Supplementary Material for Manuscript ID: water-1245899

A list of taxa and extirpation concentrations (XC95) for chloride and sulfate. Concentrations are in mg/l. Group codes used by Ohio EPA are as follows: N – non insect; M – mayfly; O – other; S – stonefly; C – caddisfly; D – dipteran; T – midges in the tribe Tanytarsini. Tolerance codes used by Ohio EPA are as follows: F – facultative; MT – moderately tolerant; MI – moderately intolerant; T – tolerant; NA – not assigned; I – intolerant; VT – very tolerant.

ITIS Serial Number	Ohio EPA Taxa Code	Name	Group	Tolerance	Chloride	Sulfate	Sulfate WAP
47691	X00401	Spongillidae	N	F	194.6	586.8	420.3
47714	X00556	Ephydatia fluviatilis	N	MT	237.7	298.4	
47705	X00653	Eunapius fragilis	N	F	146.7	197.9	169.5
659505	X00700	Radiospongilla crateriformis	N	F	105.8	115.3	
48893	X01200	Cordylophora caspia	N	MT	54.2		
50845	X01320	Hydra sp	N	F	164.4	304.5	348.4
53964	X01801	Turbellaria	N	F	306.1	1308.2	1389.3
57411	X01900	Nemertea	N	F	122.1	541.3	672.3
64183	X02600	Nematomorpha	N	F	117.9	297.4	239.3
155470	X03000	Ectoprocta	N	F	146.5	254.4	314.3
156722	X03040	Fredericella sp	N	F	255.6	482.5	505.5
155546	X03121	Paludicella articulata	N	MI	235.7	191.6	
156731	X03221	Pectinatella magnifica	N	F	80.2		
156690	X03301	Plumatellidae	N	NA	44.8		
156691	X03360	Plumatella sp	N	F	276.9	765.9	871.3
156754	X03451	Urnatella gracilis	N	MI	138.7	155.2	166.6
68422	X03600	Oligochaeta	N	T	306	1274.5	1322
68621	X03925	Branchiura sowerbyi	N	NA	108	143.7	
89856	X04410	Eiseniella tetraedra	N	NA	79.4		
69374	X04637	Placobdella phalera	N	MT	75.9	83.1	
69381	X04653	Glossiphonia complanata	N	MT	81.1	92.8	
69396	X04660	Helobdella sp	N	MT	158.7		
69397	X04661	Helobdella elongata	N	MT	124.3	120.9	
69398	X04664	Helobdella stagnalis	N	T	237.8	707	670.7
69403	X04666	Helobdella papillata	N	MT	321.6	552	1136.9
69363	X04680	Placobdella sp	N	MT	110.1	291.3	
69368	X04682	Placobdella montifera	N	MT	120.4	456.8	586
69367	X04683	Placobdella multilineata	N	F	140.9		
69366	X04685	Placobdella ornata	N	MT	215	960.7	726.1
69364	X04686	Placobdella papillifera	N	MT	183	210.9	401
69365	X04687	Placobdella parasitica	N	MT	162.4	496.4	537.2
69438	X04901	Erpobdellidae	N	MT	141.5	174.5	

69444	X04930	Erpobdella sp	N	MT	230.3	111.2	
69446	X04935	Erpobdella punctata punctata	N	MT	300.2	287.3	315.3
69449	X04960	Erpobdella sp (=Mooreobdella)	N	MT	194	199.7	
69451	X04962	Erpobdella fervida	N	MT	236	142	
69450	X04964	Erpobdella microstoma	N	MT	281.7	226.3	305
92686	X05800	Caecidotea sp	N	T	246.8	801.2	769.7
92666	X05900	Lirceus sp	N	MT	251.1	594.4	301
94025	X06201	Hyalella sp	N	F	245.4	1021.6	1042.8
95081	X06700	Crangonyx sp	N	MT	298.5	1003.7	979.7
93780	X06810	Gammarus fasciatus	N	F	225.8	802.3	600.4
573812	X06830	Gammarus minus	N	F	134.3	1241.5	1241.5
93950	X06904	Synurella dentata	N	MT	108.6	221.9	
97336	X07701	Cambaridae	N	NA	145.9	474.7	453.1
97337	X07800	Cambarus sp	N	F	95.1	266.2	302.9
650415	X07810	Cambarus (Cambarus) carinirostris	N	F	95	719.2	604.1
650416	X07820	Cambarus (Cambarus) bartonii cavatus	N	MT	109.3	492.7	503.9
97402	X07840	Cambarus (Cambarus) sciotensis	N	MI	88.2	218.6	154.6
97400	X07860	Cambarus (Puncticambarus) robustus	N	F	96.4	742.3	617
97337	X07870	Lacunicambarus sp	N	NA	71.1	128.4	
97337	X07875	Lacunicambarus polychromatus	N	MT	115.9	293.8	
203635	X07880	Lacunicambarus thomai	N	T	56	700.8	764
97421	X08200	Faxonius sp	N	F	178.6	662.2	579.6
650401	X08201	Faxonius cristavarius	N	F	48.6	189.8	188
97446	X08220	Faxonius immunis	N	T	167.2	219.6	
97466	X08230	Faxonius obscurus	N	MT	145	1335.3	1242.1
97473	X08240	Faxonius propinquus	N	F	169.2	84.7	
97424	X08250	Faxonius rusticus	N	F	296	706	813.6
97421	X08255	Faxonius rusticus x sanbornii	N	F	96.1	584.8	678.4
650422	X08260	Faxonius sanbornii sanbornii	N	F	276.3	1153.1	1050.6
97482	X08270	Faxonius sloanii	N	F	139	121.4	
650438	X08310	Procambarus (Ortmannicus) acutus acutus	N	T	122.9	80.1	

96396	X08451	Palaemon kadiakensis	N	F	158.3	496.6	
82754	X08601	Hydrachnidia	N	F	274.7	949.5	949.5
100755	X11001	Baetidae	M	NA	160.8	279.1	
100801	X11012	Acentrella nadineae	M	MI	32.5	118.7	123
568574	X11014	Acentrella turbida	M	I	130.1	270.5	269.5
568546	X11015	Acerpenna sp	M	MI	64.1	182.6	
568671	X11018	Acerpenna macdunnoughi	M	MI	87	300.3	299.9
206620	X11020	Acerpenna pygmaea	M	MI	123.7	226.4	238.8
609530	X11110	Acentrella parvula	M	I	39.8	58	
100817	X11115	Baetis tricaudatus	M	MI	214.6	353.7	413.5
568607	X11116	Plauditus cestus	M	I	35.7		
609559	X11118	Plauditus dubius	M	MI	122.2	151	162.8
568553	X11119	Plauditus dubius or P. virilis	M	I	111.4	302.1	310.9
100835	X11120	Baetis flavistriga	M	F	304.4	447.7	454.8
100771	X11121	Labiobaetis sp	M	MI	57	244.2	248.9
568680	X11123	Labiobaetis dardanus	M	MI	91.2	150.4	
568684	X11125	Labiobaetis frondalis	M	MI	92.8	375	376.4
100808	X11130	Baetis intercalaris	M	F	302.9	683.1	672.4
568681	X11150	Labiobaetis propinquus	M	MI	113.4	524.3	646.5
100794	X11155	Iswaeon anoka	M	MI	82.4	78	
568609	X11172	Plauditus punctiventris	M	MI	37.3	198.7	
100903	X11200	Callibaetis sp	M	MT	247.7	1223.5	1234
100757	X11245	Anafroptilum sp or Neocloeon sp	M	F	188.9	484.9	527.2
100757	X11250	Neocloeon sp	M	MI	167.6	529.6	580.3
100873	X11251	Anafroptilum sp	M	F	63	346.7	349
100873	X11260	Anafroptilum minor group sp 1	M	I	45.5	339	335.9
609552	X11295	Cloeon dipterum	M	T	329.3	557.5	
568598	X11430	Diphetor hageni	M	MI	110.3	448.1	449.7
100794	X11503	Heterocloeon (H.) sp.	M	I	77.7	94.8	
100899	X11600	Paracloeodes fleeki	M	MI	95.4	425	446.9
100901	X11620	Paracloeodes minutus	M	MI	140	141.8	147.6
206622	X11645	Procloeon sp	M	MI	106	372.5	372.5
206622	X11650	Procloeon sp (w/ hindwing pads)	M	MI	153.1	646.5	761
206622	X11651	Procloeon sp (w/o hindwing pads)	M	MI	165.4	534.3	534.3
609582	X11670	Procloeon viridoculare	M	MI	155.3	775.5	792
101041	X12200	Isonychia sp	M	MI	236.8	471.9	549.2

100676	X13000	Leucrocuta sp	M	MI	207.6	539.9	596.9
100692	X13100	Nixe sp	M	MI	121.1	379.8	379.8
100713	X13400	Stenacron sp	M	F	243.2	918.1	944.6
100507	X13500	Maccaffertium sp	M	MI	90.1	132.1	
100514	X13510	Maccaffertium exiguum	M	MI	155.2	254.6	225.9
100516	X13521	Stenonema femoratum	M	F	270.4	478.3	471.4
100530	X13540	Maccaffertium mediopunctatum	M	MI	68.4	98.5	74.1
206616	X13550	Maccaffertium mexicanum integrum	M	MI	209.1	190.5	197.7
100509	X13561	Maccaffertium pulchellum	M	MI	174.6	370.7	550.3
100542	X13570	Maccaffertium terminatum	M	MI	196	239.3	244.2
100548	X13590	Maccaffertium vicarium	M	MI	113.3	420.2	409.5
101095	X14501	Leptophlebiidae	M	MI	34	81.1	
101108	X14600	Choroterpes basalis	M	MI	54.5	268.6	267.6
101122	X14700	Habrophlebiodes sp	M	MI	54.3	94.5	105.8
101148	X14900	Leptophlebia sp	M	F	32	81.8	
101095	X14950	small Leptophlebiidae	M	F	102.3	865.9	400.6
101187	X15000	Paraleptophlebia sp	M	F	129.5	436.4	440
101232	X15501	Ephemerellidae	M	MI	77.3	187.6	
101324	X16200	Eurylophella sp	M	MI	60.6	310.1	316.5
101395	X16300	Teloganopsis sp	M	I	43.5		
101396	X16324	Teloganopsis deficiens	M	I	68.4	115.5	149.6
101405	X16700	Tricorythodes sp	M	MI	230.5	938	884.6
101472	X17103	Sparbarus lacustris	M	MI	26.6	26.7	
101478	X17200	Caenis sp	M	F	302.8	1005.5	1034
101494	X17600	Baetisca sp	M	MI	52.2	471.5	474.8
568559	X18100	Anthopotamus sp	M	MI	137.3	163.1	149.7
101526	X18600	Ephemera sp	M	MI	105.1	289.8	289.8
101535	X18630	Ephemera varia	M	MI	77.6	96.9	84.8
101537	X18700	Hexagenia sp	M	F	128.7	666.2	779.4
101538	X18708	Hexagenia bilineata	M	F	137.4	613.1	299.9
101552	X18750	Hexagenia limbata	M	F	122.9	674.9	748.8
102043	X21001	Calopterygidae	O	F	200.3	650.3	631.3
102052	X21200	Calopteryx sp	O	F	303.7	1299.2	1315.1
102048	X21300	Hetaerina sp	O	F	255.3	1414.7	1464.4
102060	X21604	Archilestes grandis	O	T	327	396.9	
102077	X22001	Coenagrionidae	O	T	306.1	1279.5	1331.5
102139	X22300	Argia sp	O	F	305.1	1293.9	1351.4
101603	X23600	Aeshna sp	O	MT	277.2	1154.5	990.9

101597	X23700	Anax sp	O	MT	222.7	276.6	
101598	X23704	Anax junius	O	MT	165.2	181.4	
101649	X23804	Basiaeschna janata	O	F	174.1	967.1	937.8
101646	X23905	Boyeria grafiana	O	MI	262.1	354.7	379.2
101647	X23909	Boyeria vinosa	O	F	273.4	1119.4	1055
101654	X24107	Nasiaeschna pentacantha	O	MT	188.6	201.6	
101664	X24501	Gomphidae	O	F	96.1	234.7	387.8
101730	X24700	Dromogomphus sp	O	F	58	943.9	
101665	X24900	Gomphus Complex	O	F	206	1305.7	1290
101735	X25010	Hagenius brevistylus	O	F	83	637.1	826.3
101768	X25210	Lanthus parvulus	O	MI	44.2	169.3	
101738	X25300	Ophiogomphus sp	O	MI	71.5	258.1	494.7
101720	X25410	Progomphus obscurus	O	MT	92.1	492.9	487.9
101762	X25510	Stylogomphus albistylus	O	MI	156.5	586.1	758.4
206626	X25600	Stylurus sp	O	MI	54.7	494.5	613.9
102027	X26100	Cordulegaster sp	O	F	138	840	622.8
102031	X26120	Cordulegaster maculata	O	F	25.6	485.3	566.7
101852	X26600	Didymops transversa	O	MT	139.6	468.2	461.4
101918	X26700	Macromia sp	O	MI	167.6	908.4	875
102020	X27001	Corduliidae	O	NA	120.9	319	253.9
206629	X27307	Epitheca (Epicordulia) princeps	O	MT	181.8	441.8	471.3
101880	X27340	Helocordulia uhleri	O	F	25.7	213.7	218.9
101934	X27400	Neurocordulia sp	O	F	127	259.1	303.5
101947	X27500	Somatochlora sp	O	MT	206.9	714	714
102035	X27600	Epitheca (Tetragoneuria) sp	O	MT	121.1	99.9	
101797	X28001	Libellulidae	O	MT	164.8	967.7	989.1
101866	X28208	Erythemis simplicicollis	O	MT	146.5	163.9	
101893	X28500	Libellula sp	O	MT	190.1	881.8	1176.7
101799	X28705	Pachydiplax longipennis	O	T	80.2	84.1	
101804	X28908	Perithemis tenera	O	T	82.1	104.6	
101809	X28955	Plathemis lydia	O	T	133	593.6	509.1
101976	X29000	Sympetrum sp	O	T	82.7	119.9	
101979	X29020	Sympetrum vicinum	O	T	107		
102471	X30800	Pteronarcys sp	S	MI	79.9	87.3	
102540	X32200	Amphinemura sp	S	MI	73	385.1	
102844	X33100	Leuctra sp	S	MI	184.1	971.5	962.1
102914	X34001	Perlidae	S	NA	39.1		
102917	X34100	Acroneuria sp	S	MI	110.5	311.2	369.8
102922	X34120	Acroneuria carolinensis	S	MI	111.1	460.2	419.8
609897	X34130	Acroneuria frisoni	S	MI	101	686.3	675.7

