New York State
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Division of Water

Upper Esopus Creek

Biological Assessment

2008 Survey

New York State
Department of Environmental Conservation

BIOLOGICAL STREAM ASSESSMENT

Upper Esopus Creek
Ulster County, New York
Lower Hudson River Basin

Survey date: August 13, 2008
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Stream: Upper Esopus Creek

River Basin: Lower Hudson

Reach: Oliverea to Boiceville, NY

Background

The Stream Biomonitoring Unit (SBU) sampled the Upper Esopus Creek, Ulster County, New York, on August 13, 2008. Sampling was conducted to investigate the effects of the Shandaken Portal, a deepwater release from the Schoharie Reservoir, and to assess possible impacts of aging septic system infrastructure throughout the Village of Phoenicia.

To characterize water quality, macroinvertebrate, algae and water chemistry samples were collected at eight locations from Oliverea to Boiceville. Six of these sites were historical monitoring locations and two were new, selected to bracket the Village of Phoenicia. Table 1 provides a listing of sampling sites. Macroinvertebrates and diatoms were collected using the traveling kick-net and multi-habitat methods, respectively. 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. Diatoms were preserved in 10 percent formalin for laboratory inspection of 300-cell subsamples. Water chemistries were collected using a depth-integrated wading sampler. Sampling 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 for macroinvertebrates and Appendix XV for diatoms.

Macroinvertebrate community parameters used in the determination of water quality included: species richness, biotic index, EPT richness, and percent model affinity (see Appendices II and III). The amount of expected variability of results is stated in Smith and Bode (2004). Additionally, the following three community metrics for diatoms are used in making a diatom assessment that is complementary to the macroinvertebrate assessment: pollution tolerance index, trophic index, and diatom model affinity (see Appendix XV)**.**

Results and Conclusions

1. The headwater reach of Upper Esopus Creek shows signs of increasing nutrient enrichment from nitrogen compared to historical biological assessments. This is likely due to forest defoliation caused by forest tent caterpillars and resulting nitrification.

2. Dilution from the numerous tributaries and the Shandaken Portal appears to play a significant role in diminishing nutrient effects downstream of the headwater reach.

3. Silt cover analysis shows a spike in siltation below the Shandaken Portal, Stony Clove Creek, and Village of Phoenicia; the source of the increased siltation could not be determined by this study.

4. Further study using replicated biological sampling for both macroinvertebrates and diatoms is necessary to fully define any impacts from the Shandaken Portal or the Village of Phoenicia, and to separate them from the influences of the many tributaries in the Upper Esopus Creek watershed.

Discussion

The Esopus Creek is a tributary of the lower Hudson River, located in the Catskill Mountains. The Upper Esopus Creek is the reach between the river's source at Winisook Lake in the Town of Shandaken and the Ashokan Reservoir, below Boiceville, in the Town of Olive. The drainage area of the Upper Esopus Creek at the Ashokan reservoir is approximately 192 square miles.

On August 13, 2008, the Stream Biomonitoring Unit (SBU) sampled eight sites on the Upper Esopus Creek from Oliverea to Boiceville (Figures 1-1h, Table 1). Historical stations (01, 02, 03, 04, 05, and 06) were sampled to document possible long-term changes in water quality and impacts from the Shandaken Portal. Two new stations (04a, 04b) were sampled to bracket the Village of Phoenicia. The Village of Phoenicia is unsewered and relies on septic systems for approximately 270 homes and commercial buildings (Smith et al., 2009). If these systems are failing, they are a potential source of nutrient enrichment to Upper Esopus Creek.

Previous macroinvertebrate community assessments of the Upper Esopus Creek were performed in 1995, 1996, 2000 and 2007 (Bode et al. 1995, 1996, 2000, and Smith et al. 2009; Figure 2A). In 1995, macroinvertebrate samples indicated non-impacted conditions at allsites except Station 01, which was slightly impacted. The 1996 survey assessed stations 02, 04 and 06, only and found them all non-impacted. In 2000, Stations 01 and 05 were found slightly impacted, while Stations 02, 03, 04 and 06 were non-impacted. Slightly impacted conditions in 1995 and 2000 at Station-01 were attributed to the naturally low productivity occurring in headwater stream reaches. Biological assessment of the macroinvertebrate communities in 2007 indicated non-impacted conditions at each station except Station 03 and again at Station 05. Shifts in water quality assessments of the Upper Esopus Creek are generally not indicative of trends in improving or declining water quality. Most shifts are relatively minor and within quantified variability inherent in biological sampling (Smith et al., 2004).

The current macroinvertebrate assessment of the Upper Esopus Creek indicates non-impacted conditions for every site sampled and shows little variability in water quality (Figure 2B). Impact Source Determination (ISD) indicates natural conditions at all sites except for Station 04 in Phoenicia, where results are inconclusive (Table 3).

Nutrient Biotic Indices (NBI) for phosphorus (NBI-P) and nitrogen (NBI-N) (Smith et al., 2007) (Appendix XV) both indicate a general decrease in the effects of eutrophication from upstream to downstream (Figures 3 and 4). This is a change from past surveys, and is inconsistent with the natural ecology of flowing waters (Vannote et al., 1980). The NBI-P shows all sites upstream of Station 05 to be mesotrophic except Station 03, which is just over the eutrophic threshold. Stations 05 and 06 are oligotrophic.

The elevated level of eutrophication is unusual for sites such as Station 01, located in headwater reaches. The 1995 station 01 was assessed as slightly impacted but this was attributed to naturally low productivity and limited upstream macroinvertebrate community recruitment (Bode, 1995). NBI values at Station 01 indicate a nutrient increase since 1995, suggesting a source of eutrophication at this uppermost site (Figures 3 and 4). Nitrification resulting from forest defoliation caused primarily by the native forest tent caterpillar is the likely source (Greg Lawrence, USGS, pers. comm.; Mike Mchale, USGS, pers. comm.; Lewis and Likens, 2007). Water chemistry values in nearby Hollow Tree Brook, a tributary to Stony Clove Creek, showed a spike in nitrate values in 2007, coinciding with large areas of defoliation. Similar levels of defoliation were seen in the Big Indian area along the Upper Esopus (Mike Mchale, USGS, pers. comm.). Further, the macroinvertebrate community appears particularly responsive to nitrate levels in Upper Esopus Creek (Figure 5). In the current survey, the apparent improvement in the BAP score at Station 01 compared to previous assessments is likely due to nitrification altering the natural condition of the site and releasing it from nutrient limitation. Under such circumstances, metrics such as species and EPT richness increase (Figure 6), raising the BAP score and indicating an improvement in water qualityover time.

While past assessments have attributed declines in water quality at Station 02 to nutrients from Pine Hill (V) Sewage Treatment Facility located on Birch Creek, Birch Creek now appears to dilute nutrient levels at Station 02, where NBI values drop significantly compared to Station 01 (Bode et al. 2000; Smith et al. 2007). Once the Pine Hill (V) facility came online in 1998, average total phosphorus values dropped from 30.6 ppm to 16.2 ppm in Birch Creek below the effluent discharge pipe (NYSDOH and NYSDEC, 2002). This was still significantly higher than upstream (12.7 ppm) but represented an almost 50 percent reduction in total phosphorus.

According to the 2009 Water-Data Report compiled by USGS, the 2008 total yearly discharge for Birch Creek at Big Indian was 11,849 cubic feet. Birch Creek makes up a substantial portion of the flow of Upper Esopus Creek at the confluence. The apparent improvement in NBI-N and NBI-P and the decrease in NO3/NO2 at Station 02 may be a result of dilution from Birch Creek (Figures 3 and 4; Table 5). The Shandaken Portal was 71,300.5 cubic feet in 2008 compared to 70,365 cubic feet at the nearest USGS stream gauge site less than one mile upstream in Allaben. The Shandaken Portal and tributaries should be considered a significant influence on the Upper Esopus Creek as they contribute a high volume of water that dilutes nutrient effects seen upstream.

Analysis of the diatom communities using the Diatom Assessment Profile (DAP) suggests slight impacts to water quality at all sites except stations 02 and 04A, where communities were found to be non-impacted (Figure 7; see Appendix XV for details on the DAP). The trophic index (TRI), a measure of diatom community response to enrichment, shows a decrease downstream, indicating decreasing effects of nutrients (Table 5). The Siltation Index suggests no impact from silt at any of the sites.

Water chemistry results indicate background conditions for most parameters except chlorophyll-a, total suspended solids (TSS) and turbidity. Chlorophyll-a was 4.55 mg/m^3 at Station 01 but below detection limits (2 mg/m^3) downstream to Station 05. Turbidity and TSS increase sharply between stations 03 and 04 and continue to increase to Station 06 (Table 5). Increased turbidity and TSS could be due to the Shandaken Portal, which enters the Upper Esopus Creek approximately 2 miles upstream of Station 04. However, tributaries such as Stony Clove Creek contribute a substantial amount of turbidity (Christiana Mulhivill, USGS, pers. comm.) in runoff from eroded stream banks. Further investigation is needed to determine the source of the increased turbidity and TSS. This should include monitoring of suspended sediments at the confluences of tributaries with Upper Esopus Creek.

Pebble count, periphyton, and silt cover indices suggest increased levels of silt cover on the substrate at Station 04A (Figure 8). This site is just below Phoenicia and the confluence with Stony Clove Creek, a tributary known to carry significant amounts of suspended sediments from stream bank erosion. Silt cover levels peaked at Station 04A, just below the 75^{th} percentile for the silt cover index in NYS, and then declined to the the 25^{th} percentile, at Station 06 (See Appendix XIV for pebble count and periphyton cover details). It is possible that the sediment load carried by the Shandaken Portal, as detected in the water chemistry analysis, remains suspended in the water column past Station 04, and therefore was not detected during the pebble count and silt cover analysis.

Biological community data for both macroinvertebrates and diatoms from 2008 indicate eutrophication issues in the headwaters at Station 01. Forest defoliation and resulting nitrification are the likely causes. Dilution by the many significant tributaries and the Shandaken Portal appear to play a major role in decreasing nutrient impacts on both the macroinvertebrate and diatom communities. The 2008 siltation cover index indicates that the highest silt cover is below Phoenicia and Stony Clove Creek.

Overall, macroinvertebrate community assessments indicate non-impacted conditions, while diatoms indicate slightly more degraded biological integrity (slightly impacted) at all sites sampled. A more focused, intensive study of Upper Esopus Creek and its tributaries, employing replicated biological sampling of macroinvertebrates and diatoms, is necessary to quantify the natural variability in benthic communities, identify other sources of impacts to benthic communities, and to fully define the effects of the Shandaken Portal and the Village of Phoenicia on water quality.

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Figure 1. Overview Map, sampling locations on the Upper Esopus Creek, Ulster County.

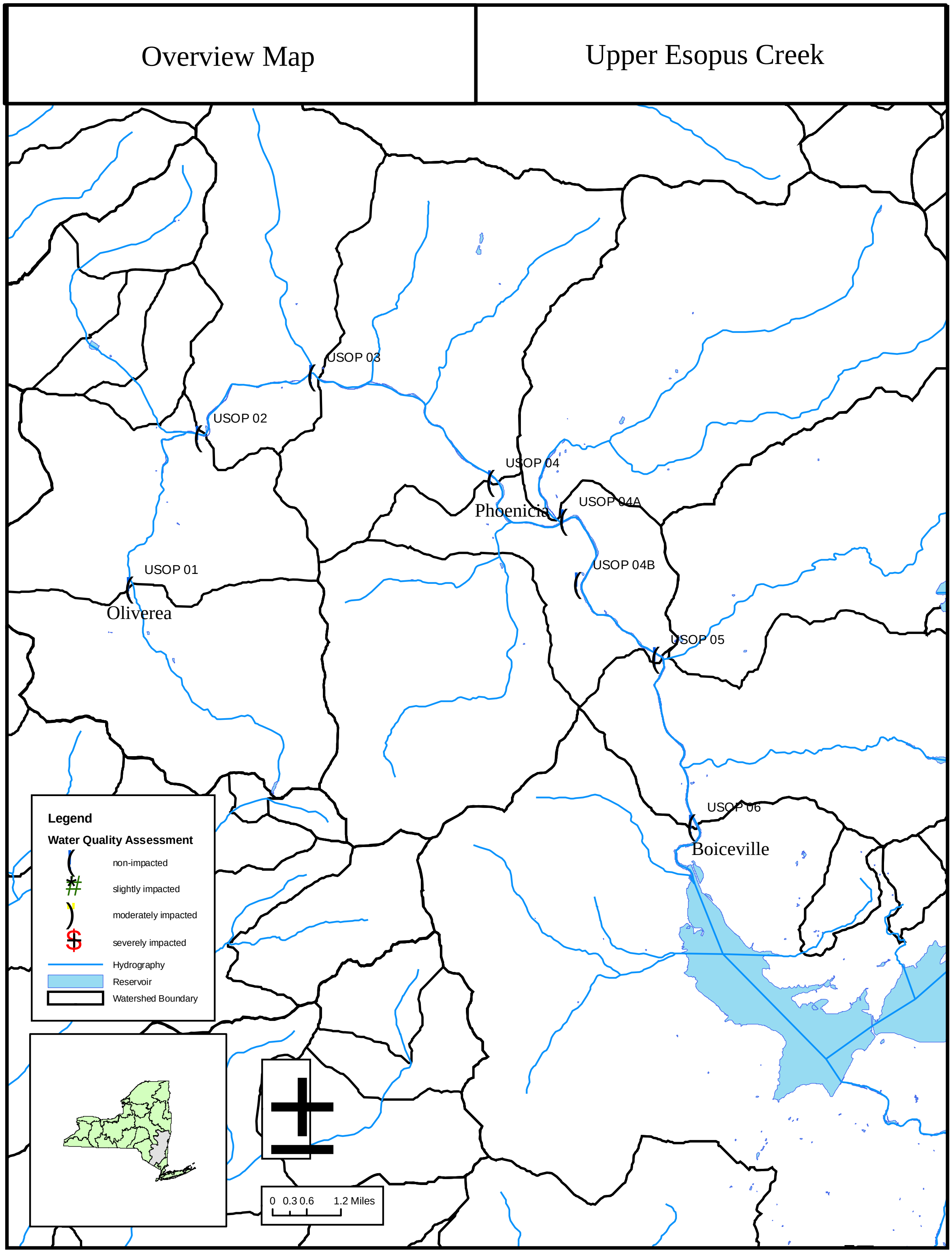


Figure 1a. Station Map, Upper Esopus Creek Station 01, Ulster County.

