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WISCOY CREEK

Biological Stream Assessment

April 1, 2015

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BIOLOGICAL STREAM ASSESSMENT

Wiscoy Creek
Wyoming and Allegany Counties, New York
Genesee River Basin

Survey date: June 25-26, 2014
Report date: April 1, 2015

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Stream: Wiscoy Creek

River Basin: Genesee River

Reach: Bliss to Rossburg, NY

Background

The Stream Biomonitoring Unit (SBU) conducted a biological assessment of water quality at seven locations on Wiscoy Creek including two locations on the North Branch Wiscoy Creek, June 25-26, 2014. The survey was initiated at the request of Department of Environmental Conservation (NYSDEC) Region 9 Fish, Wildlife, and Marine Resources staff over concerns related to angler complaints of low aquatic insect hatches. In addition, this survey provides baseline data for a significant portion of the Wiscoy Creek watershed for which little data existed previously in the SBU database.

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

Results and Conclusions

1. Overall water quality in Wiscoy Creek is fully supporting of aquatic life. Biological assessment of water quality indicates non- to slightly impacted conditions. The most degraded water quality was observed on the North Branch of Wiscoy Creek and on the main-stem Wiscoy Creek downstream of Bliss.

2. Water quality improves downstream of Bliss until its confluence with the Genesee River in Rossburg. The data suggest impacts to water quality are the result of non-point source nutrient runoff. Additionally, some locations on Wiscoy Creek would benefit from improvements to local habitat conditions including actions to reduce fine sediment and increase riparian vegetation.

3. The results of this survey are similar to the historical data available for Wiscoy Creek. It is unlikely that concerns over reduced aquatic insect emergences are the result of anything more than natural yearly variability in benthic macroinvertebrate communities.

Discussion

The Wiscoy Creek watershed is located in western New York, west of the Finger Lakes in the Genesee River Basin. Approximately 112 mi^2 in drainage area, Wiscoy Creek is formed in Bliss, NY downstream of Route 362 by the confluence of the North Branch Wiscoy Creek flowing south from Route 78 and the West Branch Wiscoy Creek near Route 39. From here, Wiscoy Creek flows east for approximately 19.5 miles until its confluence with the Genesee River in Rossburg, NY (Figures 1 – 2e). Based on 2011 national landcover data landuse in the watershed is predominately agriculture, split between pasture and hay (20%) and cultivated crop land (29%). Natural landcover types including forest cover (33%), wetland and open water (10%) also dominate. Minimal developed land exists within the watershed and is localized to a few specific population centers including Bliss, Gainesville, and Pike (Figure 1). In addition to the North and West Branches the East Koy Creek is a major tributary which joins the main-stem Wiscoy Creek before its confluence with the Genesee River in Rossburg, NY. The East Koy Creek is similar in size to the upstream watershed area of the Wiscoy Creek. Sampling was conducted in this creek by the SBU in 2014 as well, however, results of this sampling are not yet completed and will be reported on at a later time.

Previously collected biological assessment data on Wiscoy Creek exists for three locations. These sites were surveyed in 1999 and 2000 (WCOY-12.8) (Figure 2c), 2009 (WCOY-5.6) (Figure 2d) and 1999 and 2004 (WCOY-0.7) (Figure2e). Results of these previous surveys suggest water quality through 2009 has remained fully supportive of aquatic life with conditions ranging from non- to slightly impacted. Any impacts identified during these sampling events were generally attributed to non-point source nutrient runoff and in the case of WCOY-12.8, due to variable flow conditions at the time of sampling in 2000. In 2014, the SBU was contacted by NYSDEC Region 9 Fish, Wildlife, and Marine Resources staff over concerns related to angler complaints of low aquatic insect hatches in the Wiscoy Creek watershed. SBU staff were requested to survey Wiscoy Creek in its entirety to address this concern and identify any potential impacts to aquatic life. Additionally, because of the limited number of historical sampling locations relative to the size of the Wiscoy Creek watershed, this survey would serve to provide comprehensive baseline data. The SBU conducted a biological assessment on June 25-26, 2014 at seven locations on Wiscoy Creek including two locations on the North Branch.