102925	X34140	Acroneuria internata	S	MI	71	328.8	
102918	X34150	Acroneuria lycorias	S	I	29.6	104.5	107.7
102942	X34300	Neoperla sp	S	I	95.9	356	362.8
102968	X34410	Paragnetina media	S	MI	66.3	103.9	
103251	X34500	Perlesta sp	S	F	95.3	801.3	766
103244	X34600	Perlinella sp	S	MI	89.8	119.1	
103246	X34605	Perlinella drymo	S	MI	128.9	159.5	167.4
102975	X34700	Agnetina sp	S	MI	111.6	165.9	114.8
102979	X34710	Agnetina capitata	S	MI	164.4	148.2	153
102984	X34715	Agnetina flavescens	S	I	74.3	104.6	
103273	X36500	Sweltsa sp	S	MI	82.7	414	414
103684	X42700	Belostoma sp	O	T	230.1	665.9	718.8
103766	X43205	Nepa apiculata	O	MT	115.9	238.1	
103748	X43300	Ranatra sp	O	F	193.2	541.4	648
103603	X43570	Neoplea sp	O	F	199.6	781	604.5
103665	X44300	Pelocoris sp	O	MT	148.6	550.9	
103364	X44501	Corixidae	O	F	156.8	845.5	872
103444	X45000	Hesperocorixa sp	O	T	78.7	417.6	
103491	X45100	Palmacorixa sp	O	F	209.5	939.4	838.4
103369	X45300	Sigara sp	O	MT	245.6	889.5	755.3
103423	X45400	Trichocorixa sp	O	MT	197.7	864.5	990.1
103558	X45900	Notonecta sp	O	T	300	961.2	789
115002	X47600	Sialis sp	O	MT	190.6	1288	1296.8
115024	X48200	Chauliodes sp	O	MT	120.9	426.5	
115025	X48220	Chauliodes rastricornis	O	T	113.4	103.7	
115034	X48410	Corydalus cornutus	O	MI	108.9	865.4	901.9
115028	X48600	Nigronia sp	O	F	95.7	420.5	
666581	X48610	Nigronia fasciata	O	MI	147.4	573.6	567.3
115031	X48620	Nigronia serricornis	O	F	130.6	1134.2	1067.7
115085	X49101	Sisyridae	O	F	157	114.3	
115087	X49200	Climacia areolaris	O	F	200	365.1	397
115090	X49400	Sisyra sp	O	F	124.7	170.1	109.8
115278	X50301	Chimarra aterrima	C	MI	285.6	1308.3	1158.2
115276	X50315	Chimarra obscura	C	MI	287.6	1107.3	1049.8
115322	X50410	Dolophilodes distinctus	C	MI	207.5	209	270
115392	X50804	Lype diversa	C	MI	144.5	1026.2	926.4
115341	X50906	Psychomyia flavida	C	MI	179.7	145.6	161.6
598193	X51100	Cernotina sp or Holocentropus sp	C	MI	50.7	548.9	564.7
117092	X51206	Cyrnellus fraternus	C	F	158.6	661.8	809.9
117095	X51300	Neureclipsis sp	C	MI	180.3	466.7	745.3

117104	X51400	Nyctiophylax sp	C	MI	172.7	1040.1	966.1
115361	X51500	Phylocentropus sp	C	F	107	159.8	176.2
568776	X51550	Plectrocnemia sp	C	MI	328.9	127.9	
117043	X51600	Polycentropus group	C	MI	205.7	1310.1	1298.7
115408	X52200	Cheumatopsyche sp	C	F	305.1	1274.7	1306.5
115402	X52315	Diplectrona modesta	C	F	155.4	532.2	530.4
115570	X52430	Ceratopsyche morosa group	C	MI	289.9	1310.7	1358.8
115586	X52440	Ceratopsyche slossonae	C	MI	174.1	1242	1242
115589	X52450	Ceratopsyche sparna	C	F	291.8	141.6	
115456	X52510	Hydropsyche aerata	C	MI	132.5	143.5	138
115458	X52520	Hydropsyche bidens	C	MI	165.5	110.9	
115453	X52530	Hydropsyche depravata group	C	F	305.6	1300.5	1322.8
115465	X52540	Hydropsyche dicantha	C	MI	157.9	785.2	762.3
115468	X52550	Hydropsyche frisoni	C	MI	86.7	647.3	663.5
115485	X52560	Hydropsyche orris	C	MI	160.9	275.4	294.8
115481	X52570	Hydropsyche simulans	C	MI	171.7	378.8	361.9
115482	X52580	Hydropsyche valanis	C	MI	132.4	125.8	139
115484	X52590	Hydropsyche venularis	C	MI	114.9	541	
115606	X52620	Macrostemum zebratum	C	I	95.1	127.4	134.7
115552	X52801	Potamyia flava	C	MI	91	97.6	
117159	X53300	Glossosoma sp	C	MI	94.9	234.4	257.6
115221	X53400	Protoptila sp	C	I	181.2	185	137.4
115629	X53501	Hydroptilidae	C	F	233.6	777.6	840.2
115641	X53800	Hydroptila sp	C	F	289.7	1306.8	1338
115631	X54000	Leucotrichia pictipes	C	MI	145.5	67.2	
115833	X54100	Neotrichia sp	C	F	23.7	1067.5	1102.6
115714	X54160	Ochrotrichia sp	C	MI	201.5	575.6	680
115828	X54200	Orthotrichia sp	C	F	155	259	
115779	X54300	Oxyethira sp	C	F	147.9	347.9	
115902	X55107	Oligostomis pardalis	C	F	26.7	422.1	405.8
115868	X55300	Ptilostomis sp	C	F	183.2	594.1	640
116910	X55520	Brachycentrus numerosus	C	MI	144.8	168.7	178
116046	X57400	Neophylax sp	C	MI	153.5	324.1	326.3
116409	X57900	Pycnopsyche sp	C	MI	188	1306.6	1286
116794	X58020	Lepidostoma sp	C	MI	71.3	146.1	148.4
117020	X58505	Helicopsyche borealis	C	MI	204.3	523.8	539.8
116547	X59001	Leptoceridae	C	MI	121.6	254.8	
116684	X59100	Ceraclea sp	C	MI	198.3	140.1	
116696	X59110	Ceraclea ancylus	C	MI	88.3	299.8	308.9

116684	X59120	Ceraclea flava or C. neffi	C	MI	56.2	239.5	260.6
116725	X59140	Ceraclea maculata	C	MI	84.6	137	
116684	X59150	Ceraclea resurgens or C. transversa	C	F	124.2	134.9	
116729	X59160	Ceraclea spongillovorax	C	MI	145.2	278.6	
116598	X59300	Mystacides sp	C	MI	224	365.5	401.2
116599	X59310	Mystacides sepulchralis	C	MI	189.5	269	281.9
116651	X59400	Nectopsyche sp	C	MI	127.6	572.3	
116661	X59407	Nectopsyche candida	C	MI	154	186.7	196.4
116663	X59410	Nectopsyche diarina	C	MI	180	704.9	948.8
116659	X59415	Nectopsyche exquisita	C	MI	160.2	123.9	
116607	X59500	Oecetis sp	C	F	130.5	660.5	756.1
116608	X59510	Oecetis avara	C	I	89.4	442.5	658.8
116609	X59520	Oecetis cinerascens	C	F	126.2	290.1	
116613	X59550	Oecetis inconspicua complex sp A (sensu Floyd, 1995)	C	F	141.3	110.3	
116613	X59555	Oecetis inconspicua complex sp F (sensu Floyd, 1995)	C	F	157.3	129.5	
116631	X59570	Oecetis nocturna	C	F	199.7	376.8	349.6
116636	X59580	Oecetis persimilis	C	MI	97.4	478.3	476.3
116565	X59700	Triaenodes sp	C	MI	103.8	539.8	534.7
116571	X59720	Triaenodes ignitus	C	MI	174.3	596.2	592.7
116572	X59724	Triaenodes injustus	C	MI	149.6	407.6	443.6
116575	X59728	Triaenodes marginatus	C	F	132.8	510.3	611.8
116593	X59730	Triaenodes melaca	C	MI	139.1	591.6	577.1
206644	X59740	Triaenodes perna	C	MI	75.8	161.1	211.9
117714	X59950	Parapoynx sp	O	MI	88.9	401.4	
117682	X59970	Petrophila sp	O	MI	201.6	555.6	435.9
112711	X60300	Dineutus sp	O	F	130.8	845.8	867.6
112654	X60400	Gyrinus sp	O	F	150.1	1042.1	1017.6
111858	X60800	Haliplus sp	O	MT	201.1	1077.5	1291.2
111923	X60900	Peltodytes sp	O	MT	246.4	978	1014.5
112074	X61100	Acilius sp	O	T	108	141.1	
111966	X61400	Agabus sp	O	T	92.4	683.3	990.9
112561	X62200	Copelatus sp	O	MT	142.7	95.6	
111963	X63300	Hydroporini	O	T	280.8	1133	1056.5
112200	X63600	Hygrotus sp	O	MT	185.6		
112181	X63700	Ilybius sp	O	T	86.1	1007.9	
112278	X63900	Laccophilus sp	O	T	296.5	1049.3	977.9
112580	X64050	Liodessus sp	O	MT	161.4	725.1	872.4

112575	X64800	Uvarus sp	O	MT	138.8	367.6	798.4
112811	X65501	Hydrophilidae	O	F	94.6	937.7	1069.3
112878	X65700	Anacaena sp	O	MT	155	260.5	264.3
112812	X65800	Berosus sp	O	MT	319	949.3	992.8
113017	X66200	Cymbiodyta sp	O	MT	101.9	619.6	632.3
112973	X66500	Enochrus sp	O	MT	251.2	853.9	847.3
113149	X66901	Helocombus bifidus	O	MT	177.8	107.2	
113106	X67000	Helophorus sp	O	MT	174.7	384.6	423.9
113196	X67100	Hydrobius sp	O	F	104	570.9	574.2
113166	X67300	Hydrochus sp	O	MT	157.7	438.3	265.9
112858	X67500	Laccobius sp	O	F	145.1	906.2	871.3
112909	X67700	Paracymus sp	O	MT	165.1	661.9	894.6
112932	X67750	Sperchopsis tesselatus	O	F	106.1	390.9	458.1
112938	X67800	Tropisternus sp	O	T	303.7	950	951.5
114087	X68025	Ectopria sp	O	F	225.9	637	650
114072	X68075	Psephenus herricki	O	MI	243.4	952	970.3
114006	X68130	Helichus sp	O	F	243.8	1001.4	1012.5
113924	X68201	Scirtidae	O	F	202.4	1137.1	1187
113948	X68300	Cyphon sp	O	MT	147.7	440.4	320
114194	X68601	Ancyronyx variegatus	O	F	246.3	917.9	892.4
114126	X68700	Dubiraphia sp	O	F	161.8	792.2	691.6
114129	X68702	Dubiraphia bivittata	O	F	216	478.6	
114130	X68707	Dubiraphia quadrinotata	O	F	173.3	875.2	792.9
114126	X68708	Dubiraphia vittata group	O	F	277.5	1301.3	1323.2
114213	X68901	Macronychus glabratus	O	F	242.3	1128.3	1053.5
114177	X69200	Optioservus sp	O	MI	118.5	218.4	227.2
114185	X69210	Optioservus ovalis	O	MI	92.9	474.8	491.7
114190	X69225	Optioservus fastiditus	O	MI	159	531.9	571.6
114186	X69275	Optioservus trivittatus	O	MI	117.4	600.2	672.3
114095	X69400	Stenelmis sp	O	F	302.8	1292.1	1321.8
114113	X69420	Stenelmis sexlineata	O	NA	152	186.3	
114038	X69713	Lutrochus laticeps	O	MI	69.5	452.8	
113835	X69930	Lampyridae	O	F	54	621	
118840	X70501	Tipulidae	D	NA	57.1	68.3	
119654	X70502	Limoniinae	D	NA	112.9	624.7	
119656	X70600	Antocha sp	D	MI	309.7	721.1	689.8
121027	X70700	Dicranota sp	D	MI	149.9	943	1018.1
120094	X71100	Hexatoma sp	D	MI	235.9	1139.8	1160
120165	X71200	Limnophila sp	D	MI	45.1	310.6	
119704	X71300	Limonia sp	D	F	216.8	304.6	319.1
120830	X71500	Ormosia sp	D	MT	65.1		