Site Location Map	Upper Esopus Creek

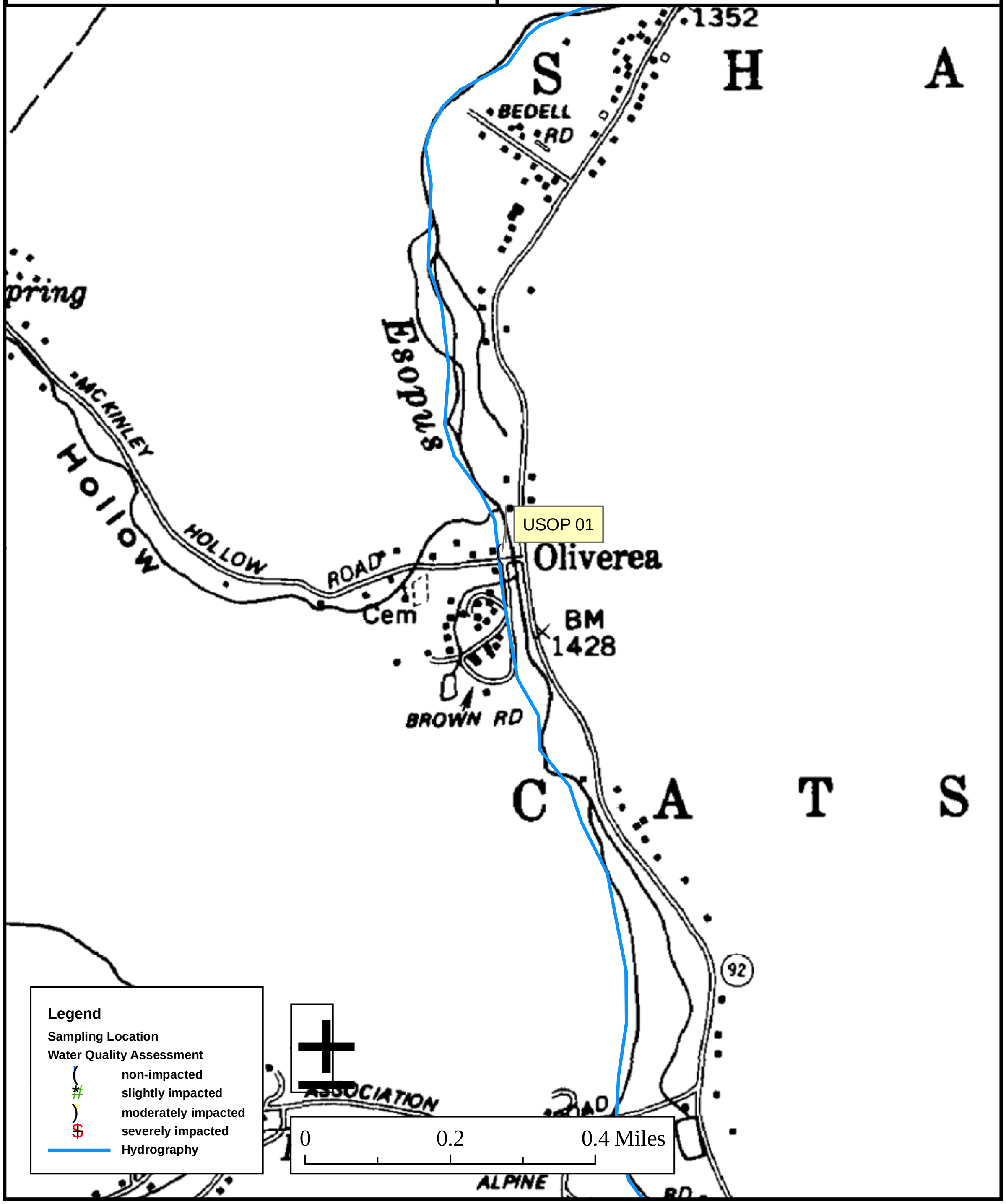


Figure 1b. Station Map, Upper Esopus Creek Station 02, Big Indian, Ulster County.

Site Location Map	Upper Esopus Creek

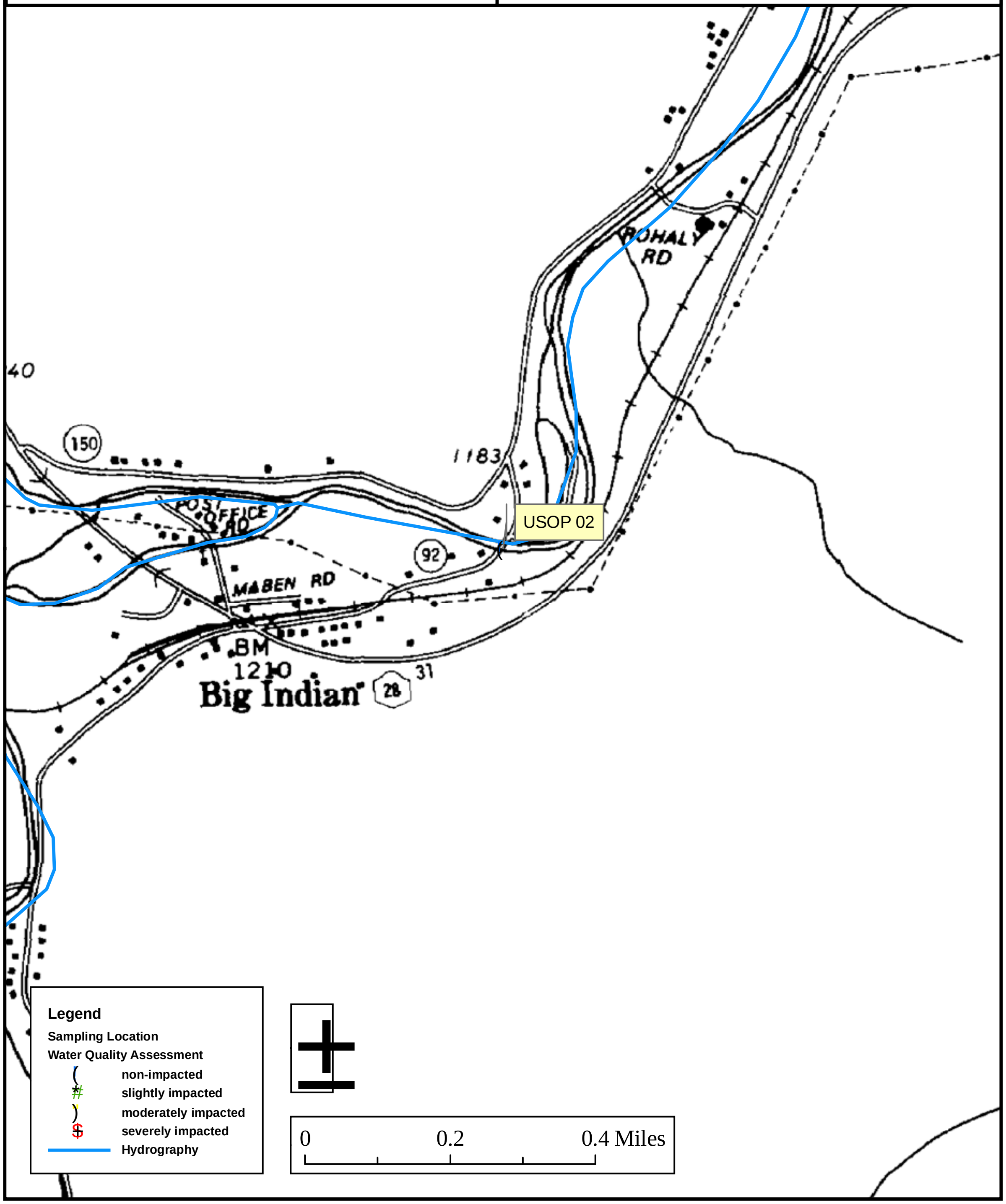


Figure 1d. Station Map, Upper Esopus Creek Station 04, above Phoenicia, Ulster County.

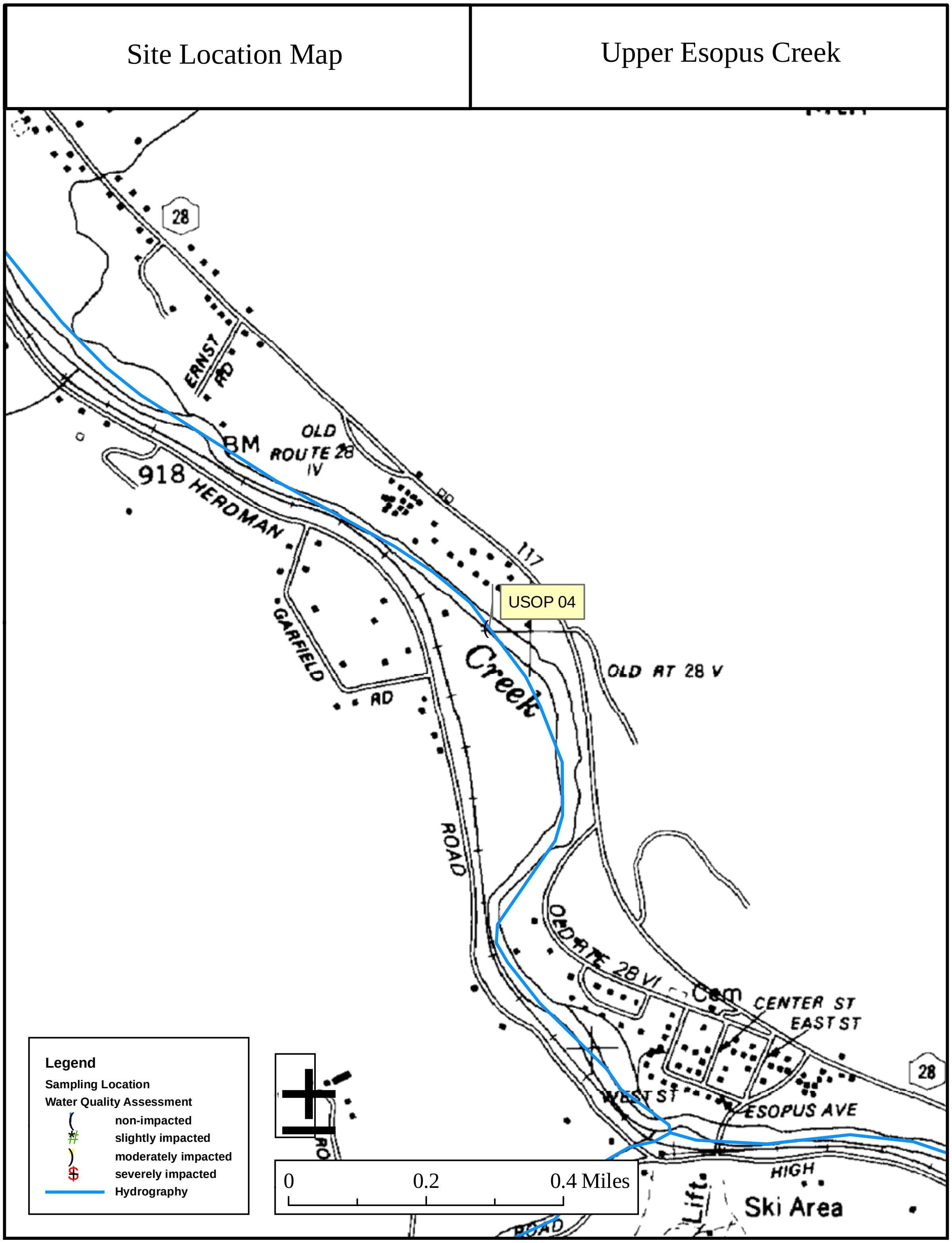


Figure 1e. Station Map, Upper Esopus Creek Station 04A, Phoenicia, Ulster County.

Site Location Map	Upper Esopus Creek

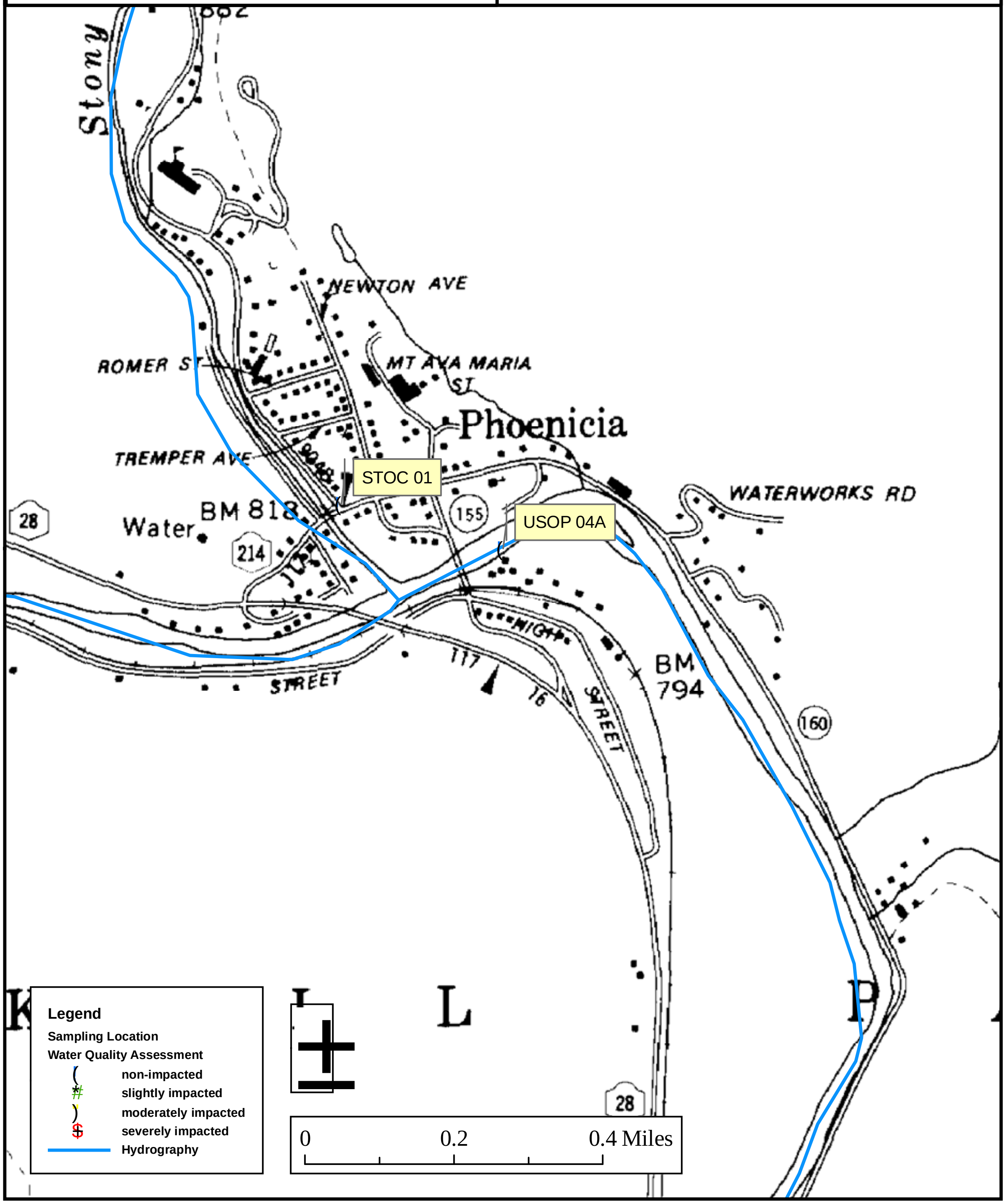


Figure 1f. Station Map, Upper Esopus Creek Station 04B, below Phoenicia, Ulster County.

