7.4.3). The stream begins to flow through a moraine boulder belt in this reach increasing substrate size and variety. Hellbranch Run in this vicinity to its mouth flows through a bouldered moraine geologic zone contributing many positive habitat attributes. The riparian corridor was also more prevalent, which contributed to the stability. The channel was also more defined with greater development compared to upstream were channelization had occurred. Another element to the higher diversity was improved wastewater treatment upstream with some distance for natural assimilation.

Big Darby Creek, RM 12.0 - 11.0, the other sampling reach with a positive and statistically significant trend in bivalve diversity, was modestly nutrient enriched from upstream NPS sources (Figure B.7.4.1). However, it did possess stable mussel habitats which included small side channels, bars with aquatic vegetation, side pools and areas behind woody debris. These habitat features protected the mussel beds from flooding which was common in the lower reach and which tended to displace and scour substrates (Figure B.7.4.2) (Tetzloff, 2000). The wooded riparian corridor directly adjacent to the stream protects the bank from erosion which in turn protected the mussel habitat.

Figure B.7.4.1. Big Darby Creek between RM 12 and 11 had 20 mussel species present (Tetzloff, 2000) due to stable treed banks and side habitat (side bars, channels and pools). Downed logs protected bank and mussel beds.

Figure B.7.4.2. Eroded banks with loss of riparian corridor on lower Big Darby Creek at RM 8.

Figure B.7.4.3. Trends in naiad mussels in the Big Darby Creek watershed over time.



Adapted from Watters and Flaute Myers, 2003.

Many of the rarer or more sensitive mussel taxa (i.e., the Clubshell, Northern Riffleshell, Rabbitsfoot, Snuffbox, and Wavy-rayed Lampmussel) are surviving in locations with stable and protective habitat features. These habitats, typically, are products of glacial remnants including end moraines, kames, and other geological features which yield steeper topography. These areas due to the pitch of the land are difficult to farm and, therefore, have led to a wider, more contiguous wooded riparian corridor. The abundant groundwater associated with these features is also felt to locally improve water quality (Figure A.2).

The groundwater in the western Darby Creek basin, particularly Little Darby Creek and its tributaries, possess relatively high concentrations of calcium bicarbonate ($Ca(HCO_3)_2$) in solution generally coupled with high hardness and alkalinity. In some locations where the water contained relatively large amounts of $Ca(HCO_3)_2$, with the equilibrium CO_2 that permits that solution, removal of the CO_2 through photosynthesis, resulted in the disruption of that equilibrium resulting in the precipitation of $CaCO_3$ (Wetzel, 1975; Curtis, 1979). This reaction, resulted in a rise of pH and calcareous incrustations on plants and other submerged objects (Cole 1983). This phenomenon has been observed in several locations in the aforementioned western portion of the Big Darby Creek watershed and Little Darby Creek. Lowered mussel diversity appeared to be associated with segments where the deposition of carbonates had resulted in cementing of the bottom substrates, which would have prevented or greatly reduced the ability of bivalves to move or re-establish within the stream bed. Locations where this phenomenon was observed included Little Darby Creek downstream from Barron Creek and Rosedale - Plain City Rd. toward Finley Guy Rd., in the reach upstream from Bradley Rd. ($\geq$ RM 20.5), and in a short reach off of Little Darby Rd. downstream from the confluence with Spring Fork (RM 17.0), and to a somewhat lesser extent (more in combination with sedimentation) near US Rt. 42.

In situations where a stable and wide riparian corridor was still present, for example downstream from Chuckery to near Rosedale - Plain City Rd, sensitive taxa like the endangered Clubshell mussel (*Pleuroblema clava*) survives in reaches where the ideal habitat of loose and well-aerated sand substrates allowed for mussel burrowing and regeneration of water quality in the lower substrates through interstitial flows. Shading provided by the intact forested canopy was felt to have reduced instream photosynthesis to a level that the bicarbonate - carbon dioxide equilibrium was not disrupted and, therefore, carbonate precipitation was not a problem. Restoring stable, contiguous wooded riparian corridors to the Little Darby Creek mainstem, and its tributaries is critical for protection of substrate quality which will protect the few sensitive mussels remaining in the scattered portions of the watershed still possessing stable habitats.