120335	X71700	Pilaria sp	D	F	149.6	752.2	883.9
120365	X71800	Pseudolimnophila sp	D	MI	81.3	383.9	249.5
119037	X71900	Tipula sp	D	F	306.9	1085.4	1067.2
119041	X71910	Tipula abdominalis	D	F	158.7	724.5	711.7
125810	X72330	Dixa sp	D	F	19.3	184.7	179.6
125854	X72340	Dixella sp	D	F	144.4	809.3	627.9
125904	X72420	Chaoborus sp	D	T	79.2	88.7	
125930	X72501	Culicidae	D	MT	69	72.8	
126234	X72600	Aedes sp	D	T	110.1	69.3	
125956	X72700	Anopheles sp	D	F	294	1293.7	1297.3
126455	X72900	Culex sp	D	T	162.6	248.7	359.5
126774	X74100	Simulium sp	D	F	270	1125	1070.8
127076	X74501	Ceratopogonidae	D	T	222.2	1292.8	1339.6
127113	X74650	Atrichopogon sp	D	F	66.2	271.6	332.4
127150	X74673	Atrichopogon websteri	D	F	73	253.9	285.6
127994	X77001	Tanypodinae	D	NA	55.3		
128079	X77100	Ablabesmyia sp	D	NA	94.5	172.1	
128081	X77110	Ablabesmyia annulata	D	F	71.3	102.2	102.9
128093	X77115	Ablabesmyia janta	D	F	127.5	216.8	276.8
128097	X77120	Ablabesmyia mallochi	D	F	305.9	1273.2	1315.9
128079	X77130	Ablabesmyia rhamphe group	D	MT	168.4	828.2	1026.4
128113	X77140	Ablabesmyia peleensis	D	NA	131	165.6	
128123	X77150	Ablabesmyia simpsoni	D	F	121.7	500.1	
127998	X77355	Clinotanypus pinguis	D	MT	164.4	897.6	981.8
128130	X77500	Conchapelopia sp	D	F	305.3	1291.6	1151.5
128249	X77740	Thienemannimyia (Hayesomyia) senata	D	F	135.8	551.3	624.4
127994	X77750	Thienemannimyia sp	D	F	248.3	808.3	857.4
128131	X77800	Helopelopia sp	D	F	303.8	685	762.3
128174	X78101	Labrundinia becki	D	F	46.3	207.1	
128177	X78130	Labrundinia neopilosella	D	NA	64.8	233.6	
128178	X78140	Labrundinia pilosella	D	F	151.6	825.5	815.9
128183	X78200	Larsia sp	D	MT	110.1	263.1	349.2
128132	X78350	Meropelopia sp	D	F	191.7	753.5	753.5
128070	X78400	Natarsia sp	D	F	143	289.6	
128070	X78401	Natarsia species A (sensu Roback, 1978)	D	T	243.6	759.2	909.3
128071	X78402	Natarsia baltimoreus	D	F	150	221.1	206.5
128203	X78450	Nilotanypus fimbriatus	D	F	254.5	452	471.4
128209	X78500	Zavrelimyia (Paramerina) fragilis	D	F	158.4	385.9	418.9

128216	X78600	Pentaneura inconspicua	D	F	127.1	991	1471.6
599368	X78601	Pentaneura inyoensis	D	F	184.2	910.2	566.1
128277	X78650	Procladius sp	D	MT	131.1	812.3	
128277	X78655	Procladius (Holotanypus) sp	D	MT	273.5	1278	1331.9
128285	X78680	Procladius (Psilotanypus) bellus	D	MT	100.3	254.4	
128056	X78702	Psectrotanypus dyari	D	VT	187.5	120.8	
128229	X78750	Rheopelopia paramaculipennis	D	MI	133.8	160.7	
128329	X79020	Tanypus neopunctipennis	D	T	176.3	1370.3	
128333	X79030	Tanypus punctipennis (sensu Roback, 1977)	D	T	51.4	888.2	
128234	X79085	Telopelopia okoboji	D	MI	112.8	147	
127994	X79100	Thienemannimyia group	D	F	164.3	219.1	
128252	X79300	Trissopelopia ogemawi	D	MI	67.7	194.7	171.8
128259	X79400	Zavrelimyia (Z.) sp	D	F	162.9	606.2	424.5
128355	X79720	Diamesa sp	D	F	224.7	659.1	683.9
128477	X80204	Brillia flavifrons group	D	F	136.3	392.1	422.4
128515	X80310	Cardiocladius obscurus	D	MI	202.3	168.6	222.9
128563	X80350	Corynoneura sp	D	MI	80.8	93.5	
128563	X80351	Corynoneura caudicula	D	F	159.7	215.1	218.2
128563	X80360	Corynoneura floridaensis	D	MI	120.3	192.1	163.9
128563	X80363	Corynoneura sp. 12	D	MI	165.1	87.1	
128567	X80370	Corynoneura lobata	D	F	164.2	649.5	601.5
128575	X80400	Cricotopus sp	D	F	75.4	184.6	
128575	X80410	Cricotopus (C.) sp	D	F	232.9	1045.7	1061.8
128578	X80415	Cricotopus (Isocladius) absurdus	D	MI	50.4	133	
128583	X80420	Cricotopus (C.) bicinctus	D	T	295.4	1299.4	1292.1
128640	X80427	Cricotopus (C.) politus	D	MI	74.6	428.8	
128575	X80430	Cricotopus (C.) tremulus group	D	MT	317.2	1169.4	1064.4
128659	X80440	Cricotopus (C.) trifascia	D	F	233.4	967.4	896.5
128575	X80510	Cricotopus (Isocladius) sylvestris group	D	T	331.6	640.6	
128681	X80570	Doncricotopus bicaudatus	D	F	101.7	278.1	
128689	X80710	Eukiefferiella brehmi group	D	MI	73.2	68.2	
128689	X80720	Eukiefferiella brevicalcar group	D	F	97.2		

128689	X80740	Eukiefferiella claripennis group	D	MT	166.5	593.2	
128689	X80750	Eukiefferiella devonica group	D	F	65.6	75.8	
128811	X81060	Lopescladius sp	D	MI	69	59.9	
128844	X81200	Nanocladius sp	D	F	185.8	120.7	
128844	X81201	Nanocladius (N.) sp	D	F	58		
128844	X81231	Nanocladius (N.) crassicornus or N. (N.) \rectinervis\""	D	F	225.8	342.1	432
128853	X81240	Nanocladius (N.) distinctus	D	MT	158.6	184.2	
128859	X81250	Nanocladius (N.) minimus	D	F	134.4	135.2	
128862	X81270	Nanocladius (N.) spiniplenus	D	F	112.3	190.9	155.2
128855	X81280	Nanocladius (Plecopteracoluthus) downesi	D	MI	66.4	169.6	204.1
128874	X81460	Orthocladius (O.) sp	D	F	128.9	233.5	257.1
128882	X81465	Orthocladius (O.) carlatus	D	F	63.9	206.4	
128913	X81530	Orthocladius (Symposiocladius) lignicola	D	MI	54.9	92.3	
128968	X81631	Parakiefferiella n.sp 1	D	F	111.5	411.3	
128968	X81632	Parakiefferiella n.sp 2	D	F	150.7	1097.7	
128968	X81633	Parakiefferiella n.sp 5	D	MI	104.9	463.5	
128978	X81650	Parametriocnemus sp	D	F	219.5	1153.1	1162.3
129005	X81690	Paratrichocladius sp	D	MI	144.8	595.4	610
129102	X81825	Rheocricotopus (Psilocricotopus) robacki	D	F	248.9	1012.5	1028.8
129162	X82070	Synorthocladius semivirens	D	F	165.1		
129182	X82100	Thienemanniella sp	D	F	176.7	306.7	
129182	X82101	Thienemanniella taurocapita	D	MI	265.2	449.1	502.2
129182	X82121	Thienemanniella lobapodema	D	F	168.1	549.5	647.3
129189	X82130	Thienemanniella similis	D	MI	185.6	195.3	138.6
129190	X82141	Thienemanniella xena	D	F	319.2	766.7	800.9
129197	X82200	Tvetenia bavarica group	D	MI	191.2	499.3	530.6
129197	X82220	Tvetenia discoloripes group	D	MI	220.6	141.2	135.5
129209	X82300	Xylotopus par	D	MI	146.8	298.7	278.9
129236	X82600	Axarus sp	D	F	64.4	421.7	547

129254	X82700	Chironomus sp	D	MT	143.6	129.8	
129254	X82710	Chironomus (C.) sp	D	MT	227.7	286.8	
129254	X82730	Chironomus (C.) decorus group	D	T	307.4	1313.9	1313.9
129254	X82770	Chironomus (C.) riparius group	D	T	198.6	194.3	
129350	X82800	Cladopelma sp	D	T	167	954.2	
129368	X82820	Cryptochironomus sp	D	F	308.4	1305.6	1331.5
129368	X82822	Cryptochironomus eminentia	D	F	95.8	121.6	
129384	X82824	Cryptochironomus ponderosus	D	F	217.5	456.3	628.6
129386	X82826	Cryptochironomus psittacinus	D	F	80	148.3	
129394	X82880	Cryptotendipes sp	D	F	57.5	337.6	
129404	X82885	Cryptotendipes pseudotener	D	F	194.1	1112.2	1140.9
129421	X82900	Demicryptochironomus sp	D	MI	109.8	88.9	
129428	X83000	Dicrotendipes sp	D	F	124.5	154.5	
129448	X83002	Dicrotendipes modestus	D	MT	277.5	335.3	428.1
129436	X83003	Dicrotendipes fumidus	D	F	249	480.1	489.9
129450	X83040	Dicrotendipes neomodestus	D	F	293.6	1097.2	1070
129458	X83050	Dicrotendipes lucifer	D	MT	144.7	204.4	
193743	X83051	Dicrotendipes simpsoni	D	T	174	285.5	
129471	X83158	Endochironomus nigricans	D	MT	163.7	273.6	299.7
129483	X83300	Glyptotendipes (G.) sp	D	MT	172.5	374	397.2
129484	X83310	Glyptotendipes (Heynotendipes) chelonia	D	MI	142.7	147.2	
129516	X83400	Harnischia sp	D	F	100.1		
129517	X83410	Harnischia curtilamellata	D	F	149.5	181.4	197.9
129522	X83590	Kiefferulus sp	D	T	46.7	162.2	
129535	X83820	Microtendipes \caelum\" (sensu Simpson & Bode, 1980)"	D	MI	209.1	645.1	646.3
129541	X83840	Microtendipes pedellus group	D	F	222.5	824.3	668.8
129547	X83860	Microtendipes rydalensis	D	MI	46.9	39.4	
129548	X83900	Nilothauma sp	D	F	105.5	311.6	247.6
129564	X84000	Parachironomus sp	D	MT	151.6	155.1	

129564	X84010	Parachironomus abortivus (sensu Simpson & Bode, 1980)	D	MT	59.5	113.9	
129569	X84020	Parachironomus carinatus	D	F	84.2	174.7	
129579	X84040	Parachironomus frequens	D	F	188.1	216	
129583	X84060	Parachironomus pectinatellae	D	MI	145.9	202.8	233.5
129608	X84116	Paracladopelma nereis	D	F	91.8	134.4	
129612	X84118	Paracladopelma undine	D	MI	78.3	159.3	
129619	X84155	Paralauterborniella nigrohalteralis	D	F	161.3	1081.5	982.2
129623	X84210	Paratendipes albimanus or P. duplicatus	D	F	302.8	1138	1022.8
129647	X84300	Phaenopsectra obediens group	D	F	248.7	804.4	804.4
129652	X84302	Phaenopsectra punctipes	D	F	88.4	366.2	158.8
129642	X84315	Phaenopsectra flavipes	D	MT	311.8	539	604.1
129657	X84420	Polypedilum (P.) n.sp 1	D	MI	79.1		
129657	X84430	Polypedilum (P.) albicorne	D	F	232.5	495.2	523.1
129666	X84440	Polypedilum (Uresipedilum) aviceps	D	MI	216.2	545.4	418.2
129671	X84450	Polypedilum (Uresipedilum) flavum	D	F	246.1	907	979
129676	X84460	Polypedilum (P.) fallax group	D	F	230	711.4	635.7
129657	X84469	Polypedilum (P.) illinoense group	D	NA	133.2	142.3	152.8
129686	X84470	Polypedilum (P.) illinoense	D	T	305.6	1286.8	1315.7
129701	X84475	Polypedilum (P.) ophioides	D	F	175.7	354	410.5
129692	X84480	Polypedilum (P.) laetum group	D	MI	170.8	375.8	214.8
129698	X84490	Polypedilum (Cerobregma) ontario	D	MI	114.2	126.8	
129657	X84520	Polypedilum (Tripodura) halterale group	D	MT	200.9	541.2	566.2
129657	X84540	Polypedilum (Tripodura) scalaenum group	D	F	309.3	529.3	534.4

129735	X84601	Saetheria species 1 (sensu Jackson, 1977)	D	F	112.8	770.9	
129737	X84612	Saetheria tylus	D	F	175.1	487.4	491.1
129746	X84700	Stenochironomus sp	D	F	230.6	825.8	829.7
129785	X84750	Stictochironomus sp	D	F	290.6	1027.9	1053.4
129823	X84790	Tribelos fuscicorne	D	F	134.3	760.6	796.2
129827	X84800	Tribelos jucundum	D	MT	192.5	571.5	414.1
129838	X84888	Xenochironomus xenolabis	D	F	182.7	363.4	412.3
129851	X84960	Pseudochironomus sp	D	F	132.2	307.9	758.5
129873	X85200	Cladotanytarsus sp	T	F	146.9	429.4	
129873	X85201	Cladotanytarsus species group A	T	F	184.3	529.5	555.8
129873	X85230	Cladotanytarsus mancus group	T	F	215.5	829.1	782.7
129873	X85261	Cladotanytarsus vanderwulpi	T	MI	129.1	348	386.1
129873	X85263	Cladotanytarsus vanderwulpi group sp 3	T	MI	65	174.9	
129873	X85264	Cladotanytarsus vanderwulpi group sp 4	T	MI	111	375.3	379.9
129873	X85265	Cladotanytarsus vanderwulpi group sp 5	T	MI	169.8	169.9	185.2
129890	X85400	Micropsectra sp	T	MT	155.2	361.4	679.7
129935	X85500	Paratanytarsus sp	T	F	272	1032	1055.8
129935	X85501	Paratanytarsus longistilus	T	MI	160.9	449.9	475.1
129959	X85615	Rheotanytarsus pellucidus	T	MI	215.5	848.3	856.1
129952	X85625	Rheotanytarsus sp	T	F	290.8	1003.1	1051.3
129969	X85711	Stempellinella leptocelloides	T	MI	86.7	326.6	332.5
129969	X85720	Stempellinella fimbriata	T	MI	115.2	230.8	223
129976	X85752	Sublettea coffmani	T	MI	127.7	352.8	438
129978	X85800	Tanytarsus sp	T	F	300.5	1307.1	1342.3
129978	X85801	Tanytarsus sp 1	T	F	26.3	160.3	162.4
129985	X85802	Tanytarsus n. sp. near curticornis	T	F	119.6	435.2	375.9
129978	X85814	Tanytarsus glabrescens group	T	F	104.2	732.2	
129978	X85815	Tanytarsus glabrescens group sp 1	T	F	97.7	425.2	439.9
129978	X85818	Tanytarsus glabrescens group sp 4	T	F	72.3	331.8	368.4

