



Department of
Environmental
Conservation

CALLICOON CREEK

Biological Stream Assessment

October 20, 2015

**DIANA L. HEITZMAN
STREAM BIOMONITORING UNIT**

425 Jordan Rd, Troy, NY 12180
P: (518) 285-5609 | F: (518) 285-5601 | diana.heizman@dec.ny.gov

www.dec.ny.gov



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BIOLOGICAL STREAM ASSESSMENT

Callicoon Creek
Sullivan County, New York
Delaware River Basin

Survey date: September 30, 2014
Report date: October 20, 2015

Diana L. Heitzman
Jeff L. Lojpersberger
Brian T. Duffy
Alexander J. Smith, PhD
Margaret A. Novak

Stream Biomonitoring Unit
Bureau of Water Assessment and Management
Division of Water
NYS Department of Environmental Conservation
Albany, New York

For additional information regarding this report please contact:

Diana Heitzman
New York State Department of Environmental Conservation
Stream Biomonitoring Unit
425 Jordan Road, Troy, NY 12180
diana.heizman@dec.ny.gov
ph 518-285-5609
fx 518-285-5601

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Stream: Callicoon Creek

River Basin: Delaware River

Reach: Jeffersonville to Callicoon, NY

Background

The Stream Biomonitoring Unit (SBU) conducted a biological assessment of water quality at eight locations on Callicoon Creek including three locations on the north branch Callicoon Creek and three locations on the east branch Callicoon Creek, August 6 (three sites were sampled during our biological screening survey of the Delaware Basin) and September 30, 2014. This survey provides current baseline water quality information for comparison with historical data collected in the watershed.

To characterize water quality and assess any impacts to aquatic life, benthic macroinvertebrate communities were collected via traveling kick sample from riffle areas at each location. Methods used are described in the Standard Operating Procedure: Biological Monitoring of Surface Waters in New York State (NYSDEC, 2014) and summarized in the appendices of this document. The contents of each sample were field-inspected to determine major groups of organisms present, and then preserved in alcohol for laboratory inspection of 100-specimen subsamples from each site. Biological assessment of water quality was conducted through calculation of benthic macroinvertebrate community metrics including the Biological Assessment Profile (BAP) score for riffle communities. Expected variability in the results of benthic macroinvertebrate community samples is presented in Smith and Bode (2004).

Results and Conclusions

1. Overall water quality in Callicoon Creek is fully supporting of aquatic life. Biological assessment of water quality indicates non- to slightly impacted conditions. Only one site had slightly impacted water quality, that was on the north branch of Callicoon Creek in the vicinity of North Branch.
2. The results of this survey are similar to the historical data available for Callicoon Creek.

Discussion

The Callicoon Creek watershed is located in southeastern New York in the Delaware River Basin. Approximately 111 mi² in drainage area, Callicoon Creek is made up of both an East and North Branch. The headwaters of the North Branch Callicoon Creek are in Callicoon Center, NY south of Hahn Road. East Branch Callicoon Creek originates just north from Route 52 in Livingston Manor, NY. From here, Callicoon Creek flows west for approximately 24 miles until its confluence with the Delaware River in Callicoon, NY (Figures 1 – 2e). Based on 2011 national landcover data, landuse in the watershed is predominately agriculture; pasture and hay (28%) and cultivated crop/wetlands (3%). Natural landcover types including forest cover (64%), also dominate. Only a small amount of developed land (5%) exists within the watershed and is localized to a few specific population centers including Callicoon, Jeffersonville, and North Branch (Figure 1).

Previously collected biological assessment data on Callicoon Creek exist for five locations; CALL-0.2, CALL-1.7, CALE-9.5, CALN-4.7 and CALN-0.6. These sites were surveyed in 1993, 1994, 1999, 2000, 2004, 2005, 2009 and 2010 (Table 2). Results of these previous surveys suggest water quality through 2010 has remained fully supportive of aquatic life with conditions ranging from non- to slightly impacted. Source identification of slight impacts from these surveys was inconclusive.

Similarly to historical surveys, the biological assessment of macroinvertebrate communities in Callicoon Creek suggest non- to slightly impacted water quality in August and September of 2014 (Figure 3). Only one site, located on the north branch (CALN-4.0) (Figure 1 and 2b) had water quality that was assessed as slightly impacted. This assessment was in-part due to dominance (68%) of the sample by two taxa; *Dolophilodes* sp. (36%) and *Polypedilum aviceps* (28%) (Table 5). In addition to their dominance, these taxa are indicative of fine particulate matter (i.e. filterers) in the water column. Their presence may be indicative of a nutrient issue or agricultural influence. Additional studies of this area of the north branch and tributaries may be warranted in the future.

Overall habitat condition in Callicoon Creek based on the Habitat Model Affinity (HMA) scores was assessed as severely and moderately altered for six of the eight locations sampled. Only one site, CALN-4.7 was assessed as natural. Habitat conditions assessed as severely altered, indicates it has been disturbed enough to have the potential to affect in-stream biological communities such as macroinvertebrates. Many of the individual habitat variables ranked poorly at these locations including; bank vegetative protection, width of the riparian zone, riffle frequency, bank stability and sediment deposition. Despite the alterations to habitat at these locations, results suggest water quality was good enough to counter these disturbances.

Overall water quality in Callicoon Creek is fully supporting of aquatic life. Biological assessment of water quality indicates non- to slightly impacted conditions. The poorest water quality was observed on the north branch of Callicoon Creek at station CALN-4.0 (Figure 3b). Water quality improves continually downstream from this location until its confluence with the Delaware River in Callicoon. The results of this survey are similar to the historical data available for Callicoon Creek. The present survey did not show a shift in biological impact category, which suggests that benthic macroinvertebrate communities have remained stable since 2010. Impact Source Determination (ISD) indicates similarity to natural communities for six of the eight locations sampled (Table 2). Some locations on Callicoon Creek would benefit from improvements to local habitat conditions. These would include improvements to increase

riparian vegetative protection, improve bank stability and widen buffers between adjacent developed and agricultural lands. These improvements could help to ensure the overall water quality in the Callicoon Creek watershed remains supportive of aquatic life.

Literature Cited

NYSDEC, 2014. Standard Operating Procedure: Biological Monitoring of Surface Waters in New York State. NYSDEC SOP #208-14. Division of Water, New York State Department of Environmental Conservation, 625 Broadway, Albany, New York, 171 pages.

Smith, A. J., and R. W. Bode. 2004. Analysis of Variability in New York State Benthic Macroinvertebrate Samples. Division of Water, New York State Department of Environmental Conservation, 625 Broadway, Albany, New York, Technical Report, 43 pages.

Figure 1. Overview map, Callicoon Creek watershed and 2014 sampling locations.

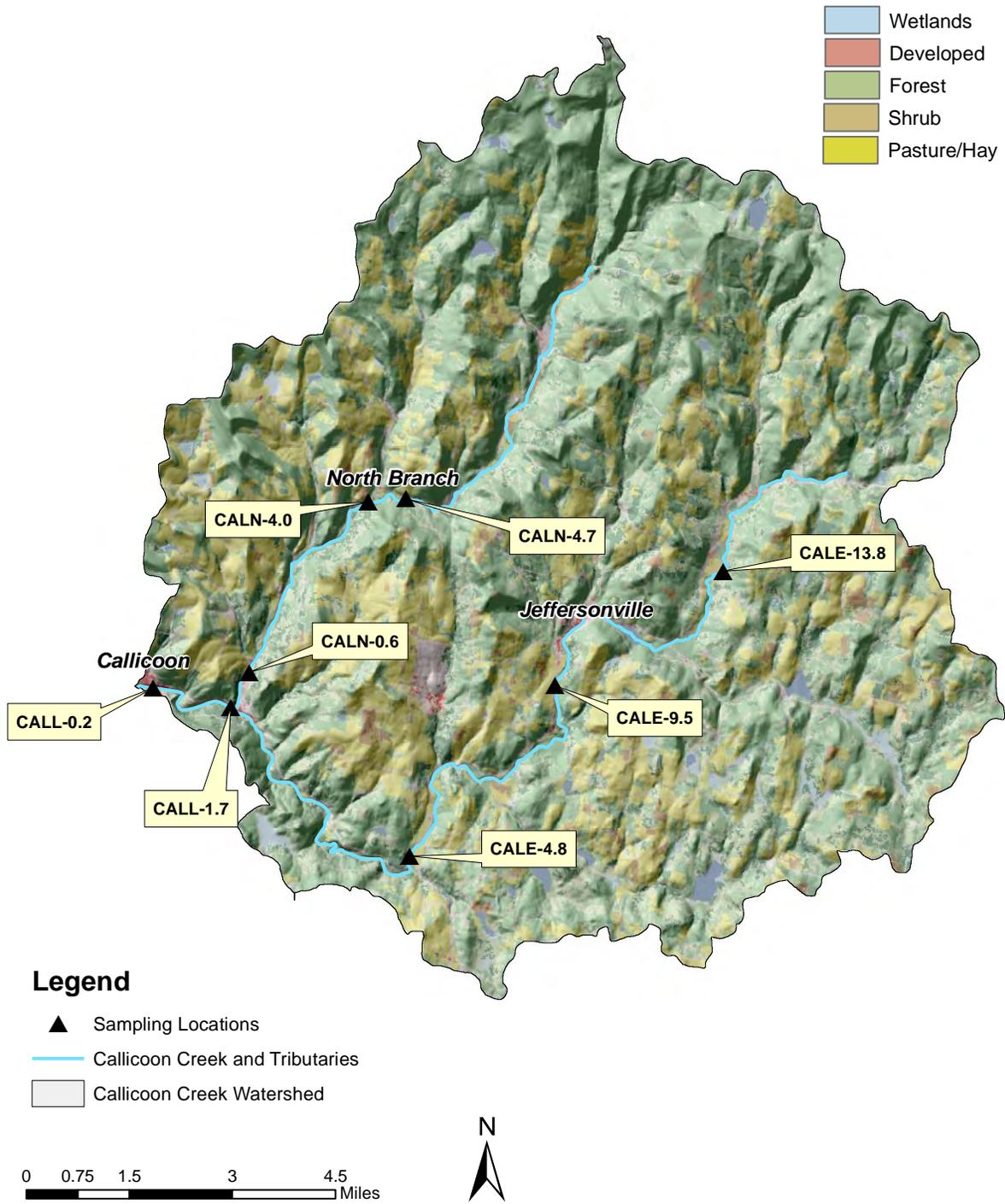


Figure 2. Site location map, Callicoon Creek, Station 0.2.

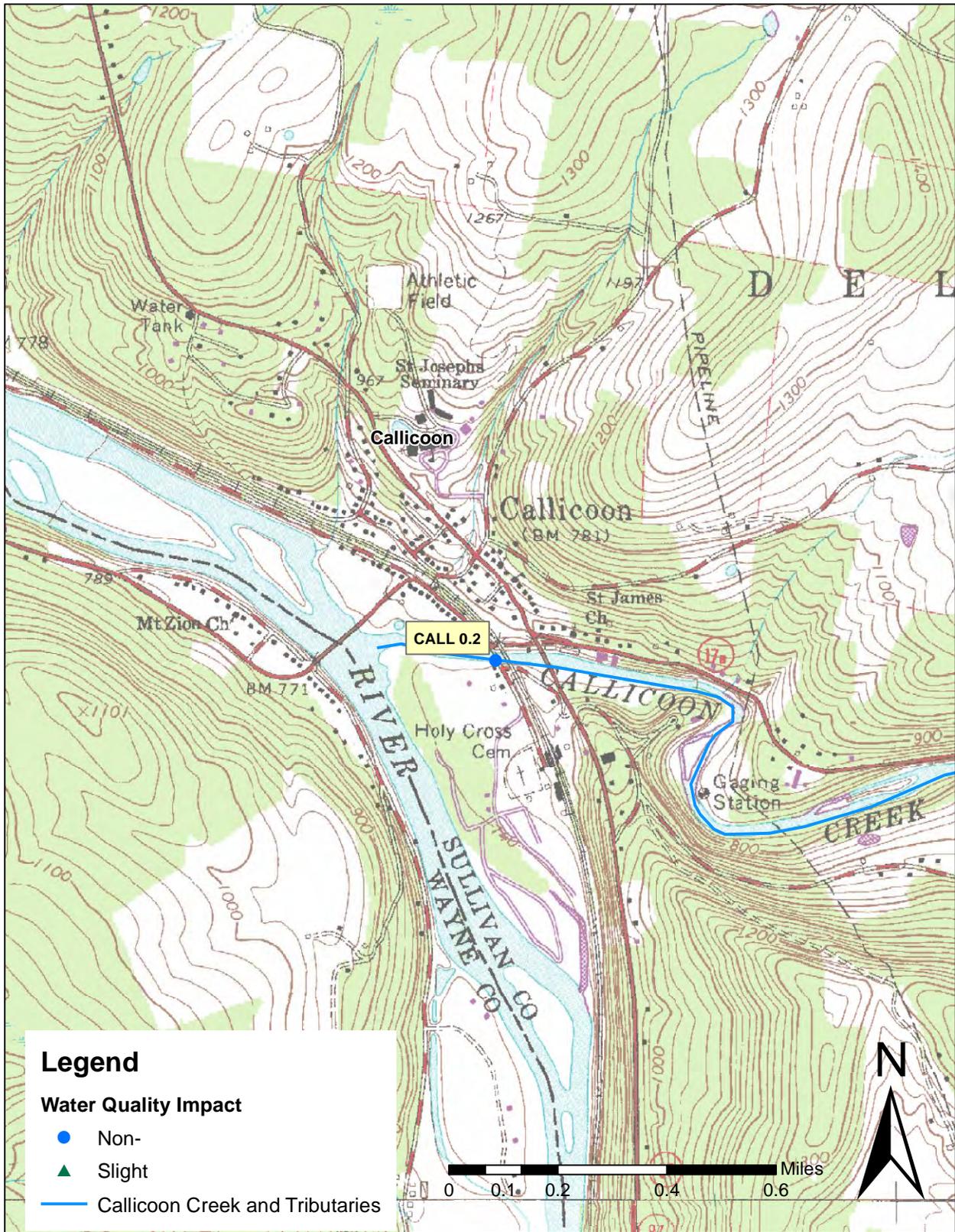


Figure 2a. Site location map, Main-stem and North Branch Callicoon Creek, Stations 1.7, 0.6



Figure 2b. Site location map, North Branch Callicoon Creek, Stations 4.0, 4.7.