Besides increases in the riparian corridor width and subsequent streambank protection, decreases in storm water flows in the lower Darby basin would decrease erosion, slow down substrate bedload (and some entrenchment occurring (Tetzloff, 2000)) and would allow over time stable mussel habitat development (side channels, side bars, aquatic vegetation (like water willow) and side pools in conjunction with woody substrates).

Figures B.7.4.4 and B.7.4.5 present historical and more recent collection locations for bivalves in the Big Darby Creek watershed to provide a frame of reference that distribution maps of specific species can be compared against. Figures B.7.4.6 to B.7.4.11 present historical and current distribution data for selected rare and endangered mussels in the Big Darby Creek watershed. Discussions of their presence or absence from certain locales pertaining to habitat and land use will be discussed.

Figure B.7.4.4. Historical collection locations for bivalve mussels in the Big Darby Creek watershed (Watters and Myers Flaute, 2003).

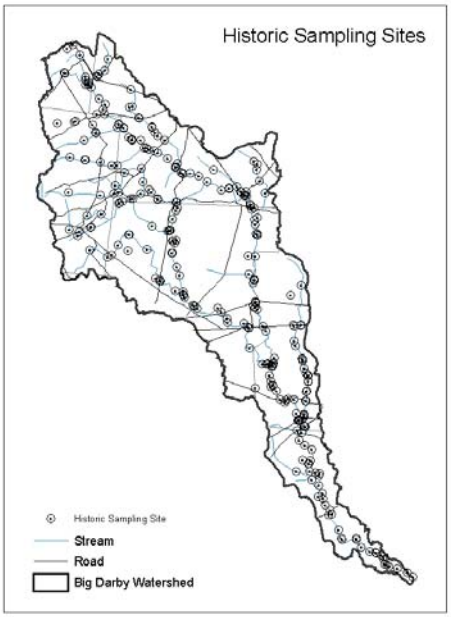
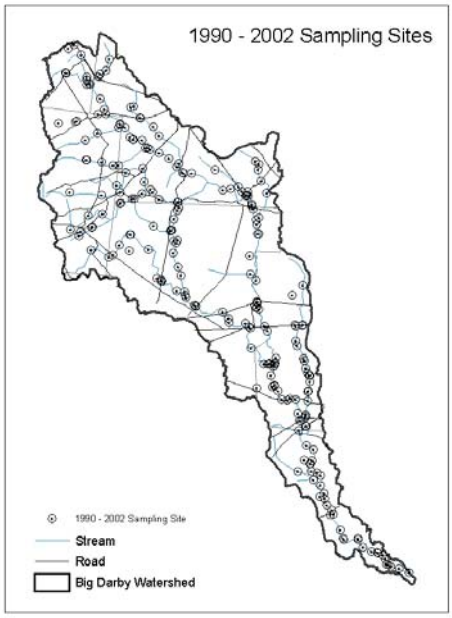


Figure B.7.4.5. Collection locations for bivalve mussels in the Big Darby Creek watershed (Watters and Myers Flaute, 2003).



The snuffbox mussel (*Epioblasma triquetra*)was found in ground moraine and till areas and/or adjacent to or in low or intermediate-level outwash terraces that are near low-level valley outwash (Figures B.7.4.6 and B.7.4.7). Ground moraine or end moraine features isolate some of these sites. With rolling or uneven terrain into the stream valley a more complete riparian corridor was still evident. Their habitat preference is clear, gravel riffles which would be present at sites dominated by alluvial and outwash terraces. Supplemental groundwater inputs would be likely as well as aerated gravel and sand riffle substrates. Their decreased presence in some historical areas was from poor WWTP operation (e.g., ammonia and metals) and NPS inputs like siltation, nutrient enrichment and low night D.O.s, and spills or kills.

Figure B.7.4.6. Historical distribution of the snuffbox in Big Darby Creek (Watters and Myers Flaute, 2003).GIS Surficial Geology Layer provided by ODNR (2000).

