New York State
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Division of Water

Wharton Creek

Biological Assessment

2009 Survey

New York State
Department of Environmental Conservation

BIOLOGICAL STREAM ASSESSMENT

Wharton Creek
Otsego County, New York
Susquehanna River Basin

Survey date: July 22, 2009
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Brian Duffy
Alexander J. Smith
Diana L. Heitzman

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

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Stream: Wharton Creek

River Basin: Susquehanna

Reach: West Exeter to New Berlin, NY

Background

The Stream Biomonitoring Unit (SBU) sampled the Wharton Creek, Otsego County, New York, on July 22, 2009. Sampling was conducted at the request of NYSDEC Region 4 fisheries staff to investigate potential impacts to water quality that may have degraded fish communities. The sampling of Wharton Creek also established baseline water quality data.

To characterize water quality, macroinvertebrate samples were collected at five locations from West Exeter to New Berlin. The site closest to the mouth, Station 04, was the only historical site. Table 1 provides a list of sampling sites. Macroinvertebrate samples were collected using the traveling kick-net method. The contents of each macroinvertebrate 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. Methods used are described in the Standard Operating Procedure: Biological Monitoring of Surface Waters in New York State (Smith et al. 2009) and summarized in Appendix I.

Macroinvertebrate community parameters used in the determination of water quality included: species richness, biotic index, EPT richness, percent model affinity, and the Nutrient Biotic Index for Phosphorus (see Appendices II, III, and V). This report summarizes the first dataset in which the Nutrient Biotic Index has been integrated into the overall water quality assessment score and as a result, previous biological assessments using only the original metrics (SPP, EPT, HBI, PMA, Appendices II and III) are not comparable without inclusion of the new metric. Amount of expected variability of results is stated in Smith and Bode (2004).

This report includes the first use of the Habitat Model Affinity (HMA), a new tool developed by the Stream Biomonitoring Unit to quantify the instream and riparian habitat condition of the assessment reach (Appendix XV). The HMA will be used to identify potential physical stress to biological communities.

Results and Conclusions

1. Water quality in Wharton Creek ranges from slightly impacted at the most upstream sampling location to non-impacted at the four locations sampled downstream.

2. Nutrient influences from agriculture appear to be the primary stressor on macroinvertebrate communities.

3. The condition of the macroinvertebrate communities collected in this water quality assessment does not explain the poor fish communities found in July 2008. Concurrent fish, macroinvertebrate, and habitat assessments would be helpful in determining whether the fish community condition was due to a temporary event or to more prolonged habitat stress.

Discussion

Wharton Creek originates in northern Otsego County in the town of Richfield. The creek flows south and east into the town of Pittsfield where it joins the Unadilla River. It is located in a region with a high percentage of agricultural land-use. On July 22, 2009, Stream Biomonitoring Unit staff completed a survey of five sampling locations on Wharton Creek from Station 01 at river mile 23.4 in the village of West Exeter to Station 04 in the village of New Berlin at river mile 0.3. Station 04, the most downstream site for the macroinvertebrate survey, was previously sampled in 2008. The additional four sites establish a baseline for the biological assessment of water quality for this water body. Drainage areas range from 15.1 square miles at Station 00 to 90.1 square miles at Station 04 (Table 1). This survey was conducted at the request of the NYSDEC Region 4 fisheries manager because of water quality concerns stemming from a fish survey conducted in July, 2008 that found a scarcity of fish at seven sites from the mouth to river mile 20.3. Fish communities at three locations upstream of river mile 20.3 were not considered depauperate.

In order to address nonpoint source nutrient pollution and because of current focus on nutrient criteria development in New York State (NYS), the Stream Biomonitoring Unit has developed and incorporated a nutrient specific metric, Nutrient Biotic Index (NBI) into the calculation of the Biological Assessment Profile (BAP) (Figure 2; Appendix IV-A) score. This NBI metric was developed specifically for NYS and identifies stream trophic status. Additionally, nutrient impairment thresholds for both phosphorus and nitrogen have been developed to reflect degradation of macroinvertebrate communities (Smith et al., 2007). This biological assessment report marks the first direct integration of the NBI into the BAP score. As a result, previous biological assessments using only the original metrics (SPP, EPT, HBI, PMA, Appendices II and III) are not comparable without inclusion of the NBI and recalculation of the BAP.

BAP scores indicate slightly impacted conditions at Station 00 and non-impacted conditions at the remaining downstream stations (Figure 2). All BAP scores are near the non – slight impact threshold. The highest specific conductance of 348 µmhos was found at Station 00 and the lowest measurement of 228 µmhos was found at Station 04. Land-use analysis shows substantial agriculture within the Wharton Creek watershed (Table 4). Impact source determination (ISD) indicates natural macroinvertebrate communities, however, nutrient influences on the communities are also strongly suggested (Table 5).

The macroinvertebrate communities do not appear to indicate water quality issues that would seriously degrade fish communities. Land-use practices such as agriculture tend to alter hydrology and increase sedimentation and can impact the survival and propagation of fish. The link between in-stream habitat, landuse, and fish communities is well established (Gorman and Karr, 1978; Walser and Bart, 1999; Lammert and Allan, 1999). Nutrient enrichment and sedimentation as a result of agriculture do appear to play a role and there are potential habitat issues.

Wharton Creek is the first assessment survey that includes the use of the Habitat Model Affinity (HMA). The HMA is based off the rapid habitat assessment developed by Barbour et al. (1999). Tran et al. (2010) established the link between the rapid habitat assessment and macroinvertebrate communities. The HMA assessed habitat conditions at Stations 00 and 03 as 'altered', suggesting habitat stress from both instream and riparian corridor alterations may begin to impact macroinvertebrate communities (Table 6, Appendix XV). Decreasing HMA scores in New York State show a significant correlation to increasing percent fines in the substrate composition (Duffy, 2011).

Pebble counts performed at each site found levels of fine sediment (<16mm) to be at or near the provisional threshold for concern (TFC) of 24% for each site (Figure 4, Appendix XIV). Elevated levels of fine sediment can be a result of disturbance in the watershed and has been shown to negatively impact macroinvertebrates (Chutter, 1969; Berkman and Rabeni, 1987; Asmus et al. 2009). Periphyton and silt cover data, collected in conjunction with the pebble count, highlight Station 00 with its elevated silt, microalgae, and macroalgae index values. The macroalgae index score is near the TFC of 3.5 while the silt index score exceeds the TFC of 3.9, indicating the increasing likelihood of biological stress from macro-algae growth and siltation (Duffy, 2011).

If there was a contaminant or temperature pulse that severely impacted the fish community leaving it depleted at the time of assessment in 2008, the macroinvertebrate community was either not affected or had recovered by July 2009. Explanation of the fish community condition at the sites in question remains inconclusive. A cooperative and concurrent assessment of both macroinvertebrate and fish communities would enable a more thorough and conclusive assessment of Wharton Creek.

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Figure 1. Overview map, sampling locations on Wharton Creek, Otsego County.

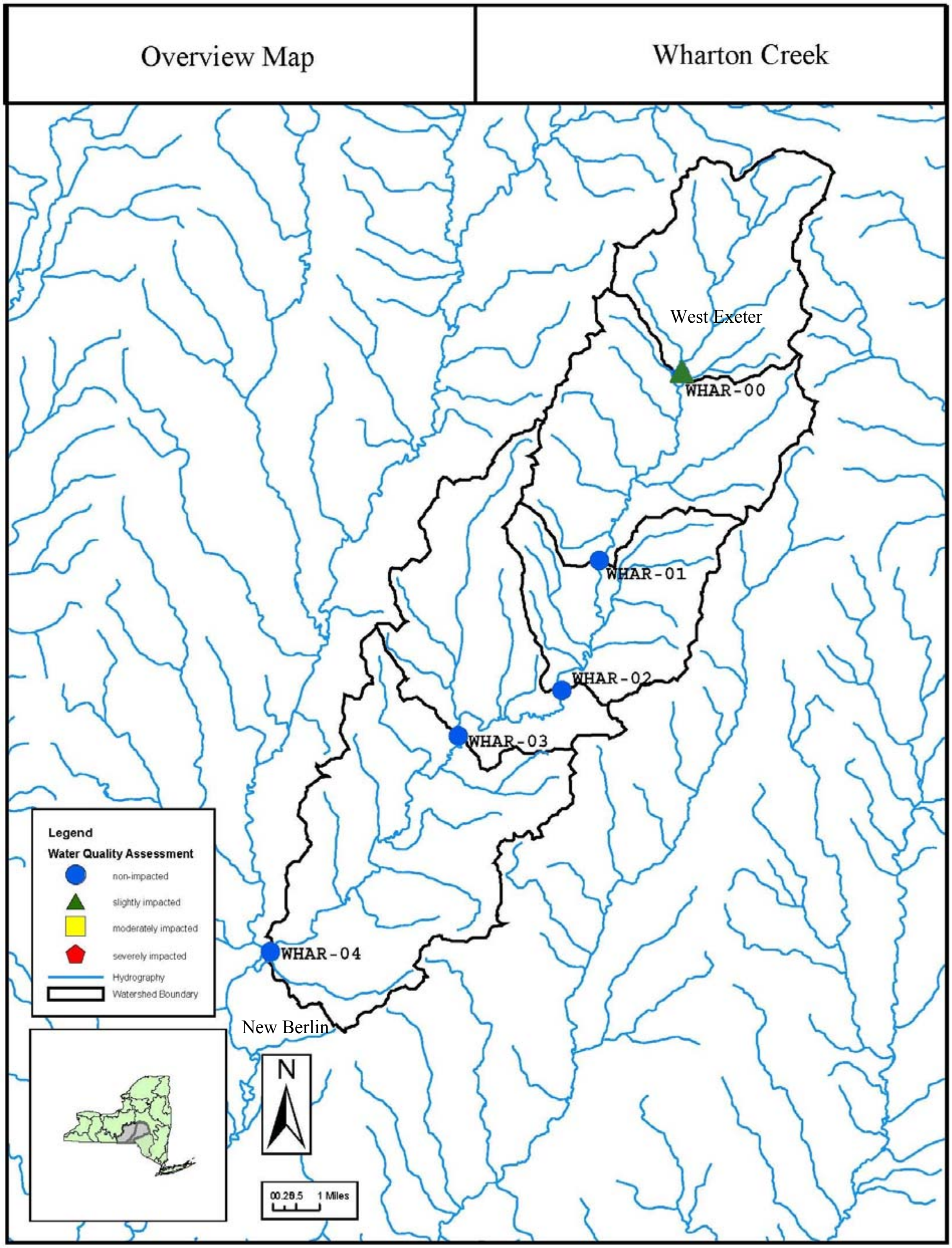


Figure 1a. Station map, Wharton Creek station 00, Otsego County.