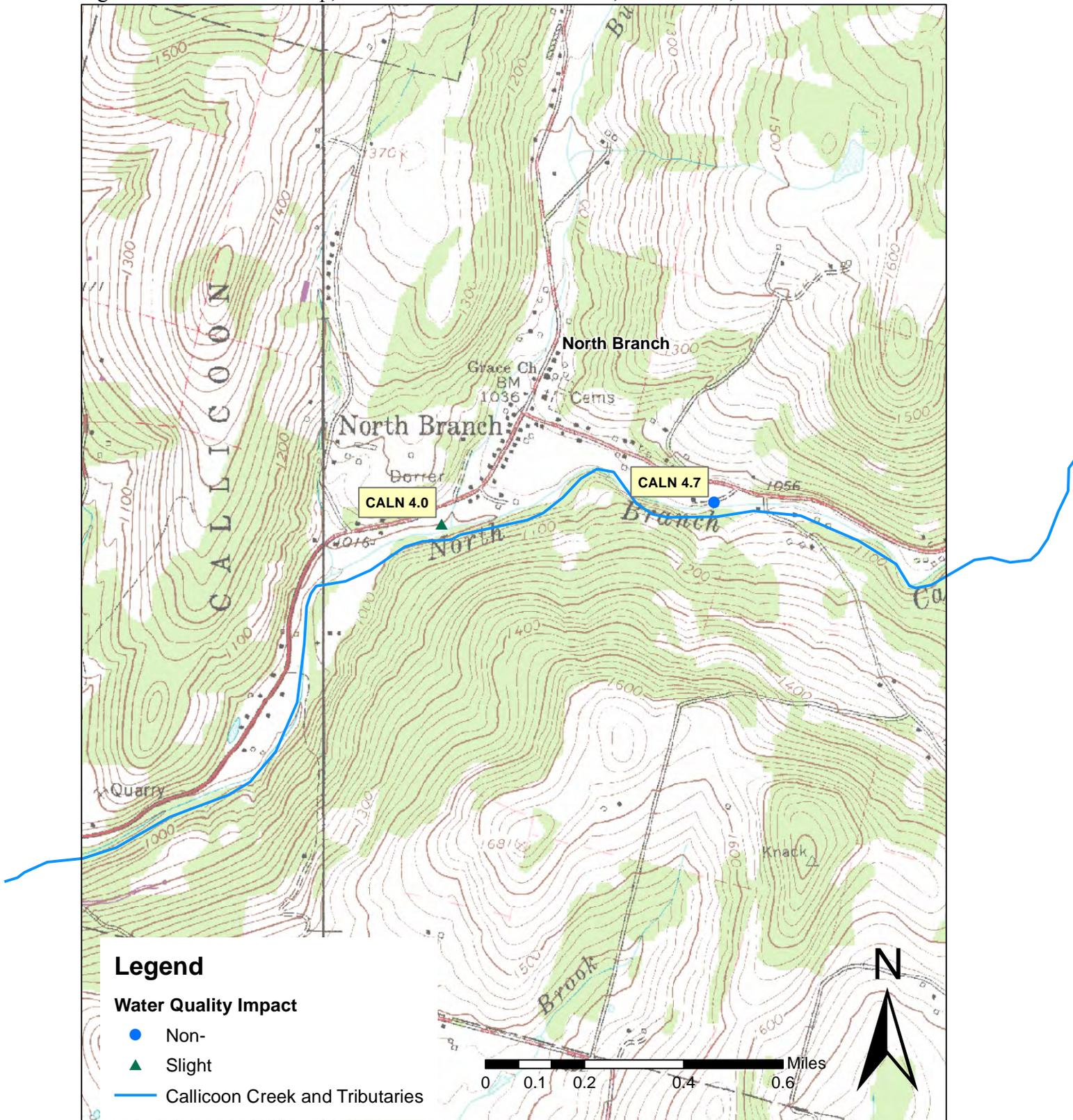


Figure 2c. Site location map, East Branch Callicoon Creek, Station 4.8.



Figure 2d. Site location map, East Branch Callicoon Creek, Station 9.5.

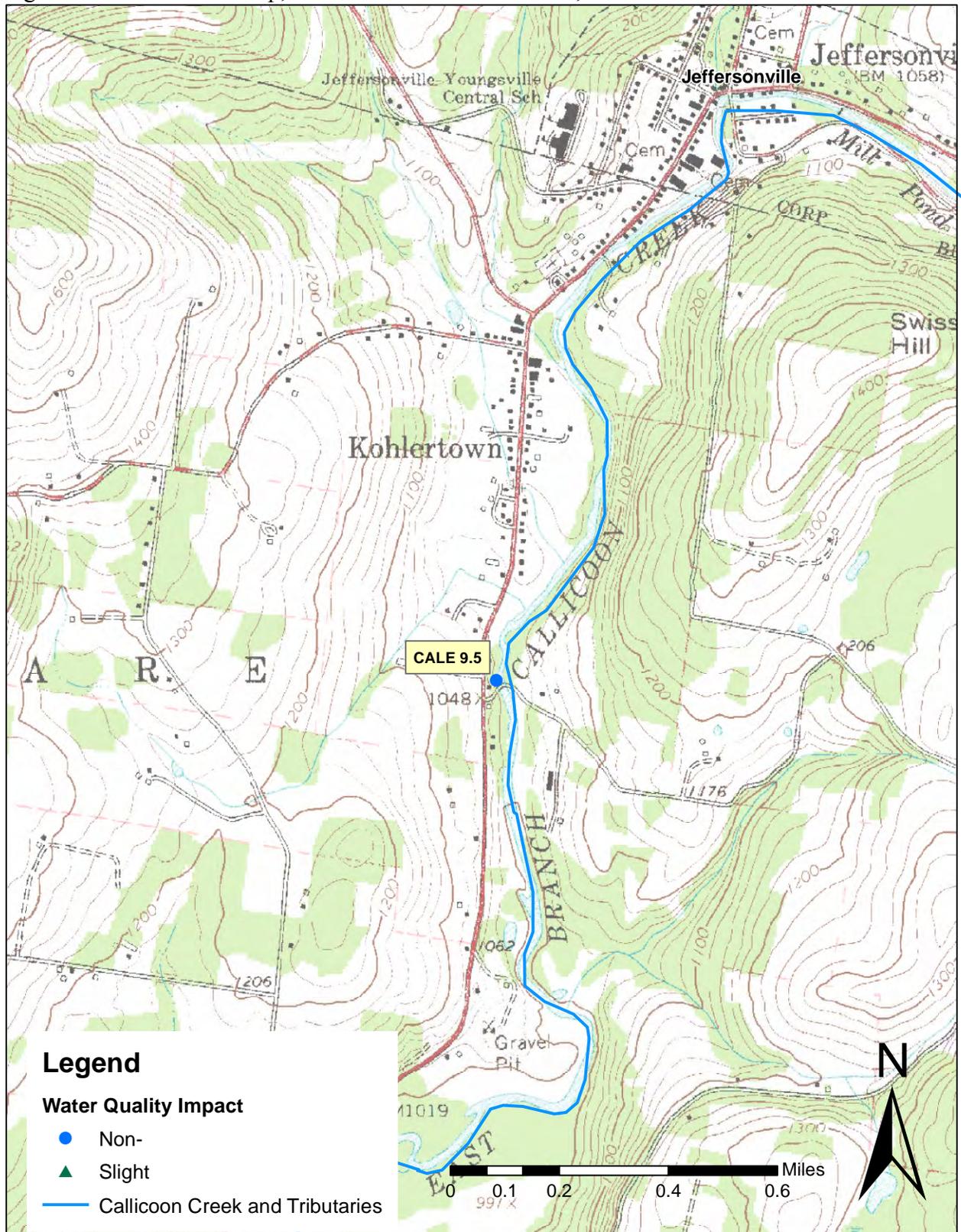


Figure 2e. Site location map, East Branch Callicoon Creek, Station 13.8.

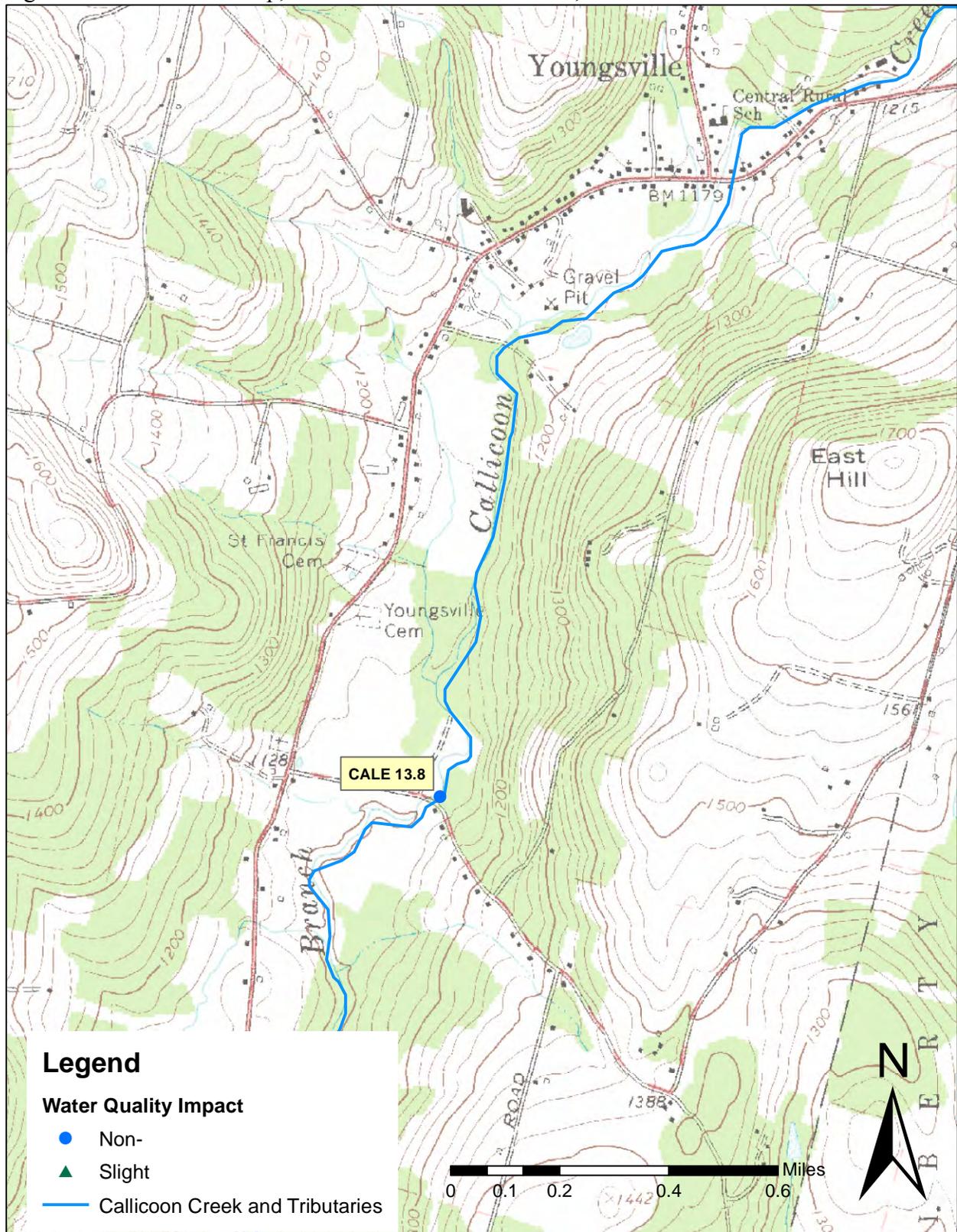


Table 1. Survey locations on Callicoon Creek; Main Stem, East and North Branches 2014.