129978	X85821	Tanytarsus glabrescens group sp 7	T	F	295.9	1017.6	955.7
129978	X85840	Tanytarsus sepp	T	F	232.3	1003.7	1041.4
131078	X86100	Chrysops sp	D	F	233.8	1288.1	1331.1
131527	X86200	Tabanus sp	D	F	117.3	661.8	564.7
130930	X86401	Atherix lantha	D	MI	121.2	1224.9	1262.9
130473	X86900	Myxosargus sp	D	MT	82.4		
130573	X87190	Odontomyia (Catatasina) sp	D	MT	66.7	87	
130573	X87250	Odontomyia (Odontomyiina) sp	D	MT	66.7		
130627	X87400	Stratiomys sp	D	MT	160.4	1109	1164.6
135830	X87501	Empididae	D	F	276.2	389.7	608.7
136352	X87510	Neoplasta sp	D	MI	70.5	169.1	
136327	X87540	Hemerodromia sp	D	F	213.7	1139.8	1151.8
136824	X87601	Dolichopodidae	D	MT	108.8	89.9	
144653	X89001	Sciomyzidae	D	MT	74.6	1135.7	1238.7
146893	X89501	Ephydridae	D	F	129.4	199.6	253.9
150730	X89700	Limnophora sp	D	F	116.2	112.5	
150806	X89704	Lispoides aequifrons	D	F	223.9	404	
150733	X89716	Limnophora discreta	D	MT	133.5	305.3	
70312	X92516	Campeloma decisum	N	F	106.9	223.1	
70331	X92613	Cipangopaludina chinensis malleata	N	MT	101	72	
70332	X92615	Cipangopaludina japonica	N	MT	173.2	319.6	
70493	X93200	Hydrobiidae	N	F	198.5	389.1	372.7
71654	X93900	Elimia sp	N	MI	305	653	701.5
76497	X94400	Fossaria sp	N	MT	194.9	930.9	871.1
76529	X94603	Pseudosuccinea columella	N	MT	68.1	166.6	
76534	X94800	Stagnicola sp	N	T	90.7	90.5	
76698	X95100	Physella sp	N	T	306.4	1287.9	1322
76592	X95900	Gyraulus sp	N	MT	212.8	58.9	
76595	X95907	Gyraulus (Torquis) parvus	N	MT	166.1	289	
76601	X96002	Helisoma anceps anceps	N	F	205.8	596.4	533.9
205210	X96120	Menetus (Micromenetus) dilatatus	N	MT	161.6	288.3	411.4
76654	X96200	Planorbella sp	N	T	90.6	88.7	
76667	X96264	Planorbella (Pierosoma) pilsbryi	N	T	210	462.9	553.1
76671	X96280	Planorbella (Pierosoma) trivolvis	N	MT	126.5	158.4	

76569	X96900	Ferrissia sp	N	F	272.9	818	824.6
76577	X96930	Laevapex fuscus	N	MT	133.5	354.5	
81387	X97601	Corbicula fluminea	N	F	250	928	963.2
81339	X97710	Dreissena polymorpha	N	F	210.1	658.9	716.1
112738	X98001	Sphaeriidae	N	NA	83.6	84.2	
81400	X98200	Pisidium sp	N	MT	295.2	1071.9	1077.7
81391	X98600	Sphaerium sp	N	F	307.5	891.2	928.8
568179	X99100	Pyganodon grandis	N	F	168.1	376.2	447.7
568432	X99120	Utterbackia imbecillis	N	MI	93.8	367.9	
80148	X99160	Anodontoides ferussacianus	N	F	133.8	205.9	
80152	X99180	Strophitus undulatus	N	MI	104.2	200.3	
79918	X99200	Alasmidonta marginata	N	MI	80.2	73.2	
80135	X99240	Lasmigona complanata	N	MI	149.9	588.7	637.2
80138	X99260	Lasmigona compressa	N	MI	108.9	682.7	
80139	X99280	Lasmigona costata	N	MI	176.3	169.9	
80293	X99320	Tritogonia verrucosa	N	MI	118	413.4	448.6
80063	X99380	Cyclonaias pustulosa	N	MI	111.6	329.8	
80060	X99400	Quadrula quadrula	N	MI	117.3	165.3	158
80036	X99420	Amblema plicata	N	MI	58.4	234.7	306.1
80041	X99440	Fusconaia flava	N	MI	161.9	382.3	429.5
79953	X99540	Eurynia dilatata	N	MI	65	112.8	
80158	X99560	Ptychobranchus fasciolaris	N	MI	58.4	113.9	
80193	X99600	Actinonaias ligamentina	N	MI	43.5		
80167	X99660	Truncilla truncata	N	MI	132	171	
80182	X99680	Leptodea fragilis	N	MI	121.9	282	266
80282	X99700	Potamilus alatus	N	MI	133.1	163	
80364	X99740	Toxolasma parvum	N	F	119.3	78.9	
80202	X99820	Villosa iris	N	MI	52.3		
80028	X99860	Lampsilis siliquoidea	N	MI	169	459.1	604
80016	X99880	Lampsilis cardium	N	MI	93.3	140.8	147.9

Headwater Summary Macroinvertebrate Index Based on Presence/Absence Data

Because artificial substrates are rarely employed at drainage areas less than 20 mi^2, most macroinvertebrate condition assessments are narrative ratings based on qualitative (i.e., presence/absence) samples. Also, because the existing multimetric index is based on a population of reference sites with drainage areas mostly greater than 3 mi^2, expectations for assemblage metrics are ambiguous for very small headwaters. Although the narrative ratings are reliable indicators of condition, categorical ratings lack the advantages inherent in a continuously scaled index. Continuous indexes are more amenable to linear statistics (e.g., correlations against stressors), and provide a finer degree of context for where condition is positioned along a stressor gradient.

A summary numeric index based on qualitative data was constructed by assembling candidate metrics based on either class counts (e.g., the number of taxa classed as mayflies), or as percentages of total taxa found at a given site (e.g., the number of mayfly taxa/total taxa x 100). The various aggregations were as follows:

Table S1. Possible metrics based on qualitative data.

Metric	Counts	Percents
Total Taxa	TOTL	
EPT taxa	EPT	PCTEPT
Predators	PREDS	PCPRED
Tolerant (VT, MT, T)	TOLS	PCTOL
Non-insect taxa	NINS	PCTNINS
Shredders	SHRED	PCTSHRED
Scrapers	SCRAPE	PCTSCRAPE
Gatherers	GATH	PCTGATH
Filterers	FILT	PCTFILT
Parasites	PARA	PCTPARA
Piercers	PIERC	PCTPIERC
Facultative Taxa	FACULT	PCTFAC
Sensitive Taxa (MI, I)	SENS	PCTSENS
Intolerant Taxa (I)	INTOL	PCTINTOL
Mayflies	MAY	PCTMAY
Dipterans	DIPT	PCTDIPT
Tanytarsini midges	TANY	PCTTANY
Caddiflies	CAD	PCTCAD
Other Taxa	OTHR	PCTOTHR
Stoneflies	STONE	PCTSTONE
EPT excluding facultative	EPTXF	
Coldwater indicators	COLD	PCTCOLD

Clearly, one might suspect that many of these metrics are highly correlated, so a principal component analysis (PCA) was run to examine how the various metrics ran together and which carried the most information. Results from the PCA and inspection of a correlation matrix suggested that, as one might expect, most of the information in the data set was carried by the covariance between the percentage of taxa classed as sensitive and those classed as tolerant.

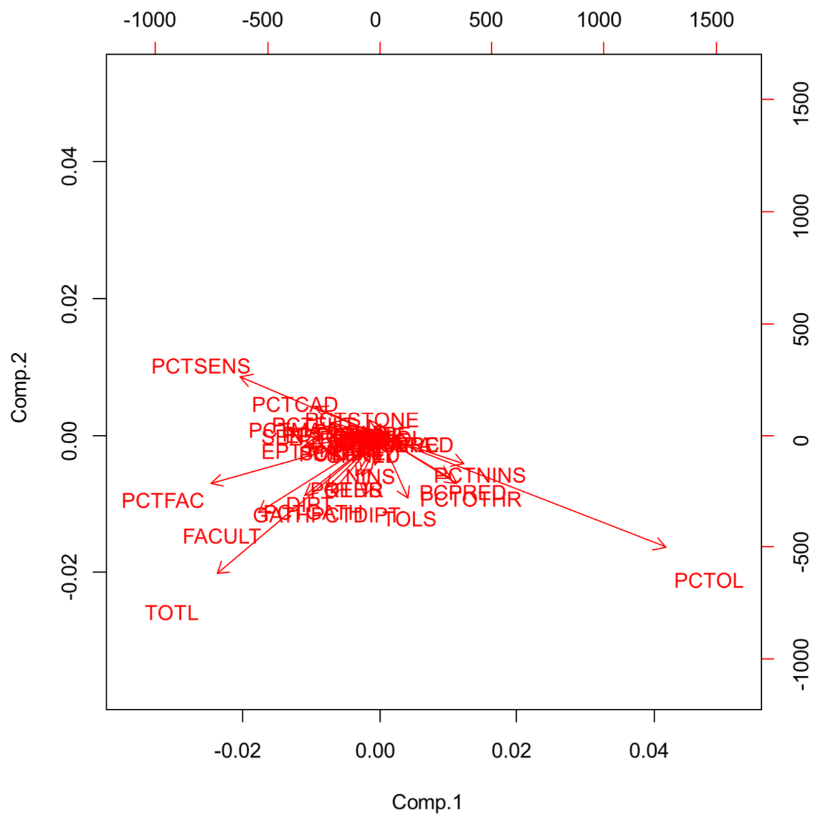


Figure S1. A PCA biplot based on covariance.

The metrics were also examined by correlations with water quality or habitat variables. These correlation matrices showed that the percentage of taxa classed and sensitive typically had the strongest negative correlation against stressors, whereas the percentage of taxa classed as non-insects typically had the highest positive correlation with stressors, and the percentage of taxa classed as tolerant also showed strong positive correlations with stressors. The percentage of taxa classed as mayflies showed the strongest negative association with TDS, and the number of caddisfly taxa appeared most sensitive to dissolved oxygen and pH. So three “positive” metrics chosen were the percent sensitive taxa, percent mayfly taxa, and the number of caddisfly taxa. The percentages of taxa classed as tolerant or non-insect were chosen as two “negative” metrics. The third “negative” metric chosen was the percent of taxa classed as predators. This metric was chosen because although it did not correlate strongly with stressors, it did respond in a consistent direction, was negatively correlated with the three “positive” metrics, and like caddisflies, tended to respond to pH and dissolved oxygen (though negatively). Neither facultative taxa or percent facultative taxa were included as a “negative” metric because neither correlated in a consistent direction with stressor variables. The correlations between candidate metrics are shown in Table 2.

Table S2. Spearman correlations between qualitative metrics, and between metric scores.

	PCTSENS	PCTMAY	CAD	PCTNINS	PCTOL	PCPRED
PCTSENS	1.0000000					
PCTMAY	0.6203664	1.0000000				
CAD	0.7666029	0.4870526	1.0000000			
PCTNINS	-0.5393989	-0.3537628	-0.4199393	1.00000000		
PCTOL	-0.7606372	-0.5426041	-0.6568298	0.58919647	1.0000000	
PCPRED	-0.2843811	-0.2655521	-0.3213713	0.03706272	0.4144577	1.00000000

	SENSC	MAYSC	CADSC	NINSC	TOLSC	PREDSC
SENSC	1					
MAYSC	0.6015	1				
CADSC	0.4882	0.3460	1			
NINSC	0.6399	0.4792	0.3388	1		
TOLSC	0.8045	0.6050	0.4995	0.6247	1	
PREDSC	0.3831	0.3583	0.3074	0.4350	0.1262	1

Reference expectations were set by plotting metric values from reference sites against drainage area, and using quantile regression to draw lines at the 0.05, 0.225, 0.50, 0.725 and 0.95 quantiles. Because few streams with drainage areas less than ~3 mi^2 are represented by reference sites, expectations for smaller drainage areas were set at the y-intercept for each quantile at 3.16 mi^2 (i.e., $10^{0.5}$). The rationale for this was given by inspecting the behavior of quantile lines drawn at the 50^{th} and 90^{th} percentiles from all sites less than 3.16 mi^2, wherein the relationships with drainage area tended to be flat or ambiguous (Figure S2). Correlations between resulting metric scores are shown in Table 2.

Metric scores were assigned based on quantile boundaries as follows:

Quantile Region	Score*
$\leq$5	0
>5 $\leq$ 22.5	2
>22.5 $\leq$ 50	4
>50 $\leq$ 72.5	6
>72.5 $\leq$ 95	8
>95	10

*Note that the scoring order here reflects “positive” metrics.

The performance of the final, summed index (the HWMI, for headwater macroinvertebrate index) was gaged by inspecting plots and correlations of index scores against common stressors (Table 3), and the variance of scores within pre-assigned narrative assessments (Figure S3). In general, the HWMI showed similar sensitivities to stressors (as gaged by correlation coefficients) when compared to other common biological measures used in headwaters (e.g., EPT richness). When binned by narrative assessments, the central tendency of HWMI scores decreased successively across the grades, and were significantly different from each other in all categories. A similar pattern was also observed when the percent of taxa classed as sensitive were binned by narrative ranges (Figure S3).