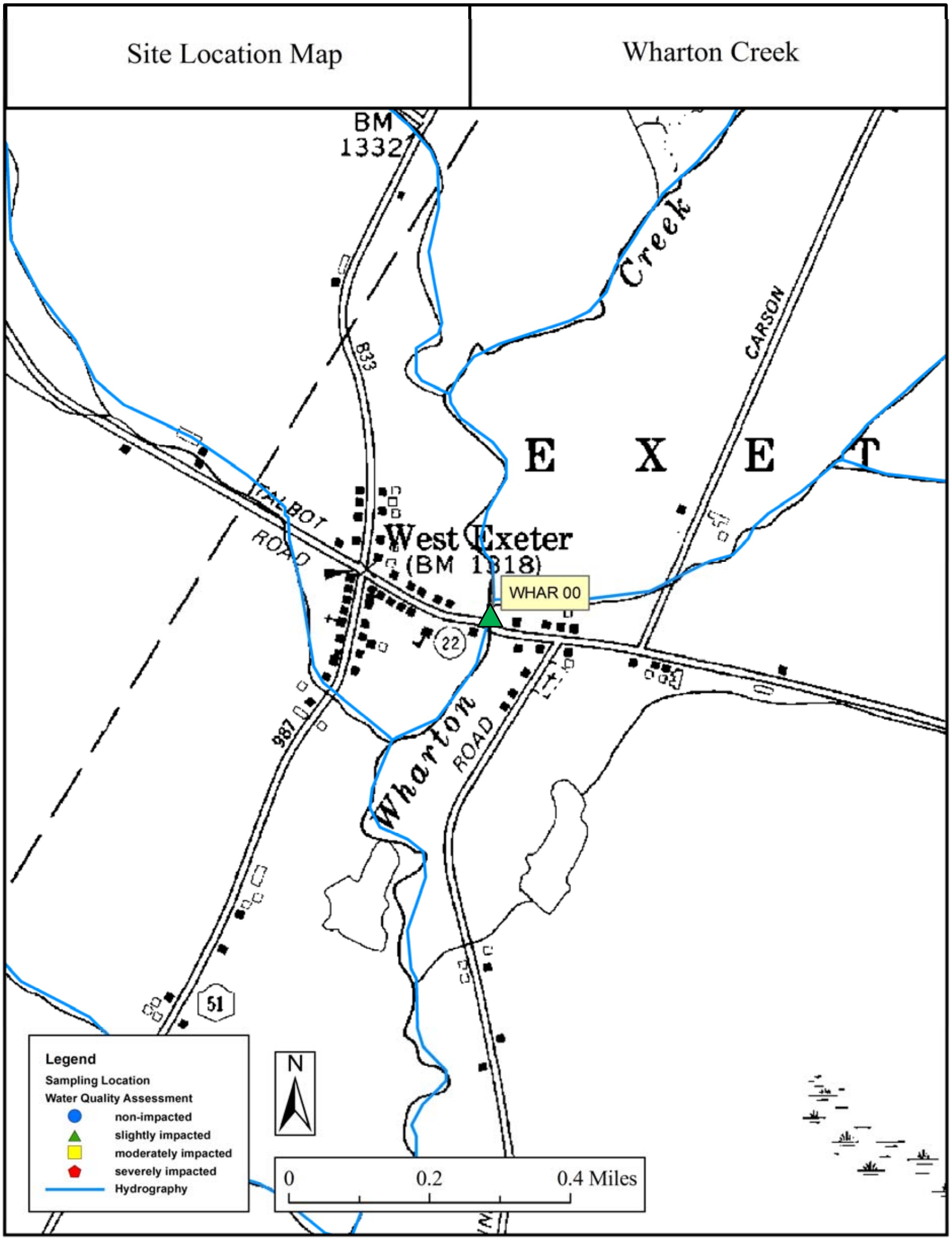


Figure 1b. Station map, Wharton Creek station 01, Otsego County.

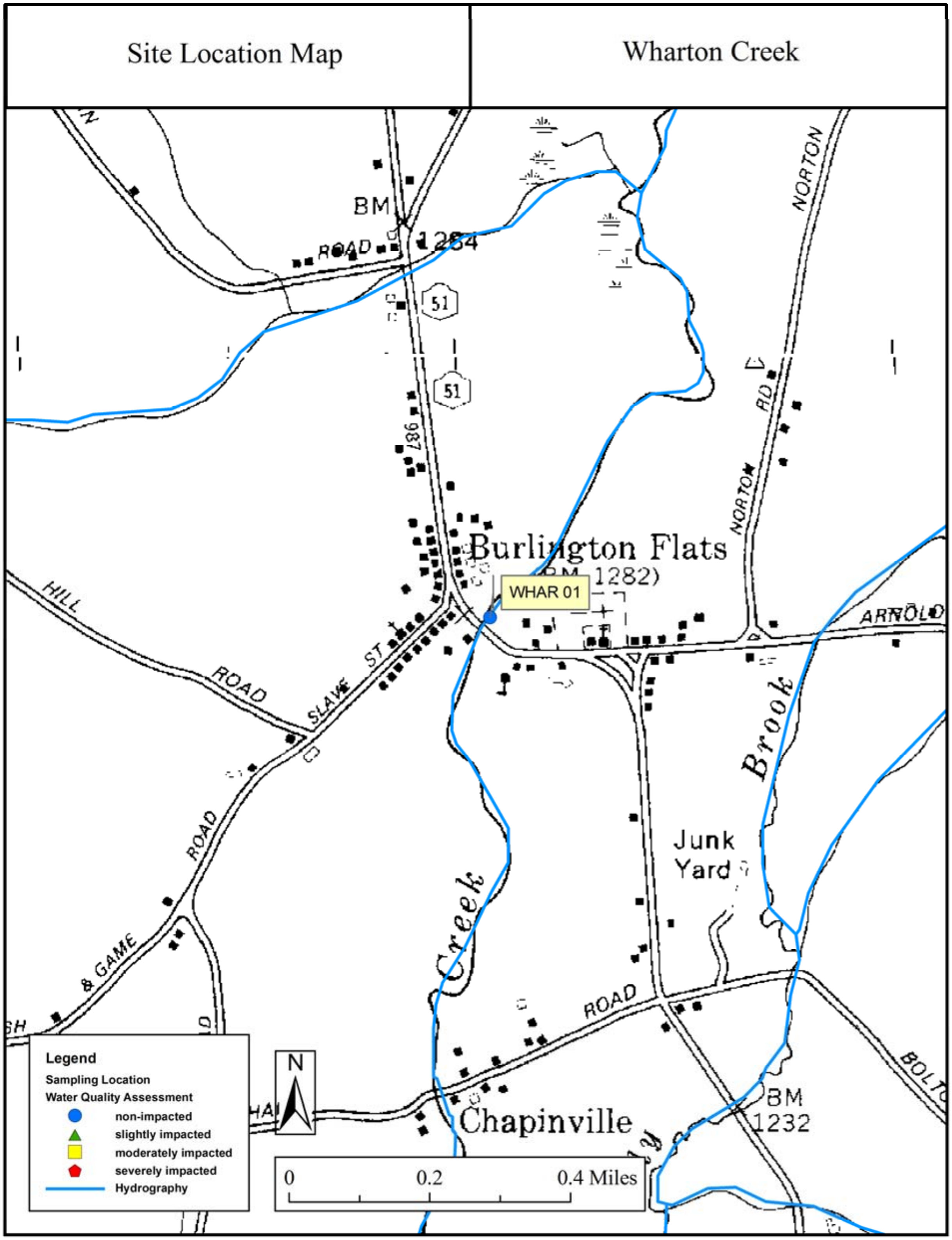


Figure 1c. Station map, Wharton Creek station 02, Otsego County.