CALL-0.2	Callicoon, NY 10 m below Co. Rt. 133 bridge Latitude: 41.764152 Longitude: -75.056232
CALL-1.7	Callicoon, NY Intersection of SR 17B & CR 121; below confluence with North Branch Callicoon Ck Latitude: 41.760347 Longitude: -75.033662
CALN-0.6	Hortonville, NY 40m upstream of Hortonville Rd bridge Latitude: 41.767805 Longitude: -75.028513
CALN-4.0	North Branch, NY Hike down tributary (Buck Bk) from CR 121 Latitude: 41.803707 Longitude: -74.994990
CALN-4.7	North Branch, NY 30m below Poley Rd bridge at DEC fishing access Latitude: 41.804318 Longitude: -74.984340
CALE-4.8	Callicoon, NY State Rte. 17B bridge Latitude: 41.729052 Longitude: -74.983332
CALE-9.5	Jeffersonville, NY 50m upstream of Sickmiller Rd bridge at DEC fishing access Latitude: 41.765023 Longitude: -74.942465
CALE-13.8	Jeffersonville, NY Dewitts Flats Rd. bridge Latitude: 41.789080 Longitude: -74.895092

Figure 3. Biological Assessment Profile (BAP) of index values, Callicoon Creek, 2014. Values are plotted on a normalized scale of water quality. The BAP represents the mean of the five values for each site, representing species richness (Spp.), Ephemeroptera, Plecoptera, Trichoptera richness (EPT), Hilsenhoff's Biotic Index (HBI), Percent Model Affinity (PMA), and the Nutrient Biotic Index for phosphorus (NBI-P). See Appendix IV for a more complete explanation.

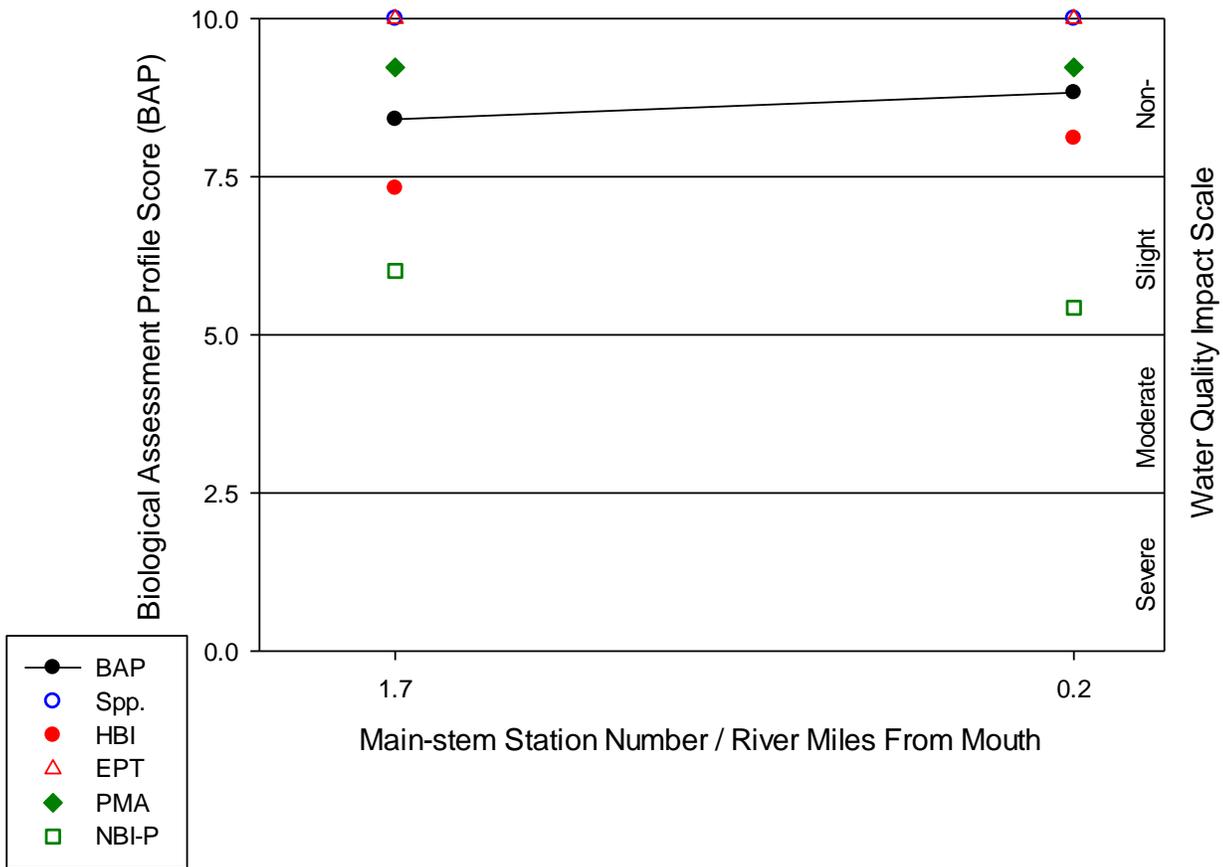


Figure 3a. Biological Assessment Profile (BAP) of index values, East Branch Callicoon Creek, 2014. Values are plotted on a normalized scale of water quality. The BAP represents the mean of the five values for each site, representing species richness (Spp), Ephemeroptera, Plecoptera, Trichoptera richness (EPT), Hilsenhoff's Biotic Index (HBI), Percent Model Affinity (PMA), and the Nutrient Biotic Index for phosphorus (NBI-P). See Appendix IV for a more complete explanation.

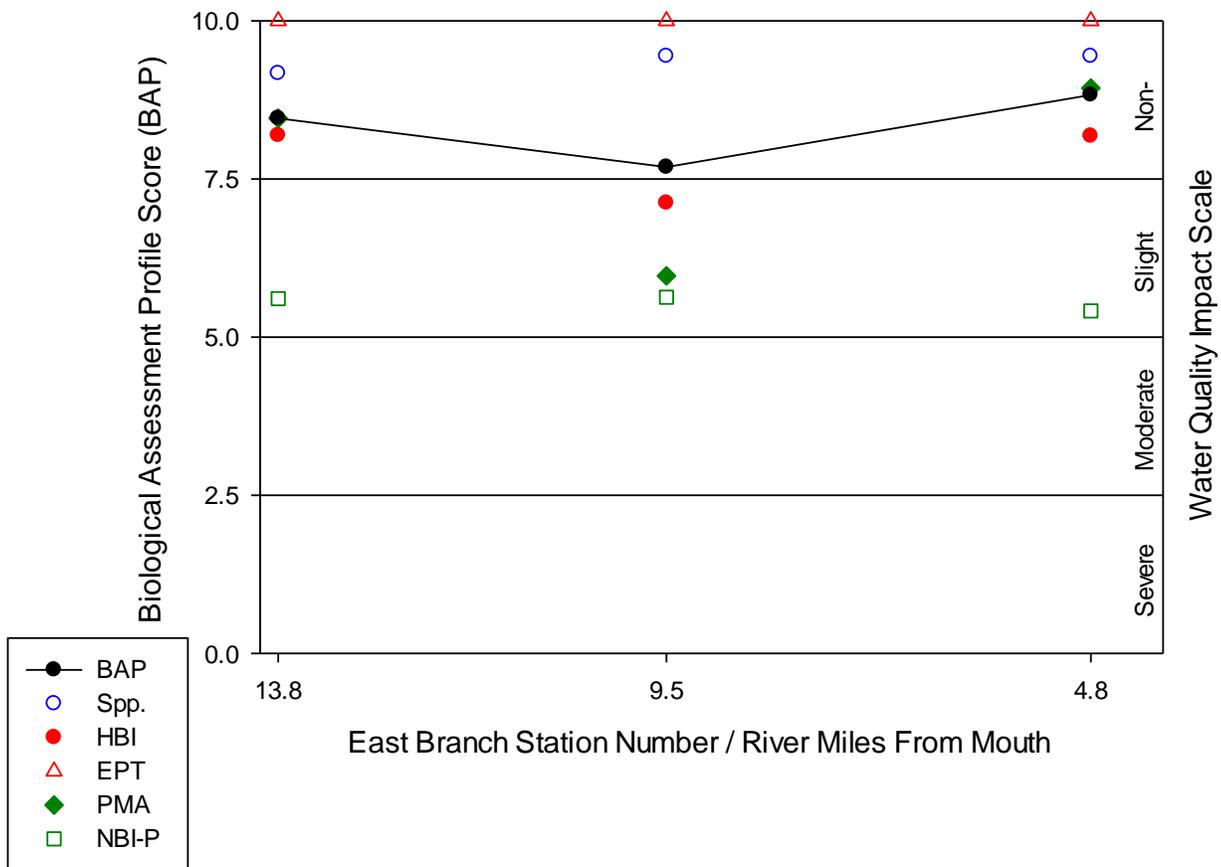


Figure 3b. Biological Assessment Profile (BAP) of index values, North Branch Callicoon Creek, 2014. Values are plotted on a normalized scale of water quality. The BAP represents the mean of the five values for each site, representing species richness (Spp), Ephemeroptera, Plecoptera, Trichoptera richness (EPT), Hilsenhoff's Biotic Index (HBI), Percent Model Affinity (PMA), and the Nutrient Biotic Index for phosphorus (NBI-P). See Appendix IV for a more complete explanation.

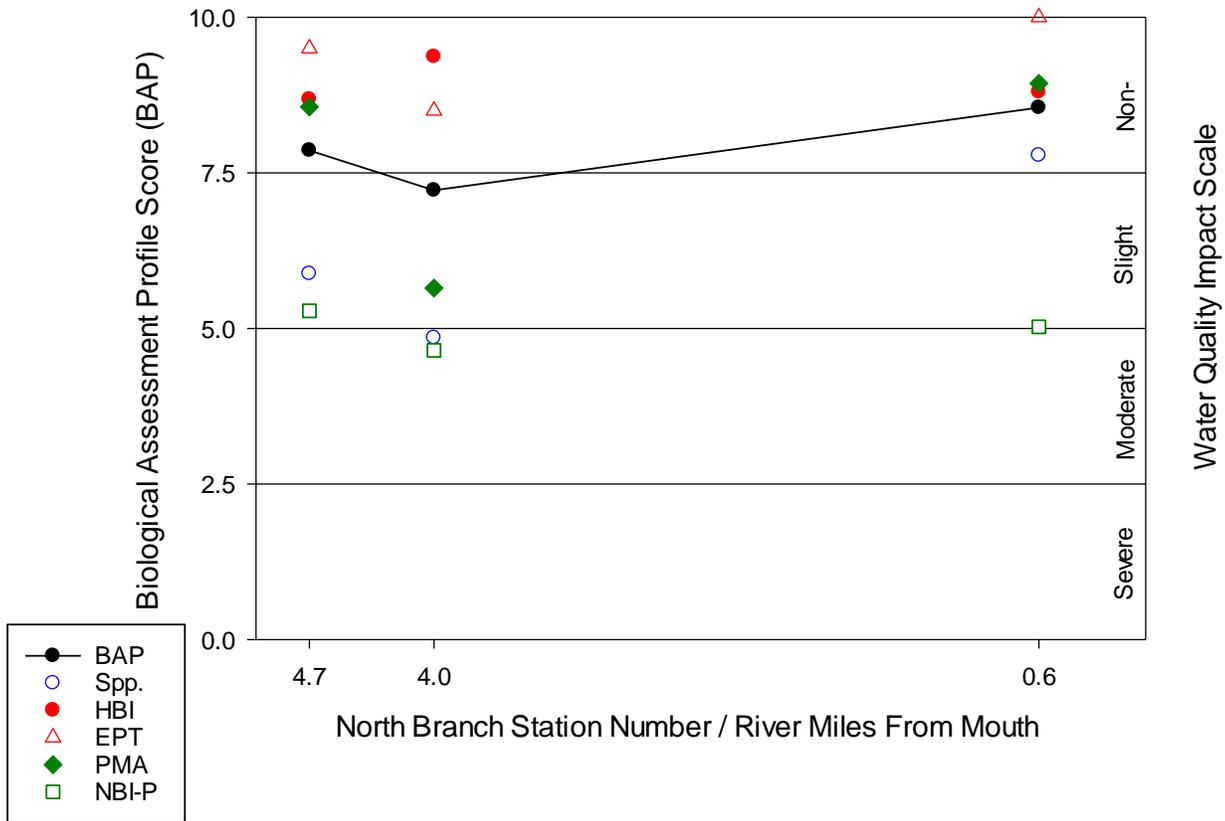


Table 2. Years each Callicoon Creek site was sampled since 1993 .