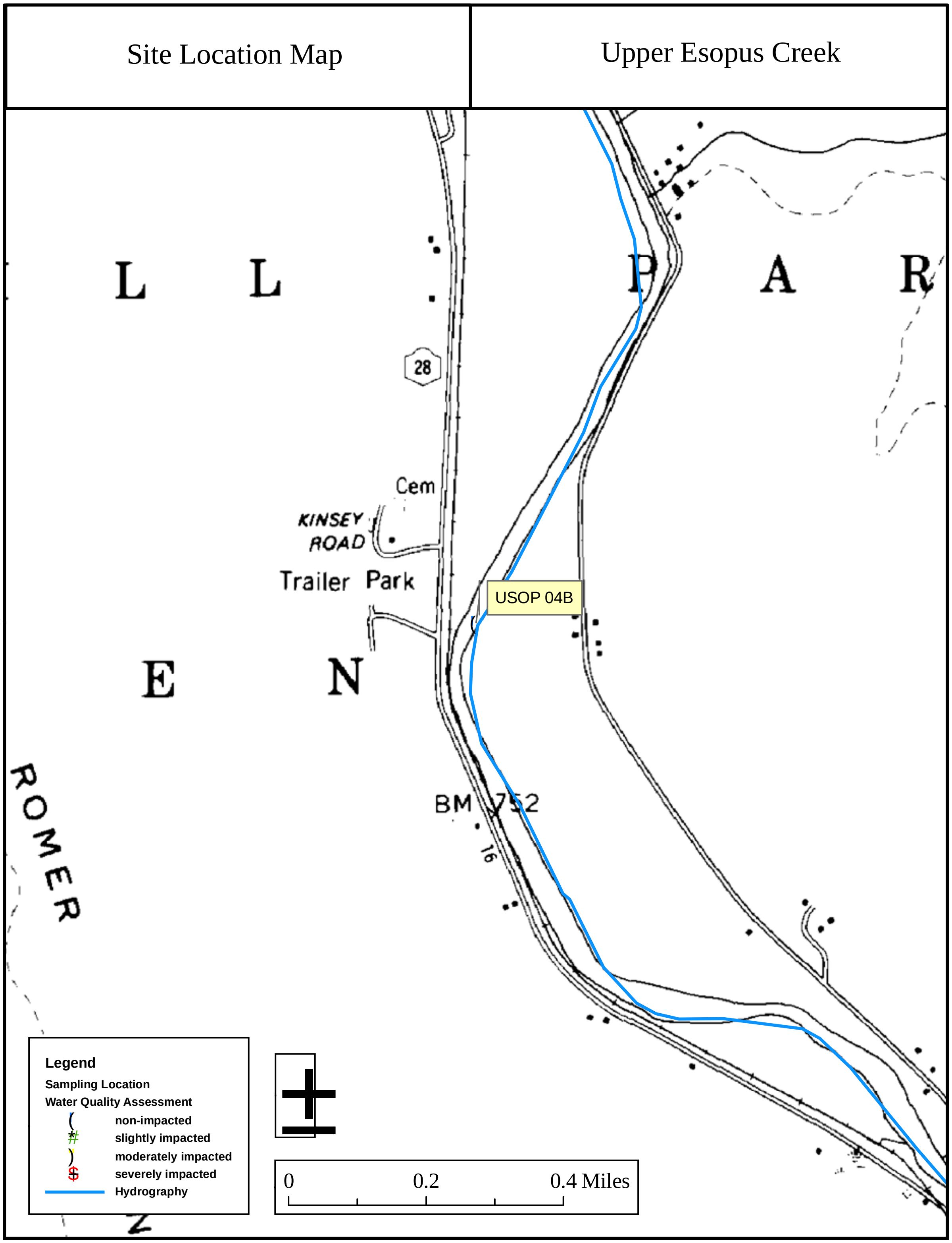


Figure 1g. Station Map, Upper Esopus Creek Station 05, Mount Pleasant, Ulster County.

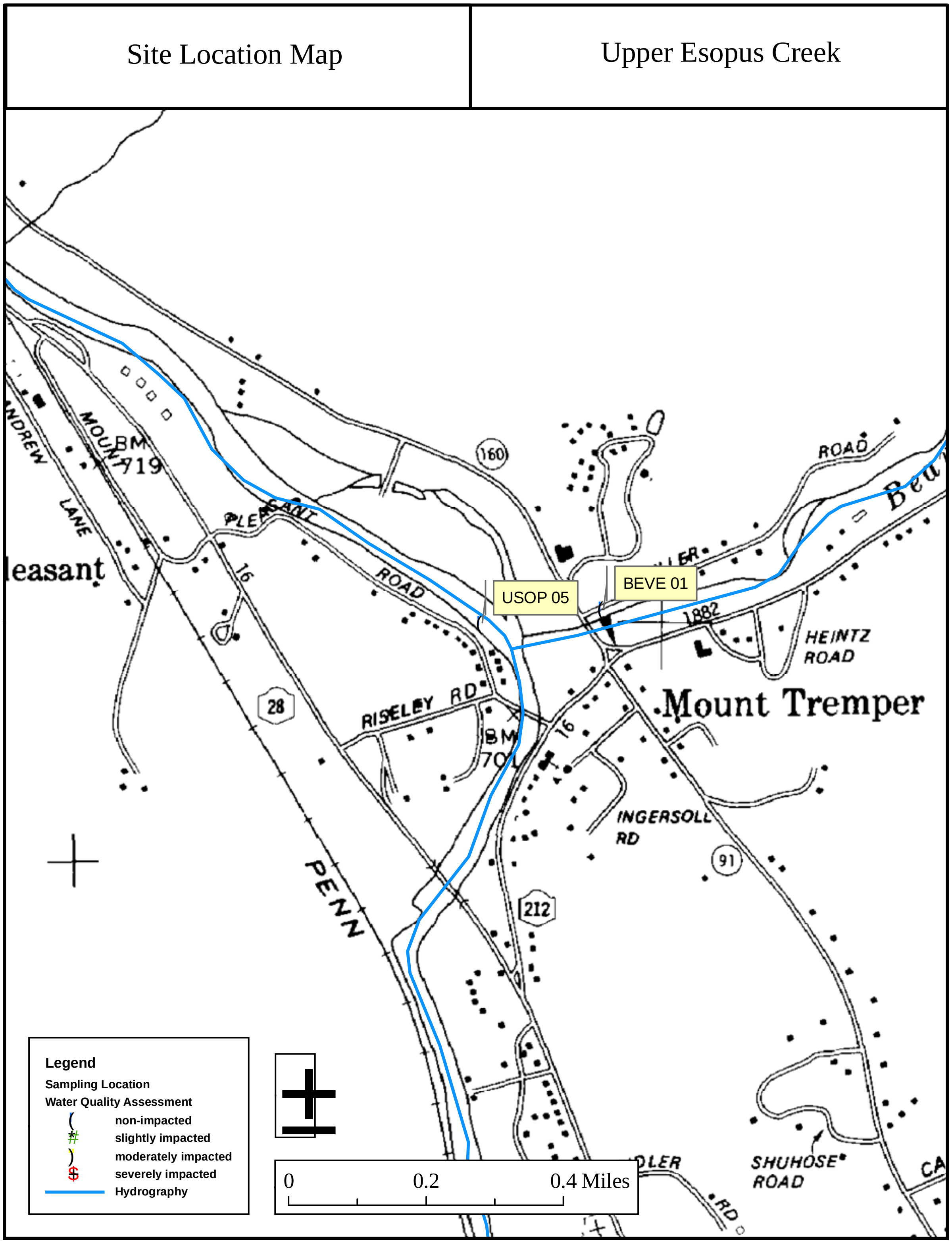


Figure 1h. Station Map, Upper Esopus Creek Station 06, Boiceville, Ulster County.

Site Location Map	Upper Esopus Creek

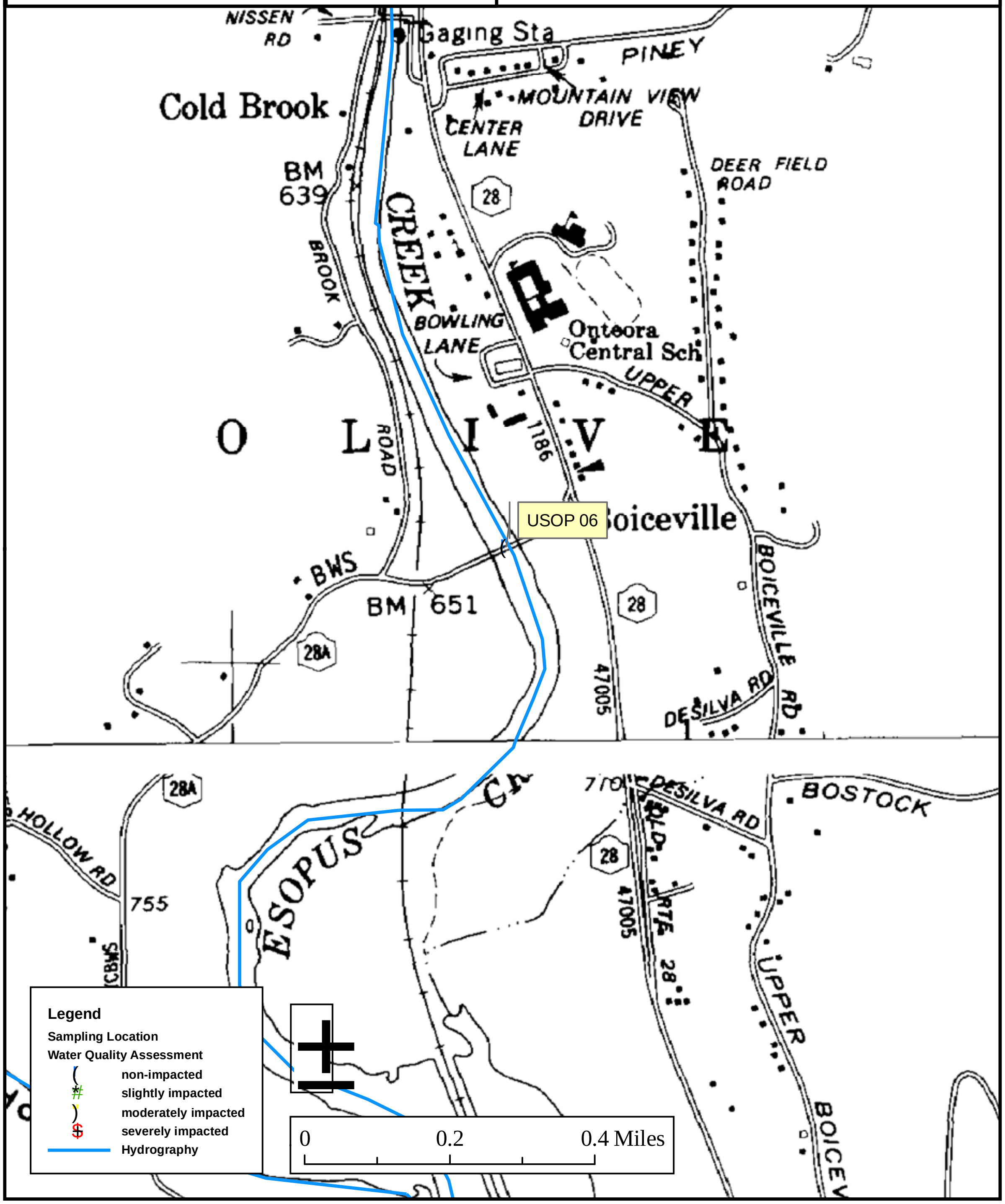


Table 1. Station Locations for the Upper Esopus Creek, Ulster County, NY, 2008.

Station	Site Description	Town/ Village	Latitude	Longitude	County	River Mile	Drainage Area (sq. mi)
01	30 m below McKinley Hollow Rd. bridge	Oliverea	42.0656	-74.4606	Ulster	20.6	16.2
02	10 m below County Rt. 47 bridge	Big Indian	42.1042	-74.4367	Ulster	16.9	43.2
03	30 m above Rt. 28 bridge	Shandaken	42.1194	-74.3975	Ulster	14.2	59.0
04	DOT access off Rt. 28	above Phoenicia	42.0922	-74.3364	Ulster	10.2	83.4
04A	At Bridge St. in Phoenicia	Phoenicia	42.08194	-74.31194	Ulster	8.3	137.8
04B	10 m above Rt. 28A bridge	Phoenicia	42.06361	-74.30639	Ulster	6.63	140.3
05	200 m above confluence with Beaver Kill	Mount Pleasant	42.0467	-74.2803	Ulster	4.6	144.2
06	10 m above Rt. 28A bridge	Boiceville	42.0039	-74.2683	Ulster	1.3	191.2

Table 2. Overview of Field Data. Cells marked by (-) indicate the parameter was not recorded in the field. Embedd. = embeddedness, Cond. = conductivity, DO = dissolved oxgygen, Sat. = % saturation of DO

Station	Depth (meters)	Width (meters)	Current (cm/sec)	Canopy (%)	Embedd. (%)	Temp. (oC)	Cond. (umhos)	DO (mg/l)	Sat. (%)	pH (units)
01	0.1	8	111	50	20	13	40	11.3	107	7.58
02	0.2	12	100	10	20	15.5	61	9.3	93	7.94
03	0.2	12	125	25	40	16.1	68	10.4	105	8.55
04	0.3	40	143	10	30	18.9	71	7.56	81	8.29
04A	0.2	40	111	10	30	19.1	69	7.26	79	8.81
04B	0.5	45	120	10	30	19.9	70	6.6	73	9.03
05	0.3	30	125	10	-	20.6	71	6.79	75	9.57
06	0.3	75	125	10	20	21	76	4.16	47	9.22

Figure 1c. Station Map, Upper Esopus Creek Station 03, Shandaken, Ulster County.