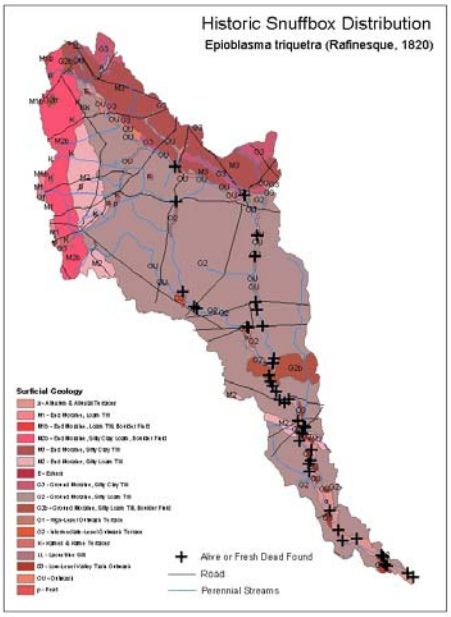
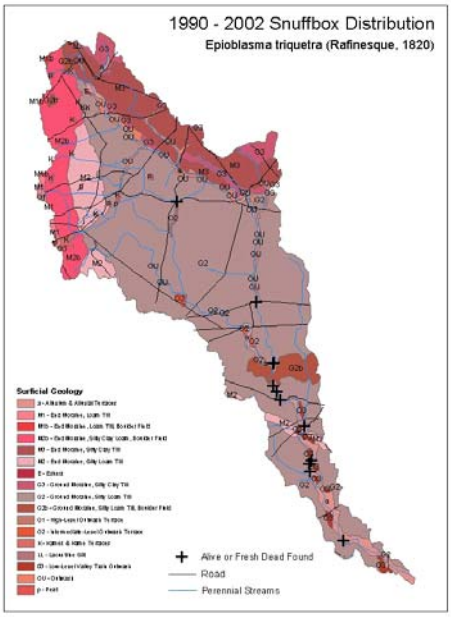


Figure B.7.4.7. Historical distribution of the snuffbox in Big Darby Creek, 1990 -2002 (Watters and Myers Flaute, 2003).GIS Surficial Geology Layer provided by ODNR (2000).



The washboard mussel (*Megalonaias nervosa*) was present in an area of ground moraine and till with boulders (Figures B.7.4.8 and B.7.4.9). There is a larger wide riparian area due to land use (parkland). The other site was in protected side pool in alluvium and alluvial terraces adjacent to low-level valley outwashes (somewhat narrow steep sided stream valley) with riparian corridor adjacent completely to the stream bank which stabilizes banks and allows for development of side pools or other habitat. The bottom was primarily loose sand and small gravel with a slight amount of silt settled on the pool surface.

Figure B.7.4.8. Historical distribution of the Washboard bivalve mussel in Big Darby Creek (Watters and Myers Flaute, 2003).GIS Surficial Geology Layer provided by ODNR (2000).

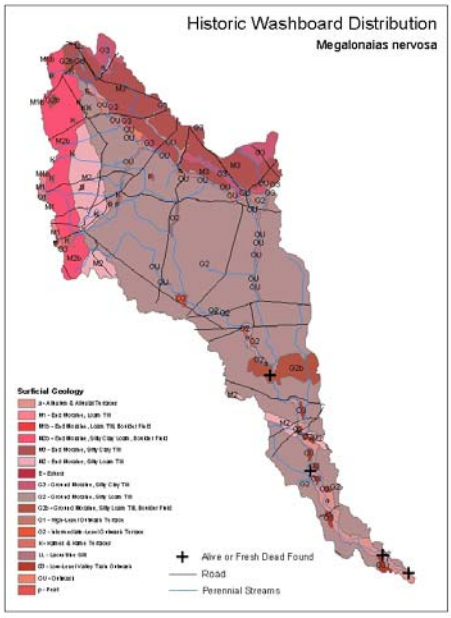
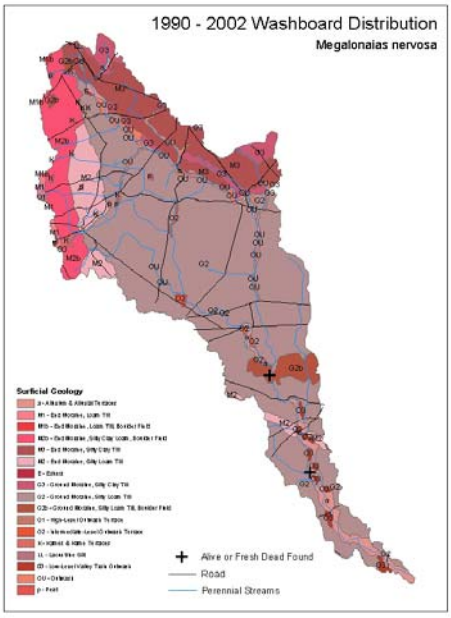