Station	1993	1994	1999	2000	2004	2005	2009	2010	2014
CALL-0.2	X	X	X	X	X	X	X	X	X
CALL-1.7							X		X
CALN-0.6			X		X		X		X
CALN-4.0									X
CALN-4.7			X						X
CALE-4.8									X
CALE-9.5			X		X		X		X
CALE-13.8									X

Table 3. Summary of Impact Source Determination (ISD) results for Callicoon Creek, 2014. Category abbreviations are Mun./Ind.= Municipal/Industrial sources, Non-point = Non-point source nutrient runoff, Sew./An. Wastes = Sewage effluent and animal waste sources. Further detail on ISD is found in Appendix X. Shaded values represent $\geq 50\%$ similarity to ISD model communities indicating a significant result. Values $\leq 50\%$ represent inconclusive results.

Station	Mun./Ind.	Non-point	Sew./An. Wastes	Siltation	Toxic
CALL-0.2	29	34	35	35	29
CALL-1.7	33	45	46	51	34
CALN-0.6	28	48	27	26	33
CALN-4.0	54	53	21	21	32
CALN-4.7	23	38	30	27	32
CALE-4.8	43	48	46	44	49
CALE-9.5	48	58	51	49	43
CALE-13.8	33	46	44	36	46

Table 4. Summary of physical attributes measured at each sampling location on Callicoon Creek, 2014.

Station	Depth (m)	Width (m)	Current (cm/sec)	Embed. (%)	Temp. (°C)	Conduct. (µmhos)	pH	DO (mg/L)	DO Sat. (%)
CALL-0.2	0.2	25	47	20	22.6	39	8.3	9.2	111
CALL-1.7	0.3	25	24	20	22.7	31.1	7.9	8.9	109
CALN-0.6	0.2	4	40	40	14.0	145	7.0	10.6	103
CALN-4.0	0.3	5	113	25	17.9	23.6	7.4	9.2	101
CALN-4.7	0.1	8	50	25	13.8	140	6.7	10.1	97
CALE-4.8	0.2	8	60	15	17.2	176	7.5	10.8	112
CALE-9.5	0.2	5	50	10	17.6	171	7.4	10.5	110
CALE-13.8	0.1	6	50	10	16.5	147	7.3	9.7	99

Figure 4. Habitat assessment scores for each sampling location on Callicoon Creek, 2014.

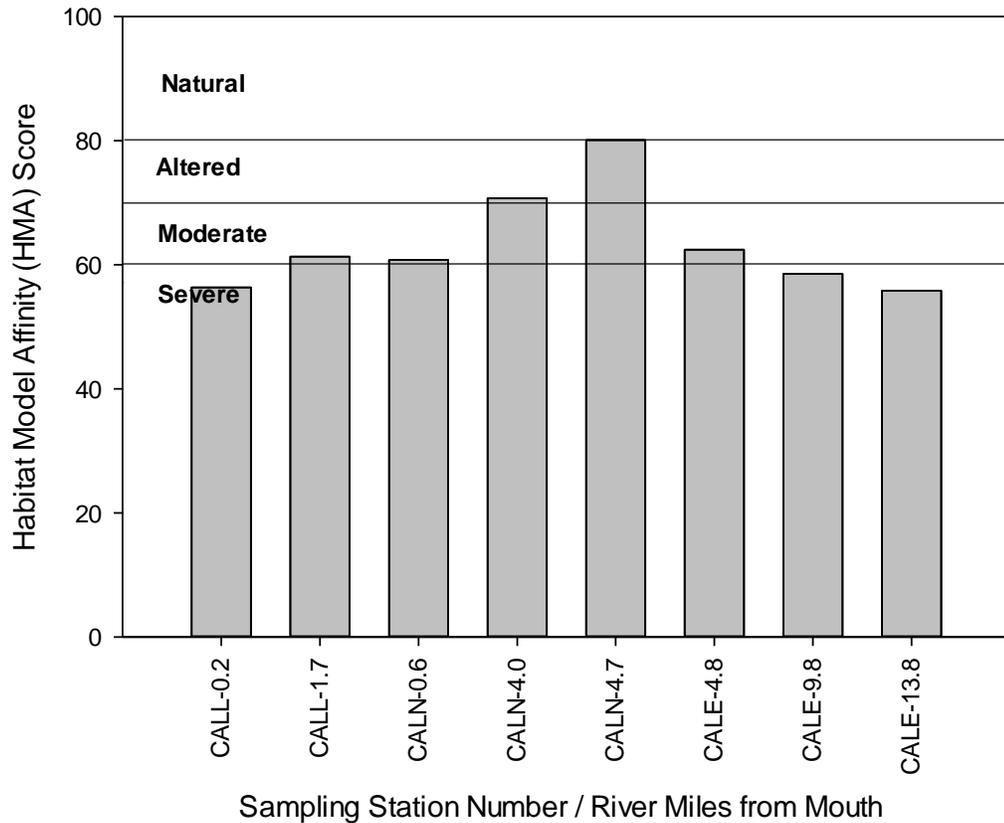


Table 5. Summary of physical habitat attribute scores* used in calculating the Habitat Model Affinity (Figure 4) at locations on Callicoon, 2014.

Station	Epi. Cover	Embed.	Vel/Dep Reg.	Sed. Dep.	Flow Status	Chan. Alt.	Rif. Freq.	Bank Stab.	Bank Veg.	Rip. Width
CALL-0.2	13	16	11	10	15	11	9	10	4	3
CALL-1.7	12	12	7	6	16	12	9	14	12	11
CALN-0.6	14	11	12	11	11	13	15	15	5	3
CALN-4.0	14	14	12	14	10	13	17	11	12	11
CALN-4.7	17	16	11	16	12	17	19	12	14	11
CALE-4.8	13	17	16	15	10	13	8	9	6	6
CALE-9.5	12	16	13	14	11	11	10	11	5	3
CALE-13.8	8	16	15	7	8	13	10	4	10	10

* The following attributes are ranked on a scale from 0 (poor) - 20 (optimal). Epi. Cover = Epifaunal substrate cover, Embed. = Embeddedness, Vel/Dep Reg. = Velocity Depth Regime, Sed. Dep. = Sediment Deposition, Flow Status = Channel Flow Status, Chan. Alt. = Channel Alteration, Rif. Freq. = Riffle Frequency, Bank Stab. = Bank Stability, Bank Veg. = Bank Vegetative Cover, Rip. Width = Riparian Corridor Width. Values of 10 or below are highlighted to identify those parameters ranked as marginal or poor.

Table 6. Macroinvertebrate species collected in Callicoon Creek, 2014.

Genus species	Location - Station							
	CALL 0.2	CALL 1.7	CALN 0.6	CALN 4.0	CALN 4.7	CALE 4.8	CALE 9.5	CALE 13.8
<i>Acentrella</i> sp.							2	
<i>Acentrella turbida</i>		2	5	7		10		7
<i>Acroneuria abnormis</i>	2	1	2	2		2	2	
<i>Acroneuria carolinensis</i>		1						
<i>Agneta capitata</i>	5	1	2		2			2
<i>Ancyronyx</i> sp.								1
<i>Atherix</i> sp.	1	1				1		
<i>Baetis flavistriga</i>		3	13	2	10	1	1	6
<i>Baetis intercalaris</i>	13	12	11	3	3	6		2
<i>Baetis tricaudatus</i>			2	2	17			
<i>Brachycentrus appalachia</i>	1							
<i>Brillia flavifrons</i>							1	
<i>Cardiocladius obscurus</i>				2				
<i>Ceratopsyche bronta</i>		2		1			4	5
<i>Ceratopsyche morosa</i>		1	1			5	4	1
<i>Ceratopsyche slossonae</i>			2	2	1		3	6
<i>Ceratopsyche sparna</i>	1	1	5	5	5	10	17	3
<i>Cheumatopsyche</i> sp.	1	1				1	9	2
<i>Chimarra aterrima?</i>						2	2	
<i>Chimarra obscura</i>						4	10	
<i>Chimarra socia</i>	1	1						
<i>Conchapelopia</i> sp.	6							3
<i>Corydalus cornutus</i>	1					2	1	
<i>Cricotopus bicinctus</i>						1	3	1
<i>Cryptochironomus fulvus</i> gr.	2	2						
<i>Diamesa</i> sp.	1							
<i>Dicranota</i> sp.	1	2			1			
<i>Dineutus</i> sp.		2						
<i>Dolophilodes</i> sp.			9	36	7	3	1	3
<i>Drunella cornutella</i>				1				
<i>Epeorus</i> sp.			1					
<i>Epeorus vitreus</i>		1						
<i>Ephemerella</i> sp.	3	3	1		4			
<i>Eukiefferiella brehmi</i> gr.						1		
<i>Eukiefferiella claripennis</i> gr.						1		

Genus species	Location - Station							
	CALL 0.2	CALL 1.7	CALN 0.6	CALN 4.0	CALN 4.7	CALE 4.8	CALE 9.5	CALE 13.8
<i>Eukiefferiella</i> sp.							1	
<i>Gammarus</i> sp.	1					1		
<i>Glossosoma</i> sp.			4			1		1
<i>Helicopsyche borealis</i>	3							
<i>Hexatoma</i> sp.	1	1	5	2	5	1		6
<i>Hydropsyche betteni</i>							2	
<i>Isonychia</i> sp.	5		9		13	10	5	5
<i>Leucotrichia</i> sp.							1	
<i>Leucrocuta</i> sp.	1	1						
<i>Maccaffertium luteum</i>			1					
<i>Maccaffertium modestum</i>	4					12	3	7
<i>Maccaffertium</i> sp.	1	2	2		5		4	
<i>Maccaffertium terminatum</i>		5						
<i>Maccaffertium vicarium</i>		1						
<i>Micropsectra dives</i> gr.	1							
<i>Micropsectra</i> sp.		4						
<i>Microtendipes pedellus</i> gr.	5	9	1					1
<i>Neureclipsis</i> sp.	1	1				2	1	
<i>Nigronia serricornis</i>		1						
<i>Ophiogomphus</i> sp.	2							
<i>Optioservus</i> sp.			2				4	2
<i>Optioservus fastiditus</i>					2			
<i>Optioservus trivittatus</i>	1	1				3		
<i>Orthocladus dubitatus</i>							1	1
<i>Orthocladus</i> sp.						1		
<i>Parachaetocladus</i> sp.								1
<i>Paragnetina immarginata</i>			4		5		1	
<i>Paragnetina media</i>			1			2		
<i>Paraleptophlebia</i> sp.			1		3			
<i>Parametriocnemus</i> sp.								1
<i>Perlesta</i> sp.	1			1				1
<i>Phaenopsectra</i> sp.		1						
<i>Plauditus</i> sp.	1	1						
<i>Polypedilum aviceps</i>	2	2	10	28	4	1	1	9
<i>Polypedilum fallax</i> gr.		1						
<i>Polypedilum flavum</i>	2	6						
<i>Polypedilum scalaenum</i> gr.		1						
<i>Promoresia elegans</i>	6	2						

Genus species	Location - Station							
	CALL 0.2	CALL 1.7	CALN 0.6	CALN 4.0	CALN 4.7	CALE 4.8	CALE 9.5	CALE 13.8
<i>Psephenus herricki</i>	2	2				2		
<i>Psilotreta sp.</i>	3	2						
<i>Pteronarcys proteus</i>				1				1
<i>Rheotanytarsus exiguus gr.</i>	5	8		1		1	1	3
<i>Rheotanytarsus pellucidus</i>	2							
<i>Rhithrogena sp.</i>					3			
<i>Rhyacophila formosa</i>						1		
<i>Rhyacophila manistee</i>					2			
<i>Rhyacophila sp.</i>						1		
<i>Serratella sp.</i>	1							
<i>Simulium sp.</i>			1	2	1			
<i>Stenelmis crenata</i>		1						
<i>Stenelmis sp.</i>	4	2	1			6	1	1
<i>Stenochironomus sp.</i>	1							
<i>Tanytarsus glabrescens gr.</i>	3	2						
<i>Thienemanniella xena</i>							3	
<i>Thienemannimyia gr. spp.</i>		2						
<i>Tipula sp.</i>	1							
<i>Tricorythodes sp.</i>		4						
<i>Tvetenia bavarica gr.</i>			3		6		1	9
<i>Tvetenia vitracies</i>	1			2		3	5	4
Undetermined Ceratopogonidae					1			
Undetermined Ephemerellidae								2
Undetermined Glossosomatidae							1	
Undetermined Lumbriculidae			1			1		
Undetermined Naididae						1	3	1
Undetermined Nemertea							1	
Undetermined Orthocladinae								2

Appendix I. Biological Methods for Kick Sampling

A. Rationale: The use of the standardized kick sampling method provides a biological assessment technique that lends itself to rapid assessments of stream water quality.