Site Location Map	Upper Esopus Creek

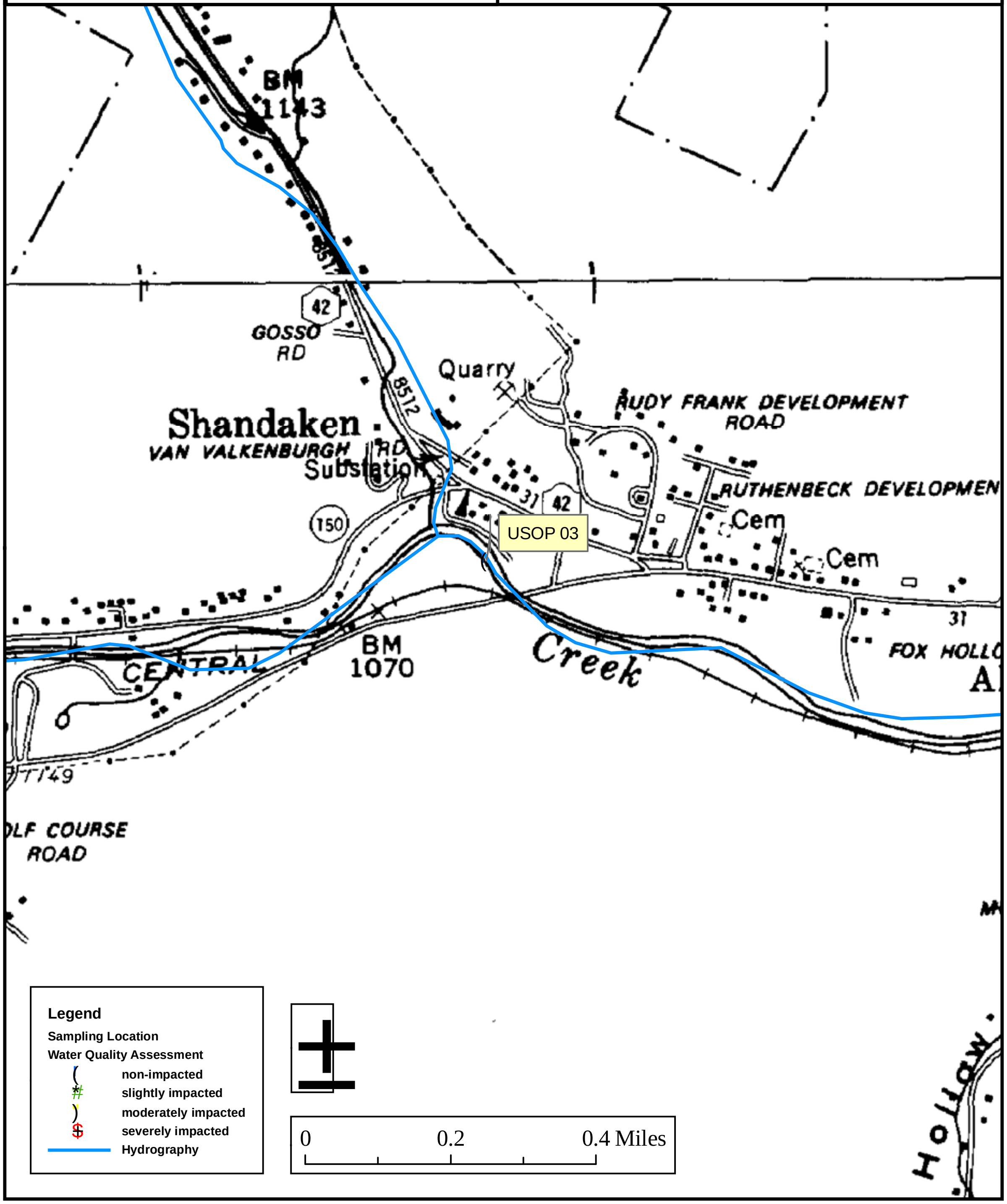


Figure 2A. Biological Assessment Profile (BAP) of index values, Upper Esopus Creek, 1995-2008. Figure 2B. Biological Assessment Profile (BAP) of index values, Upper Esopus Creek, 2008. Values are plotted on a normalized scale of water quality. Water quality scores are the mean of four values for each site, representing species richness, EPT richness, Hilsenhoff's Biotic Index and Percent Model Affinity. See Appendix IV for a more complete explanation.

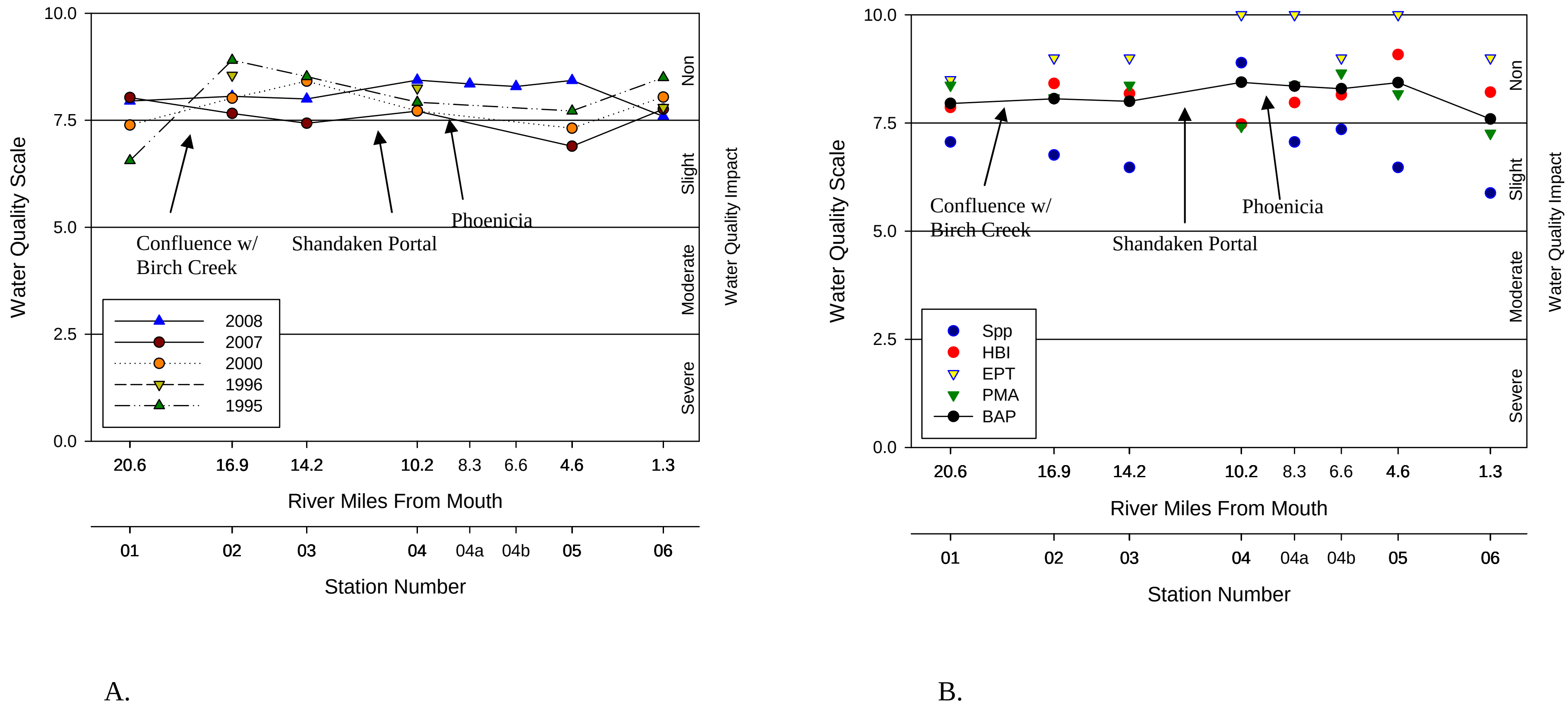


Figure 3. Nutrient Biotic Index Values for Phosphorus (NBI-P) on the Upper Esopus Creek. See Appendix X for a detailed explanation of the index.

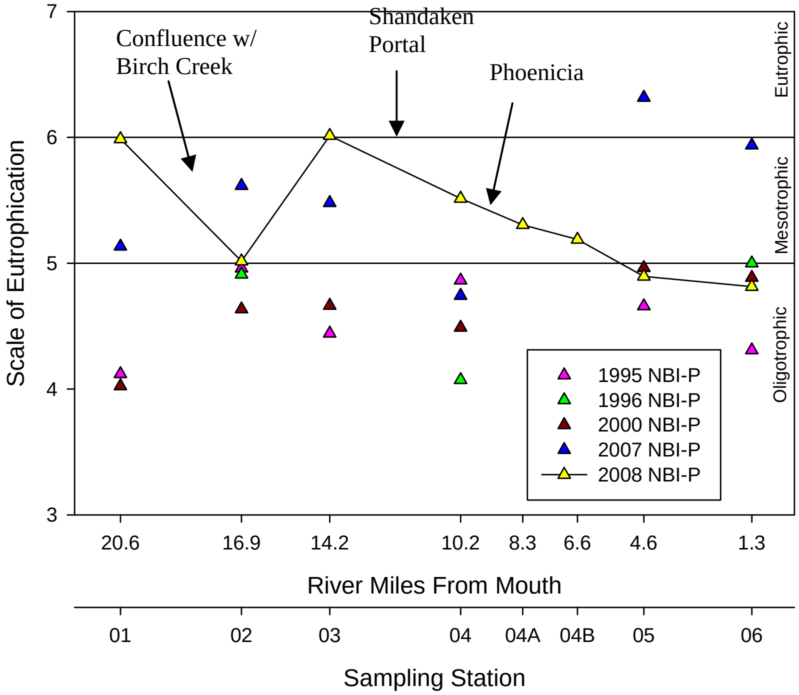


Figure 4. Nutrient Biotic Index Values for Nitrogen (NBI-N) on the Upper Esopus Creek. See Appendix X for a detailed explanation of the index.

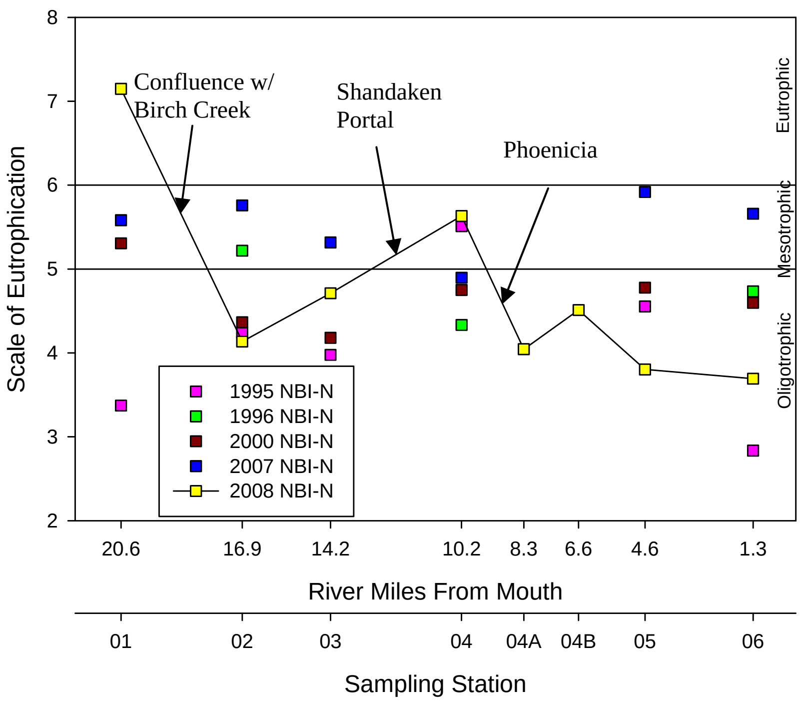
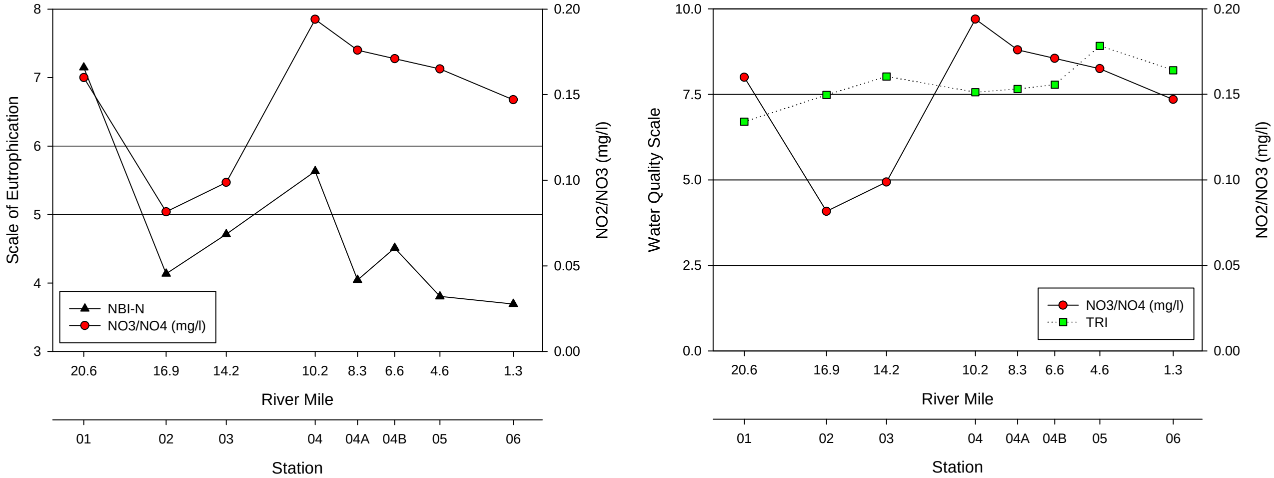


Figure 5. NBI-N (A) and diatom metric TRI (B) versus NO2/NO3 (mg/l) in 2008. Both biological metrics respond to NO2/NO3 levels. Downstream sites indicate better assimilative capacity for NO2/NO3.



A. B.

Figure 6. Station 01 NBI (Scale of Eutrophication) values for all previous sampling years as they relate to Spp and EPT (Water Quality Impact) metric values. Spp and EPT increases reflect the increase in NBI values indicating enrichment and release from natural nutrient limitation. See Appendix IV for an explanation of metrics.