Figure B.7.4.9. Current distribution of the Washboard bivalve mussel in Big Darby Creek based on sampling from1990 - 2002 (Watters and Myers Flaute, 2003).GIS Surficial Geology Layer provided by ODNR (2000).



The federally endangered clubshell mussel (*Pleuroblema clava*) seems to be found near end moraine or in ground moraine (silty loam till) areas near alluvium terraces and/or outwash terraces (Figures B.7.4.10 and B.7.4.11). This matches their habitat preference for loose, coarse sand /gravel riffles (Watters, 1995). The clubshell mussel has a decreased presence downstream from West Jefferson and downstream from PCI discharges, but they are still present in more isolated reaches near alluvial and outwash terraces where wider riparian corridor is present, or where physical habitat (i.e., gradient adjacent stream) keeps land use activities and NPS inputs more distant from the river, whether from park activities, private lots, or agriculture. There is a probable threat in Spring Fork and downstream in Little Darby Creek from Green Meadows WWTP where there has continued to be water quality exceedences from their discharge. Siltation, embeddedness, and other NPS issues (nutrients, D.O.) are concerns and were reviewed earlier in this section.

Figure B.7.4.10. Historical distribution of the Clubshell bivalve mussel in Big Darby Creek (Watters and Myers Flaute, 2003).GIS Surficial Geology Layer provided by ODNR (2000).

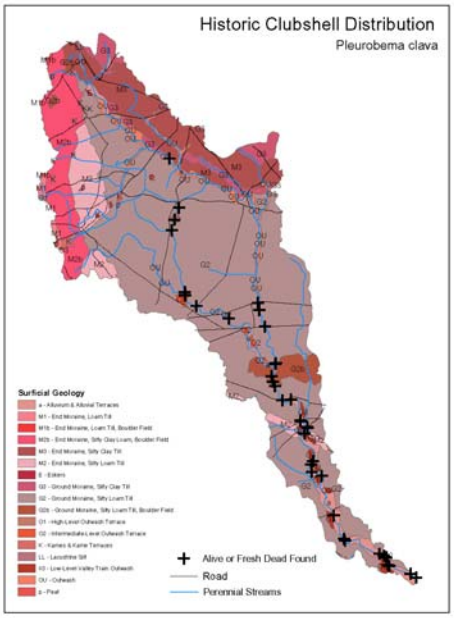
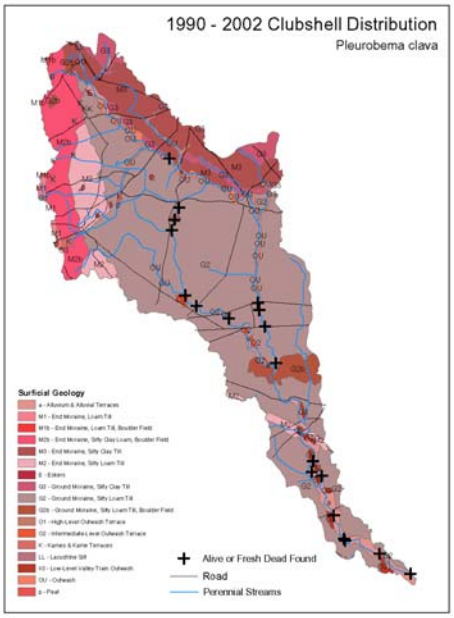


Figure B.7.4.11. Current distribution of the Clubshell bivalve mussel in Big Darby Creek based on sampling from1990 - 2002 (Watters and Myers Flaute, 2003).GIS Surficial Geology Layer provided by ODNR (2000).