B. Site Selection: Sampling sites are selected based on these criteria: (1) The sampling location should be a riffle with a substrate of rubble, gravel and sand; depth should be one meter or less, and current speed should be at least 0.4 meter per second. (2) The site should have comparable current speed, substrate type, embeddedness, and canopy cover to both upstream and downstream sites to the degree possible. (3) Sites are chosen to have a safe and convenient access.

C. Sampling: Macroinvertebrates are sampled using the standardized traveling kick method. An aquatic net is positioned in the water at arms' length downstream and the stream bottom is disturbed by foot, so that organisms are dislodged and carried into the net. Sampling is continued for a specified time and distance in the stream. Rapid assessment sampling specifies sampling for five minutes over a distance of five meters. The contents of the net are emptied into a pan of stream water. The contents are then examined, and the major groups of organisms are recorded, usually on the ordinal level (e.g., stoneflies, mayflies, caddisflies). Larger rocks, sticks, and plants may be removed from the sample if organisms are first removed from them. The contents of the pan are poured into a U.S. No. 30 sieve and transferred to a quart jar. The sample is then preserved by adding 95% ethyl alcohol.

D. Sample Sorting and Subsampling: In the laboratory, the sample is rinsed with tap water in a U.S. No. 40 standard sieve to remove any fine particles left in the residues from field sieving. The sample is transferred to an enamel pan and distributed homogeneously over the bottom of the pan. A small amount of the sample is randomly removed with a spatula, rinsed with water, and placed in a petri dish. This portion is examined under a dissecting stereomicroscope and 100 organisms are randomly removed from the debris. As they are removed, they are sorted into major groups, placed in vials containing 70 percent alcohol, and counted. The total number of organisms in the sample is estimated by weighing the residue from the picked subsample and determining its proportion of the total sample weight.

E. Organism Identification: All organisms are identified to the species level whenever possible. Chironomids and oligochaetes are slide-mounted and viewed through a compound microscope; most other organisms are identified as whole specimens using a dissecting stereomicroscope. The number of individuals in each species and the total number of individuals in the subsample are recorded on a data sheet. All organisms from the subsample are archived (either slide-mounted or preserved in alcohol). If the results of the identification process are ambiguous, suspected of being spurious, or do not yield a clear water quality assessment, additional subsampling may be required.

Appendix II. Macroinvertebrate Community Parameters

1. Species Richness: the total number of species or taxa found in a sample. For subsamples of 100-organisms each that are taken from kick samples, expected ranges in most New York State streams are: greater than 26, non-impacted; 19-26, slightly impacted; 11-18, moderately impacted, and less than 11, severely impacted.
2. EPT Richness: the total number of species of mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) found in an average 100-organisms subsample. These are considered to be clean-water organisms, and their presence is generally correlated with good water quality (Lenat, 1987). Expected assessment ranges from most New York State streams are: greater than 10, non-impacted; 6-10, slightly impacted; 2-5, moderately impacted, and 0-1, severely impacted.
3. Hilsenhoff Biotic Index: a measure of the tolerance of organisms in a sample to organic pollution (sewage effluent, animal wastes) and low dissolved oxygen levels. It is calculated by multiplying the number of individuals of each species by its assigned tolerance value, summing these products, and dividing by the total number of individuals. On a 0-10 scale, tolerance values range from intolerant (0) to tolerant (10). For the purpose of characterizing species' tolerance, intolerant = 0-4, facultative = 5-7, and tolerant = 8-10. Tolerance values are listed in Hilsenhoff (1987). Additional values are assigned by the NYS Stream Biomonitoring Unit. The most recent values for each species are listed in Quality Assurance document, Bode et al. (2002). Impact ranges are: 0-4.50, non-impacted; 4.51-6.50, slightly impacted; 6.51-8.50, moderately impacted, and 8.51-10.00, severely impacted.
4. Percent Model Affinity: a measure of similarity to a model, non-impacted community based on percent abundance in seven major macroinvertebrate groups (Novak and Bode, 1992). Percentage abundances in the model community are: 40% Ephemeroptera; 5% Plecoptera; 10% Trichoptera; 10% Coleoptera; 20% Chironomidae; 5% Oligochaeta; and 10% Other. Impact ranges are: greater than 64, non-impacted; 50-64, slightly impacted; 35-49, moderately impacted, and less than 35, severely impacted.
5. Nutrient Biotic Index: a measure of stream nutrient enrichment identified by macroinvertebrate taxa. It is calculated by multiplying the number of individuals of each species by its assigned tolerance value, summing these products, and dividing by the total number of individuals with assigned tolerance values. Tolerance values ranging from intolerant (0) to tolerant (10) are based on nutrient optima for Total Phosphorus (listed in Smith, 2005). Impact ranges are: 0-5.00, non-impacted; 5.01-6.00, slightly impacted; 6.01-7.00, moderately impacted, and 7.01-10.00, severely impacted.

Appendix III. Levels of Water Quality Impact in Streams

The description of overall stream water quality based on biological parameters uses a four-tiered system of classification. Level of impact is assessed for each individual parameter and then combined for all parameters to form a consensus determination. Four parameters are used: species richness, EPT richness, biotic index, and percent model affinity (see Appendix II). The consensus is based on the determination of the majority of the parameters. Since parameters measure different aspects of the macroinvertebrate community, they cannot be expected to always form unanimous assessments. The assessment ranges given for each parameter are based on subsamples of 100-organisms each that are taken from macroinvertebrate riffle kick samples. These assessments also apply to most multiplate samples, with the exception of percent model affinity.

1. *Non-impacted*: Indices reflect very good water quality. The macroinvertebrate community is diverse, usually with at least 27 species in riffle habitats. Mayflies, stoneflies, and caddisflies are well represented; EPT richness is greater than 10. The biotic index value is 4.50 or less. Percent model affinity is greater than 64. Nutrient Biotic Index is 5.00 or less. Water quality should not be limiting to fish survival or propagation. This level of water quality includes both pristine habitats and those receiving discharges which minimally alter the biota.

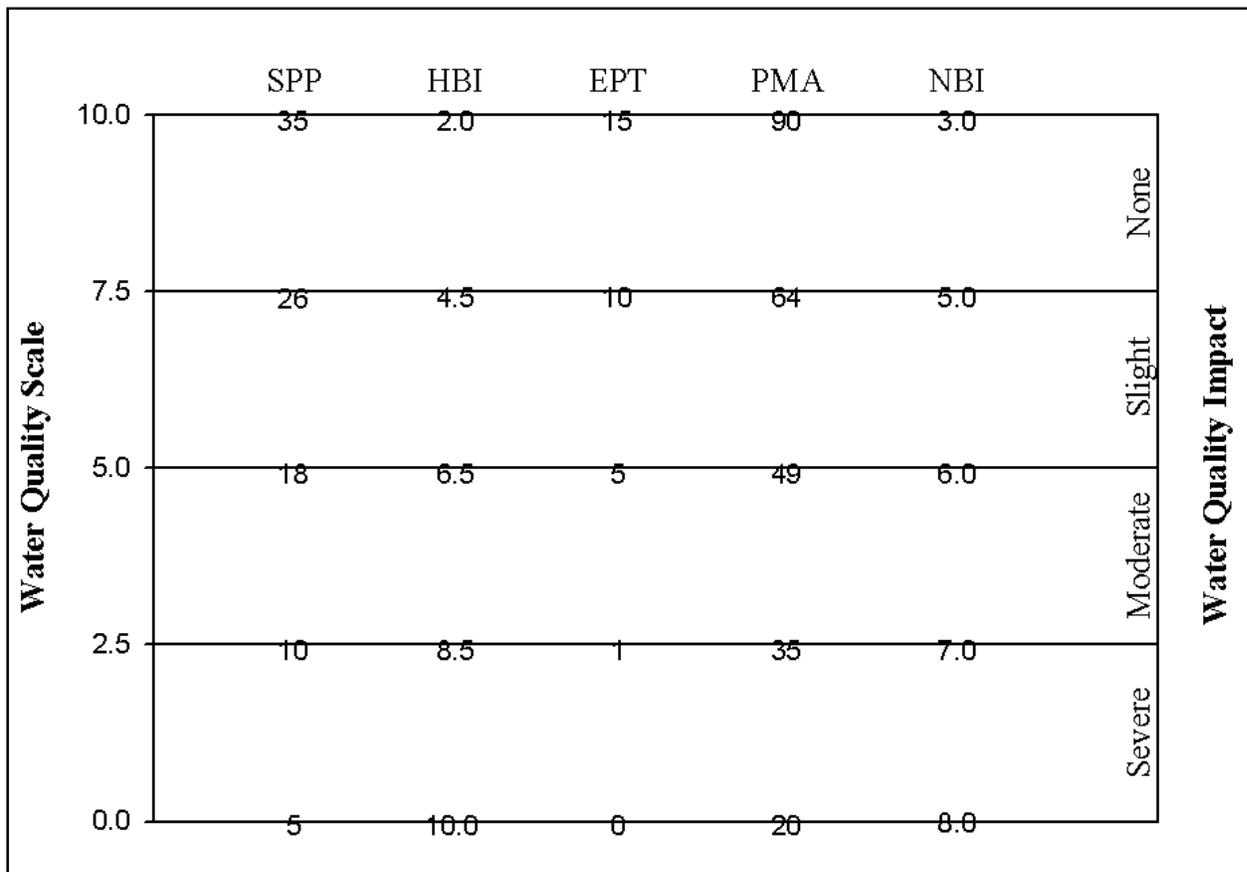
2. *Slightly impacted*: Indices reflect good water quality. The macroinvertebrate community is slightly but significantly altered from the pristine state. Species richness is usually 19-26. Mayflies and stoneflies may be restricted, with EPT richness values of 6-10. The biotic index value is 4.51-6.50. Percent model affinity is 50-64. Nutrient Biotic Index is 5.01-6.00. Water quality is usually not limiting to fish survival, but may be limiting to fish propagation.

3. *Moderately impacted*: Indices reflect poor water quality. The macroinvertebrate community is altered to a large degree from the pristine state. Species richness is usually 11-18 species. Mayflies and stoneflies are rare or absent, and caddisflies are often restricted; the EPT richness is 2-5. The biotic index value is 6.51-8.50. Percent model affinity is 35-49. Nutrient Biotic Index is 6.01-7.00. Water quality often is limiting to fish propagation, but usually not to fish survival.

4. *Severely impacted*: Indices reflect very poor water quality. The macroinvertebrate community is limited to a few tolerant species. Species richness is 10 or fewer. Mayflies, stoneflies and caddisflies are rare or absent; EPT richness is 0-1. The biotic index value is greater than 8.50. Percent model affinity is less than 35. Nutrient Biotic Index is greater than 7.00. The dominant species are almost all tolerant, and are usually midges and worms. Often, 1-2 species are very abundant. Water quality is often limiting to both fish propagation and fish survival.

Appendix IV-A. Biological Assessment Profile: Conversion of Index Values to a 10-Scale

The Biological Assessment Profile (BAP) of index values, developed by Phil O'Brien, Division of Water, NYSDEC, is a method of plotting biological index values on a common scale of water quality impact. Values from the five indices -- species richness (SPP), EPT richness (EPT), Hilsenhoff Biotic Index (HBI), Percent Model Affinity (PMA), and Nutrient Biotic Index (NBI) - defined in Appendix II are converted to a common 0-10 scale using the formulae in the Quality Assurance document (Bode, et al., 2002), and as shown in the figure below.



Appendix IV-B. Biological Assessment Profile: Plotting Values

To plot survey data:

1. Position each site on the x-axis according to miles or tenths of a mile upstream of the mouth.
2. Plot the values of the four indices for each site as indicated by the common scale.
3. Calculate the mean of the four values and plot the result. This represents the assessed impact for each site.