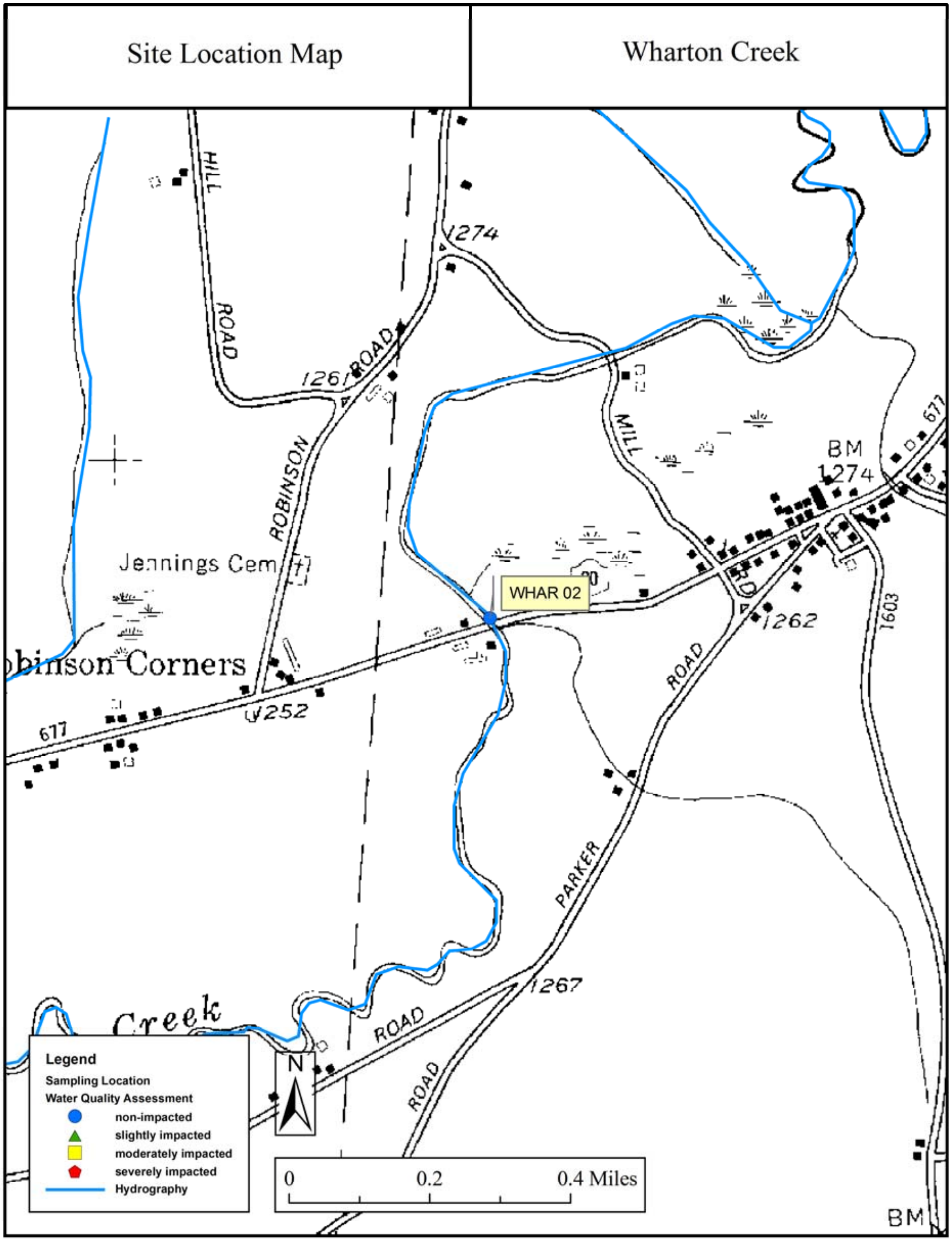


Figure 1d. Station map, Wharton Creek station 03, Otsego County.

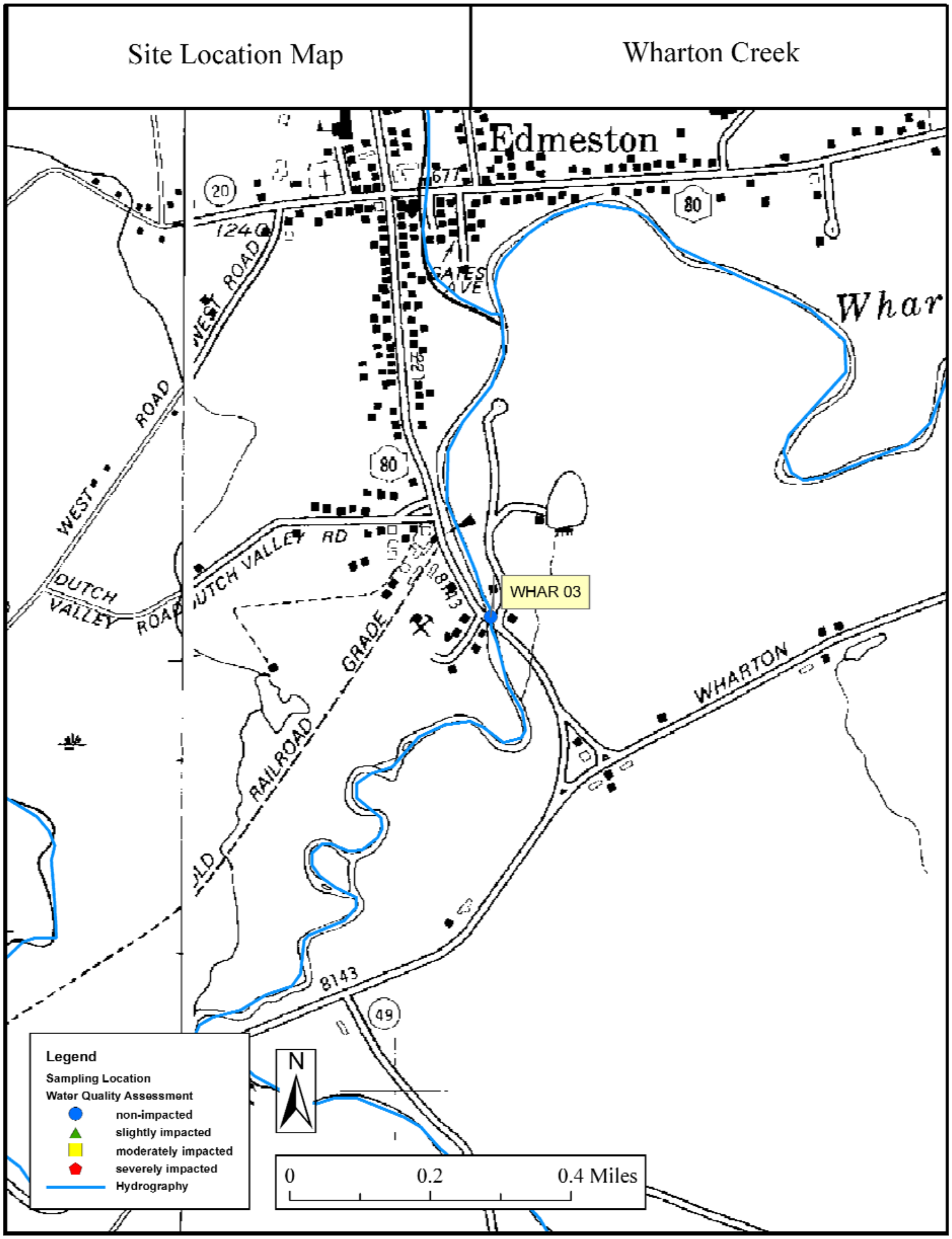


Figure 1e. Station map, Wharton Creek station 04, Otsego County.

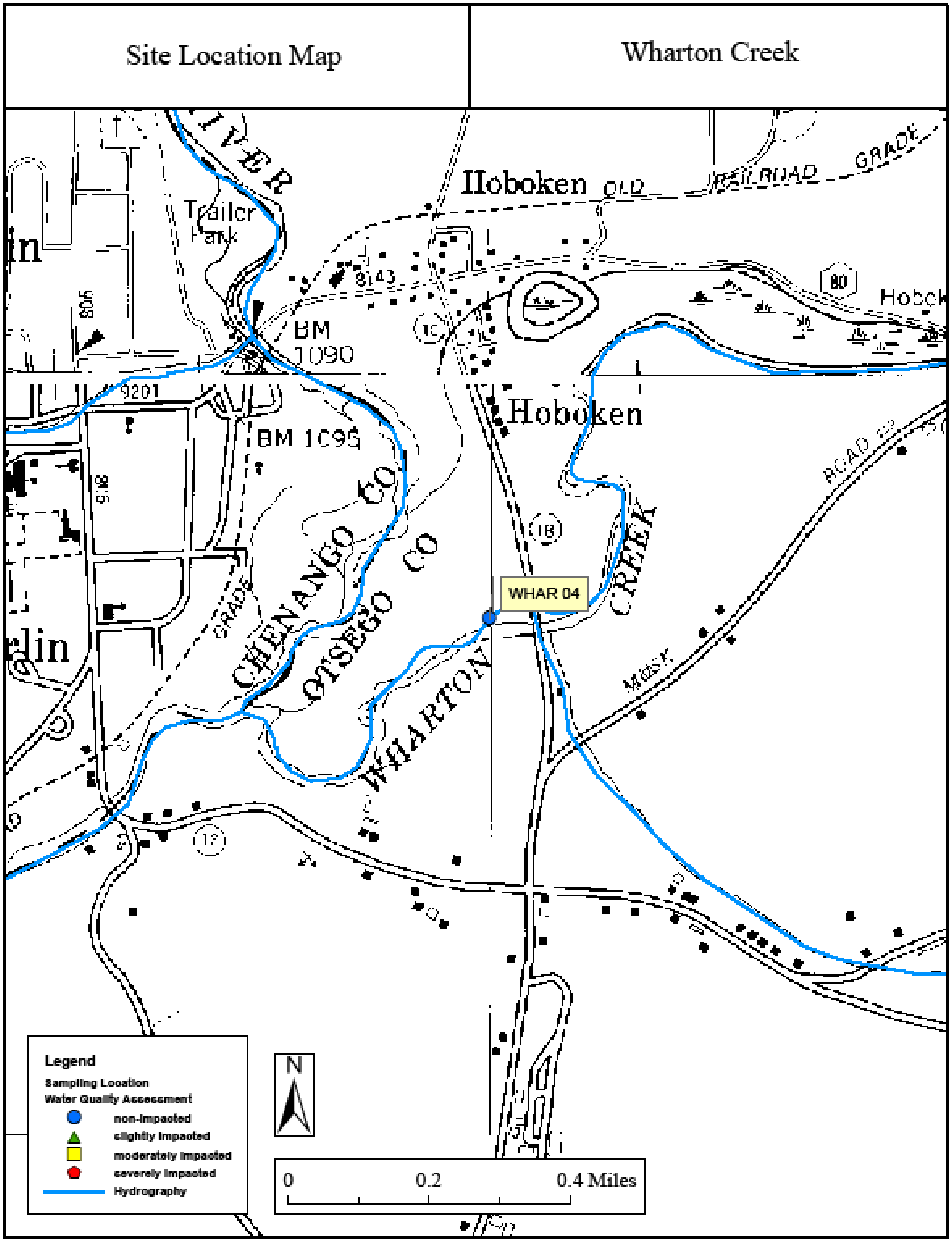


Table 1. Station Locations for the Wharton Creek, Otsego County, NY, 2009.