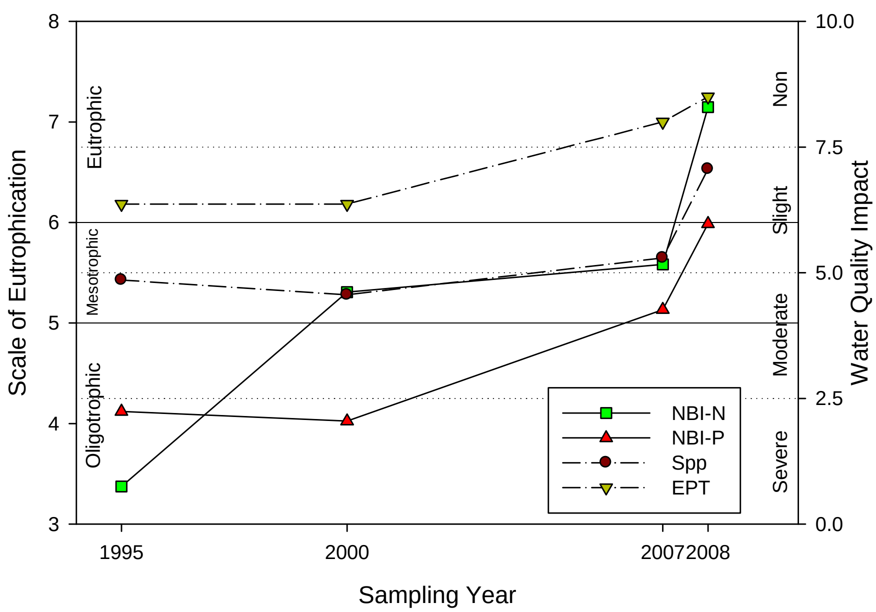


Figure 7. Diatom Assessment Profile (DAP) of Index Values, Upper Esopus Creek, 2008. Values are plotted on a normalized scale of water quality. The water quality scores represent the mean of three values for each site, representing the Pollution Tolerance Index (PTI), Trophic Index, and Diatom Model Affinity (DMA). See Appendix XVI for a more complete explanation.

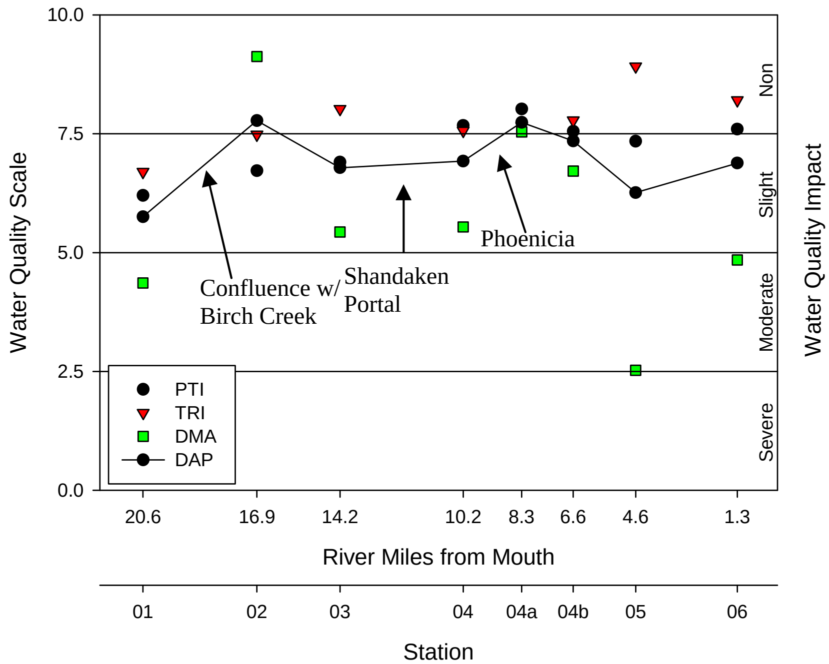


Table 3. Impact Source Determinations (ISD), Upper Esopus Creek, 2008. Numbers represent percent similarity to community type models for each impact category. Highest similarities at each station are shaded. Similarities less than 50% are inconclusive. Highest numbers represent probable stressor(s) to the community. See Appendix XI for further explanation.

Station		*Community Type*						
		Natural	Nutrients	Toxic	Organic	Complex	Siltation	Impoundment
USOP	01	68	37	36	46	33	37	44
	02	56	27	26	35	28	28	29
	03	52	43	36	38	37	36	34
	04	41	47	45	45	47	47	45
	04A	59	44	33	40	29	44	30
	04B	61	39	42	46	32	41	38
	05	59	32	30	34	27	37	27
	06	53	51	40	40	48	46	51*

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

Table 4. Summary of Macroinvertebrate and Diatom Community Metrics, Upper Esopus Creek, 2008. See Appendices IV and XV for metric descriptions. Columns with asterisks (*) indicate raw metric scores not included in BAP or DAP calculation. See Appendix X for NBI metric descriptions.

	Macroinvertebrates							Diatoms				
Station	Spp	HBI	EPT	PMA	BAP	NBI-P*	NBI-N*	PTI	TRI	DMA	DAP	Silt.*
01	7.06	7.86	8.5	8.37	7.95	5.99	7.15	2.24	56.4	46	5.75	1.23
02	6.76	8.41	9	8.08	8.06	5.01	4.13	2.34	50.4	88	7.78	8.71
03	6.47	8.18	9	8.37	8	6.01	4.71	2.38	39.6	53	6.79	10.99
04	8.89	7.47	10	7.42	8.44	5.51	5.63	2.53	48.8	53	6.92	13.92
04A	7.06	7.97	10	8.37	8.35	5.30	4.04	2.60	46.9	66	7.74	6.69
04B	7.35	8.15	9	8.65	8.29	5.19	4.51	2.51	44.4	60	7.35	8.65
05	6.47	9.08	10	8.17	8.43	4.89	3.80	2.47	21.7	35	6.26	5.10
06	5.88	8.21	9	7.26	7.59	4.81	3.69	2.52	35.9	49	6.88	6.21

Table 5. Summary of Water Chemistry Results for Upper Esopus Creek, Ulster County, NY, 2008. Minus sign (-) after a number indicates a value below practical quantification limits.

Station	NH3 (mg/L)	Cl^-	Chl-a (mg/m3)	NO3 (mg/L)	NO3/NO2 (mg/L)	NO2 (mg/L)	TKN (mg/L)	TP (mg/L)	TSS (mg/L)	Turb (NTU)
01	0.0108	3.95	4.55	0.16	0.16	0.01-	0.1-	0.0039	1-	1.12
02	0.0112	5.65	2-	0.0809	0.0816	0.01-	0.1-	0.004	1-	0.64
03	0.0145	7.45	2-	0.0977	0.0987	0.01-	0.1-	0.0042	1-	0.97
04	0.0186	7.5	2-	0.193	0.194	0.01-	0.168	0.0103	3.5	4.8
04A	0.0102	7.25	2-	0.175	0.176	0.01-	0.1-	0.0107	5.3	4.51
04B	0.0117	7.13	2-	0.169	0.171	0.01-	0.1-	0.0111	5.1	4.28
05	0.0122	7.1	2.29	0.164	0.165	0.01-	0.101	0.0127	7.5	6.45
06	0.0141	7.51	2.53	0.146	0.147	0.01-	0.1-	0.0105	3.2	8.91

Figure 8. Periphyton and Silt Cover Index Values (0-10 scale) for Upper Esopus Creek, 2008. Highest macroalgae cover is found at Station 01 and silt cover is highest at Station 04A below Phoenicia and Stony Clove Creek.

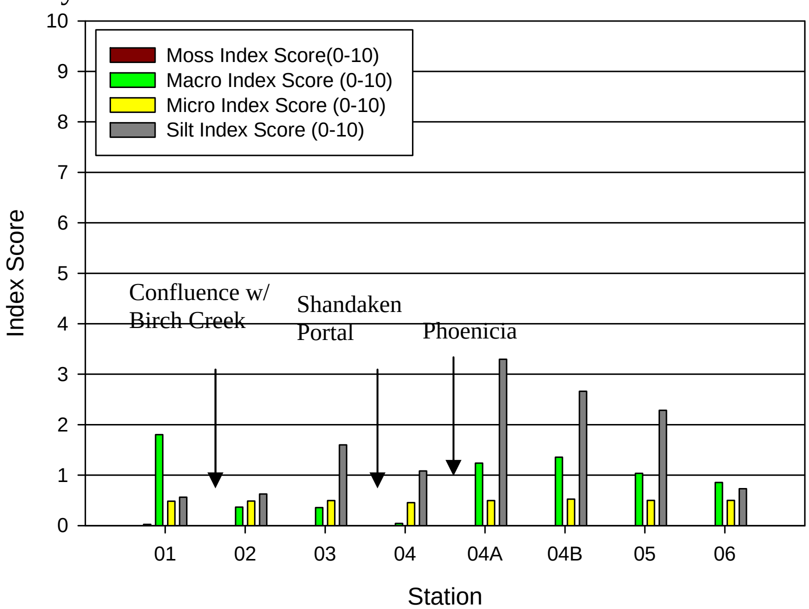


Table 6. Macroinvertebrate Taxa Collected in the Upper Esopus Creek, 2008.

		Taxa	Station 01	02	03	04	04A	04B	05	06
Ephemeroptera	**Isonychidae**	*Isonychia bicolor*	0	28	23	2	24	33	24	25
	Baetidae	*Acentrella turbida*	11	25	20	4	8	3	1	1
		Baetis flavistriga	4	4	2	0	3	3	4	1
		Baetis intercalaris	0	0	1	0	6	3	1	0
		Baetis tricaudatus	19	5	7	0	0	0	0	0
		Plauditus sp.	1	2	0	5	4	9	5	1
	Heptagenaiidae	*Epeorus vitreus*	0	0	0	0	0	0	12	6
		Epeorus sp.	0	0	2	0	1	0	0	0
		Heptagenia sp.	3	0	0	1	2	2	1	0
		Stenonema luteum	0	0	0	0	18	0	17	0
		Stenonema sp.	2	2	3	0	0	6	0	0
		Undetermined Heptageniidae	0	0	0	0	0	0	0	1
	Ephemerellidae	*Drunella cornutella*	6	4	5	0	0	0	0	0
		Serratella serrata	0	0	0	1	1	0	2	0
	Tricorythodae	*Tricorythodes sp.*	0	0	0	1	0	0	0	0
Plecoptera	**Leuctridae**	*Leuctra sp.*	0	0	0	8	0	0	2	0
	Perlidae	*Acroneuria abnormis*	0	0	0	0	0	1	0	0
		Acroneuria sp.	0	3	0	1	1	0	0	0
		Agnetina capitata	0	1	1	0	1	0	1	0
		Paragnetina immarginata	0	0	0	1	0	1	3	0
		Paragnetina sp.	0	0	0	0	0	0	0	1
Coleoptera	**Elmidae**	*Optioservus sp.*	0	0	0	1	0	0	0	0
		Stenelmis concinna	1	0	0	0	0	0	0	0
Trichoptera	**Philopotamidae**	*Chimarra aterrima*	0	0	0	0	0	0	0	15
		Dolophilodes sp.	3	1	1	2	0	0	5	4
	Hydropsychidae	*Cheumatopsyche sp.*	3	0	0	2	2	1	0	4
		Hydropsyche bronta	0	2	4	4	5	1	1	0
		Hydropsyche morosa	0	0	6	4	2	1	3	11
		Hydropsyche slossonae	5	3	0	1	0	0	0	0
		Hydropsyche sparna	0	2	3	12	0	8	1	5
		Hydropsyche sp.	0	0	0	0	1	0	0	0
	Brachycentridae	*Brachycentrus nigrosoma*	3	0	0	0	0	0	0	0
	Lepidostomidae	*Lepidostoma sp.*	1	0	0	0	0	0	1	1
Diptera	**Tipulidae**	*Antocha sp.*	0	0	0	2	0	0	0	0
		Hexatoma sp.	0	1	1	0	0	0	0	0
	Blephariceridae	Undetermined Blephariceridae	0	0	1	0	0	0	0	0
	Simulidae	*Simulium tuberosum*	1	0	0	0	0	0	0	0
	Empididae	*Hemerodromia sp.*	1	0	0	6	0	1	2	0
	Chironomidae	*Thienemannimyia gr. spp.*	4	0	1	0	0	0	0	1
		Diamesa sp.	1	0	0	0	0	0	0	0
		Pagastia orthogonia	1	0	0	0	0	0	1	0
		Potthastia gaedii gr.	0	0	0	0	0	1	0	0
		Potthastia longimana gr.	0	0	0	1	0	0	0	0
		Sympotthastia sp.	2	0	0	2	0	0	0	0
		Cardiocladius obscurus	0	0	1	0	0	3	0	0
		Cricotopus bicinctus	0	0	0	3	1	2	0	0

		Taxa	Station							
			01	02	03	04	04A	04B	05	06
		Cricotopus trifascia gr.	0	1	0	0	0	0	0	0
		Cricotopus vierriensis	0	0	0	0	1	1	0	2
		Cricotopus sp.	0	1	0	0	0	0	0	0
		Eukiefferiella devonica gr.	1	0	0	0	0	0	0	1
		Orthocladius dubitatus	5	1	1	0	0	0	2	0
		Orthocladius obumbratus	0	3	0	0	0	0	0	0
		Rheocricotopus robacki	0	0	0	1	0	0	0	0
		Tvetenia vitracies	0	0	0	0	0	1	0	1
		Tvetenia sp.	0	1	0	0	0	0	0	0
		Microtendipes pedellus gr.	0	0	0	1	1	2	2	0
		Microtendipes rydalensis gr.	0	0	0	1	1	0	0	0
		Parachironomus frequens	0	0	0	1	0	0	0	0
		Polypedilum aviceps	0	1	2	2	3	2	2	0
		Polypedilum flavum	0	1	11	10	6	4	7	4
		Micropsectra dives gr.	17	0	2	0	0	0	0	0
		Micropsectra sp.	0	3	0	0	0	0	0	0
		Rheotanytarsus exiguus gr.	0	0	1	0	0	0	0	0
		Rheotanytarsus pellucidus	1	0	0	0	1	0	0	0
		Sublettea coffmani	0	0	0	1	0	1	0	0
		Tanytarsus glabrescens gr.	0	3	0	0	0	0	0	0
		Tanytarsus sp.	2	2	0	0	0	0	0	0
		Undetermined Tanytarsini	2	0	0	0	0	0	0	0
Nemertea		Undetermined Nemertea	0	0	0	0	4	1	0	2
Turbellaria		Undetermined Turbellaria	0	0	0	0	2	0	0	0
Oligochaeta		Undetermined Lumbricina	0	0	0	0	0	2	0	0
		Undetermined Lumbriculidae	0	0	1	10	1	7	0	12
		Undetermined Enchytraeidae	0	0	0	1	0	0	0	0
Gastropoda	**Ancylidae**	*Ferrissia sp.*	0	0	0	0	0	0	0	1
Amphipoda		Undetermined Gammaridae	0	0	0	1	0	0	0	0
		Total	100	100	100	93	100	100	100	100