Example data:

	Station 1		Station 2	
	metric value	10-scale value	metric value	10-scale value
Species richness	20	5.59	33	9.44
Hilsenhoff Biotic Index	5.00	7.40	4.00	8.00
EPT richness	9	6.80	13	9.00
Percent Model Affinity	55	5.97	65	7.60
Nutrient Biotic Index	6.0	5.0	6.0	5.0
Average		6.152 (slight)		7.8 (non-)

Appendix V. Water Quality Assessment Criteria

Non-Navigable Flowing Waters

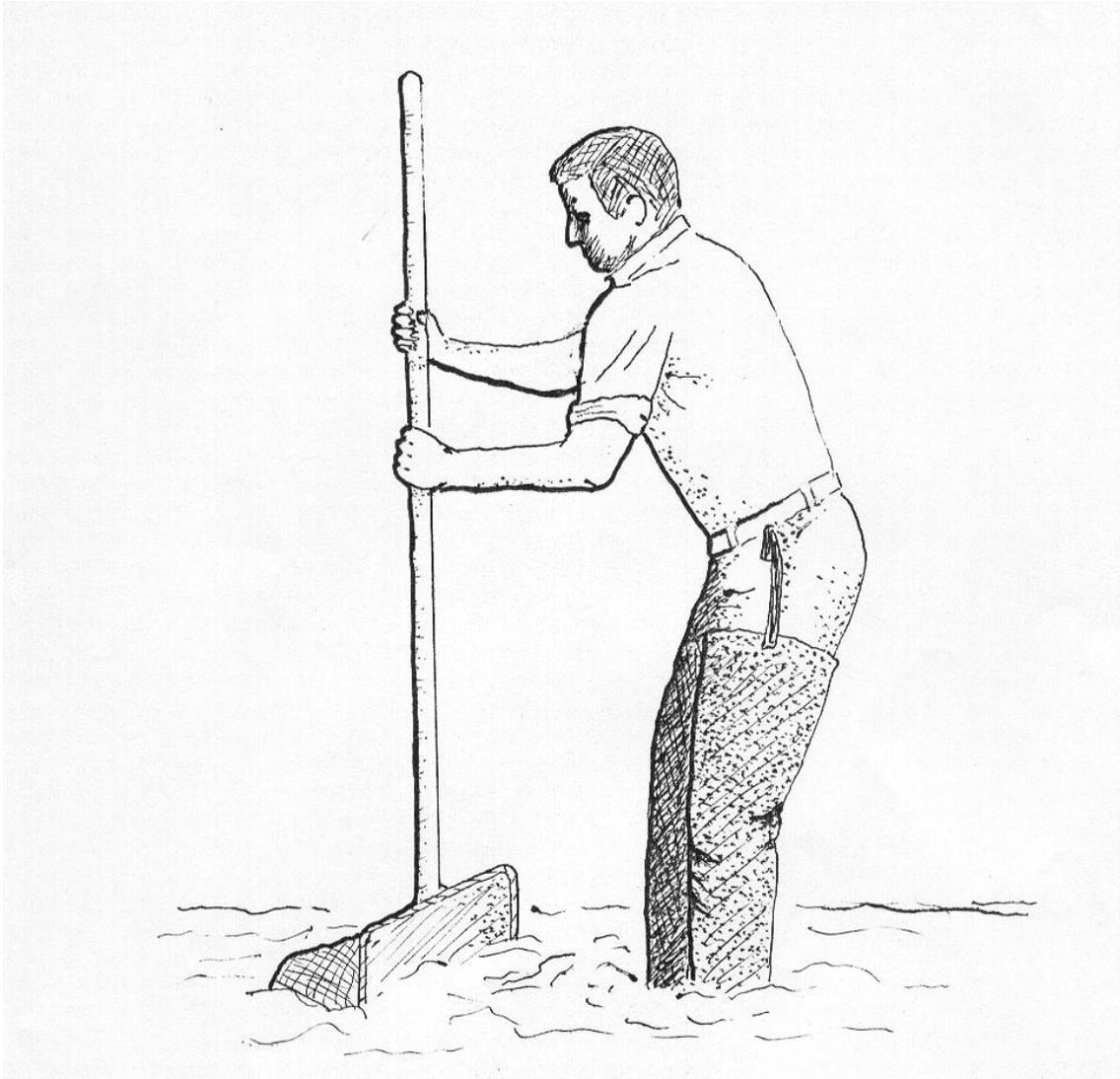
	Species Richness	Hilsenhoff Biotic Index	EPT Value	Percent Model Affinity*	Nutrient Biotic Index
Non-Impacted	>26	0.00-4.50	>10	>64	<5.00
Slightly Impacted	19-26	4.51-6.50	6-10	50-64	5.01-6.00
Moderately Impacted	11-18	6.51-8.50	2-5	35-49	6.01-7.00
Severely Impacted	0-10	8.51-10.00	0-1	<35	>7.01

* Percent model affinity criteria used for traveling kick samples but not for multiplate samples.

Navigable Flowing Waters

	Species Richness	Hilsenhoff Biotic Index	EPT Richness	Species Diversity
Non-Impacted	>21	0.00-7.00	>5	>3.00
Slightly Impacted	17-21	7.01-8.00	4-5	2.51-3.00
Moderately Impacted	12-16	8.01-9.00	2-3	2.01-2.50
Severely Impacted	0-11	9.01-10.00	0-1	0.00-2.00

Appendix VI. The Traveling Kick Sample



Rocks and sediment in a riffle are dislodged by foot upstream of a net. Dislodged organisms are

← current

carried by the current into the net. Sampling continues for five minutes, as the sampler gradually moves downstream to cover a distance of five meters

Appendix VII-A. Aquatic Macroinvertebrates Usually Indicative of Good Water Quality

Mayfly nymphs are often the most numerous organisms found in clean streams. They are sensitive to most types of pollution, including low dissolved oxygen (less than 5 ppm), chlorine, ammonia, metals, pesticides, and acidity. Most mayflies are found clinging to the undersides of rocks.



MAYFLIES

Stonefly nymphs are mostly limited to cool, well-oxygenated streams. They are sensitive to most of the same pollutants as mayflies, except acidity. They are usually much less numerous than mayflies. The presence of even a few stoneflies in a stream suggests that good water quality has been maintained for several months.



STONEFLIES

Caddisfly larvae often build a portable case of sand, stones, sticks, or other debris. Many caddisfly larvae are sensitive to pollution, although a few are tolerant. One family spins nets to catch drifting plankton, and is often numerous in nutrient-enriched stream segments.



CADDISFLIES

The most common beetles in streams are riffle beetles (adult and larva pictured) and water pennies (not shown). Most of these require a swift current and an adequate supply of oxygen, and are generally considered clean-water indicators.



BEETLES



Appendix VII-B. Aquatic Macroinvertebrates Usually Indicative of Poor Water Quality

Midges are the most common aquatic flies. The larvae occur in almost any aquatic situation. Many species are very tolerant to pollution. Large, red midge larvae called “bloodworms” indicate organic enrichment. Other midge larvae filter plankton, indicating nutrient enrichment when numerous.



MIDGES

Black fly larvae have specialized structures for filtering plankton and bacteria from the water, and require a strong current. Some species are tolerant of organic enrichment and toxic contaminants, while others are intolerant of pollutants.



BLACK FLIES



The segmented worms include the leeches and the small aquatic worms. The latter are usually unnoticed. They burrow in the substrate and feed on bacteria in the sediment. They can thrive under conditions of severe pollution and very low oxygen levels, and are thus valuable pollution indicators. Many leeches are also tolerant of poor water quality.



WORMS

more common, though



Aquatic sowbugs are crustaceans that are often numerous in situations of high organic content and low oxygen levels. They are classic indicators of sewage pollution, and can also thrive in toxic situations.

Digital images by Larry Abele, New York State Department of Environmental Conservation, Stream Biomonitoring Unit.



SOWBUGS

Appendix VIII. The Rationale of Biological Monitoring

Biological monitoring refers to the use of resident benthic macroinvertebrate communities as indicators of water quality. Macroinvertebrates are larger-than-microscopic invertebrate animals that inhabit aquatic habitats; freshwater forms are primarily aquatic insects, worms, clams, snails, and crustaceans.

Concept:

Nearly all streams are inhabited by a community of benthic macroinvertebrates. The species comprising the community each occupy a distinct niche defined and limited by a set of environmental requirements. The composition of the macroinvertebrate community is thus determined by many factors, including habitat, food source, flow regime, temperature, and water quality. The community is presumed to be controlled primarily by water quality if the other factors are determined to be constant or optimal. Community components which can change with water quality include species richness, diversity, balance, abundance, and presence/absence of tolerant or intolerant species. Various indices or metrics are used to measure these community changes. Assessments of water quality are based on metric values of the community, compared to expected metric values.

Advantages:

The primary advantages to using macroinvertebrates as water quality indicators are that they:

- are sensitive to environmental impacts
- are less mobile than fish, and thus cannot avoid discharges
- can indicate effects of spills, intermittent discharges, and lapses in treatment
- are indicators of overall, integrated water quality, including synergistic effects
- are abundant in most streams and are relatively easy and inexpensive to sample
- are able to detect non-chemical impacts to the habitat, e.g. siltation or thermal changes
- are vital components of the aquatic ecosystem and important as a food source for fish
- are more readily perceived by the public as tangible indicators of water quality
- can often provide an on-site estimate of water quality
- can often be used to identify specific stresses or sources of impairment
- can be preserved and archived for decades, allowing for direct comparison of specimens
- bioaccumulate many contaminants, so that analysis of their tissues is a good monitor of toxic substances in the aquatic food chain

Limitations:

Biological monitoring is not intended to replace chemical sampling, toxicity testing, or fish surveys. Each of these measurements provides information not contained in the others. Similarly, assessments based on biological sampling should not be taken as being representative of chemical sampling. Some substances may be present in levels exceeding ambient water quality criteria, yet have no apparent adverse community impact.

Appendix IX. Glossary

Anthropogenic: caused by human actions

Assessment: a diagnosis or evaluation of water quality

Benthos: organisms occurring on or in the bottom substrate of a waterbody

Bioaccumulate: accumulate contaminants in the tissues of an organism

Biomonitoring: the use of biological indicators to measure water quality

Community: a group of populations of organisms interacting in a habitat

Drainage basin: an area in which all water drains to a particular waterbody; watershed

Electrofishing: sampling fish by using electric currents to temporarily immobilize them, allowing capture

EPT richness: the number of taxa of mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) in a sample or subsample

Eutrophic: high nutrient levels normally leading to excessive biological productivity

Facultative: occurring over a wide range of water quality; neither tolerant nor intolerant of poor water quality

Fauna: the animal life of a particular habitat

Impact: a change in the physical, chemical, or biological condition of a waterbody

Impairment: a detrimental effect caused by an impact

Index: a number, metric, or parameter derived from sample data used as a measure of water quality

Intolerant: unable to survive poor water quality

Longitudinal trends: upstream-downstream changes in water quality in a river or stream

Macroinvertebrate: a larger-than-microscopic invertebrate animal that lives at least part of its life in aquatic habitats

Mesotrophic: intermediate nutrient levels (between oligotrophic and eutrophic) normally leading to moderate biological productivity

Multiplate: multiple-plate sampler, a type of artificial substrate sampler of aquatic macroinvertebrates

Non Chironomidae/Oligochaeta (NCO) richness: the number of taxa neither belonging to the family Chironomidae nor the subclass Oligochaeta in a sample or subsample

Oligotrophic: low nutrient levels normally leading to unproductive biological conditions

Organism: a living individual

PAHs: Polycyclic Aromatic Hydrocarbons, a class of organic compounds that are often toxic or carcinogenic.

Rapid bioassessment: a biological diagnosis of water quality using field and laboratory analysis designed to allow assessment of water quality in a short turn-around time; usually involves kick sampling and laboratory subsampling of the sample

Riffle: wadeable stretch of stream usually with a rubble bottom and sufficient current to have the water surface broken by the flow; rapids

Species richness: the number of macroinvertebrate taxa in a sample or subsample

Station: a sampling site on a waterbody

Survey: a set of samplings conducted in succession along a stretch of stream

Synergistic effect: an effect produced by the combination of two factors that is greater than the sum of the two factors

Tolerant: able to survive poor water quality

Trophic: referring to productivity

Appendix X. Methods for Calculation of the Nutrient Biotic Index

Definition: The Nutrient Biotic Index (Smith et al., 2007) is a diagnostic measure of stream nutrient enrichment identified by macroinvertebrate taxa. The frequency of occurrences of taxa at varying nutrient concentrations allowed the identification of taxon-specific nutrient optima using a method of weighted averaging. The establishment of nutrient optima is possible based on the observation that most species exhibit unimodal response curves in relation to environmental variables (Jongman et al., 1987). The assignment of tolerance values to taxa based on their nutrient optimum provided the ability to reduce macroinvertebrate community data to a linear scale of eutrophication from oligotrophic to eutrophic. Two tolerance values were assigned to each taxon, one for total phosphorus, and one for nitrate (listed in Smith, 2005). This provides the ability to calculate two different nutrient biotic indices, one for total phosphorus (NBI-P), and one for nitrate (NBI-N). Study of the indices indicate better performance by the NBI-P, with strong correlations to stream nutrient status assessment based on diatom information.