The Ohio endangered rabbitsfoot mussel (*Quadrula cylindrica cylindrica*), since it rarely burrows buts lays on the surface substrates in slack water, has been susceptible to various impacts - sediment accumulation, low D.O.s from NPS nutrient effects, poor quality wastewater discharges, and spills (Watters,1995). It is still present in more stable isolated locations in Little Darby Creek in mixed sand and gravel (one site in lower BDC) where there is still cooler water temperatures and generally solid riparian buffers that allow for some shaded canopy (Cummings, 1992) (Figures B.7.4.12 and B.7.4.13).

Figure B.7.4.12. Historical distribution of the Rabbitsfoot bivalve mussel in Big Darby Creek (Watters and Myers Flaute, 2003).GIS Surficial Geology Layer provided by ODNR (2000).

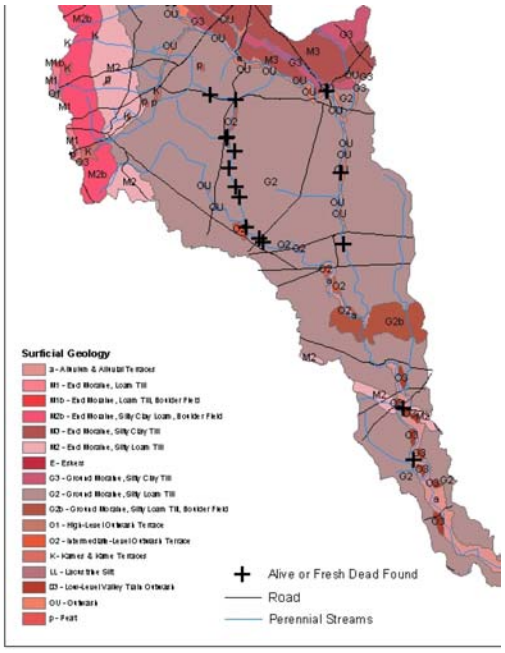
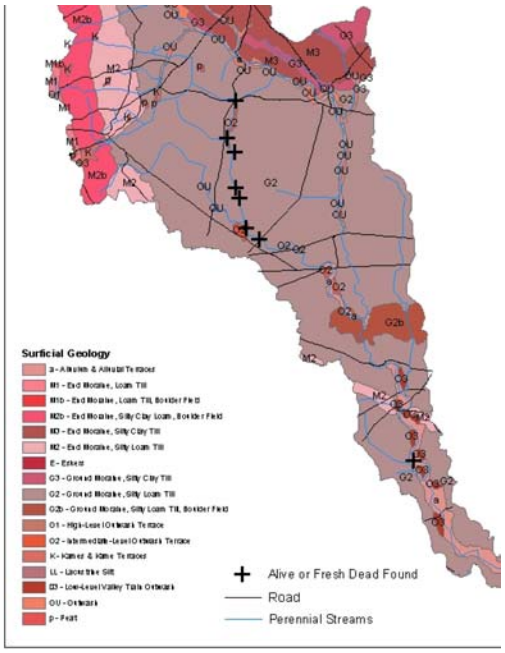


Figure B.7.4.13. Current distribution of the Rabbitsfoot bivalve mussel in Big Darby Creek based on sampling from1990 - 2002 (Watters and Myers Flaute, 2003).GIS Surficial Geology Layer provided by ODNR (2000).