Genus Species	Station							
	01	02	03	04	04A	04B	05	06
Cymbella minuta var. *silesiaca*	12	5	3	10	14	5	65	2
Cymbella muelleri	13	9	6	2	9	3	0	2
Cymbella prostrata	0	0	1	0	0	0	0	0
Cymbella rupicola	0	0	0	0	0	0	3	0
Cymbella tumida	10	6	1	53	12	14	3	15
Cymbella turgidula	32	61	33	24	7	2	10	35
Diatoma								
Diatoma girdle sp.	4	0	0	0	2	0	0	0
Diatoma mesodon	5	0	0	0	1	0	0	0
Diploneis								
Diploneis puella	1	1	10	6	0	0	0	0
Eunotia								
Eunotia arcus	0	0	0	0	1	0	0	0
Eunotia pectinalis var. *minor*	1	0	0	0	0	0	0	0
Fragilaria								
Fragilaria bidens	0	0	0	0	0	0	28	0
Fragilaria capucina	2	0	7	11	10	4	0	8
Fragilaria capucina var. *mesolepta*	2	0	0	4	0	0	0	0
Fragilaria construens var. *venter*	3	0	0	0	0	1	0	0
Fragilaria crotonensis	0	2	3	2	0	0	0	0
Fragilaria girdle sp.	10	8	56	10	7	8	0	18
Fragilaria vaucheriae	0	46	103	37	52	83	66	75
Frustulia								
Frustulia rhomboides	0	0	0	0	0	0	0	2
Gomphoneis								
Gomphoneis herculeana	0	5	27	5	4	8	1	3
Gomphonema								
Gomphonema acuminatum	0	0	0	0	0	0	0	2
Gomphonema clevei	0	0	0	2	0	0	5	0
Gomphonema girdle sp.	0	2	0	0	5	2	2	2
Gomphonema gracile	0	0	0	0	0	0	0	2
Gomphonema helveticum	0	0	0	0	0	2	0	0
Gomphonema kobayasii	0	0	0	0	0	0	0	3
Gomphonema parvulum	11	7	2	6	13	6	55	0
Gomphonema parvulum var. *exilissimum*	0	7	0	21	0	8	0	8
Gomphonema productum	0	0	0	0	0	5	0	2
Gomphonema pumilum	0	5	16	13	9	11	12	11
Gomphonema sphaerophorum	0	0	0	0	0	2	7	12
Gomphonema subclavatum var. *mexicanum*	3	0	0	0	0	0	0	0
Gomphonema truncatum	0	0	0	0	0	1	0	0
Gomphonema truncatum var. *capitatum*	0	0	0	3	0	0	0	0
Hantzschia								
Hantzschia amphioxys	0	0	0	1	0	0	0	0

Genus Species	Station							
	01	02	03	04	04A	04B	05	06
Melosira								
Melosira varians	7	8	5	22	20	17	2	47
Meridion								
Meridion circulare	6	6	1	0	1	2	1	2
Meridion circulare var. *constrictum*	0	0	0	1	0	0	0	0
Navicula								
Navicula arvensis	0	1	0	0	0	0	0	0
Navicula atomus	0	0	0	0	2	0	0	0
Navicula capitata	0	0	0	0	0	0	0	2
Navicula capitatoradiata	0	0	0	3	0	0	0	0
Navicula cincta	0	0	0	0	0	0	0	2
Navicula cryptocephala	0	1	0	1	0	0	3	2
Navicula decussis	0	1	0	0	0	0	0	0
Navicula girdle sp.	0	0	0	0	0	0	2	0
Navicula goeppertiana	0	0	0	0	0	1	0	2
Navicula gysingensis	0	1	0	0	0	0	0	0
Navicula menisculus	0	0	0	0	0	2	4	1
Navicula peregrina	0	0	0	0	0	0	0	1
Navicula pupula	0	0	1	0	0	0	0	0
Navicula radiosa var. *parva*	2	2	2	3	2	2	0	5
Navicula radiosa var. *tenella*	3	34	22	25	28	23	14	11
Navicula recens	0	0	0	2	0	5	0	8
Navicula rhynchocephala	1	0	0	0	1	0	0	0
Navicula rhynchocephala var. *germainii*	0	1	0	0	0	0	0	0
Navicula veneta	0	0	0	0	0	0	5	0
Navicula viridula var. *avenacea*	0	0	0	0	2	0	0	0
Navicula viridula var. *rostellata*	0	0	0	0	0	0	0	2
Nitzschia								
Nitzschia capitellata	0	1	2	1	0	0	0	2
Nitzschia dissipata	0	7	18	43	3	16	4	2
Nitzschia fonticola	0	0	6	0	0	0	0	0
Nitzschia frustulum	2	3	8	6	2	3	2	0
Nitzschia frustulum var. *perminuta*	0	0	0	1	0	0	0	0
Nitzschia girdle sp.	0	0	2	0	1	0	1	0
Nitzschia graciliformis	0	2	0	0	0	0	0	0
Nitzschia inconspicua	0	0	2	0	0	0	0	0
Nitzschia intermedia	0	0	0	0	2	0	0	0
Nitzschia linearis	0	1	3	2	0	0	0	0
Nitzschia microcephala	0	0	2	0	0	0	0	0
Nitzschia palea	0	0	1	0	0	0	0	0
Nitzschia pusilla	0	1	1	0	0	0	0	0
Other								
Unknown pennate girdle sp.	0	0	0	0	0	0	1	0

Genus Species	Station							
	01	02	03	04	04A	04B	05	06
Pinnularia								
Pinnularia microstauron	0	0	0	0	2	0	0	0
Pinnularia obscura	0	0	0	0	0	0	1	0
Pinnularia subcapitata	2	0	0	0	0	0	0	0
Planothidium								
Planothidium frequentissimum	0	0	1	0	0	3	0	0
Reimeria								
Reimeria sinuata	0	15	13	8	12	10	6	19
Rhoicosphenia								
Rhoicosphenia curvata	0	14	3	2	2	1	0	4
Stauroneis								
Stauroneis anceps	0	0	0	0	0	1	0	0
Stephanodiscus								
Stephanodiscus niagarae	0	0	2	0	0	0	0	0
Surirella								
Surirella angusta	0	0	0	0	0	2	0	0
Surirella girdle sp.	0	0	0	0	0	0	1	0
Synedra								
Synedra acus	0	0	4	3	0	2	0	0
Synedra mazamaensis	1	0	0	0	0	0	0	0
Synedra rumpens	39	10	10	2	0	0	0	4
Synedra rumpens var. *familiaris*	40	18	0	0	0	0	0	0
Synedra rumpens var. *scotica*	0	0	0	5	0	0	0	0
Synedra socia	0	0	2	0	0	0	0	0
Synedra tenera	0	2	0	0	0	0	0	0
Synedra ulna	179	135	58	18	2	9	14	26
Synedra ulna var. *chaseana*	4	0	0	1	0	0	0	0
Synedra ulna var. *contracta*	52	2	0	2	4	0	0	0
Tabellaria								
Tabellaria fenestrata	0	0	0	1	0	0	0	0
Tabellaria flocculosa	1	2	0	3	3	2	1	1
TOTAL	**648**	**643**	**619**	**625**	**628**	**624**	**647**	**644**

Table 8. Laboratory Data Summary, Esopus Creek, Ulster County, NY, 2008.

LABORATORY DATA SUMMARY				
STREAM NAME: Upper Esopus Creek				
DATE SAMPLED: 8/13/2008				
SAMPLING METHOD: Kick				
LOCATION	USOP	USOP	USOP	USOP
STATION	01	02	03	04
DOMINANT SPECIES / %CONTRIBUTION / TOLERACE / COMMON NAME				
Tolerance Definitions:	1. Baetis tricaudatus 19 % facultative mayfly	Isonychia bicolor 28 % intolerant mayfly	Isonychia bicolor 23 % intolerant mayfly	Hydropsyche sparna 12 % facultative caddisfly
Intolerant = not tolerant of poor water quality	2. Micropsectra dives gr. 17 % intolerant midge	Acentrella turbida 25 % intolerant mayfly	Acentrella turbida 20 % intolerant mayfly	Polypedilum flavum 10 % facultative midge
Facultative = occurring over a wide range of water quality	3. Acentrella turbida 11 % intolerant mayfly	Baetis tricaudatus 5 % facultative mayfly	Polypedilum flavum 11 % facultative midge	Undetermined Lumbriculidae 10 % tolerant worm
Tolerant = tolerant of poor water quality	4. Drunella cornutella 6 % intolerant mayfly	Baetis flavistriga 4 % intolerant mayfly	Baetis tricaudatus 7% facultative mayfly	Leuctra sp. 8 % intolerant stonefly
	5. Hydropsyche slossonae 5 % intolerant caddisfly	Drunella cornutella 4 % intolerant mayfly	Hydropsyche morosa 6% facultative caddisfly	Hemerodromia sp. 6 % facultative dance fly
% CONTRIBUTION OF MAJOR GROUPS (NUMBER OF TAXA IN PARENTHESIS)				
Chironomidae (midges)	36 (10.0)	17 (10.0)	19 (7.0)	23 (10.0)
Trichoptera (caddisflies)	15 (5.0)	8 (4.0)	14 (4.0)	25 (6.0)
Ephemeroptera (mayflies)	46 (7.0)	70 (7.0)	63 (8.0)	14 (6.0)
Plecoptera (stoneflies)	0 (0.0)	4 (2.0)	1 (1.0)	10 (3.0)
Coleoptera (beetles)	1 (1.0)	0 (0.0)	0 (0.0)	1 (1.0)
Oligochaeta (worms)	0 (0.0)	0 (0.0)	1 (1.0)	11 (2.0)
Mollusca (clams and snails)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Crustacea (crayfish, scuds, sowbugs)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.0)
Other insects (odonates, diptera)	2 (2.0)	1 (1.0)	2 (2.0)	8 (2.0)
Other (Nemertea, Platyhelminthes)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
SPECIES RICHNESS	25	24	23	31
BIOTIC INDEX	4.14	3.59	3.82	4.53
EPT RICHNESS	12	13	13	15
PERCENT MODEL AFFINITY	73	70	73	64
FIELD ASSESSMENT	VG		VG	VG
OVERALL ASSESSMENT	non-impacted	non-impacted	non-impacted	non-impacted

Table 9 cont'd. Laboratory Data Summary, Esopus Creek, Ulster County, NY, 2008.

LABORATORY DATA SUMMARY				
STREAM NAME: Upper Esopus Creek				
DATE SAMPLED: 8/13/2008				
SAMPLING METHOD: Kick				
LOCATION	USOP	USOP	USOP	USOP
STATION	04A	04B	05	06
DOMINANT SPECIES / %CONTRIBUTION / TOLERACE / COMMON NAME				
Tolerance Definitions:	1. Isonychia bicolor 24 % intolerant mayfly	Isonychia bicolor 33 % intolerant mayfly	Isonychia bicolor 24 % intolerant mayfly	Isonychia bicolor 25 % intolerant mayfly
Intolerant = not tolerant of poor water quality	2. Stenonema luteum 18 % intolerant mayfly	Plauditus sp. 9 % intolerant mayfly	Stenonema luteum 17 % intolerant mayfly	Chimarra aterrima? 15 % intolerant caddisfly
Facultative = occurring over a wide range of water quality	3. Acentrella turbida 8 % intolerant mayfly	Hydropsyche sparna 8 % facultative caddisfly	Epeorus vitreus 12 % intolerant mayfly	Undetermined Lumbriculidae 12 % tolerant worm
Tolerant = tolerant of poor water quality	4. Baetis intercalaris 6 % facultative mayfly	Undetermined Lumbriculidae 7 % tolerant worm	Polypedilum flavum 7% facultative midge	Hydropsyche morosa 11 % facultative caddisfly
	5. Polypedilum flavum 6 % facultative midge	Stenonema sp. 6 % intolerant mayfly	Plauditus sp. 5% intolerant mayfly	Epeorus vitreus 6 % intolerant mayfly
% CONTRIBUTION OF MAJOR GROUPS (NUMBER OF TAXA IN PARENTHESIS)				
Chironomidae (midges)	14 (7.0)	17 (9.0)	14 (5.0)	9 (5.0)
Trichoptera (caddisflies)	10 (4.0)	11 (4.0)	11 (5.0)	40 (6.0)
Ephemeroptera (mayflies)	67 (9.0)	59 (7.0)	67 (9.0)	35 (6.0)
Plecoptera (stoneflies)	2 (2.0)	2 (2.0)	6 (3.0)	1 (1.0)
Coleoptera (beetles)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Oligochaeta (worms)	1 (1.0)	9 (2.0)	0 (0.0)	12 (1.0)
Mollusca (clams and snails)	0 (0.0)	0 (0.0)	0 (0.0)	1 (1.0)
Crustacea (crayfish, scuds, sowbugs)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Other insects (odonates, diptera)	0 (0.0)	1 (1.0)	2 (1.0)	0 (0.0)
Other (Nemertea, Platyhelminthes)	2 (0.0)	1 (0.0)	0 (0.0)	1 (0.0)
SPECIES RICHNESS	25	26	23	21
BIOTIC INDEX	4.03	3.85	2.92	3.79
EPT RICHNESS	15	13	17	13
PERCENT MODEL AFFINITY	73	76	71	63
FIELD ASSESSMENT		VG	VG	
OVERALL ASSESSMENT	non-impacted	non-impacted	non-impacted	non-impacted

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 95percent 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-organism 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.