Calculation of the NBI-P and NBI-N: Calculation of the indices [2] follows the approach of Hilsenhoff (1987).

$$\text{NBI Score (TP or NO}_3^-) = 3 (a \times b) / c$$

Where **a** is equal to the number of individuals for each taxon, **b** is the taxon's tolerance value, and **c** is the total number of individuals in the sample for which tolerance values have been assigned.

Classification of NBI Scores: NBI scores have been placed on a scale of eutrophication with provisional boundaries between stream trophic status.

Index	Oligotrophic	Mesotrophic	Eutrophic
NBI-P	< 5.0	> 5.0 - 6.0	> 6.0
NBI-N	< 4.5	> 4.5 - 6.0	> 6.0

References:

- Hilsenhoff, W. L., 1987, An improved biotic index of organic stream pollution. *The Great Lakes Entomologist* 20(1): 31-39.
- Jongman, R. H. G., C. J. F. ter Braak and O. F. R. van Tongeren, 1987, *Data analysis in community and landscape ecology*. Pudoc Wageningen, Netherlands, 299 pages.
- Smith, A.J., R. W. Bode, and G. S. Kleppel, 2007, A nutrient biotic index for use with benthic macroinvertebrate communities. *Ecological Indicators* 7(200):371-386.

Tolerance values assigned to taxa for calculation of the Nutrient Biotic Indices

TAXON	TP T-Value	NO3 T-Value
<i>Acentrella sp.</i>	5	5
<i>Acerpenna pygmaea</i>	0	4
<i>Acroneuria abnormis</i>	0	0
<i>Acroneuria sp.</i>	0	0
<i>Agnentina capitata</i>	3	6
<i>Anthopotamus sp.</i>	4	5
<i>Antocha sp.</i>	8	6
<i>Apatania sp.</i>	3	4
<i>Atherix sp.</i>	8	5
<i>Baetis brunneicolor</i>	1	5
<i>Baetis flavistriga</i>	7	7
<i>Baetis intercalaris</i>	6	5
<i>Baetis sp.</i>	6	3
<i>Baetis tricaudatus</i>	8	9
<i>Brachycentrus appalachia</i>	3	4
<i>Caecidotea racovitzai</i>	6	2
<i>Caecidotea sp.</i>	7	9
<i>Caenis sp.</i>	3	3
<i>Cardiocladius obscurus</i>	8	6
<i>Cheumatopsyche sp.</i>	6	6
<i>Chimarra aterrima?</i>	2	3
<i>Chimarra obscura</i>	6	4
<i>Chimarra socia</i>	4	1
<i>Chimarra sp.</i>	2	0
<i>Chironomus sp.</i>	9	6
<i>Cladotanytarsus sp.</i>	6	4
<i>Corydalis cornutus</i>	2	2
<i>Cricotopus bicinctus</i>	7	6
<i>Cricotopus tremulus gr.</i>	8	9
<i>Cricotopus trifascia gr.</i>	9	9
<i>Cricotopus vierriensis</i>	6	5
<i>Cryptochironomus fulvus gr.</i>	5	6
<i>Diamesa sp.</i>	10	10
<i>Dicranota sp.</i>	5	10
<i>Dicrotendipes neomodestus</i>	10	4
<i>Dolophilodes sp.</i>	4	3

TAXON	TP T-Value	NO3 T-Value
<i>Drunella cornutella</i>	4	4
<i>Ectopria nervosa</i>	10	9
<i>Epeorus (Iron) sp.</i>	0	0
<i>Ephemerella sp.</i>	4	4
<i>Ephemerella subvaria</i>	4	1
<i>Ephoron leukon?</i>	1	1
<i>Eukiefferiella devonica gr.</i>	9	9
<i>Ferrissia sp.</i>	9	5
<i>Gammarus sp.</i>	8	9
<i>Glossosoma sp.</i>	6	0
<i>Goniobasis livescens</i>	10	10
<i>Helicopsyche borealis</i>	1	2
<i>Hemerodromia sp.</i>	5	6
<i>Heptagenia sp.</i>	0	0
<i>Hexatoma sp.</i>	0	1
<i>Hydropsyche betteni</i>	7	9
<i>Hydropsyche bronta</i>	7	6
<i>Hydropsyche morosa</i>	5	1
<i>Hydropsyche scalaris</i>	3	3
<i>Hydropsyche slossonae</i>	6	10
<i>Hydropsyche sp.</i>	5	4
<i>Hydropsyche sparna</i>	6	7
<i>Hydroptila consimilis</i>	9	10
<i>Hydroptila sp.</i>	6	6
<i>Hydroptila spatulata</i>	9	8
<i>Isonychia bicolor</i>	5	2
<i>Lepidostoma sp.</i>	2	0
<i>Leucotrichia sp.</i>	6	2
<i>Leucocuta sp.</i>	1	3
<i>Macrostemum carolina</i>	7	2
<i>Macrostemum sp.</i>	4	2
<i>Micrasema sp. 1</i>	1	0
<i>Micropsectra dives gr.</i>	6	9
<i>Micropsectra polita</i>	0	7
<i>Micropsectra sp.</i>	3	1
<i>Microtendipes pedellus gr.</i>	7	7
<i>Microtendipes rydalensis gr.</i>	2	1
<i>Nais variabilis</i>	5	0

TAXON	TP T-Value	NO3 T-Value
<i>Neoperla sp.</i>	5	5
<i>Neureclipsis sp.</i>	3	1
<i>Nigronia serricornis</i>	10	8
<i>Nixe (Nixe) sp.</i>	1	5
<i>Ophiogomphus sp.</i>	1	3
<i>Optioservus fastiditus</i>	6	7
<i>Optioservus ovalis</i>	9	4
<i>Optioservus sp.</i>	7	8
<i>Optioservus trivittatus</i>	7	6
<i>Orthocladus nr. dentifer</i>	3	7
<i>Pagastia orthogonia</i>	4	8
<i>Paragnetina immarginata</i>	1	2
<i>Paragnetina media</i>	6	3
<i>Paragnetina sp.</i>	1	6
<i>Paraleptophlebia mollis</i>	2	1
<i>Paraleptophlebia sp.</i>	2	3
<i>Parametriocnemus lundbecki</i>	8	10
<i>Paratanytarsus confusus</i>	5	8
<i>Pentaneura sp.</i>	0	1
<i>Petrophila sp.</i>	5	3
<i>Phaenopsectra dyari?</i>	4	5
<i>Physella sp.</i>	8	7
<i>Pisidium sp.</i>	8	10
<i>Plauditus sp.</i>	2	6
<i>Polycentropus sp.</i>	4	2
<i>Polypedilum aviceps</i>	5	7
<i>Polypedilum flavum</i>	9	7
<i>Polypedilum illinoense</i>	10	7
<i>Polypedilum laetum</i>	7	6
<i>Polypedilum scalaenum gr.</i>	10	6
<i>Potthastia gaedii gr.</i>	9	10
<i>Promoresia elegans</i>	10	10
<i>Prostoma graecense</i>	2	7
<i>Psephenus herricki</i>	10	9
<i>Psephenus sp.</i>	3	4
<i>Psychomyia flavida</i>	1	0
<i>Rheocricotopus robacki</i>	4	4
<i>Rheotanytarsus exiguus gr.</i>	6	5
<i>Rheotanytarsus pellucidus</i>	3	2

TAXON	TP T-Value	NO3 T-Value
<i>Rhithrogena sp.</i>	0	1
<i>Rhyacophila fuscula</i>	2	5
<i>Rhyacophila sp.</i>	0	1
<i>Serratella deficiens</i>	5	2
<i>Serratella serrata</i>	1	0
<i>Serratella serratoides</i>	0	1
<i>Serratella sp.</i>	1	1
<i>Sialis sp.</i>	5	6
<i>Simulium jenningsi</i>	6	2
<i>Simulium sp.</i>	7	6
<i>Simulium tuberosum</i>	1	0
<i>Simulium vittatum</i>	7	10
<i>Sphaerium sp.</i>	9	4
<i>Stenacron interpunctatum</i>	7	7
<i>Stenelmis concinna</i>	5	0
<i>Stenelmis crenata</i>	7	7
<i>Stenelmis sp.</i>	7	7
<i>Stenochironomus sp.</i>	4	3
<i>Stenonema mediopunctatum</i>	3	3
<i>Stenonema modestum</i>	2	5
<i>Stenonema sp.</i>	5	5
<i>Stenonema terminatum</i>	2	3
<i>Stenonema vicarium</i>	6	7
<i>Stylaria lacustris</i>	5	2
<i>Sublettea coffmani</i>	3	5
<i>Synorthocladius nr.</i>	6	9
<i>semivirens</i>		
<i>Tanytarsus glabrescens gr.</i>	5	6
<i>Tanytarsus guerlus gr.</i>	5	5
<i>Thienemannimyia gr. spp.</i>	8	8
<i>Tipula sp.</i>	10	10
<i>Tricorythodes sp.</i>	4	9
<i>Tvetenia bavarica gr.</i>	9	10
<i>Tvetenia vitracies</i>	7	6
Undet. Tubificidae w/ cap. setae	10	8
Undet. Tubificidae w/o cap. setae	7	7
Undetermined Cambaridae	6	5

TAXON	TP T-Value	NO3 T-Value
Undet. Ceratopogonidae	8	9
Undet. Enchytraeidae	7	8
Undet. Ephemereillidae	3	6
Undetermined Gomphidae	2	0
Undet. Heptageniidae	5	2
Undetermined Hirudinea	9	10
Undetermined Hydrobiidae	6	7
Undetermined Hydroptilidae	5	2
Undet. Limnephilidae	3	4
Undet. Lumbricina	8	8
Undet. Lumbriculidae	5	6
Undetermined Perlidae	5	7
Undetermined Sphaeriidae	10	8
Undetermined Turbellaria	8	6
<i>Zavrelia sp.</i>	9	9

Appendix XI. Impact Source Determination Methods and Community Models

Definition: Impact Source Determination (ISD) is the procedure for identifying types of impacts that exert deleterious effects on a waterbody. While the analysis of benthic macroinvertebrate communities has been shown to be an effective means of determining severity of water quality impacts, it has been less effective in determining what kind of pollution is causing the impact. ISD uses community types or models to ascertain the primary factor influencing the fauna.

Development of methods: The method found to be most useful in differentiating impacts in New York State streams was the use of community types based on composition by family and genus. It may be seen as an elaboration of Percent Model Affinity (Novak and Bode, 1992), which is based on class and order. A large database of macroinvertebrate data was required to develop ISD methods. The database included several sites known or presumed to be impacted by specific impact types. The impact types were mostly known by chemical data or land use. These sites were grouped into the following general categories: agricultural nonpoint, toxic-stressed, sewage (domestic municipal), sewage/toxic, siltation, impoundment, and natural. Each group initially contained 20 sites. Cluster analysis was then performed within each group, using percent similarity at the family or genus level. Within each group, four clusters were identified. Each cluster was usually composed of 4-5 sites with high biological similarity. From each cluster, a hypothetical model was then formed to represent a model cluster community type; sites within the cluster had at least 50 percent similarity to this model. These community type models formed the basis for ISD (see tables following). The method was tested by calculating percent similarity to all the models and determining which model was the most similar to the test site. Some models were initially adjusted to achieve maximum representation of the impact type. New models are developed when similar communities are recognized from several streams.

Use of the ISD methods: Impact Source Determination is based on similarity to existing models of community types (see tables following). The model that exhibits the highest similarity to the test data denotes the likely impact source type, or may indicate "natural," lacking an impact. In the graphic representation of ISD, only the highest similarity of each source type is identified. If no model exhibits a similarity to the test data of greater than 50 percent, the determination is inconclusive. The determination of impact source type is used in conjunction with assessment of severity of water quality impact to provide an overall assessment of water quality.

Limitations: These methods were developed for data derived from subsamples of 100-organisms each that are taken from traveling kick samples of New York State streams. Application of these methods for data derived from other sampling methods, habitats, or geographical areas would likely require modification of the models.