Similarly to historical surveys, biological assessment of macroinvertebrate communities in the Wiscoy Creek suggested non- to slightly impacted water quality in June of 2014 (Figure 3).The poorest water quality was assessed at the furthest upstream site located on the North Branch (WCOY-N2.6) (Figure 1 and 2). This site was assessed as slightly impacted but nearing moderately impacted conditions. This assessment was due, in part, to the low numbers of pollution intolerant taxa, specifically those in the orders Ephemeroptera, Plecoptera and Trichoptera (EPT). Also, the community at this site was dissimilar in composition to reference model stream invertebrate communities measured by percent model affinity (PMA), and there was an abundance of nutrient tolerant taxa as indicated by the nutrient biotic index for phosphorus (NBI-P) (Figure 3). For example over 60% of the sample from WCOY N2.6 was made up of only a few taxa and these were indicative of nutrient enrichment. These included the freshwater scud *Gammarus* sp. (20%), the non-biting midges *Micropsectra dives* gr. (26%) and *Pagastia orthogonia* (8%), and the riffle beetle *Optioservus fastiditus* (10%) (Table 5). Impact source determination (ISD) indicated sewage effluent and animal wastes as the most likely source of impact to benthic macroinvertebrate communities (Table 2). The surrounding land at this location consists of dense agriculture in the form of both cropland and pasture in close proximity to the stream (Figure 1). Habitat improvements have been made at this location to bolster the local fishery. Details on Wiscoy Creek fisheries assessment can be found in Cornett (2013). Although habitat at this site was assessed as altered this does not indicate habitat conditions that would negatively impact the invertebrate community (Figure 5, Table 4). Therefore, it is probable that water quality at this site is degraded due to high non-point source nutrient runoff and siltation from surrounding agricultural land. This is further supported by the low NBI-P score for this location and the presence of silt as a component of the substrate (Figure 4, Table 3).

Although still assessed as slightly impacted, water quality conditions improve downstream on the North Branch just upstream from the confluence with the main-stem Wiscoy Creek in Bliss at station WCOY-N0.2. The main-stem in Bliss at station WCOY-19.4 (Figures 2a and 3) was assessed as non-impacted. Like the upstream location, the lower North Branch site contains large areas of agriculture in its immediate floodplain, however, before it reaches Bliss several substantial tributaries join it. These tributaries drain elevated, forested regions of the watershed likely contributing less nutrient enriched, less sediment laden water before reaching WCOY-N0.2 (Figure 1). WCOY-19.4, which has some of the highest water quality of the locations surveyed, also has the greatest percentage of forest cover in its upstream watershed (Figure 1 and 3). While this location had a diverse benthic macroinvertebrate community with high species richness and high percentage of intolerant taxa, especially those in the EPT orders (Figure 3), the data suggest WCOY-19.4 is still affected by nutrients as indicated by the low NBI-P score (Figure 3). The low NBI-P score is likely the result of the presence of several filter feeding caddisfly species including *Ceratopsyche bronta*, *C. slossonae*, the tolerant mayflies *Baetis flavistriga*, *B. intercalaris* and *B. tricaudatus*, as well as the filtering non-biting midge larvae *Microtendipes pedellus* gr. and *Tanytarsus* sp. (Table 5).

Downstream of the confluence of the main-stem Wiscoy Creek and its North Branch, water quality impact declines from non-impacted at WCOY-19.4 to slightly impacted at WCOY-16.5 (Figure 3). This is despite the lack of development and agricultural activity at this location. However, substrate conditions do change compared with other sampling locations. There is a much higher percentage of small substrates including coarse gravel and gravel and an absence of the more common larger rubble found elsewhere in the stream (Figure 4, Table 3). These smaller substrates may in part inhibit colonization by some taxa, especially if interstitial pore space is minimal. The substrate data suggest this is likely the case because embeddedness increases from 25% upstream at WCOY-19.4 to 50% at WCOY-16.5 and remains high downstream (Table 6). Besides embeddedness and sediment deposition, which were ranked the worst for this site of all the individual habitat variables assessed, overall habitat condition remains good. Some of the individual habitat variables ranked as part of the assessment may have less of a direct effect on the macroinvertebrate community, for example riparian vegetation quality and buffer width. While other components such as embeddedness and sediment deposition, which were ranked low at this site, may have greater influence on the structure of the macroinvertebrate community (Table 4, Figure 5). As a result individual habitat parameters may occasionally be more indicative of certain invertebrate responses compared with the overall habitat assessment which is the case here.