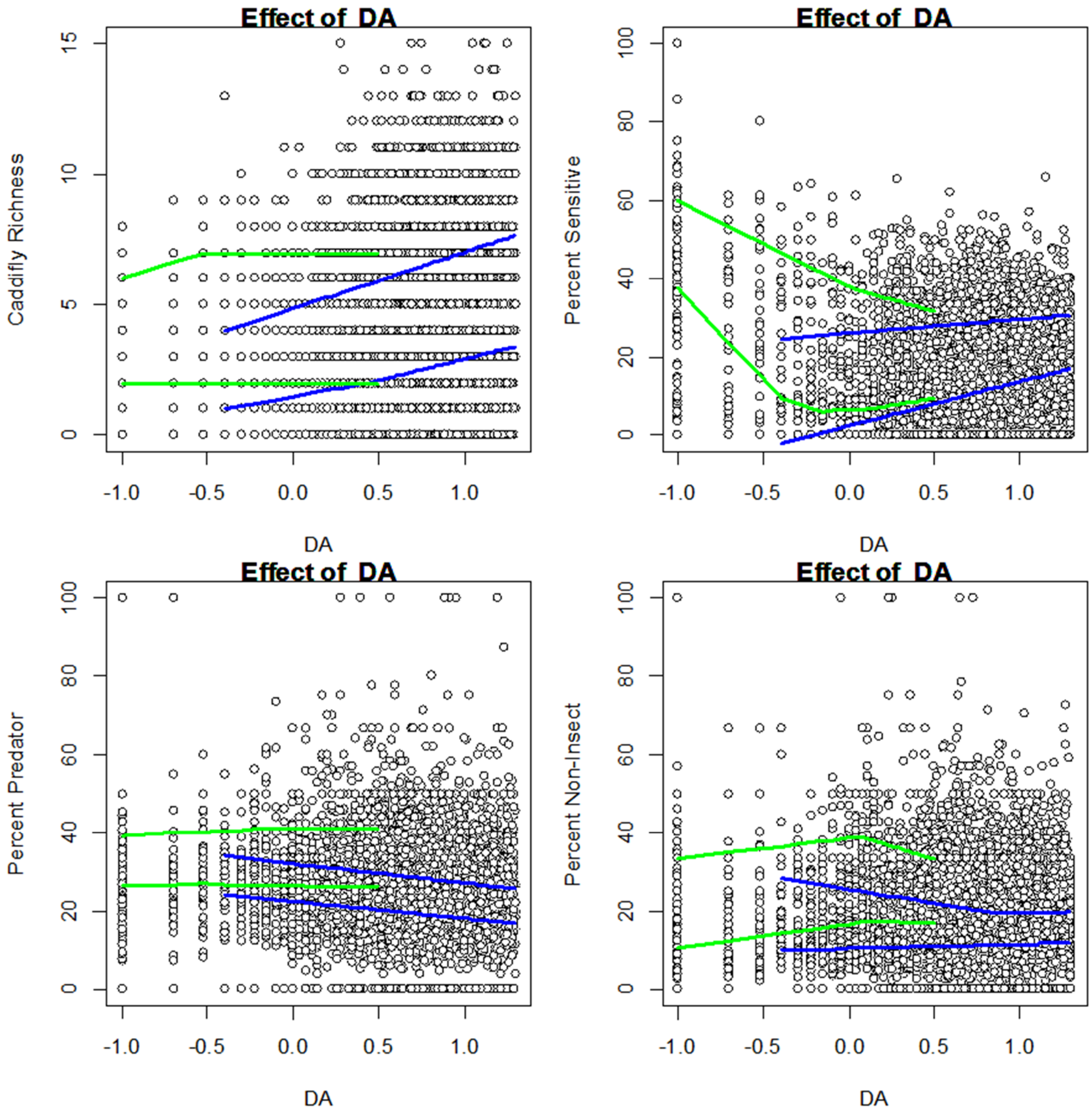


Figure S2. Quantile regression lines at the 25th and 75th percentiles for select metrics at reference sites (blue lines), and at the 50th and 90th percentile for all sites with drainage areas < 3.16mi² (green lines).

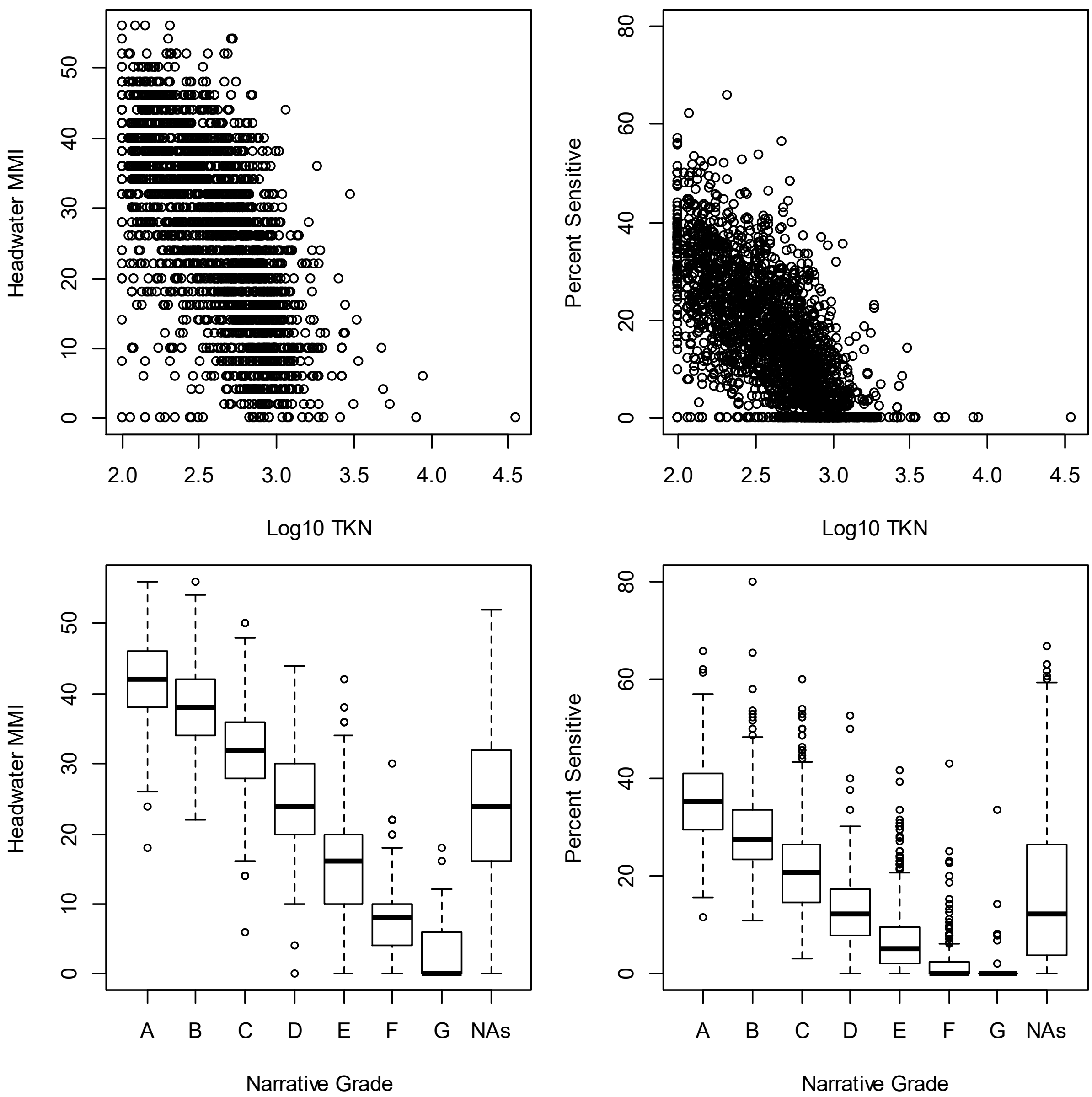


Figure S3. Plots of the HWMI and percent of taxa classed as sensitive against TKN concentrations, and boxplots of the HWMI and percent sensitive taxa binned by narrative assessment grades (i.e., A = Exceptional, etc.).

Table 3. Correlations of biological metrics or summary index scores against common water quality indicators. HWMI is an abbreviation for the headwater macroinvertebrate index.

	Arsenic	Chloride	COD	D.O.	NH3	TKN	TP	QHEI
HWMI	-0.5312	-0.4197	-0.4679	0.2737	-0.5086	-0.6373	-0.5266	0.5099
EPT	-0.4414	-0.3872	-0.3979	0.2594	-0.4612	-0.5555	-0.4790	0.4538
PCTSENS	-0.5344	-0.4993	-0.4540	0.2400	-0.4708	-0.6817	-0.5889	0.5017
PICI	-0.4296	-0.3113	-0.4273	0.2707	-0.5111	-0.5223	-0.4285	0.4777
ICI	-0.3108	-0.2489	-0.1531	0.2760	-0.4602	-0.4482	-0.3407	0.1891

Lastly, in terms of “attainment” status, when waters classed as WWH are coded to whether the HWMI is greater than or less than the 25th percentile from the respective ecoregional reference population scores, the percentages of sites falling below the cutoff are as follows:

	HELP	IP	EOLP	WAP	ECBP
Percent of WWH sites with HWMI<25th% of reference	41.4	36.8	31.4	30	64.6
Percent of WWH sites with Narratives < Good	62.7	57.7	49.8	59.9	52.7

The distributions of HWMI scores by reference site and ecoregion are shown in Figure S4. Compared to the ICI, the 25th percentiles from reference sites show more variability between ecoregions. Relative to the condition status based on narrative ratings, status based on the HWMI results in a smaller proportion of waters being classed as impaired in all ecoregions except the ECBP. The reversal in the ECBP may be due to the slight tendency to rate ECBP sites higher with lower numbers of sensitive taxa and higher numbers of tolerant taxa relative to the IP, EOLP and WAP (Figure S5). The net effect of this can be seen in distributions of HWMI scores plotted by ecoregion and narrative grades (Figure S6). For all regions except the ECBP, most of the HWMI scores within the “Good” bin (i.e., grade C in Figure S6), and many in the “Marginal” bin, were above the respective 25th percentile reference scores.

Lastly, the HWMI provided a slight advantage over narrative ratings in terms of specificity to some environmental gradients. For example, TKN concentrations tended to be higher at sites rated impaired by the HWMI compared to those rated “Marginal” or less (Figure S7). The net effect of this can be observed in a receiver-operator curve (Figure S8). For other gradients like TDS, no advantage was apparent (Figure S9).

Summary

In terms of sensitivity to environmental gradients, the HWMI is similar to EPT or sensitive taxa richness, at least in a correlative sense, but is much more sensitive than the existing ICI, and appears to provide some advantage over narrative ratings. Essentially the HWMI represents the counter gradient of sensitive and tolerant taxa. Inclusion of other metrics likely makes a marginal contribution to overall sensitivity to the environmental gradient, but adds redundancy to the final index.

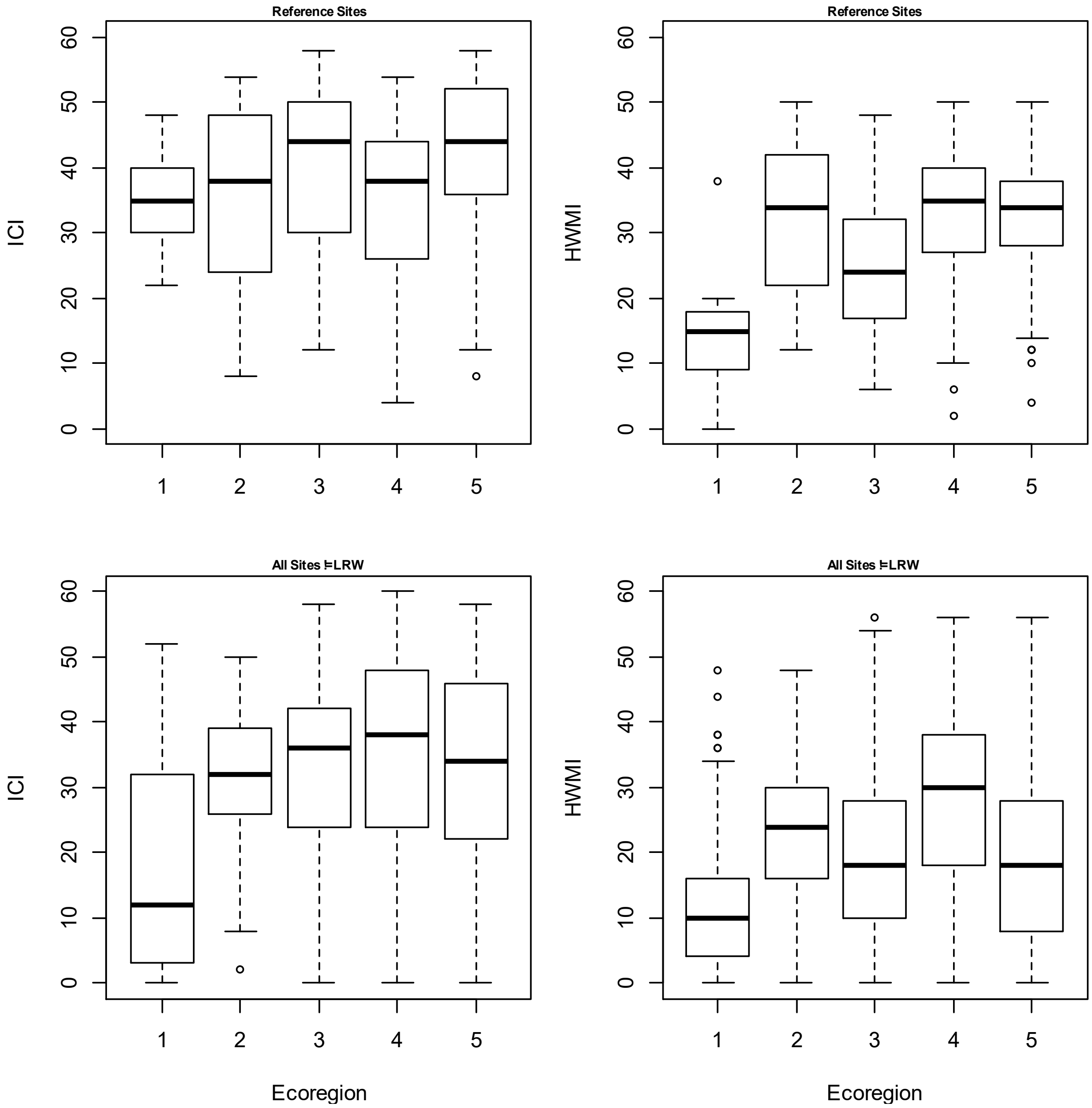


Figure S4. Distributions of ICI and HWMI scores by ecoregion and stratified by reference sites (top row) or survey sites (excluding LRW sites).