Station	Site Description	Town/ Village	Latitude	Longitude	County	River Mile	Drainage Area (sq. mi)
00	100 m upstream of Talbot Rd	West Exeter	42.80136	-75.1463	Otsego	23.4	15.2
01	100 m below Route 51	Burlington Flats	42.74282	75.18202	Otsego	18	35.4
02	At former Mill Rd crossing	Robinson Corners	42.71172	-75.1955	Otsego	13.9	48.1
03	150 m below Route80	Edmeston	42.68743	-75.24073	Otsego	9.5	64.8
04	100 m below CR 18 bridge	New Berlin	42.62	-75.3211	Otsego	0.6	90.1

Table 2. Station Photos for Wharton Creek, Otsego County, NY, 2009.

Station 00	
Station 01	
Station 02	

Station 03	
Station 04	

Table 3. Overview of Field Data. Cells marked by (-) signify parameter was not recorded in the field. Embedd. = embeddedness, Cond. = conductivity, DO = dissolved oxygen, Sat. = % saturation of DO

Station	Depth (meters)	Width (meters)	Current (cm/sec)	Canopy (%)	Embedd. (%)	Temp. (oC)	Cond. (µmhos)	DO (mg/l)	Sat. (%)	pH (units)
00	0.1	4	75	35	50	20.5	348	-		8.27
01	0.2	8	90	80	40	18.1	278	-		8.01
02	0.2	7	80	60	35	19	248	-		8.2
03	0.1	5	75	10	35	18.1	238	-		8.26
04	0.1	20	75	20	45	16.9	228	-		8.13

Figure 2. Biological Assessment Profile (BAP) of index values, Wharton Creek, 2009. Values are plotted on a normalized scale of water quality. The water quality scores represent the mean of five values for each site, representing species richness, EPT richness, Hilsenhoff's Biotic Index (HBI), Percent Model Affinity (PMA), and Nutrient Biotic Index (NBI). See Appendices II, III, and IV for a more complete explanation.

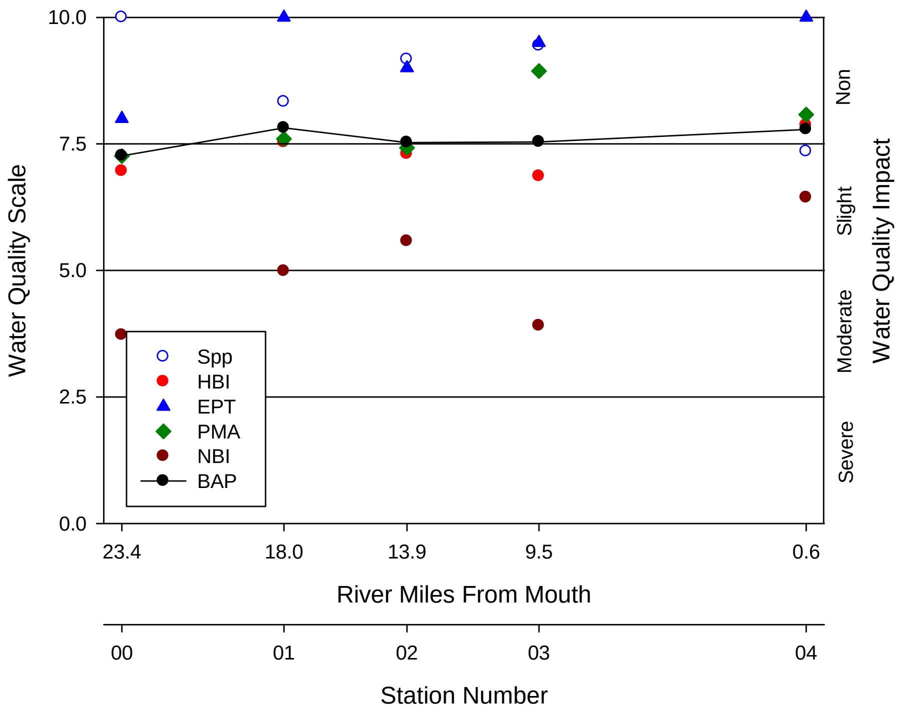


Table 4. Land-use data for Wharton Creek, 2009.

Station	Natural	Developed	Agriculture
00	59.9	2.9	37.3
01	64.5	2.3	33.2
02	63.1	2.5	34.3
03	58.4	2.6	39.0
04	57.4	2.5	40.1

Table 5. Impact Source Determination (ISD), Wharton Creek, 2009. Numbers represent percent similarity to community type models for each impact category. Highest similarities at each station are shaded. Similarities less than 50% are inconclusive. Highest numbers represent probable stressor(s) to the community. See Appendix XI for further explanation.

Station		*Community Type*						
		Natural	Nutrients	Toxic	Organic	Complex	Siltation	Impoundment
WHAR	00	63	50	54	56	41	54	55*
	01	68	58	43	39	38	48	45
	02	61	55	43	38	40	47	40
	03	59	56	53	44	45	48	50
	04	60	57	38	34	32	47	40

Note: Impact Source Determinations (ISD) are intended as supplemental data to the macroinvertebrate community assessments.
*Impoundment results are considered spurious.

Table 6. Habitat Model Affinities (HMA) for Wharton Creek, 2009. HMA is calculated by comparing the habitat data to the habitat model based on the reference condition. Assessment indicates its departure from reference condition. HMA >78 = natural, 69-78 = altered, 59-68 = moderate, <59 = severe

Station	HMA	Assessment
00	77	Altered
01	87	Natural
02	86	Natural
03	73	Altered
04	80	Natural

Figure 3. Substrate composition for Wharton Creek, 2009, as indicated by pebble count. A Threshold for Concern (TFC) of 24% is identified at the point at which substrate composition is typically associated with a degraded macroinvertebrate community. See Appendix XIV for details.

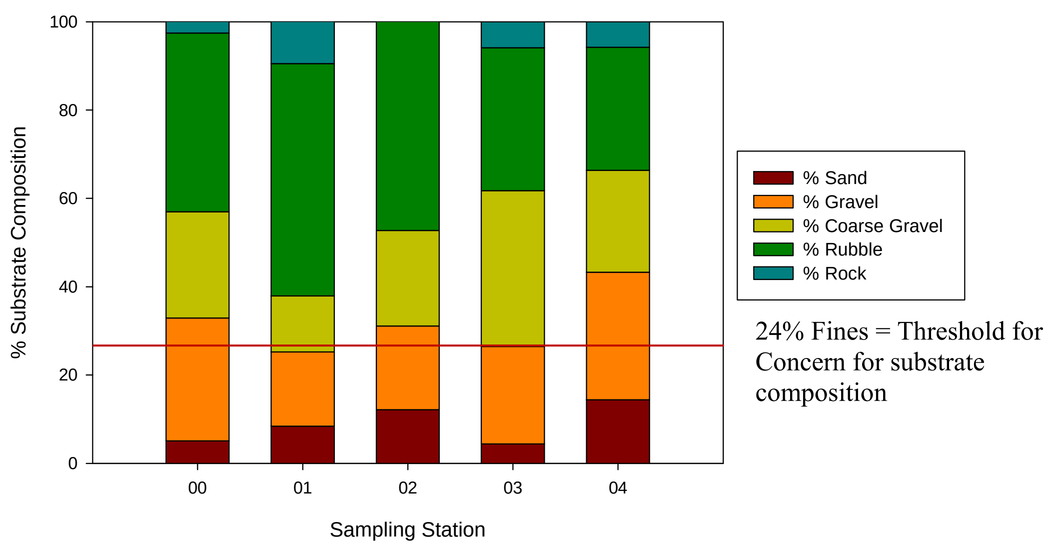


Figure 4. Periphyton and Silt Cover Index Values (0-10 scale) for Wharton Creek, 2009. Index values that are typically associated with degraded macroinvertebrate communities are identified as thresholds for concern (TFC) for silt and macroalgae indices. See Appendix XIV for details.

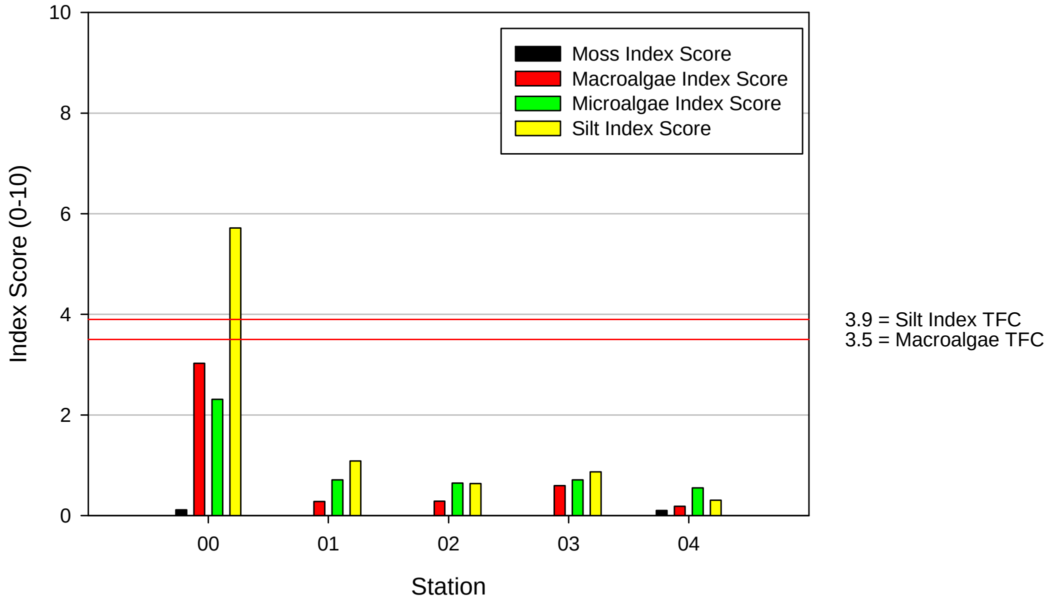


Table 7. Macroinvertebrate taxa collected in the Wharton Creek, 2009.