Two of the hosts of the similar Cumberlandian subspecies of rabbitsfoot are the bigeye chub and spotfin shiner, which are resident in the Big Darby Creek basin (Watters,1995). The bigeye chub (*Notropus amblops*) prefers cool, clear water flowing through silt-free or silt-limited sand/ gravel riffles and pools (Trautman, 1981). It was last collected in 1930s in LDC, but recently with the removal of the dam at the mouth of Little Darby Creek bigeye chub populations were reestablished in Little Darby Creek. Ohio EPA fish collection data indicates bigeye chubs have been sampled and identified at RM 4.0 (1997) and at RMs 0.2, 4.1, 6.5, and 34.7 in 2001. It has not yet been collected in the reaches where current rabbitsfoot mussel populations reside. (It was

also collected in BDC at RM 10.4 downstream from rabbitsfoot mussel location in lower BDC.) The continued reestablishment and stability of bigeye chubs (a possible host of the rabbitsfoot mussel) in the middle reaches of Little Darby Creek depends on riparian buffer restoration in some areas of LDC (and BDC) to decrease NPS sedimentation. The spotfin shiner (*Cyprinella spiloptera*) is present throughout the watershed due to success of a better reproductive strategy against siltation (eggs attached under rocks). It is available as a possible host for the rabbitsfoot mussel to parasitize with glochidia and juveniles during the reproductive cycle. Practical habitat improvements in the LDC basin, in particular, could benefit this species and its potential host fish.

The federally endangered northern riffleshell mussel (*Epioblasma torulosa rangiana*) distribution was concentrated in Big Darby Creek from downstream the LDC confluence in park lands to the mouth (Figures B.7.4.14 and B.7.4.15). The moraine areas with alluvium or outwash sand and gravel seem to be the preferred glacial substrates which coincide with the preferred specific habitat of firm sand/gravel riffles in larger streams and medium to large rivers (Watters, 1995; Cummings et al., 1992). Current locations, if still there, are in park lands with

Figure B.7.4.14. Historical distribution of the Ohio Northern Riffleshell mussel in Big Darby Creek (Watters and Myers Flaute, 2003).GIS Surficial Geology Layer provided by ODNR (2000).

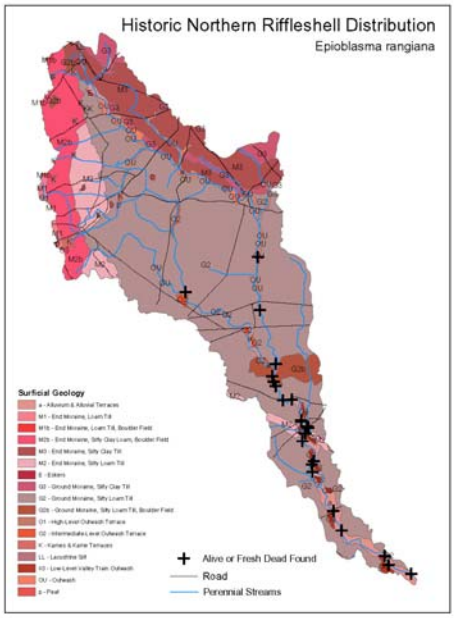
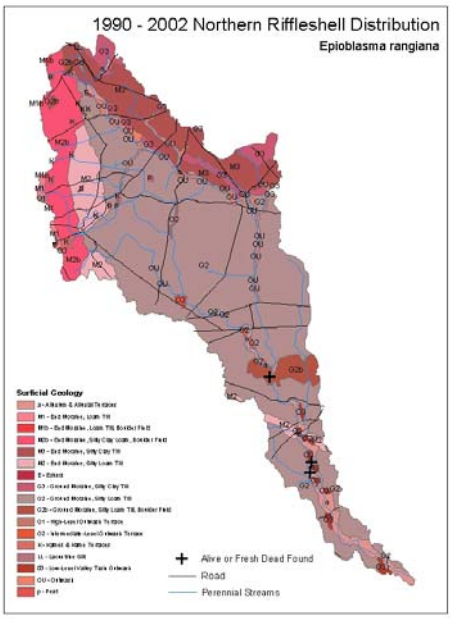


Figure B.7.4.15. Current distribution of the Northern Riffleshell mussel in Big Darby Creek based on sampling from1990 - 2002 (Watters and Myers Flaute 2003).GIS Surficial Geology Layer provided by ODNR (2000).