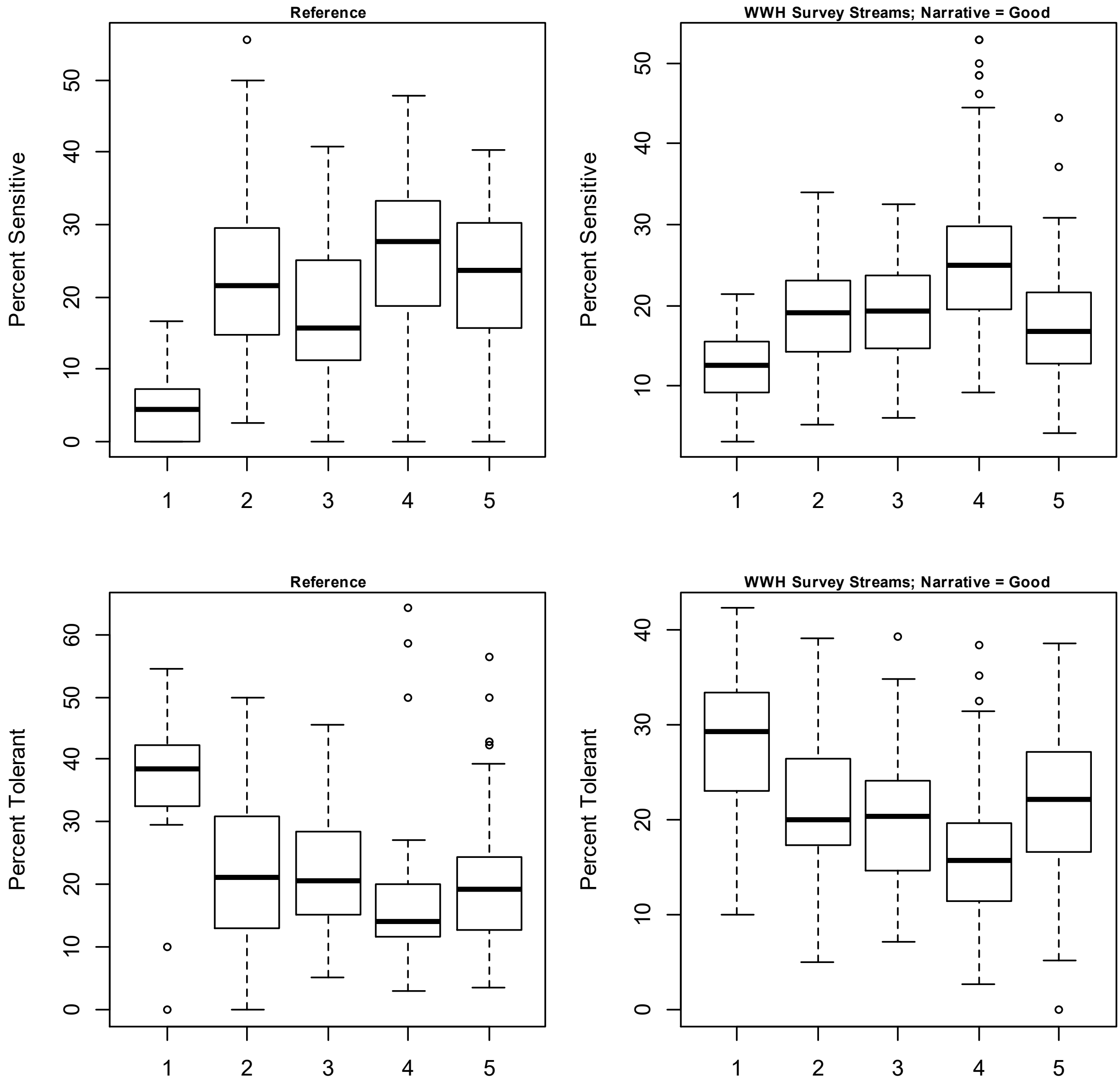


Figure S5. Distributions of percent sensitive (top row) and percent tolerant taxa (bottom row) by ecoregion for reference sites (left column) and WWH streams with a narrative rating of “Good” (right column).

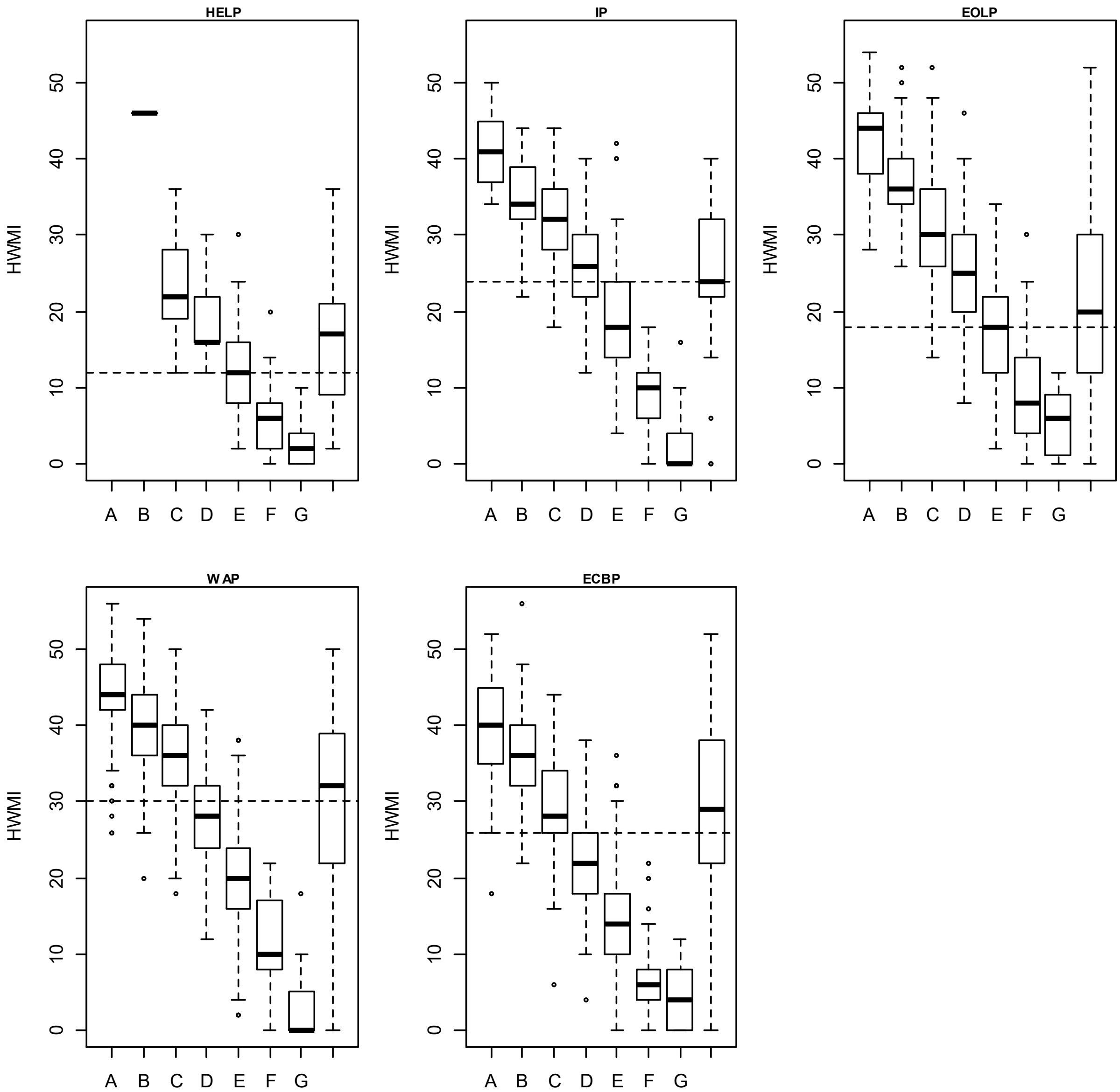


Figure S6. Distributions of HWMI scores for sites with WWH designations plotted by ecoregion and narrative grade. The dashed line in each plot represents the 25th percentile from reference sites. Note that y-axis scales vary by ecoregion.

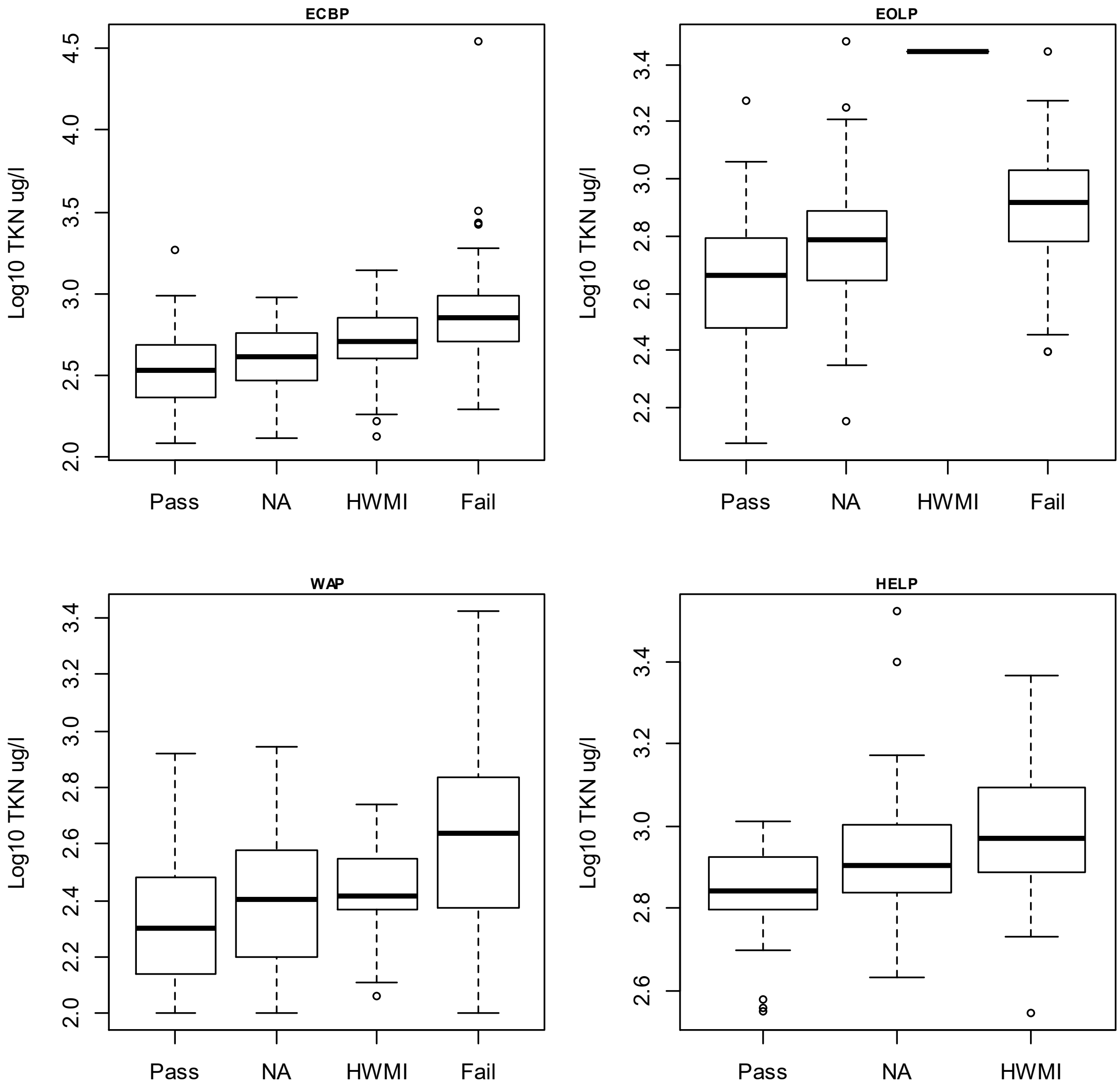


Figure S7. Distributions of TKN concentrations binned by whether condition was deemed passing by both the HWMI and narrative assessments (Pass), failing by narrative assessment only (NA), failing by the HWMI only (HWMI), or failing according to both (Fail).

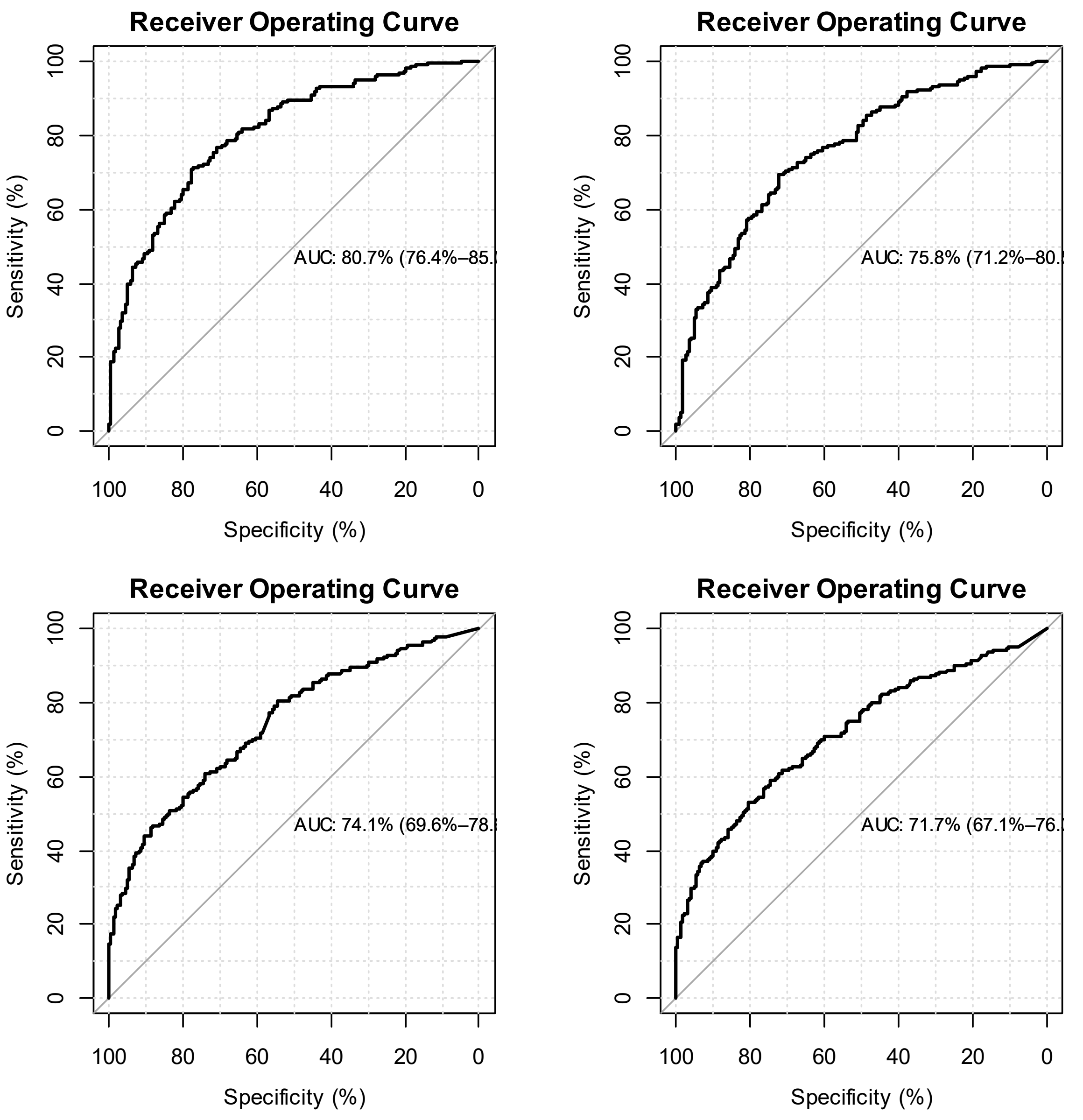


Figure S8. ROC plots for TKN concentrations for the ECBP (top row) and the WAP (bottom row). The left-hand panels are based on pass/fail as judged by the HWMI; the right-hand panels are pass/fail as judged by narrative ratings.