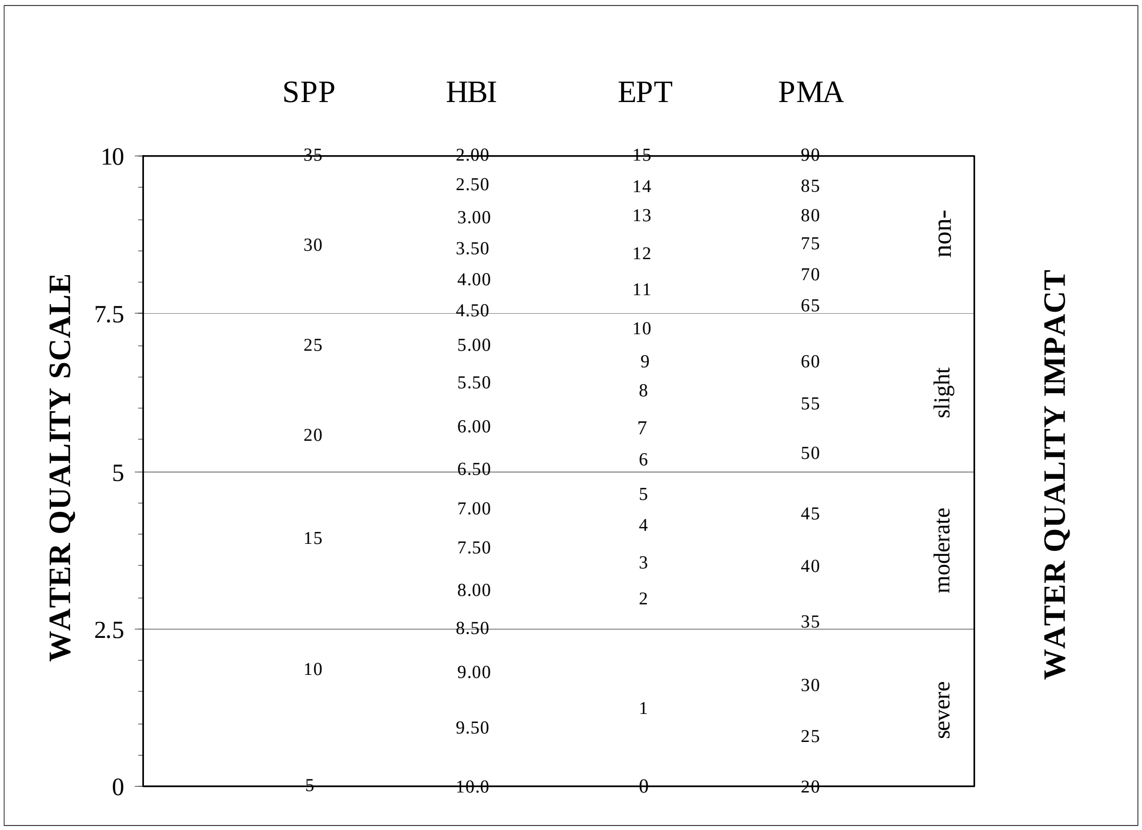
2. *Slightly impacted*: Indices reflect good water quality. The macroinvertebrate community is slightly but significantly altered from the pristine state. Species richness is usually 19-26. Mayflies and stoneflies may be restricted, with EPT richness values of 6-10. The biotic index value is 4.51-6.50. 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.



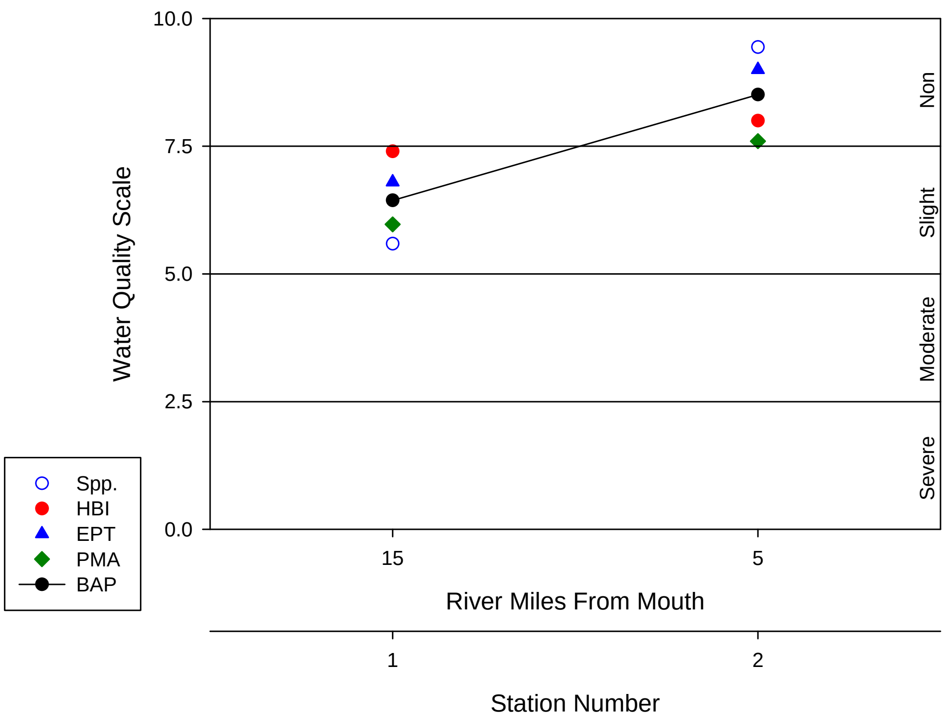
Appendix IV-B. Biological Assessment Profile: Plotting Values

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
Average		6.44 (slight)		8.51 (non-)

Sample BAP plot:



Appendix V. Water Quality Assessment Criteria

Non-Navigable Flowing Waters

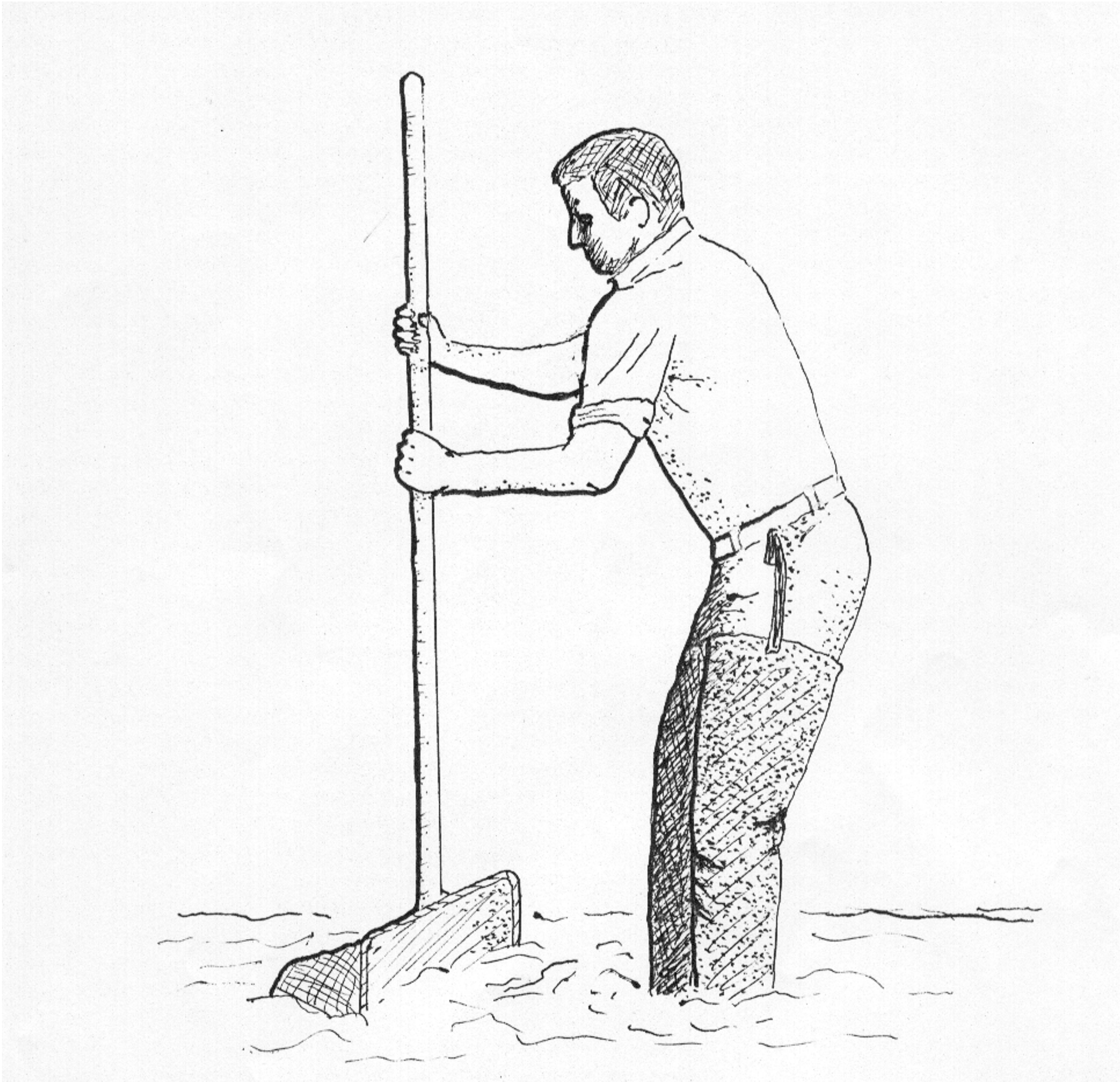
	Species Richness	Hilsenhoff Biotic Index	EPT Value	Percent Model Affinity*	Diversity **
Non-Impacted	>26	0.00-4.50	>10	>64	>4
Slightly Impacted	19-26	4.51-6.50	6-10	50-64	3.01-4.00
Moderately Impacted	11-18	6.51-8.50	2-5	35-49	2.01-3.00
Severely Impacted	0-10	8.51-10.00	0-1	<35	0.00-2.00

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



⟵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 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 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.

SOWBUGS

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

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 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).

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

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

For conversion raw NBI values to 10 scale values refer to Appendix IVA.

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

TAXON	TP T-Value	NO3 T-Value
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

TAXON	TP T-Value	NO3 T-Value
Sublettea coffmani	3	5
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 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.

Table 7. Diatom Taxa Collected In Upper Esopus Creek, Ulster County, NY, 2008.

Genus Species	Station							
	01	02	03	04	04A	04B	05	06
Achnanthes								
Achnanthes bioretii	0	0	0	2	0	0	0	0
Achnanthes curtissima	0	5	2	11	8	0	0	0
Achnanthes deflexa	2	2	1	36	25	26	0	43
Achnanthes girdle sp.	4	0	4	6	9	0	0	0
Achnanthes hungarica	0	0	0	1	0	0	0	0
Achnanthes laevis	2	0	0	2	1	0	0	0
Achnanthes lanceolata	4	4	1	4	0	3	2	0
Achnanthes lanceolata var. *dubia*	4	0	2	0	0	0	1	0
Achnanthes linearis	3	0	0	0	4	6	0	5
Achnanthes minutissima	76	101	108	113	206	150	0	84
Achnanthes minutissima var. *affinis*	0	0	0	0	0	0	96	0
Achnanthes minutissima var. *gracillima*	0	0	0	0	0	0	130	0
Achnanthes subhudsonis	0	0	0	0	2	0	0	0
Achnanthes suchlandtii	0	0	0	0	1	0	0	0
Amphora pediculus	0	1	0	0	0	0	0	0
Asterionella								
Asterionella formosa	1	0	0	4	0	1	0	0
Aulacoseira								
Aulacoseira granulata	0	0	0	0	0	2	0	0
Caloneis								
Caloneis lewisii	0	0	0	1	0	0	0	0
Cocconeis								
Cocconeis placentula	4	0	2	0	0	0	0	0
Cocconeis placentula var. *euglypta*	2	14	7	4	12	38	10	6
Cocconeis placentula var. *klinoraphis*	0	2	0	0	0	0	0	0
Cocconeis placentula var. *lineata*	1	5	8	7	8	0	8	12
Cyclotella								
Cyclotella bodanica	0	0	0	4	6	2	0	0
Cyclotella comensis	0	0	0	1	2	1	0	4
Cyclotella distinguenda	0	0	0	2	2	1	0	1
Cyclotella girdle sp.	0	0	0	1	0	0	1	0
Cyclotella meneghiniana	0	0	0	0	1	0	0	7
Cyclotella ocellata	0	0	0	1	0	0	0	0
Cyclotella stelligera	0	0	0	6	0	4	3	0
Cymbella								
Cymbella cistula	2	2	1	2	0	0	2	4
Cymbella delicatula	0	0	0	0	0	0	0	3
Cymbella girdle sp.	6	5	8	0	14	0	1	2
Cymbella gracilis	0	0	0	0	0	0	0	2
Cymbella leptoceros	0	0	0	2	0	0	0	0
Cymbella minuta	89	70	38	50	92	124	74	126

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

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)

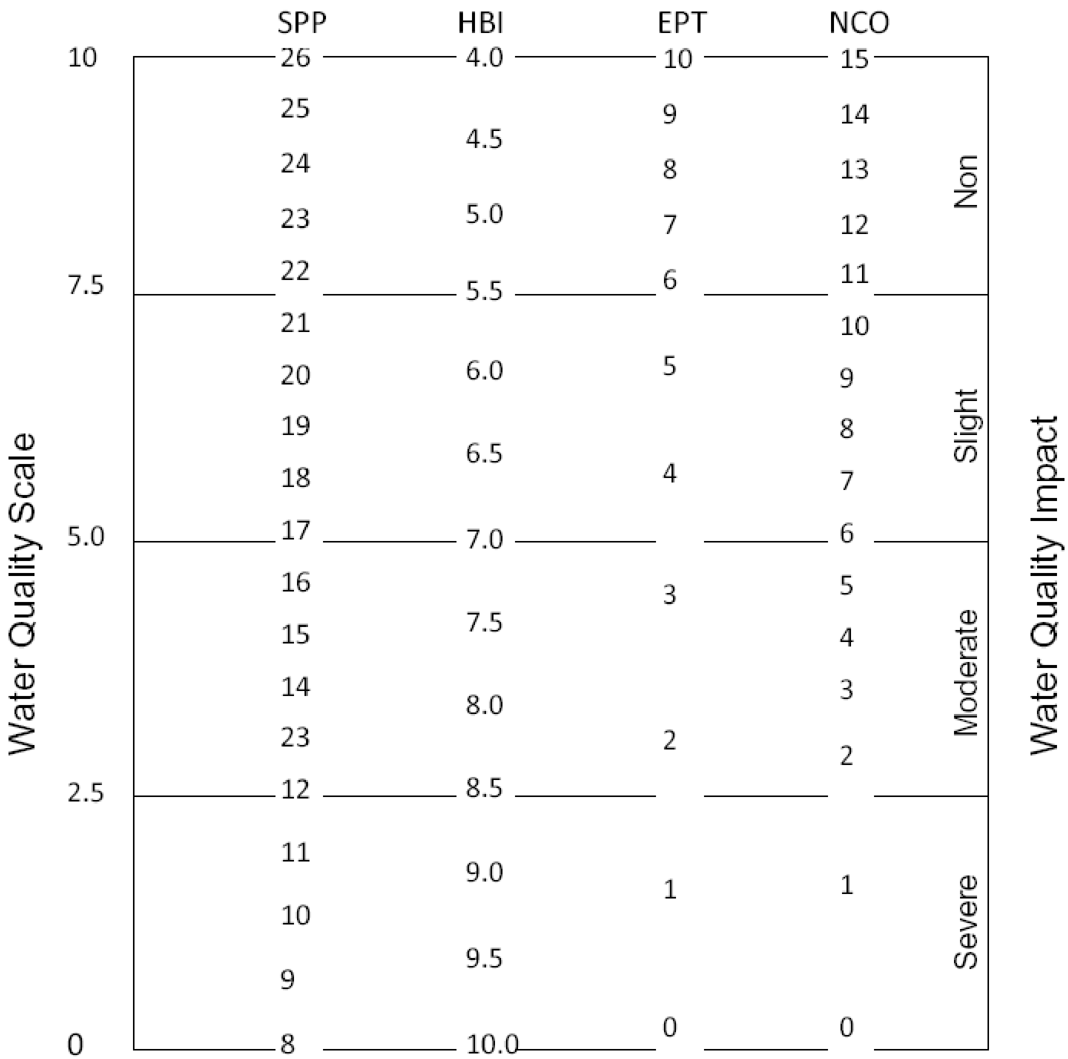
	MUNICIPAL/INDUSTRIAL								TOXIC					
	A	B	C	D	E	F	G	H	A	B	C	D	E	F
PLATYHELMINTHES	-	40	-	-	-	5	-	-	-	-	-	-	5	-
OLIGOCHAETA	20	20	70	10	-	20	-	-	-	10	20	5	5	15
HIRUDINEA	-	5	-	-	-	-	-	-	-	-	-	-	-	-
GASTROPODA	-	-	-	-	-	5	-	-	-	5	-	-	-	5
SPHAERIIDAE	-	5	-	-	-	-	-	-	-	-	-	-	-	-
ASELLIDAE	10	5	10	10	15	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

	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. Biological Assessment Profile of Slow, Sandy Streams.