wide riparian buffer and in good habitat reach in lower Darby that had been relatively isolated. Losses due to poor wastewater quality and habitat instability seem to be major causes of the decreased distribution. Small malfunctioning waste treatment plants are being tied into a regional WWTP which also is functioning at a higher quality is addressing those water quality issues. Loss of stable mussel habitat (i.e., bars, side channels, water willow beds, unmoving unembedded riffles) due to increased storm water loads from upstream (particularly Hellbranch Run from increased metropolitan Columbus development pressures) inputs need to be slowed and controlled. Unembedded stable riffle/run habitat are essential to allow for the continued existence and possible reproduction of these and other sensitive mussel populations in the future. Also some mussel populations due to reduced numbers likely will have difficulty maintaining or increasing their numbers even after reducing or eliminating these stressors (Watters for USFWS, 1994).

The Ohio endangered rayed bean mussel (*Villosa fabalis*) seemed to have preferred locales with substrates from alluvium and glacial outwash with water willow habitat (Figures B.7.4.16 and B.7.4.17) (Watters,1995). However, it could be extirpated from the basin due to various factors; chemical impacts, sedimentation, loss of habitat, competition, habitat fragmentation which inhibit reproduction or recruitment (Butler et al. for USFWS, 2002). Its small size ($\leq$ 1 inch) does make it more difficult to locate.

In general, protection from destabilization of habitat due to loss of riparian width or increases in storm water inputs, NPS sedimentation, excess NPS nutrient inputs and poor quality wastewater inputs are essential to keep sensitive mussel distributions intact. Current ammonia and metal toxicity testing using mussels has indicated the possibility that lowered water quality criteria in specific locations might be needed to fully protect mussel species downstream from input sources (Ingersoll et al., 2003). These developments will continue to be monitored.

Figure B.7.4.16. Historical distribution of the Rayed Bean mussel in Big Darby Creek (Watters and Myers, 2002).GIS Surficial Geology Layer provided by ODNR (2000).

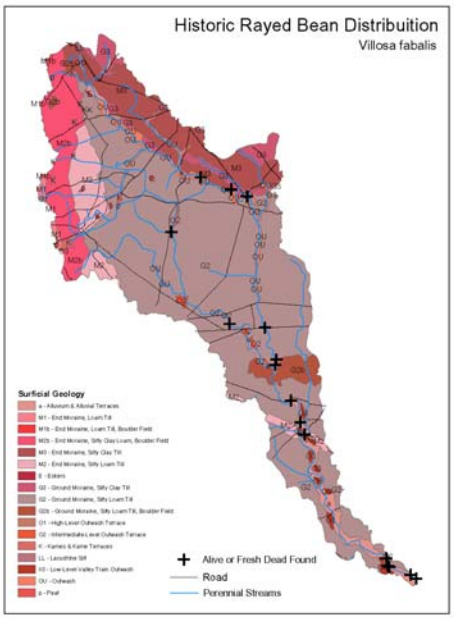
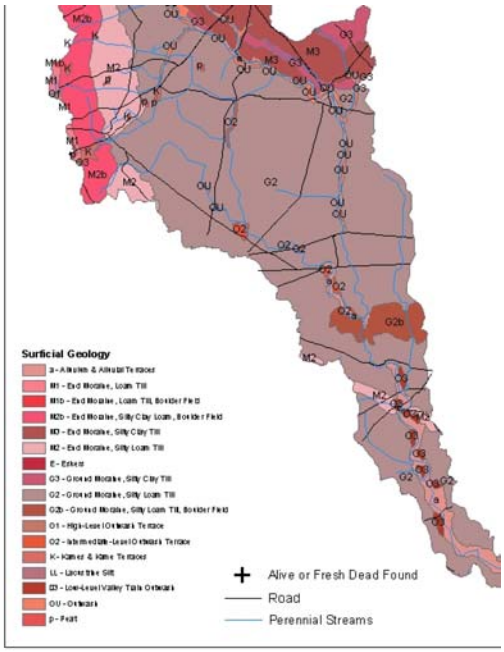



Figure B.7.4.17. Current distribution of the Rayed Bean mussel in Big Darby Creek based on sampling from1990 - 2002 (Watters and Myers, 2002).GIS Surficial Geology Layer provided by ODNR (2000).