	Taxa	Station				
		00	01	02	03	04
COLEOPTERA	*Optioservus fastiditus*	2	3	3		3
	Optioservus sp.	10			5	
	Optioservus trivittatus	2	17	23		18
	Oulimnius latiusculus	1				
	Psephenus herricki	1	3	2	6	4
	Stenelmis crenata	6	3	8	7	3
DECAPODA	*Orconectes rusticus*				1	
	Undetermined Cambaridae			2		
DIPTERA	*Cardiocladius obscurus*		1	1	4	
	Cricotopus bicinctus	5			1	
	Cricotopus sp.			1		
	Cricotopus tremulus gr.	1				
	Cricotopus trifascia gr.	1			1	
	Eukiefferiella brehmi gr.	1				
	Eukiefferiella devonica gr.	4		1		
	Micropsectra dives gr.		10	1	2	1
	Micropsectra polita	4	7	3		1
	Micropsectra sp.	1				
	Orthocladius dubitatus	3			4	
	Orthocladius sp.	2			1	
	Pagastia orthogonia	1				
	Parachironomus sp.	1				
	Parametriocnemus sp.	1	1	1	1	
	Polypedilum aviceps	1			1	
	Polypedilum flavum	1	2	1	4	1
	Rheotanytarsus exiguus gr.	2		1	2	
	Rheotanytarsus pellucidus	1				
	Stempellinella sp.	1				
	Stenochironomus sp.	1				
	Tanytarsus curticornis gr.	1	2		1	
	Tanytarsus sp.					2
	Thienemannimyia gr. spp.	2			1	1
	Tvetenia bavarica gr.			1	1	
	Tvetenia vitracies	3	1			
	Antocha sp.	2		1	2	2
	Simulium sp.				5	
	Hexatoma sp.	1		1		
	Undetermined Ceratopogonidae			1		

	Taxa	Station				
		00	01	02	03	04
EPHEMEROPTERA	*Acentrella turbida*			4	5	4
	Baetis flavistriga	14				1
	Baetis intercalaris	5	13	11	5	16
	Baetis tricaudatus	1	3	2	1	2
	Caenis sp.			2		3
	Epeorus vitreus		1			
	Isonychia bicolor		2		2	10
	Leucrocuta sp.		1	1	1	3
	Plauditus sp.			1		
	Rhithrogena sp.					3
	Stenonema sp.		1			
	Undetermined Baetidae		1		15	
	Undetermined Ephemerellidae		1			
MEGALOPTERA	*Nigronia serricornis*			1		1
PLECOPTERA	*Agnetina capitata*			2		
	Neoperla sp.		1	2		1
	Paragnetina media		1	2	2	
TRICHOPTERA	*Cheumatopsyche sp.*	4			5	5
	Chimarra aterrima	1	2		1	5
	Chimarra socia		3			
	Dolophilodes sp.		1		1	
	Glossosoma sp.		1			1
	Hydropsyche alhedra			4		
	Hydropsyche bronta	4	2	2	3	3
	Hydropsyche morosa	1	4	11	6	2
	Hydropsyche slossonae	3	7		1	
	Hydropsyche sparna	2	4	1	2	3
	Hydroptila sp.	3				
	Rhyacophila mainensis	1				
VENEROIDEA	*Sphaerium sp.*			1		
	Total	102	99	99	100	99

Table 8. Laboratory Data Summary, Wharton Creek, 2009.

LABORATORY DATA SUMMARY					
STREAM NAME: Wharton Creek		**DRAINAGE: Susquehanna**			
DATE SAMPLED: 7/22/2009		**COUNTY: Otsego**			
SAMPLING METHOD: Kick					
STATION	00	01	02	03	04
LOCATION	WHAR	WHAR	WHAR	WHAR	WHAR
DOMINANT SPECIES/%CONTRIBUTION/TOLERANCE/COMMON NAME					
1.	Baetis flavistriga 14% intolerant mayfly	Optioservus trivittatus 17% intolerant beetle	Optioservus trivittatus 23% intolerant beetle	Undetermined Baetidae 15% facultative mayfly	Optioservus trivittatus 18% intolerant beetle
2. **Intolerant = not tolerant of poor water quality**	Optioservus sp. 10% intolerant beetle	Baetis intercalaris 13% facultative mayfly	Baetis intercalaris 11% facultative mayfly	Stenelmis crenata 7% facultative beetle	Baetis intercalaris 16% facultative mayfly
3. **Facultative = occuring over a wide range of water quality**	Stenelmis crenata 6% facultative beetle	Micropsectra dives gr. 10% intolerant midge	Hydropsyche morosa 11% facultative caddisfly	Hydropsyche morosa 6% facultative caddisfly	Isonychia bicolor 10% intolerant mayfly
4. **Tolerant = tolerant of poor water quality**	Baetis intercalaris 5% facultative mayfly	Micropsectra polita 7% facultative midge	Stenelmis crenata 8% facultative beetle	Psephenus herricki 6% intolerant beetle	Chimarra aterrima 5% intolerant caddisfly
5.	Cricotopus bicinctus 5% tolerant midge	Hydropsyche sparna 4% facultative caddisfly	Acentrella turbida 4% intolerant mayfly	Baetis intercalaris 5% facultative mayfly	Cheumatopsyche sp. 5% facultative caddisfly
% CONTRIBUTION OF MAJOR GROUPS (NUMBER OF TAXA IN PARENTHESIS)					
Chironomidae (midges)	38 (21.0)	24 (7.0)	11 (9.0)	24 (13.0)	6 (5.0)
Trichoptera (caddisflies)	19 (8.0)	14 (6.0)	18 (4.0)	19 (7.0)	19 (6.0)
Ephemeroptera (mayflies)	20 (3.0)	23 (8.0)	21 (6.0)	29 (6.0)	42 (8.0)
Plecoptera (stoneflies)	0 (0.0)	2 (2.0)	6 (3.0)	2 (1.0)	1 (1.0)
Coleoptera (beetles)	22 (6.0)	26 (4.0)	36 (4.0)	18 (3.0)	28 (4.0)
Oligochaeta (worms)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Mollusca (clams and snails)	0 (0.0)	0 (0.0)	1 (1.0)	0 (0.0)	0 (0.0)
Crustacea (crayfish, scuds, sowbugs)	0 (0.0)	0 (0.0)	2 (1.0)	1 (1.0)	0 (0.0)
Other insects (odonates, diptera)	3 (2.0)	0 (0.0)	4 (4.0)	7 (2.0)	3 (2.0)
Other (Nemertea, Platyhelminthes)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
SPECIES RICHNESS	40	27	32	33	26
BIOTIC INDEX	4.93	4.48	4.66	5.01	4.13
EPT RICHNESS	11	16	13	14	15
PERCENT MODEL AFFINITY	63	65	64	79	70
FIELD ASSESSMENT	Poor	Good	Good	Good	Good
OVERALL ASSESSMENT	non-impacted	non-impacted	non-impacted	non-impacted	non-impacted

Table 9. Field Data Summary, Wharton Creek, 2009.

FIELD DATA SUMMARY					
STREAM NAME: Wharton Creek	**DATE SAMPLED: 7/22/09**				
REACH: West Exeter to New Berlin					
FIELD PERSONNEL INVOLVED: Smith;Duffy					
LOCATION	WHAR				
STATION	00	01	02	03	04
PHYSICAL CHARACTERISTICS					
Width (meters)	4	8	7	5	20
Depth (meters)	0.1	0.2	0.2	0.1	0.1
Current speed (cm per sec.)	75	90	80	75	75
Substrate (%)					
Rock (>25.4 cm, or bedrock)	3	15	2	5	5
Rubble (6.35 - 25.4 cm)	45	40	40	50	45
Gravel (0.2 - 6.35 cm)	45	35	55	40	45
Sand (0.06 - 2.0 mm)	7	10	3	5	5
Silt (0.004 - 0.06 mm)					
Embeddedness (%)	50	40	35	35	45
CHEMICAL MEASUREMENTS					
Temperature (° C)	20.5	18.1	19	18.1	16.9
Specific Conductance (umhos)	348	278	248	238	228
Dissolved Oxygen (mg/l)					
pH	8.27	8.01	8.2	8.26	8.13
BIOLOGICAL ATTRIBUTES					
Canopy (%)	35	80	60	10	20
Aquatic Vegetation					
algae - suspended					
algae - attached, filamentous	Y	Y	Y	Y	
algae - diatoms	100	100	100	100	100
macrophytes or moss					
Occurrence of Macroinvertebrates					
Ephemeroptera (mayflies)	Y	Y	Y	Y	Y
Plecoptera (stoneflies)	Y	Y	Y	Y	Y
Trichoptera (caddisflies)	Y	Y	Y	Y	Y
Coleoptera (beetles)	Y	Y	Y		Y
Megaloptera (dobsonflies, alderflies)					Y
Odonata (dragonflies, damselflies)					
Chironomidae (midges)	Y	Y	Y	Y	Y
Simuliidae (black flies)					
Decapoda (crayfish)	Y	Y	Y	Y	Y
Gammaridae (scuds)					
Mollusca (snails, clams)					
Oligochaeta (worms)					
Other					
FIELD FAUNAL ASSESSMENT	Poor	Good	Good	Good	Good

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.