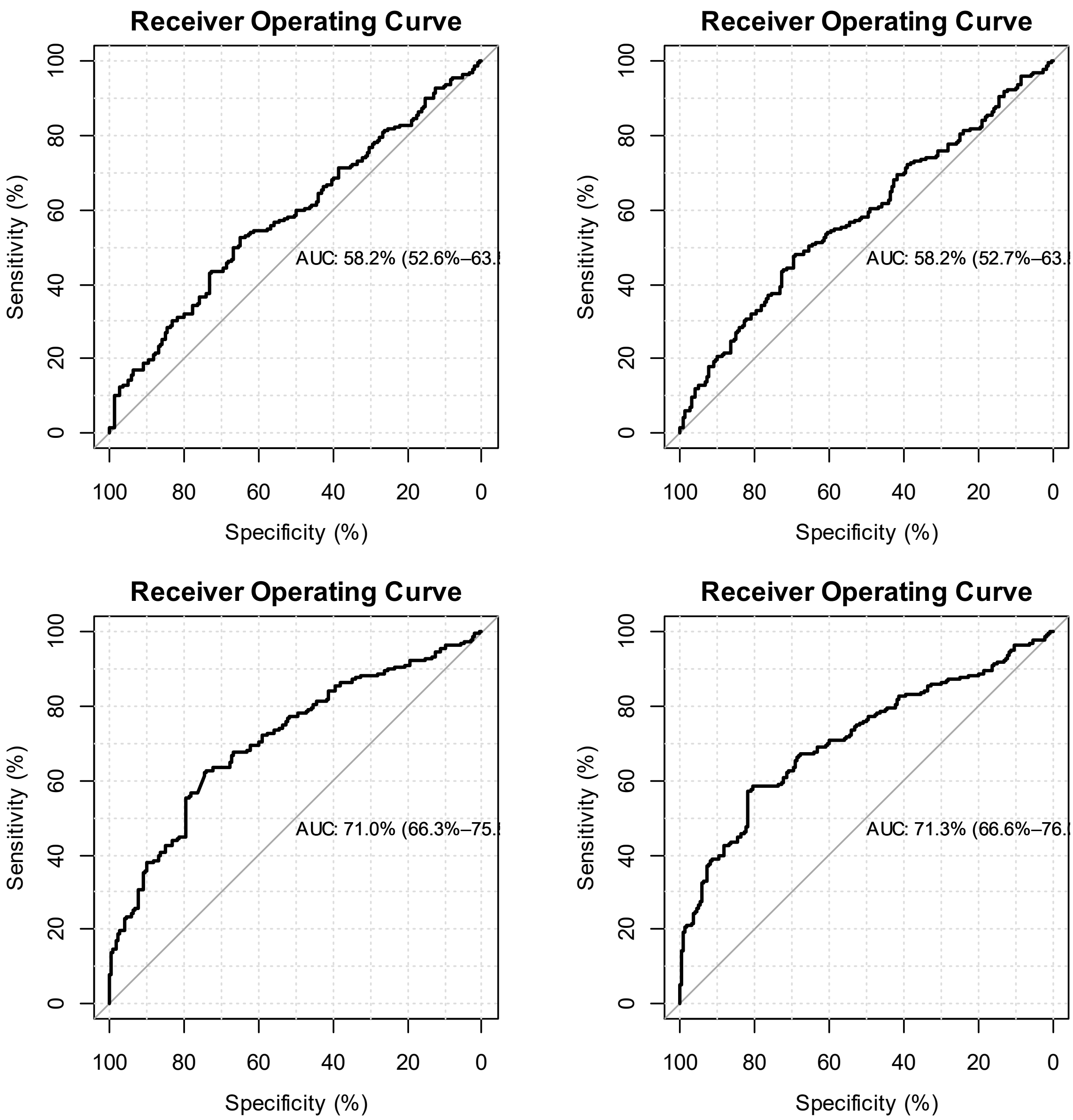


Figure S9. ROC plots for TDS concentrations for the ECBP (top row) and the WAP (bottom row). The left-hand panels are based on pass/fail as judged by the HWMI; the right-hand panels are pass/fail as judged by narrative ratings.

Addendum, May 15, 2018: A brief note on the stability of the HWMI when applied to very small headwaters.

The HWMI was developed to provide a summary numeric index for qualitative macroinvertebrate samples based on reference expectations. The original documentation describing the development and performance of the final index did not explicitly discuss performance with respect to drainage area. Quantile regression lines demonstrate that HWMI is neutral with respect to drainage area, indicating that a criterion benchmark for a high-tier aquatic life use derived from the reference sites (i.e., the 75th percentile) can be applied across the board, as well as ecoregion-specific benchmarks for lower tiers.

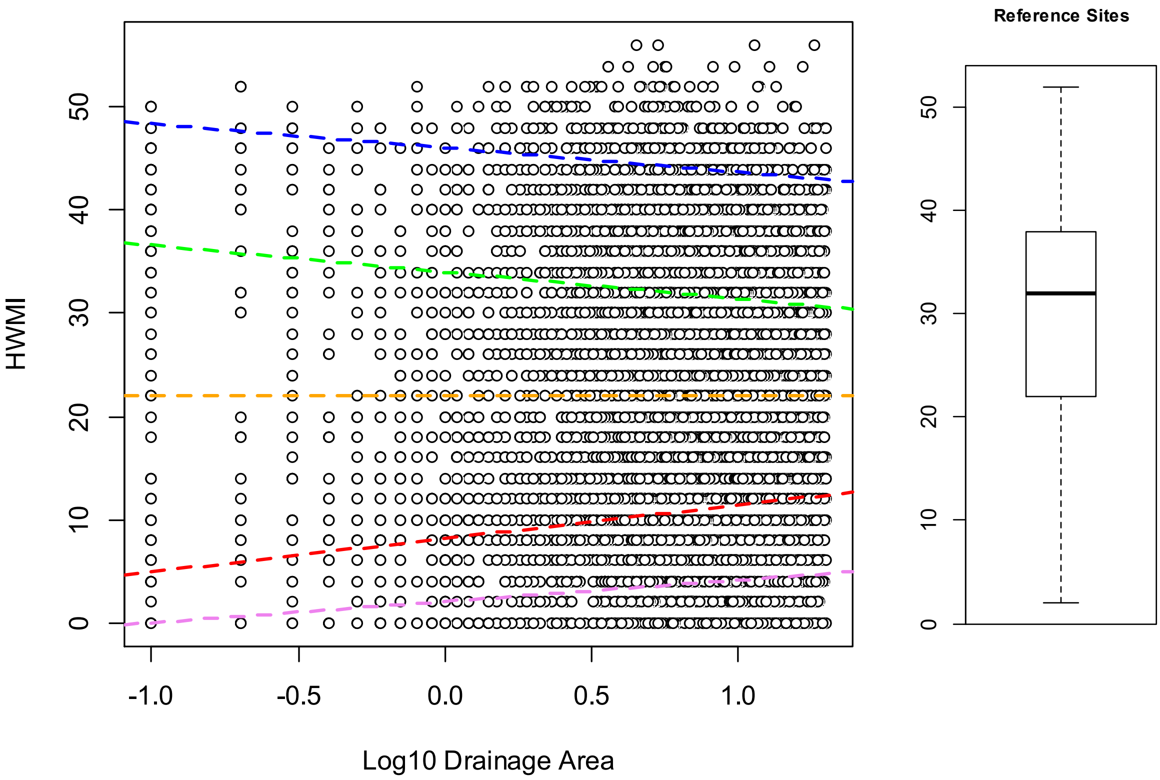


Figure S10. A scatter plot of HWMI scores by drainage area. Lines in the plot are drawn from quantile regression at the 95th (blue), 75th, 50th, 25th and 10th (violet) percentiles. The box plot shows the distribution of scores from reference sites.

With respect to response to stressor gradients, very little water chemistry exists for sites less than 2.5 mi^2 in drainage area; however, a sufficient number of QHEI scores exist to examine the performance of the HWMI over a gradient of habitat quality. For these very small streams, the HWMI has a tighter correlation with the QHEI than the fish IBI (Figure S11).

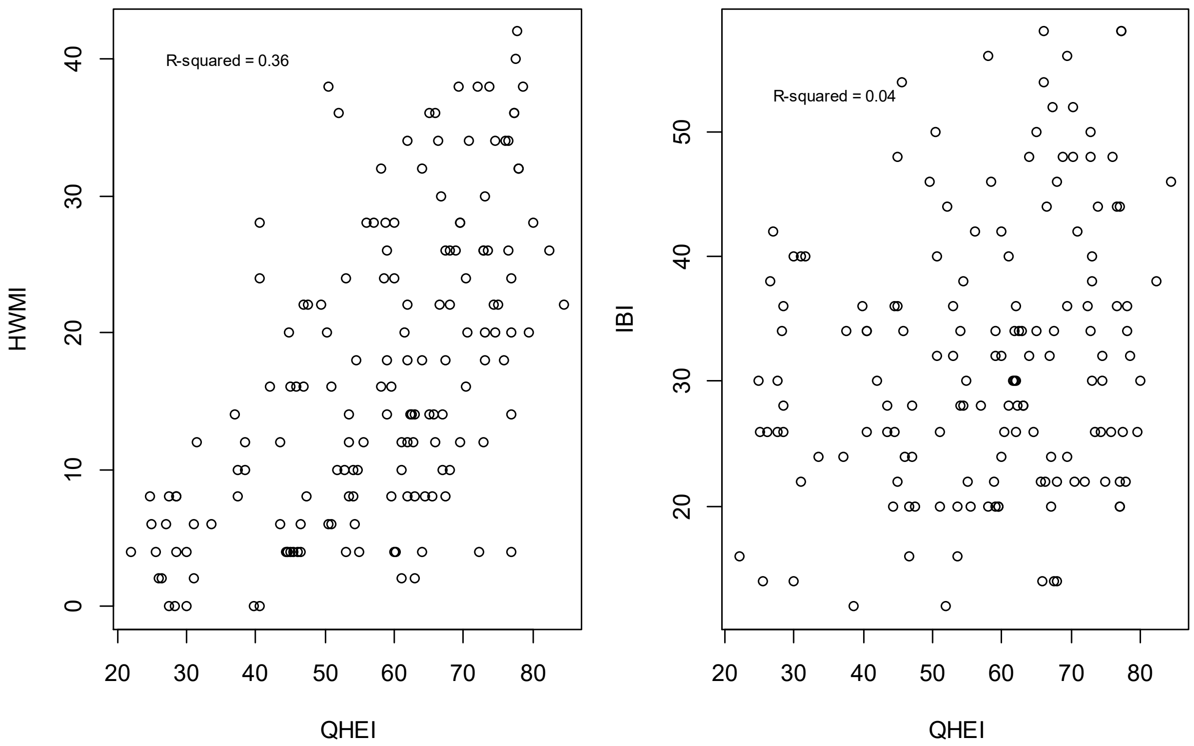


Figure S11. Scatter plots of HWMI and fish IBI scores against the same set of QHEI scores.

Lastly, the HMWI scores binned by narrative grades assigned to samples by the macroinvertebrate biologists show clear separation in terms of interquartile ranges between major grades (i.e., E to G; Figure S12).