ISD Models

	NATURAL												
	A	B	C	D	E	F	G	H	I	J	K	L	M
PLATYHELMINTHES	-	-	-	-	-	-	-	-	-	-	-	-	-
OLIGOCHAETA	-	-	5	-	5	-	5	5	-	-	-	5	5
HIRUDINEA	-	-	-	-	-	-	-	-	-	-	-	-	-
GASTROPODA	-	-	-	-	-	-	-	-	-	-	-	-	-
SPHAERIIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-
ASELLIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-
GAMMARIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-
Isonychia	5	5	-	5	20	-	-	-	-	-	-	-	-
BAETIDAE	20	10	10	10	10	5	10	10	10	10	5	15	40
HEPTAGENIIDAE	5	10	5	20	10	5	5	5	5	10	10	5	5
LEPTOPHLEBIIDAE	5	5	-	-	-	-	-	-	5	-	-	25	5
EPHEMERELLIDAE	5	5	5	10	-	10	10	30	-	5	-	10	5
Caenis/Tricorythodes	-	-	-	-	-	-	-	-	-	-	-	-	-
PLECOPTERA	-	-	-	5	5	-	5	5	15	5	5	5	5
Psephenus	5	-	-	-	-	-	-	-	-	-	-	-	-
Optioservus	5	-	20	5	5	-	5	5	5	5	-	-	-
Promoresia	5	-	-	-	-	-	25	-	-	-	-	-	-
Stenelmis	10	5	10	10	5	-	-	-	10	-	-	-	5
PHILOPOTAMIDAE	5	20	5	5	5	5	5	-	5	5	5	5	5
HYDROPSYCHIDAE	10	5	15	15	10	10	5	5	10	15	5	5	10
HELICOPSYCHIDAE/ BRACHYCENTRIDAE/													
RHYACOPHILIDAE	5	5	-	-	-	20	-	5	5	5	5	5	-
SIMULIIDAE	-	-	-	5	5	-	-	-	-	5	-	-	-
Simulium vittatum	-	-	-	-	-	-	-	-	-	-	-	-	-
EMPIDIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-
TIPULIDAE	-	-	-	-	-	-	-	-	5	-	-	-	-
CHIRONOMIDAE													
Tanypodinae	-	5	-	-	-	-	-	-	5	-	-	-	-
Diamesinae	-	-	-	-	-	-	5	-	-	-	-	-	-
Cardiocladius	-	5	-	-	-	-	-	-	-	-	-	-	-
Cricotopus/ Orthocladius	5	5	-	-	10	-	-	5	-	-	5	5	5
Eukiefferiella/ Tvetenia	5	5	10	-	-	5	5	5	-	5	-	5	5
Parametricnemus	-	-	-	-	-	-	-	5	-	-	-	-	-
Chironomus	-	-	-	-	-	-	-	-	-	-	-	-	-
Polypedilum aviceps	-	-	-	-	-	20	-	-	10	20	20	5	-
Polypedilum (all others)	5	5	5	5	5	-	5	5	-	-	-	-	-
Tanytarsini	-	5	10	5	5	20	10	10	10	10	40	5	5
TOTAL	100	100	100	100	100	100	100	100	100	100	100	100	100

ISD Models (cont'd)

NONPOINT NUTRIENTS, PESTICIDES										
	A	B	C	D	E	F	G	H	I	J
PLATYHELMINTHES	-	-	-	-	-	-	-	-	-	-
OLIGOCHAETA	-	-	-	5	-	-	-	-	-	15
HIRUDINEA	-	-	-	-	-	-	-	-	-	-
GASTROPODA	-	-	-	-	-	-	-	-	-	-
SPHAERIIDAE	-	-	-	5	-	-	-	-	-	-
ASELLIDAE	-	-	-	-	-	-	-	-	-	-
GAMMARIDAE	-	-	-	5	-	-	-	-	-	-
Isonychia	-	-	-	-	-	-	-	5	-	-
BAETIDAE	5	15	20	5	20	10	10	5	10	5
HEPTAGENIIDAE	-	-	-	-	5	5	5	5	-	5
LEPTOPHLEBIIDAE	-	-	-	-	-	-	-	-	-	-
EPHEMERELLIDAE	-	-	-	-	-	-	-	5	-	-
Caenis/Tricorythodes	-	-	-	-	5	-	-	5	-	5
PLECOPTERA	-	-	-	-	-	-	-	-	-	-
Psephenus	5	-	-	5	-	5	5	-	-	-
Optioservus	10	-	-	5	-	-	15	5	-	5
Promoresia	-	-	-	-	-	-	-	-	-	-
Stenelmis	15	15	-	10	15	5	25	5	10	5
PHILOPOTAMIDAE	15	5	10	5	-	25	5	-	-	-
HYDROPSYCHIDAE	15	15	15	25	10	35	20	45	20	10
HELICOPSYCHIDAE/ BRACHYCENTRIDAE/ RHYACOPHILIDAE	-	-	-	-	-	-	-	-	-	-
SIMULIIDAE	5	-	15	5	5	-	-	-	40	-
Simulium vittatum	-	-	-	-	-	-	-	-	5	-
EMPIDIDAE	-	-	-	-	-	-	-	-	-	-
TIPULIDAE	-	-	-	-	-	-	-	-	-	5
CHIRONOMIDAE										
Tanypodinae	-	-	-	-	-	-	5	-	-	5
Cardiocladius	-	-	-	-	-	-	-	-	-	-
Cricotopus/ Orthocladius	10	15	10	5	-	-	-	-	5	5
Eukiefferiella/ Tvetenia	-	15	10	5	-	-	-	-	5	-
Parametrioctenus	-	-	-	-	-	-	-	-	-	-
Microtendipes	-	-	-	-	-	-	-	-	-	20
Polypedilum aviceps	-	-	-	-	-	-	-	-	-	-
Polypedilum (all others)	10	10	10	10	20	10	5	10	5	5
Tanytarsini	10	10	10	5	20	5	5	10	-	10
TOTAL	100	100	100	100	100	100	100	100	100	100

ISD Models (cont'd)

	MUNICIPAL/INDUSTRIAL								TOXIC					
	A	B	C	D	E	F	G	H	A	B	C	D	E	F
PLATYHELMINTHES	-	40	-	-	-	5	-	-	-	-	-	-	5	-
OLIGOCHAETA	20	20	70	10	-	20	-	-	-	10	20	5	5	15
HIRUDINEA	-	5	-	-	-	-	-	-	-	-	-	-	-	-
GASTROPODA	-	-	-	-	-	5	-	-	-	5	-	-	-	5
SPHAERIIDAE	-	5	-	-	-	-	-	-	-	-	-	-	-	-
ASELLIDAE	10	5	10	10	15	5	-	-	10	10	-	20	10	5
GAMMARIDAE	40	-	-	-	15	-	5	5	5	-	-	-	5	5
Isonychia	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BAETIDAE	5	-	-	-	5	-	10	10	15	10	20	-	-	5
HEPTAGENIIDAE	5	-	-	-	-	-	-	-	-	-	-	-	-	-
LEPTOPHLEBIIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EPHEMERELLIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Caenis/Tricorythodes	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PLECOPTERA	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Psephenus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Optioservus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Promoresia	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenelmis	5	-	-	10	5	-	5	5	10	15	-	40	35	5
PHILOPOTAMIDAE	-	-	-	-	-	-	-	40	10	-	-	-	-	-
HYDROPSYCHIDAE	10	-	-	50	20	-	40	20	20	10	15	10	35	10
HELICOPSYCHIDAE/ BRACHYCENTRIDAE/ RHYACOPHILIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SIMULIIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Simulium vittatum	-	-	-	-	-	-	20	10	-	20	-	-	-	5
EMPIDIDAE	-	5	-	-	-	-	-	-	-	-	-	-	-	-
CHIRONOMIDAE														
Tanypodinae	-	10	-	-	5	15	-	-	5	10	-	-	-	25
Cardiocladius	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cricotopus/ Orthocladius	5	10	20	-	5	10	5	5	15	10	25	10	5	10
Eukiefferiella/ Tvetenia	-	-	-	-	-	-	-	-	-	-	20	10	-	-
Parametricnemus	-	-	-	-	-	-	-	-	-	-	-	5	-	-
Chironomus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polypedilum aviceps	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polypedilum (all others)	-	-	-	10	20	40	10	5	10	-	-	-	-	5
Tanytarsini	-	-	-	10	10	-	5	-	-	-	-	-	-	5
TOTAL	100	100	100	100	100	100	100	100	100	100	100	100	100	100

ISD Models (cont'd)

	SEWAGE EFFLUENT, ANIMAL WASTES									
	A	B	C	D	E	F	G	H	I	J
PLATYHELMINTHES	-	-	-	-	-	-	-	-	-	-
OLIGOCHAETA	5	35	15	10	10	35	40	10	20	15
HIRUDINEA	-	-	-	-	-	-	-	-	-	-
GASTROPODA	-	-	-	-	-	-	-	-	-	-
SPHAERIIDAE	-	-	-	10	-	-	-	-	-	-
ASELLIDAE	5	10	-	10	10	10	10	50	-	5
GAMMARIDAE	-	-	-	-	-	10	-	10	-	-
Isonychia	-	-	-	-	-	-	-	-	-	-
BAETIDAE	-	10	10	5	-	-	-	-	5	-
HEPTAGENIIDAE	10	10	10	-	-	-	-	-	-	-
LEPTOPHLEBIIDAE	-	-	-	-	-	-	-	-	-	-
EPHEMERELLIDAE	-	-	-	-	-	-	-	-	5	-
Caenis/Tricorythodes	-	-	-	-	-	-	-	-	-	-
PLECOPTERA	-	-	-	-	-	-	-	-	-	-
Psephenus	-	-	-	-	-	-	-	-	-	-
Optioservus	-	-	-	-	-	-	-	-	5	-
Promoesia	-	-	-	-	-	-	-	-	-	-
Stenelmis	15	-	10	10	-	-	-	-	-	-
PHILOPOTAMIDAE	-	-	-	-	-	-	-	-	-	-
HYDROPSYCHIDAE	45	-	10	10	10	-	-	10	5	-
HELICOPSYCHIDAE/ BRACHYCENTRIDAE/ RHYACOPHILIDAE	-	-	-	-	-	-	-	-	-	-
SIMULIIDAE	-	-	-	-	-	-	-	-	-	-
Simulium vittatum	-	-	-	25	10	35	-	-	5	5
EMPIDIDAE	-	-	-	-	-	-	-	-	-	-
CHIRONOMIDAE										
Tanypodinae	-	5	-	-	-	-	-	-	5	5
Cardiocladius	-	-	-	-	-	-	-	-	-	-
Cricotopus/ Orthocladius	-	10	15	-	-	10	10	-	5	5
Eukiefferiella/ Tvetenia	-	-	10	-	-	-	-	-	-	-
Parametricnemus	-	-	-	-	-	-	-	-	-	-
Chironomus	-	-	-	-	-	-	10	-	-	60
Polypedilum aviceps	-	-	-	-	-	-	-	-	-	-
Polypedilum (all others)	10	10	10	10	60	-	30	10	5	5
Tanytarsini	10	10	10	10	-	-	-	10	40	-
TOTAL	100	100	100	100	100	100	100	100	100	100

ISD Models (cont'd)

	SILTATION				
	A	B	C	D	E
PLATYHELMINTHES	-	-	-	-	-
OLIGOCHAETA	5	-	20	10	5
HIRUDINEA	-	-	-	-	-
GASTROPODA	-	-	-	-	-
SPHAERIIDAE	-	-	-	5	-
ASELLIDAE	-	-	-	-	-
GAMMARIDAE	-	-	-	10	-
Isonychia	-	-	-	-	-
BAETIDAE	-	10	20	5	-
HEPTAGENIIDAE	5	10	-	20	5
LEPTOPHLEBIIDAE	-	-	-	-	-
EPHEMERELLIDAE	-	-	-	-	-
Caenis/Tricorythodes	5	20	10	5	15
PLECOPTERA	-	-	-	-	-
Psephenus	-	-	-	-	-
Optioservus	5	10	-	-	-
Promoresia	-	-	-	-	-
Stenelmis	5	10	10	5	20
PHILOPOTAMIDAE	-	-	-	-	-
HYDROPSYCHIDAE	25	10	-	20	30
HELICOPSYCHIDAE/ BRACHYCENTRIDAE/ RHYACOPHILIDAE	-	-	-	-	-
SIMULIIDAE	5	10	-	-	5
EMPIDIDAE	-	-	-	-	-
CHIRONOMIDAE					
Tanypodinae	-	-	-	-	-
Cardiocladius	-	-	-	-	-
Cricotopus/ Orthocladius	25	-	10	5	5
Eukiefferiella/ Tvetenia	-	-	10	-	5
Parametrioctenemus	-	-	-	-	-
Chironomus	-	-	-	-	-
Polypedilum aviceps	-	-	-	-	-
Polypedilum (all others)	10	10	10	5	5
Tanytarsini	10	10	10	10	5
TOTAL	100	100	100	100	100