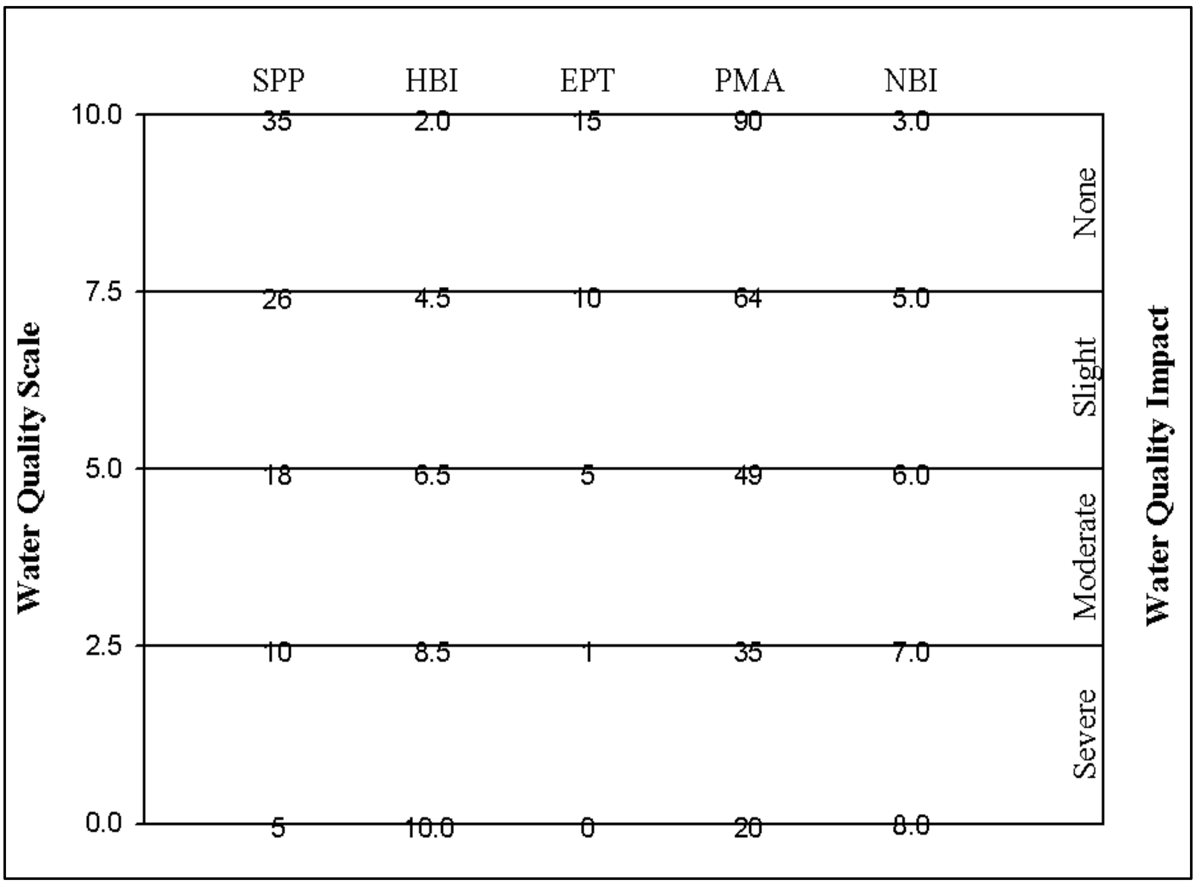
2. *Slightly impacted*: Indices reflect good water quality. The macroinvertebrate community is slightly but significantly altered from the pristine state. Species richness is usually 19-26. Mayflies and stoneflies may be restricted, with EPT richness values of 6-10. The biotic index value is 4.51-6.50. 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 (Smith, et al., 2009), and as shown in the figure below. The formula to convert raw NBI values to a common 0-10 scale are show in Appendix V.



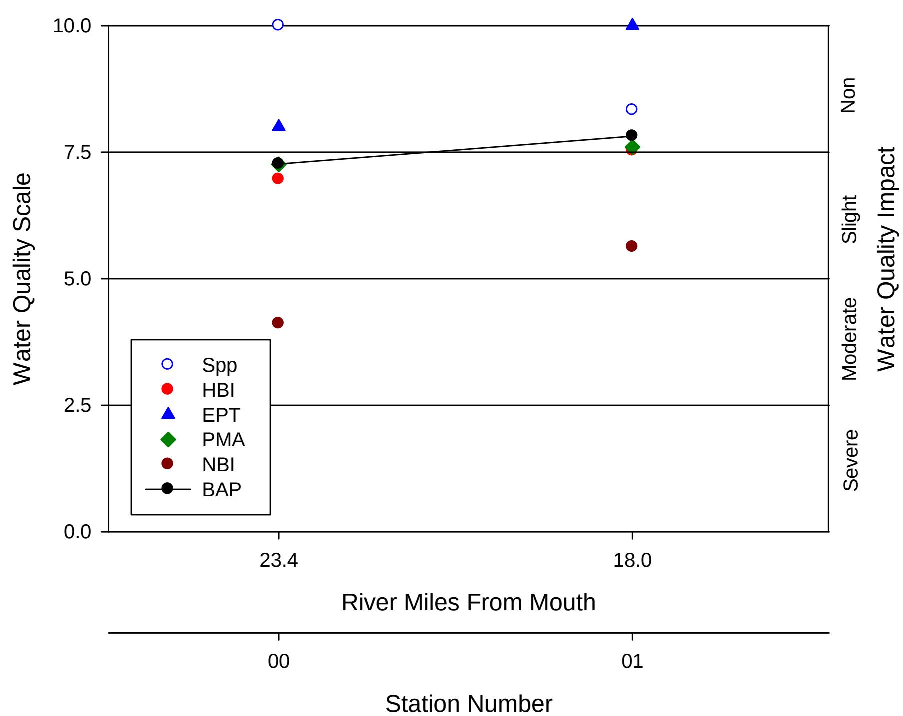
Appendix IV-B. Biological Assessment Profile: Plotting Values

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 00		Station 01	
	metric value	10-scale value	metric value	10-scale value
Species richness	40	10	29	8.33
Hilsenhoff Biotic	4.93	6.96	4.47	7.53
EPT richness	11	8.00	18	10
Percent Model	63	7.26	65	7.6
Nutrient Biotic Index	6.35	4.11	5.75	5.62
Average		7.26 (slight)		7.81 (non-)

Sample BAP plot:



Appendix V. 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 indicates 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).

$$\text{NBI Score}_{(\text{TP or NO3}^-)} = \sum (a \text{ x } b) / c$$

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	Eutrophic
NBI-P	< 5.0	> 5.0 - 6.0	> 6.0 - 7.0	>7
NBI-N	< 4.5	> 4.5 - 6.0	> 6.0 - 7.0	>7
Water Quality Assessment	Non	Slight	Moderate	Severe

Inclusion of the NBI-P into the Biological Assessment Profile (BAP)

The raw NBI value for phosphorus is used when converting to a 10 scale value for inclusion in the BAP. This maintains the sensitivity of this index to both nutrients when applied to water quality assessment.

Conversion of NBI values to a 10 scale value:

NBI <3.01 replace with 10
NBI <5.01 replace with 10-(NBI-2.5)
NBI <6.01 replace with 7.5-((NBI-5.0)*2.5)
NBI <7.01 replace with 5-((NBI-6.0)*2.5)
NBI >7.00 replace with 2.5-((NBI-7.0)*2.5)
NBI >8.00 replace with 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
Acentrella sp.	5	5
Acerpenna pygmaea	0	4
Acroneuria abnormis	0	0
Acroneuria sp.	0	0
Agnetina capitata	3	6
Anthopotamus sp.	4	5
Antocha sp.	8	6
Apatania sp.	3	4
Atherix sp.	8	5
Baetis brunneicolor	1	5
Baetis flavistriga	7	7
Baetis intercalaris	6	5
Baetis sp.	6	3
Baetis tricaudatus	8	9
Brachycentrus appalachia	3	4
Caecidotea racovitzai	6	2
Caecidotea sp.	7	9
Caenis sp.	3	3
Cardiocladius obscurus	8	6
Cheumatopsyche sp.	6	6
Chimarra aterrima?	2	3
Chimarra obscura	6	4
Chimarra socia	4	1
Chimarra sp.	2	0
Chironomus sp.	9	6
Cladotanytarsus sp.	6	4
Corydalus cornutus	2	2
Cricotopus bicinctus	7	6
Cricotopus tremulus gr.	8	9
Cricotopus trifascia gr.	9	9
Cricotopus vierriensis	6	5
Cryptochironomus fulvus gr.	5	6
Diamesa sp.	10	10
Dicranota sp.	5	10
Dicrotendipes neomodestus	10	4
Dolophilodes sp.	4	3
Drunella cornutella	4	4
Ectopria nervosa	10	9
Epeorus (Iron) sp.	0	0
Ephemerella sp.	4	4
Ephemerella subvaria	4	1
Ephoron leukon?	1	1
Eukiefferiella devonica gr.	9	9
Ferrissia sp.	9	5
Gammarus sp.	8	9
Glossosoma sp.	6	0
Goniobasis livescens	10	10
Helicopsyche borealis	1	2
Hemerodromia sp.	5	6
Heptagenia sp.	0	0
Hexatoma sp.	0	1
Hydropsyche betteni	7	9
Hydropsyche bronta	7	6
Hydropsyche morosa	5	1
Hydropsyche scalaris	3	3
Hydropsyche slossonae	6	10
Hydropsyche sp.	5	4
Hydropsyche sparna	6	7
Hydroptila consimilis	9	10
Hydroptila sp.	6	6
Hydroptila spatulata	9	8
Isonychia bicolor	5	2
Lepidostoma sp.	2	0
Leucotrichia sp.	6	2
Leucrocuta sp.	1	3
Macrostemum carolina	7	2
Macrostemum sp.	4	2
Micrasema sp. 1	1	0
Micropsectra dives gr.	6	9
Micropsectra polita	0	7
Micropsectra sp.	3	1
Microtendipes pedellus gr.	7	7
Microtendipes rydalensis gr.	2	1
Nais variabilis	5	0
Neoperla sp.	5	5
Neureclipsis sp.	3	1
Nigronia serricornis	10	8
Nixe (Nixe) sp.	1	5
Ophiogomphus sp.	1	3
Optioservus fastiditus	6	7
Optioservus ovalis	9	4
Optioservus sp.	7	8
Optioservus trivittatus	7	6
Orthocladius nr. dentifer	3	7
Pagastia orthogonia	4	8
Paragnetina immarginata	1	2
Paragnetina media	6	3
Paragnetina sp.	1	6
Paraleptophlebia mollis	2	1
Paraleptophlebia sp.	2	3
Parametriocnemus lundbecki	8	10
Paratanytarsus confusus	5	8
Pentaneura sp.	0	1
Petrophila sp.	5	3
Phaenopsectra dyari?	4	5
Physella sp.	8	7
Pisidium sp.	8	10
Plauditus sp.	2	6
Polycentropus sp.	4	2
Polypedilum aviceps	5	7
Polypedilum flavum	9	7
Polypedilum illinoense	10	7
Polypedilum laetum	7	6
Polypedilum scalaenum gr.	10	6
Potthastia gaedii gr.	9	10
Promoresia elegans	10	10
Prostoma graecense	2	7
Psephenus herricki	10	9
Psephenus sp.	3	4