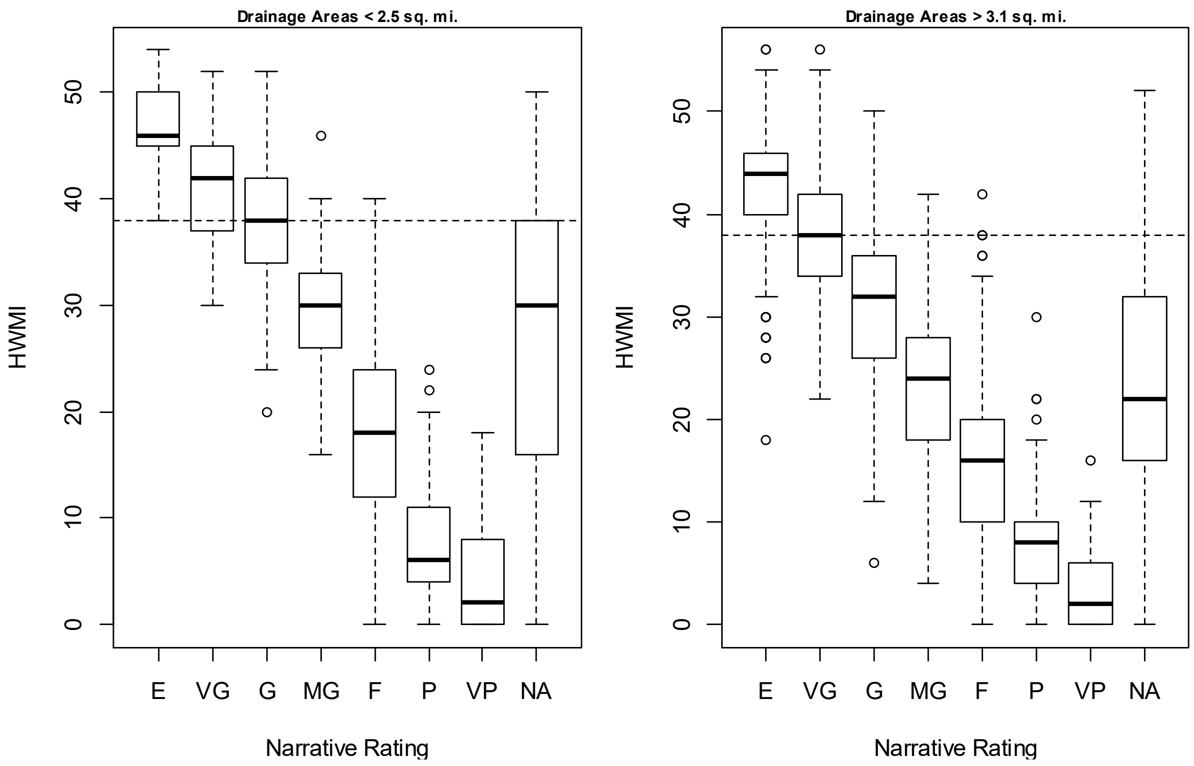
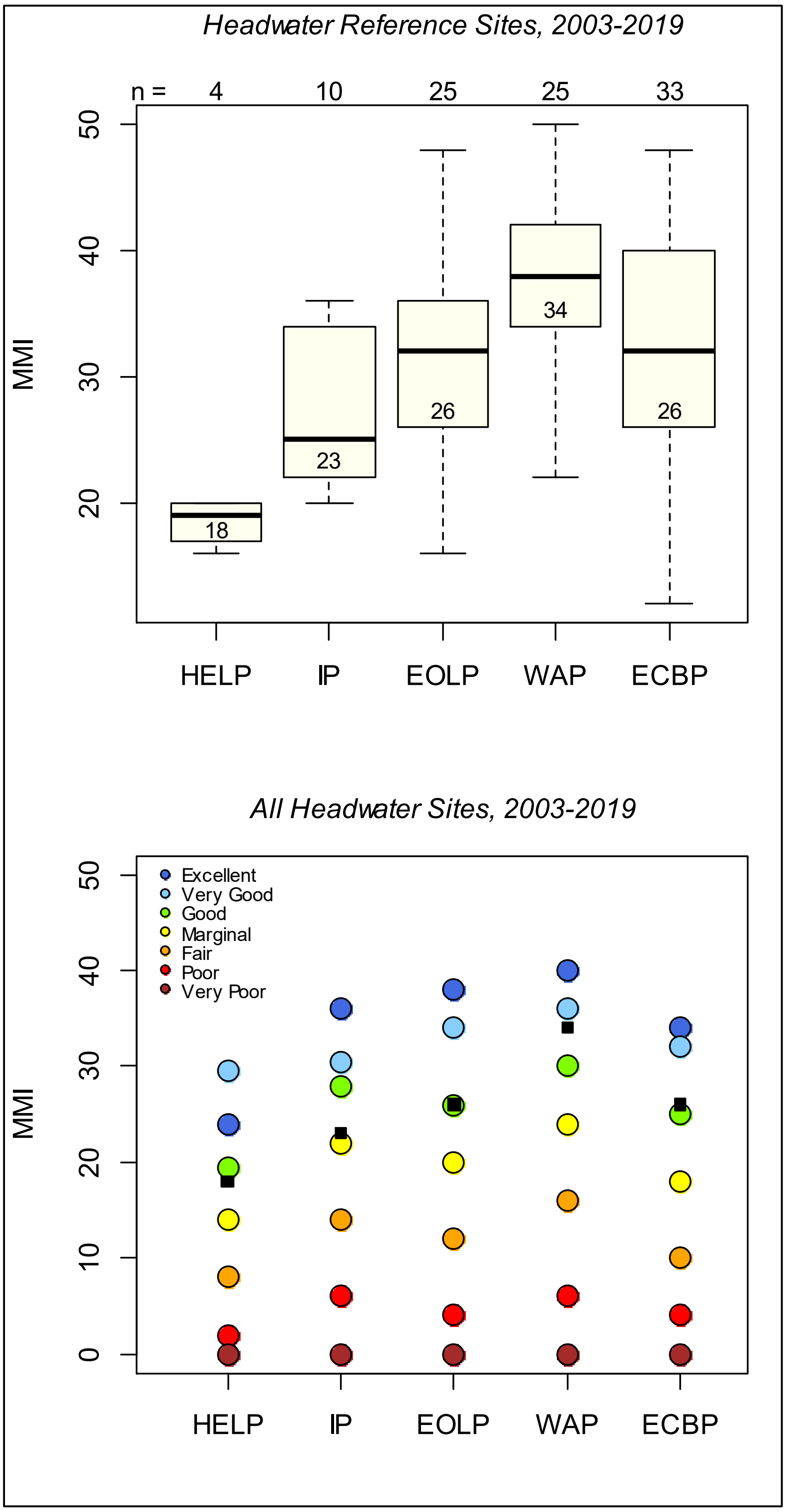


Figure S12. Distributions of HWMI scores by narrative grades assigned to samples by the macroinvertebrate biologists. The left panel is for sites less than 2.5 mi^2, and the right panel is for sites greater than 3.1 mi^2. The dashed-horizontal line in each plot represents the 75th percentile score from reference sites.

Addendum, June 24, 2021: Scoring cutoffs for the base aquatic life use (i.e., Warmwater Habitat) are identified by the 25th percentile from regional reference sites. Because the number of reference sites for headwaters becomes small when stratified by ecoregion, the 25th percentiles for the respective ecoregions are compared to 25th percentile HWMI scores binned by narrative grades assigned for all headwater sites. The top panel of the accompanying figure shows distributions of HWMI scores for headwater reference sites sampled between 2003 and 2019. The 25th percentiles are labeled in each boxplot, and the number of reference sites within an ecoregion is shown along the top margin. The 2003-2019 time-period captures the implementation of agricultural best management practices intended to reduce soil erosion, and thus better captures reference expectations than drawing from the entire period of record (1981-2019). The lower panel shows 25th percentiles for MMI scores binned by narrative grades assigned by the macroinvertebrate biologists (n.b., the narratives were assigned without knowledge of the HWMI scores) and stratified by ecoregion. The black squares show the corresponding cutoff suggested by the reference sites. For the HELP, EOLP and ECBP the 25th percentiles from the respective reference sites are similar to the 25th percentiles from sores with a narrative grade of "Good". For the IP, the reference cutoff falls within the range of "Good" and "Marginal", and in the WAP, the reference cutoff is within the range of "Very Good" and "Good". These results suggests that the 25th percentiles from the reference sites are reasonable approximations for a Warmwater Habitat benchmark for use in modeling or statistical analyses.



Scoring equations for the HWMI (in SQL syntax). Note that drainage area is log10 of square miles.

Percent Sensitive

```
CASE WHEN NVL(TOTL,0)<10 THEN 0
WHEN DA>=0.5 AND NVL(SENS/TOTL*100,0) > 8.520277*DA+30.774369 THEN 10
WHEN DA<0.5 AND NVL(SENS/TOTL*100,0)> 35.0345075 THEN 10
WHEN DA>=0.5 AND NVL(SENS/TOTL*100,0) > 2.748877*DA+26.086957 THEN 8
WHEN DA<0.5 AND NVL(SENS/TOTL*100,0)> 27.4613955 THEN 8
WHEN DA>=0.5 AND NVL(SENS/TOTL*100,0) > 7.291028*DA+14.7796 THEN 6
WHEN DA<0.5 AND NVL(SENS/TOTL*100,0)> 18.425114 THEN 6
WHEN DA>=0.5 AND NVL(SENS/TOTL*100,0) > 13.1130715*DA+-0.1216001 THEN 4
WHEN DA<0.5 AND NVL(SENS/TOTL*100,0)> 6.43493565 THEN 4
WHEN DA>=0.5 AND NVL(SENS/TOTL*100,0) > 6.448487*DA+-1.797539 THEN 2
WHEN DA<0.5 AND NVL(SENS/TOTL*100,0)> 1.4267045 THEN 2
ELSE 0
END SENSC,
```

Percent Mayfly

```
CASE WHEN NVL(TOTL,0)<10 THEN 0
WHEN DA>=0.5 AND NVL(MAY/TOTL*100,0) > -5.178875*DA+29.166667 THEN 10
WHEN DA<0.5 AND NVL(MAY/TOTL*100,0)> 26.5772295 THEN 10
WHEN DA>=0.5 AND NVL(MAY/TOTL*100,0) > -0.9534321*DA+18.3749356 THEN 8
WHEN DA<0.5 AND NVL(MAY/TOTL*100,0)> 17.89821955 THEN 8
WHEN DA>=0.5 AND NVL(MAY/TOTL*100,0) > 2.740925*DA+11.340337 THEN 6
WHEN DA<0.5 AND NVL(MAY/TOTL*100,0)> 12.7107995 THEN 6
WHEN DA>=0.5 AND NVL(MAY/TOTL*100,0) > 5.663701*DA+4.545455 THEN 4
WHEN DA<0.5 AND NVL(MAY/TOTL*100,0)> 7.3773055 THEN 4
WHEN DA>=0.5 AND NVL(MAY/TOTL*100,0) > 6.910712*DA+-1.216916 THEN 2
WHEN DA<0.5 AND NVL(MAY/TOTL*100,0)> 2.23844 THEN 2
ELSE 0
END MAYSC,
```

Number of Caddisfly

```
CASE WHEN NVL(TOTL,0)<10 THEN 0
WHEN DA>=0.5 AND CAD > 2.366589*DA+7.229346 THEN 10
WHEN DA<0.5 AND CAD > 8.4126405 THEN 10
WHEN DA>=0.5 AND CAD > 2.502062*DA+4 THEN 8
WHEN DA<0.5 AND CAD > 5.251031 THEN 8
WHEN DA>=0.5 AND CAD > 2.186379*DA+2.57183 THEN 6
WHEN DA<0.5 AND CAD > 3.6650195 THEN 6
WHEN DA>=0.5 AND CAD > 1.317579*DA+1.431644 THEN 4
WHEN DA<0.5 AND CAD > 2.0904335 THEN 4
WHEN DA>=0.5 AND CAD > 0*DA+1 THEN 2
WHEN DA<0.5 AND CAD > 1 THEN 2
ELSE 0
END CADSC,
```

Percent Tolerant Taxa

```
CASE WHEN NVL(TOTL,0)<10 THEN 0
WHEN DA>=0.5 AND NVL(TOLS/TOTL*100,0) > -14.29808*DA+55.03687 THEN 0
WHEN DA<0.5 AND NVL(TOLS/TOTL*100,0)> 47.88783 THEN 0
WHEN DA>=0.5 AND NVL(TOLS/TOTL*100,0) > -11.7609*DA+37.42617 THEN 2
WHEN DA<0.5 AND NVL(TOLS/TOTL*100,0)> 31.54572 THEN 2
WHEN DA>=0.5 AND NVL(TOLS/TOTL*100,0) > -2.629171*DA+21.879586 THEN 4
WHEN DA<0.5 AND NVL(TOLS/TOTL*100,0)> 20.5650005 THEN 4
WHEN DA>=0.5 AND NVL(TOLS/TOTL*100,0) > -3.305626*DA+14.960026 THEN 6
WHEN DA<0.5 AND NVL(TOLS/TOTL*100,0)> 13.307213 THEN 6
WHEN DA>=0.5 AND NVL(TOLS/TOTL*100,0) > 1.649508*DA+4.218659 THEN 8
WHEN DA<0.5 AND NVL(TOLS/TOTL*100,0)> 5.043413 THEN 8
ELSE 10
END TOLSC,
```

Percent Non-Insects

```
CASE WHEN NVL(TOTL,0)<10 THEN 0
WHEN DA>=0.5 AND NVL(NINS/TOTL*100,0) > -6.023033*DA+32.392167 THEN 0
WHEN DA<0.5 AND NVL(NINS/TOTL*100,0)> 29.3806505 THEN 0
WHEN DA>=0.5 AND NVL(NINS/TOTL*100,0) > -3.499447*DA+22.849854 THEN 2
WHEN DA<0.5 AND NVL(NINS/TOTL*100,0)> 21.1001305 THEN 2
WHEN DA>=0.5 AND NVL(NINS/TOTL*100,0) > 0*DA+15.38462 THEN 4
WHEN DA<0.5 AND NVL(NINS/TOTL*100,0)> 15.38462 THEN 4
WHEN DA>=0.5 AND NVL(NINS/TOTL*100,0) > 2.176345*DA+8.906562 THEN 6
WHEN DA<0.5 AND NVL(NINS/TOTL*100,0)> 9.9947345 THEN 6
WHEN DA>=0.5 AND NVL(NINS/TOTL*100,0) > 2.320639*DA+4.071047 THEN 8
WHEN DA<0.5 AND NVL(NINS/TOTL*100,0)> 5.2313665 THEN 8
ELSE 10
END NINSC,
```

Percent Predators

```
CASE WHEN NVL(TOTL,0)<10 THEN 0
WHEN DA>=0.5 AND NVL(PREDS/TOTL*100,0) > -5.392487*DA+38.397046 THEN 0
WHEN DA<0.5 AND NVL(PREDS/TOTL*100,0)> 35.7008025 THEN 0
WHEN DA>=0.5 AND NVL(PREDS/TOTL*100,0) > -4.843725*DA+31.73541 THEN 2
WHEN DA<0.5 AND NVL(PREDS/TOTL*100,0)> 29.3135475 THEN 2
WHEN DA>=0.5 AND NVL(PREDS/TOTL*100,0) > -4.214623*DA+26.818036 THEN 4
WHEN DA<0.5 AND NVL(PREDS/TOTL*100,0)> 24.7107245 THEN 4
WHEN DA>=0.5 AND NVL(PREDS/TOTL*100,0) > -4.677956*DA+22.380878 THEN 6
WHEN DA<0.5 AND NVL(PREDS/TOTL*100,0)> 20.0419 THEN 6
WHEN DA>=0.5 AND NVL(PREDS/TOTL*100,0) > 0.9261267*DA+11.5282912 THEN 8
WHEN DA<0.5 AND NVL(PREDS/TOTL*100,0)> 11.99135455 THEN 8
ELSE 10
END PREDSC,
```