The Biological Assessment Profile of index values is a method of plotting biological index values on a common scale of water quality impact. For kick-net samples from slow, sandy streams, these indices are used: SPP (species richness), HBI (Hilsenhoff Biotic Index), Ephemeroptera, Plecoptera, and Trichoptera (EPT richness), and non Chironomidae/Oligochaeta (NCO richness). Values from the four indices are converted to a common 0-10 scale as shown in this figure. The mean scale value of the four indices represents the assessed impact for each site.

Appendix XIII. Biological Impacts of Waters with High Conductivity

Definition: Conductivity is a measure of the ability of an aqueous solution to carry an electric current. It may be used to estimate salinity, total dissolved solids (TDS), and chlorides. Salinity is the amount of dissolved salts in a given amount of solution. TDS, although not precisely equivalent to salinity, is closely related, and for most purposes can be considered synonymous. EPA has not established ambient water-quality criteria for salinity; for drinking water, maximum contaminant levels are 250 mg/L for chlorides, and 500 mg/L for dissolved solids (EPA, 1995).

Measurement: Conductivity is measured as resistance and is reported in micromhos per centimeter (μmhos/cm), which is equivalent to microsiemens per centimeter (μS/cm). To estimate TDS and salinity, multiply conductivity by 0.64 and express the result in parts per million. For marine waters, salinity is usually expressed in parts per thousand. To estimate chlorides, multiply conductivity by 0.21 and express the result in parts per million. Departures from these estimates can occur when elevated conductivity is a result of natural conditions, such as in situations of high alkalinity (bicarbonates), or sulfates.

Effects on macroinvertebrates: Bioassays on test animals found the toxicity threshold for *Daphnia magna* to be 6-10 parts per thousand salinity (6000-10,000 mg/L) (Ingersoll et al., 1992). Levels of concern for this species were set at 0.3-6 parts per thousand salinity (300-6000 mg/L) (U.S. Dept. of Interior, 1998).

Stream Biomonitoring findings: Of 22 New York State streams sampled with specific conductance levels exceeding 800 μmhos/cm, 9% were assessed as severely impacted, 50% were assessed as moderately impacted, 32% were assessed as slightly impacted, and 9% were assessed as non-impacted. Many of the benthic communities in the impacted streams were dominated by oligochaetes, midges, and crustaceans (scuds and sowbugs). Thirty-five percent of the streams were considered to derive their high conductance primarily from natural sources, while the remainder were the result of contributions from point and nonpoint anthropogenic (human caused) sources. For nearly all streams with high conductivity, other contaminants are contained in the water column, making it difficult to isolate effects of high conductance.

Recommendations**:** Conductivity may be best used as an indicator of elevated amounts of anthropogenic-source contaminants. Based on findings that the median impact at sites with specific conductance levels exceeding 800 μmhos/cm is moderate impact, 800 μmhos/cm is designated as a level of concern with expected biological impairments. Eight-hundred umhos/cm corresponds to ~170 mg/L chlorides, ~510 parts per million Total Dissolved Solids, and ~0.51 parts per thousand salinity.

References:

US Dept. of Interior. 1998. Guidelines for interpretation of the biological effects of selected constituents in biota, water, and sediment. National Irrigation Water Quality Program Information Report No. 3.

Ingersoll, C.G., F.J. Dwyer, S.A. Burch, M.K. Nelson, D.R. Buckler, and J.B. Hunn. 1992. The use of freshwater and saltwater animals to distinguish between the toxic effects of salinity and contaminants in irrigation drain water. *Environmental Toxicology and Chemistry*, 11:503-511.

U.S. EPA. 995. Drinking water regulations and health advisories. U.S. Environmental Protection Agency, Office of Water, Washington, D.C., 11 pages.

Appendix XIV. 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 U.S. 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; either 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. NYSDEC size categories are: Sand < 2mm (.08"), Gravel 2-16mm (.08-2.5"), Course Gravel 16-64mm (.63-2.5"), Cobble 64-256mm (2.5-10.1"), Boulder > 256mm (>10.1").

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 (not diagonally across) the sides 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 complete.

Percentile analyses of substrate composition for pebble counts performed in NYS:

	Percentiles			
% Substrate	**25th**	**50th**	**75th**	**90th**
Silt	0.0	0.0	0.0	0.0
Sand	0.9	2.5	5.4	10.2
Gravel	7.6	11.2	20.6	29.0
Crse Grvl	19.7	29.4	42.9	57.4
Rubble	24.2	33.1	43.4	53.7
Rock	2.0	6.6	23.0	33.4
Bedrock	0.0	0.0	0.0	0.0

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 2 cm in diameter. If smaller than 2 cm, do not tally an entry, but measure the substrate size with the gravelometer as described previously.

Appendix XIV. cont'd.

Record moss and macro-algae cover using a scale from 0-3 with separate estimates for each, where:

0 = no moss or macro-algae present;
1 = some moss or macro-algae present, but < 5% coverage;
2 = 5-25% cover of substratum by moss or macro-algae, and
3 = > 25% cover of substratum by moss or macro-algae.

Estimate average thickness of micro-algae (periphyton) on the rock with a 0-6 thickness scale, where:

0 = substrate is rough with no apparent growth;
1 = substrate is slimy, but biofilm is not visible (tracks cannot be drawn in the film with the back of your fingernail; endolithic algae can appear green but will not scratch easily from the substratum);
2 = a thin layer of microalgae is visible (tracks can be drawn in the film with the back of your fingernail);
3 = accumulation of microalgae to a thickness of 0.5-1 mm;
4 = accumulation of microalgae from 1-5 mm thick;
5 = accumulation of microalgae from 5-20 mm;
6 = layer of microalgae is > 20 mm.

Note: If substrate is too large to pickup, algal growth should still be characterized.

Weighted Periphyton and Silt Index Calculation (PI) (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)

Percentile analyses of periphyton and silt index scores in NYS:

	Percentiles			
Index	25th	50th	75th	90th
Moss	0	0	0	0.34
Macro-aglae	0.85	2.63	5.96	7.98
Micro-algae	0.44	0.50	0.83	1.55
Silt Cover	0.60	1.89	3.63	4.45

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Appendix XV. Methods For Assessments of Water Quality Using Diatoms

Rationale: Water quality assessment using diatom communities is considered complimentary to assessments made through analysis of benthic macroinvertebrate communities. In some instances diatom communities may be used by themselves or in concert with macroinvertebrate communities to make water quality assessment determinations. In NYS, six different diatom community metrics are used to assess water quality. They are 1) Pollution Tolerance Index (PTI); 2) the Trophic Index (TRI); 3) the Salinity Index; 4) the Acidity Index; 5) the Siltation Index, and 6) the Diatom Model Affinity (DMA). A description of these individual metrics and calculation procedures follows in Section C. Analysis of Data.

A. Sampling: All major benthic habitats available—stones, macrophytes and mud—are sampled for diatom analysis at every site and mixed in a single, multi-habitat sample (MHS) that is representative of the periphytic flora of that site. Epilithon—diatom community growing on rocks—is scraped from pebbles, cobbles and boulders with a knife. Epiphyton—diatom community developing on plants—is collected from nonvascular and vascular plants by adding the whole plant or parts of it to the MHS. Brown flocculent material forming over mud is sampled for epipelic diatoms—those occurring on the surface of mud—using a pipette. All samples are preserved with 4% formaldehyde in the field.

B. Sample Processing and Organism Identification: Samples are processed in the laboratory with sulfuric acid following the method of Hasle and Fryxell (1970). Cleaned material is washed with distilled water eight times and then preserved in 100% ethanol. For light microscopy, the cleaned material is dried onto a cover glass with the flame of an alcohol lamp. A drop of ethanol is employed to speed the evaporation and spread the diatoms into an even layer. Permanent mounts are prepared using Naphrax® and at least 300 cells per mount are identified using an oil immersion objective lens at 1,000x magnification.

C. Analysis of Data: The data for this study were analyzed using three indices as part of the DAP: Pollution Tolerance Index, Trophic Index, and Diatom Model Affinity. The Siltation Index is ancillary to the DAP.

1. The Pollution Tolerance Index (PTI) is calculated as the sum of the relative abundance of each species multiplied by the pollution tolerance class of that species (Bahls, 1993). Provisional ranges for the levels of impact are: >2.50, non-impacted; 2.01-2.50, slightly impacted; 1.51-2.00, moderately impacted; and <1.50, severely impacted.

2. The Trophic Index is a measure of the percent mesotrophic to hypereutrophic individuals. Provisional ranges for the levels of impact are: 0-50, non-impacted; 51-70, slightly impacted; 71-85, moderately impacted; and 86-100, severely impacted.

3. The Diatom Model Affinity (DMA) is a percent similarity, reference-based, community metric which complements the Percent Model Affinity (PMA) metric used for benthic macroinvertebrate communities. It was derived through analysis of generic and species composition from NYS reference condition streams. Using a model diatom community composed of a combination of four major groups, the DMA compares a sample's similarity to the model. High similarity to the model indicates minimal disturbance, while low similarity suggests perturbation.

4. The Siltation Index (SI) is a measurement of the percent relative abundance of individuals belonging to motile genera, mostly *Navicula*, *Nitzschia*, and *Surirella*, which are adapted to living on unstable substrates. SI ranges from 0 to 100, using the following provisional ranges for the levels of siltation: Mountain streams: <20, no siltation; 20-39, minor siltation; 40-60, moderate siltation; and >60, heavy siltation. Plain streams (low elevation and slop*e): <60,* no siltation; 60-69, minor siltation; 70-80, moderate siltation; and >80, heavy siltation.

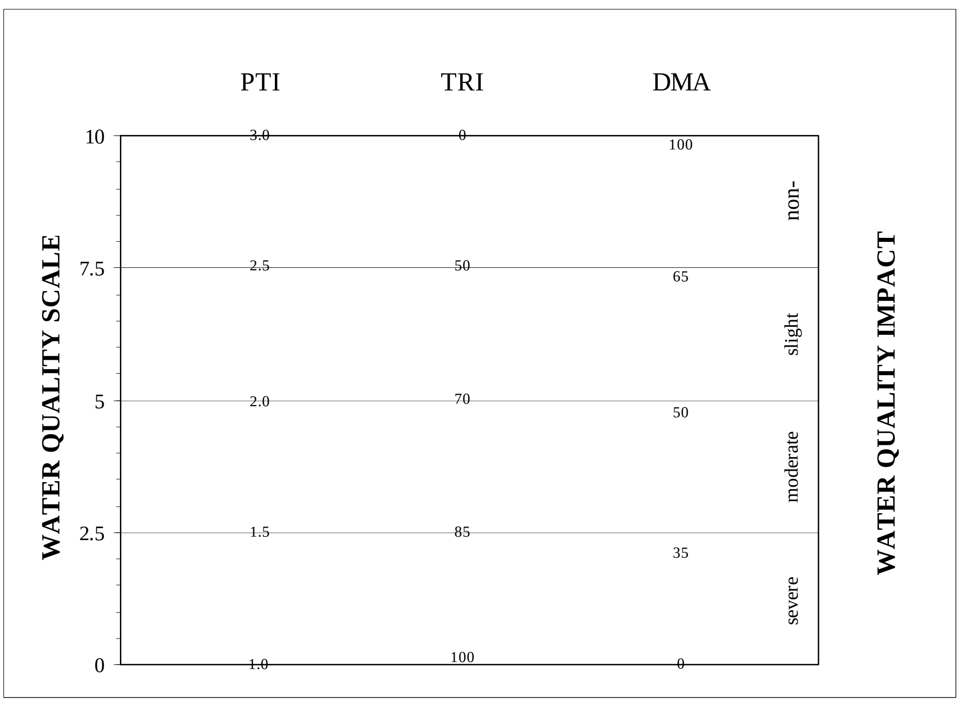
5. The Salinity Index is a measure of percent halophilous individuals, indicating dissolved salts. Levels of impact are: 0-10, non-impacted; 11-30, slightly impacted; 31-50, moderately impacted; and 51-100, severely impacted.

6. The Acidity Index is a measure of percent acidophilous individuals, reflecting acid effects. Levels of impact are: 0-20, non-impacted; 21-50, slightly impacted; 51-75, moderately impacted; and 76-100, severely impacted.

<u>Diatom Assessment Profile (DAP) of Index Values for Diatom Communities</u>

As with the Biological Assessment Profile (BAP) of index values for benthic macroinvertebrate assessments, a select set of the diatom metrics are combined to form a multimetric known as the Diatom Assessment Profile (DAP) of index values. Like the BAP, this multimetric score corresponds to a similar scale of four water quality impact categories. The individual metrics used in calculating the DAP are 1) the PTI; 2) the TRI, and 3) DMA. The impact categories and corresponding DAP values are: Non-Impact 10-7.5, Slight Impact 7.5-5, Moderate Impact 5-2.5, and Severe Impact 2.5-0.

<u>Calculation of the DAP</u>



Diatom Assessment Profile (DAP) of index values for multiple habitat samples from wadeable streams. Values from three indices; Polution Tolerance Index (PTI), Trophic Index (TRI), and Diatom Model Affinity (DMA) are converted to a common 0-10 scale as shown in this figure. The mean value of the three indices represents the assessed impact for each site.

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