NBI tolerance values (cont'd)

TAXON	TP T-Value	NO3 T-Value
Psychomyia flavida	1	0
Rheocricotopus robacki	4	4
Rheotanytarsus exiguus gr.	6	5
Rheotanytarsus pellucidus	3	2
Rhithrogena sp.	0	1
Rhyacophila fuscula	2	5
Rhyacophila sp.	0	1
Serratella deficiens	5	2
Serratella serrata	1	0
Serratella serratoides	0	1
Serratella sp.	1	1
Sialis sp.	5	6
Simulium jenningsi	6	2
Simulium sp.	7	6
Simulium tuberosum	1	0
Simulium vittatum	7	10
Sphaerium sp.	9	4
Stenacron interpunctatum	7	7
Stenelmis concinna	5	0
Stenelmis crenata	7	7
Stenelmis sp.	7	7
Stenochironomus sp.	4	3
Stenonema mediopunctatum	3	3
Stenonema modestum	2	5
Stenonema sp.	5	5
Stenonema terminatum	2	3
Stenonema vicarium	6	7
Stylaria lacustris	5	2
Sublettea coffmani	3	5

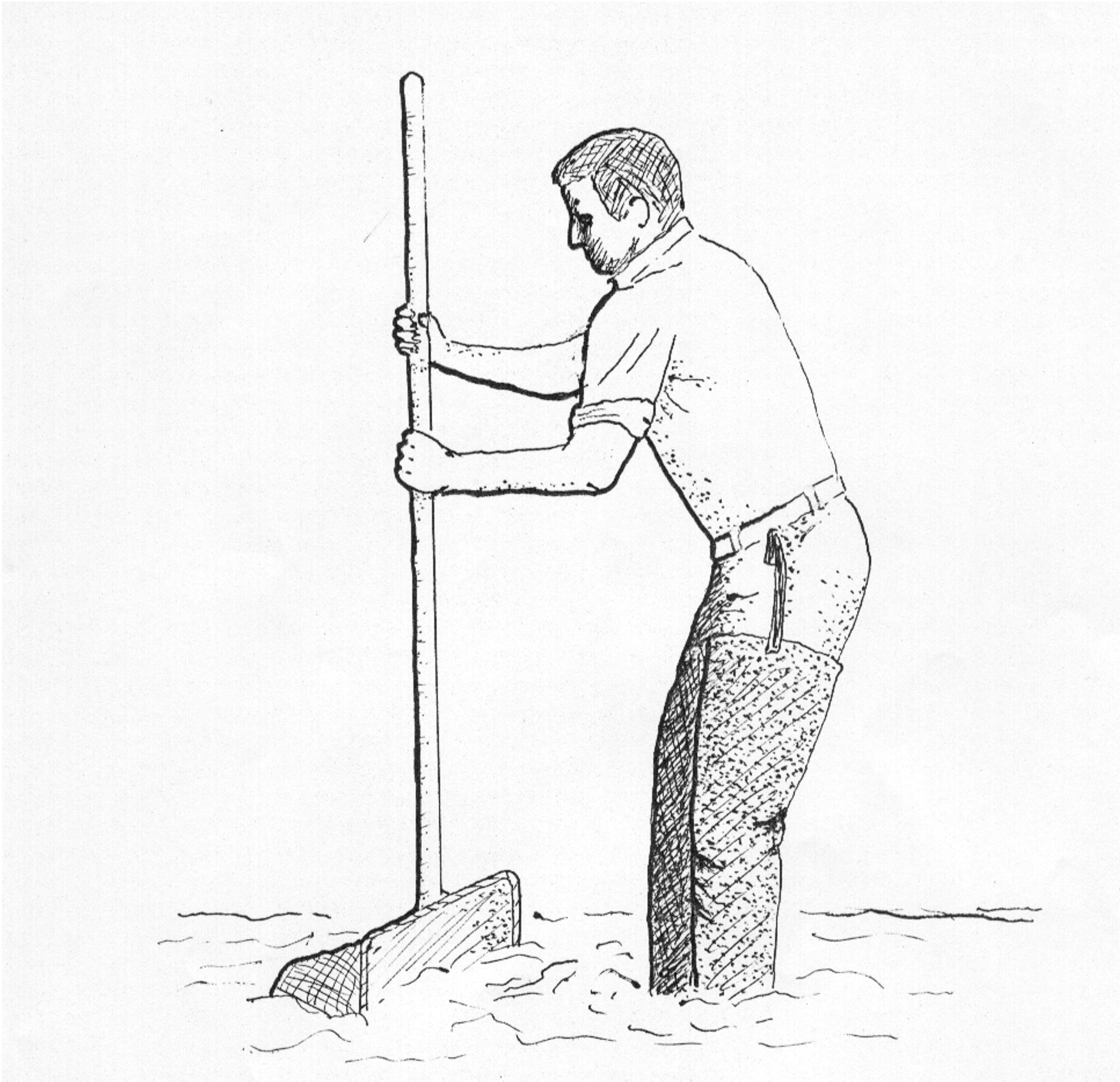
TAXON	TP T-Value	NO3 T-Value
Synorthocladius nr. semivirens	6	9
Tanytarsus glabrescens gr.	5	6
Tanytarsus guerlus gr.	5	5
Thienemannimyia gr. spp.	8	8
Tipula sp.	10	10
Tricorythodes sp.	4	9
Tvetenia bavarica gr.	9	10
Tvetenia vitracies	7	6
Undet. Tubificidae w/ cap. setae	10	8
Undet. Tubificidae w/o cap. setae	7	7
Undetermined Cambaridae	6	5
Undet. Ceratopogonidae	8	9
Undet. Enchytraeidae	7	8
Undet. Ephemerellidae	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
Zavrelia sp.	9	9

Appendix VI. Water Quality Assessment Criteria

Non-Navigable Flowing Waters

	Species Richness	Hilsenhoff Biotic Index	EPT Value	Percent Model Affinity*	Nutrient Biotic Index
Non-Impacted	>26	0-4.50	>10	>64	0-5.00
Slightly Impacted	19-26	4.51-6.50	6-10	50-64	5.00-6.00
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	>7.00

Appendix VII. The Traveling Kick Sample



←current

Rocks and sediment in a riffle are dislodged by foot upstream of a net. Dislodged organisms are 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 VIII-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 VIII-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 more common, though 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

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 IX. 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 X. 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 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
Parametriocnemus	-	-	-	-	-	-	-	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	-
Parametriocnemus	-	-	-	-	-	-	-	-	-	-
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	-	-
Parametriocnemus	-	-	-	-	-	-	-	-	-	-	-	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	-
Promoresia	-	-	-	-	-	-	-	-	-	-
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	-	-	-	-	-	-	-
Parametriocnemus	-	-	-	-	-	-	-	-	-	-
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					IMPOUNDMENT									
	A	B	C	D	E	A	B	C	D	E	F	G	H	I	J
PLATYHELMINTHES	-	-	-	-	-	-	10	-	10	-	5	-	50	10	-
OLIGOCHAETA	5	-	20	10	5	5	-	40	5	10	5	10	5	5	-
HIRUDINEA	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
GASTROPODA	-	-	-	-	-	-	-	10	-	5	5	-	-	-	-
SPHAERIIDAE	-	-	-	5	-	-	-	-	-	-	-	-	5	25	-
ASELLIDAE	-	-	-	-	-	-	5	5	-	10	5	5	5	-	-
GAMMARIDAE	-	-	-	10	-	-	-	10	-	10	50	-	5	10	-
Isonychia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BAETIDAE	-	10	20	5	-	-	5	-	5	-	-	5	-	-	5
HEPTAGENIIDAE	5	10	-	20	5	5	5	-	5	5	5	5	-	5	5
LEPTOPHLEBIIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EPHEMERELLIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Caenis/Tricorythodes	5	20	10	5	15	-	-	-	-	-	-	-	-	-	-
PLECOPTERA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Psephenus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
Optioservus	5	10	-	-	-	-	-	-	-	-	-	-	-	5	-
Promoresia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenelmis	5	10	10	5	20	5	5	10	10	-	5	35	-	5	10
PHILOPOTAMIDAE	-	-	-	-	-	5	-	-	5	-	-	-	-	-	30
HYDROPSYCHIDAE	25	10	-	20	30	50	15	10	10	10	10	20	5	15	20
HELICOPSYCHIDAE/ BRACHYCENTRIDAE/ RHYACOPHILIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-
SIMULIIDAE	5	10	-	-	5	5	-	5	-	35	10	5	-	-	15
EMPIDIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CHIRONOMIDAE															
Tanypodinae	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-
Cardiocladius	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cricotopus/ Orthocladius	25	-	10	5	5	5	25	5	-	10	-	5	10	-	-
Eukiefferiella/ Tvetenia	-	-	10	-	5	5	15	-	-	-	-	-	-	-	-
Parametriocnemus	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-
Chironomus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polypedilum aviceps	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polypedilum (all others)	10	10	10	5	5	5	-	-	20	-	-	5	5	5	5
Tanytarsini	10	10	10	10	5	5	10	5	30	-	-	5	10	10	5
TOTAL	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Appendix XII. Pebble Count and Periphyton/Silt Cover Index

Pebble Count

This method is used to describe the substrate particle size classes within the "riffle" habitat of high gradient stream types that are targeted by the NYSDEC for macroinvertebrate community assessments. The method is based on the more rigorous technique developed by Wolmen (1954) to describe coarse river bed materials, and modifications of this technique developed by the Forest Service to describe channel bed materials within stream reaches (Bevenger and King, 1995).

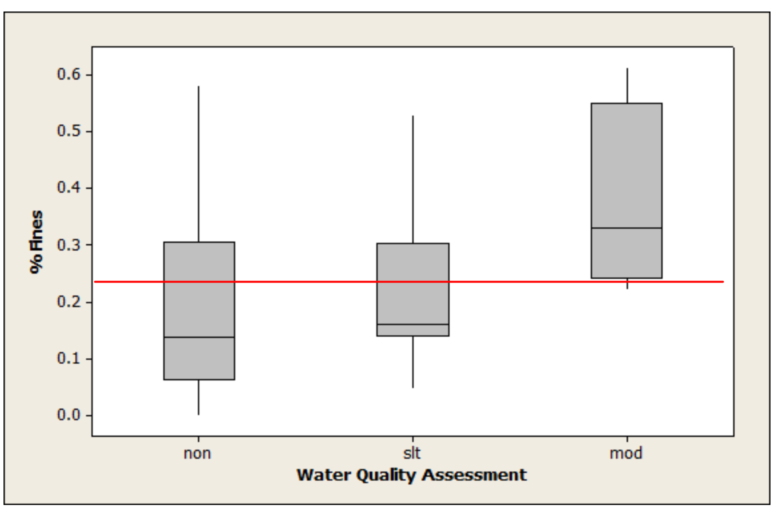
1. A minimum of 100 particles are to be recorded on a tally sheet.
2. Diagonal transects across the stream are paced off until a minimum 100 count is reached. Transects begin at the lower end of the wetted portion of the stream bed within the macroinvertebrate sampling section or riffle. A pebble is selected as described in step 3; every two paces in streams > 20m across, or every pace in streams < 20m across.
3. With eyes closed, a pebble is randomly selected from the bottom. The pebble is then categorized by its particle size. Size categories were initially based on Wentworth's size classes, which were then lumped into larger biologically based size classes used by the NYSDEC to describe substrate composition. The NYSDEC size categories are (in mm):

Silt	Sand	Gravel	Cgravel	Rubble	Rock	Bedrock
	<2	2-16	16-64	64-256	>256	

4. Size categories are determined by using a gravelometer, essentially a metal plate with squares of the above size classes cut out. The particle must be placed thru the smallest cut out so that the intermediate axis is perpendicular to the sides (not diagonally across) of the cut out. The smallest size class which the pebble falls through is called out to a recorder, who keeps track of the tally until the 100-particle minimum is reached, at which time the transect is completed.

Linking Substrate to Water Quality Assessment

Substrate composition with percent fines (<16mm) at a level of 24% has been identified as a threshold for concern in New York State. This is the average of the medians between slight and moderate biological impact categories. This value should be used as an indicator that substrate composition (% fines) may be a stressor to the macroinvertebrate community.



Appendix XII. cont'd.

Moss, macro-algae, micro-algae, and silt cover Analysis
Characterize the amount of moss, macro-algae, micro-algae, and silt cover separately for each substrate larger than 16 mm in diameter. Record moss and macro-algae cover using a scale from 0-3 with separate estimates for each. Thickness is estimated for microalgae and silt. Note that if substrate is too large to pick up, algal growth should still be characterized. All four categories are described below.

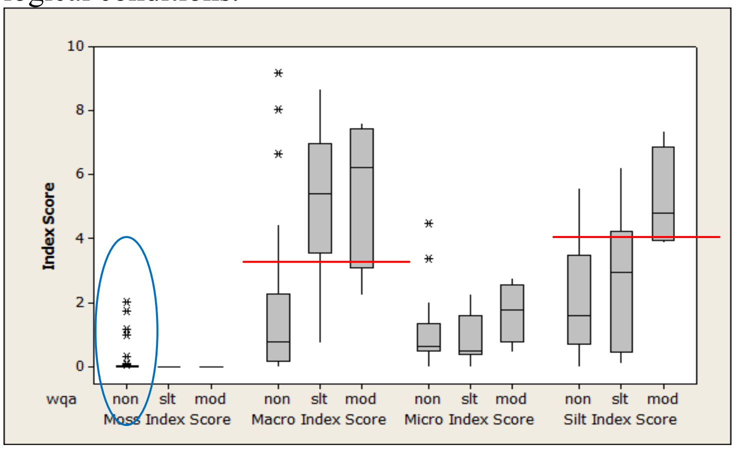
Cover Category	Moss/ Macroalgae	Microalgae	Silt
0	none present	rough , no growth	none present
1	<5%	slimy, not visible	a line can be drawn by scratching
2	5-25%	visible biofilm, a line can be drawn by scratching	0.5-5 mm
3	>25%	0.5 - 1 mm	5-20 mm
4	NA	1-5 mm	>20 mm
5	NA	5-20 mm	NA

Weighted Periphyton and Silt Index Calculation (0-10)
Moss and Macro Algae percent cover
= ((%Cat. 0*0) + (%Cat. 1*2) + (%Cat. 2*6) + (%Cat. 3*10))/100

Micro Algae Thickness
= ((%Cat. 0*0)+(%Cat. 1*5)+(%Cat. 2*2)+(%Cat. 3*4)+(%Cat. 4*7)+(%Cat. 5*10))/100

Silt Cover Index
= (%Cat0*0)+(%Cat1*3)+(%Cat2*6)+(%Cat3*8)+(%Cat4*10)

Linking Periphyton and Silt Cover to Water Quality Assessment
Statistically significant different index score values between water quality assessment categories were found for both macroalgae and silt. An average of the medians was used to determine thresholds for concern for macroalgae (3.5) and silt (3.9). Moss index scores were not found to be significantly different, however, as indicated by the plot, the presence of moss is an indicator of non-impacted biological conditions.



Bevenger, G. S. and R. M. King (1995). A pebble count procedure for assessing watershed cumulative effects. Research paper RM-RP-319. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado. 17 p. (USA).

Wolman, M. G. (1954). A method of sampling coarse river-bed material. *Transactions of the American Geophysical Union*, 35(6): 951-956.

Appendix XIII. Habitat Model Affinity – High Gradient Streams

The utility and applicability of EPA's Rapid Habitat Assessment protocol (Barbour et al., 1999) to New York State's Stream Biomonitoring Unit was established by Tran et al. (2010). Protocols for the collection of habitat data is described in detail in the *Standard Operating Procedure: Biological Monitoring of Surface Waters in New York* State (Smith et al., 2009).

The Habitat Model Affinity (HMA) for high gradient streams is calculated based on comparison to a reference condition habitat model. Habitat is one of the many influences to the biological communities and the HMA provides a quantifiable tool for the assessment of in-stream and riparian habitat within the sampling reach. The calculated HMA scores fall into broader categorical assessments of habitat condition: natural, altered, moderate, and severe. Because of natural differences in habitat, low gradient streams are assessed using a different set of criteria. A low gradient model is under development.

Procedure for Calculating HMA

1. Determine the total score (out of 20) for each of 10 habitat parameters.
2. For each parameter, compare the stream score to the model, taking the lesser of the two values, and add up these values
3. Habitat Model Affinity = (Lesser Value Total/Model Total)*100

An example calculation of HMA and assessment category thresholds are provided below

Habitat Parameter	Model	Stream	Lesser Value
1. Epifaunal Substrate/Available Cover	17	13	13
2. Embeddedness	17	19	17
3. Velocity/Depth Regime	19	16	16
4. Sediment Deposition	18	17	17
5. Channel Flow Status	19	15	15
6. Channel Alteration	18	18	18
7. Frequency of Riffles	19	19	19
8. Bank Stability (L+R)	18	13	13
9. Vegetative Protection (L+R)	18	14	14
10. Riparian Vegetative Width (L+R)	18	10	10
Model Total	**181**	**Lesser Value Total**	**152**

HMA Category Thresholds	Habitat Assessment
80 - 100	Natural
70 - 79	Altered
60 - 69	Moderate
< 60	Severe

Example Calculation of HMA = (152/181)*100
HMA = 84
Categorical Assessment = Natural

References

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