Moving downstream toward the confluence with the Genesee River, water quality in Wiscoy Creek begins to improve. Benthic macroinvertebrate community data suggests water quality transitions from slightly impacted at WCOY-12.8 (Figure 1, 2c and 3) to non-impacted at WCOY-5.6 and WCOY-0.7 (Figure 1, 2d, 2e and 3). Substrate composition becomes most similar to upstream sites at WCOY-5.6 and 0.7 (Figure 4). Habitat also improves at these two locations after being reduced at WCOY-12.8 (Figure 5). Habitat was assessed as severely altered at WCOY-12.8, indicating it has been disturbed enough to have the potential to affect in-stream biological communities such as macroinvertebrates. Many of the individual habitat variables ranked poorly at this location including; epifaunal substrate cover, embeddedness, sediment deposition, channel alteration, bank vegetative protection and width of the riparian zone. Despite the alterations to habitat, water quality at this location was good enough to counter these disturbances. Therefore, it is likely that even minor improvements to habitat at WCOY-12.8 would improve biological community condition substantially.

Improved habitat conditions and their benefits could be observed at stations WCOY-5.6 and 0.7. At these locations habitat assessments improved substantially compared with WCOY-12.8 as well as did benthic macroinvertebrate condition assessments (Figure 3, Table 2). The improvements in biological community condition are evident in increased species richness, richness of sensitive orders of insects (EPT) and similarity to model macroinvertebrate communities (PMA) (Figure 3). However, nutrients from non-point source runoff still appear to reduce water quality. East Koy Creek joins the Wiscoy Creek upstream of station WCOY-0.7. This river contains a large amount of agricultural land in its watershed which could be introducing additional nutrients to the Wiscoy Creek. Similarly there is a significant dam and pond upstream of this site as well which may influence the amount of fine particulate organic matter available in the water column. As a result benthic macroinvertebrate community condition is likely not as good as it might otherwise be absent runoff with high nutrient concentrations and the effects of the dam on dynamics of water column chemistry. Many of the macroinvertebrate taxa at these two locations can be characterized as nutrient tolerant and function through filtration of fine particulate organic matter such as suspended algae. For example WCOY-5.6 and 0.7 had substantial proportions of filtering non-biting midge larvae (Diptera: Chironomidae) such as *Micropsectra dives* gr., *Microtendipes pedellus* gr., *M. rydalensis* gr., *Polypedilum aviceps*, *Tanytarsus curticornis*, and *T. glabrescens* gr. as well as several different species of filter feeding caddisfly larvae in the genus *Ceratopsyche* sp. (Table 5).

Overall water quality in Wiscoy Creek is fully supporting of aquatic life. Biological assessment of water quality indicates non- to slightly impacted conditions. The poorest water quality was observed on the North Branch of Wiscoy Creek at stations WCOY-N2.6 and N0.2 and on the main-stem Wiscoy Creek downstream of Bliss at WCOY-16.5 (Figure 3). Water quality improves continually downstream until its confluence with the Genesee River in Rossburg. The data suggest impacts to water quality are the result of non-point source nutrient runoff. This is most likely from substantial areas of agricultural land in close proximity to the stream throughout the watershed. Additionally, some locations on Wiscoy Creek would benefit from improvements to local habitat conditions. These would include improvements which would reduce the presence of fine sediment deposition and increase riparian vegetative protection and widen buffers between adjacent disturbed lands. In addition to improving water quality through reductions in nutrient and sediment loads habitat improvements will also benefit fisheries substantially in Wiscoy Creek. These benefits will likely arrive through better temperature control with improved riparian and stream bank improvements.

The results of this survey are similar to the historical data available for Wiscoy Creek. Although limited for the size of the watershed, this historical data provides some context for identifying whether significant changes in benthic macroinvertebrate condition have occurred. The present survey data did not show a shift in biological impact category and therefore suggests benthic macroinvertebrate communities have remained stable. It is likely that any observed reductions in aquatic insect emergences result from natural yearly variability.

Literature Cited

Cornett, S. 2013. Wiscoy Creek Trout Population and Fishery Monitoring Summary 2006-2012. Division of Fish Wildlife and Marine Resources, NewYork State Department of Environmental Conservation, Region 9, Allegany, New York, Technical Report, 71 pages.

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

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

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

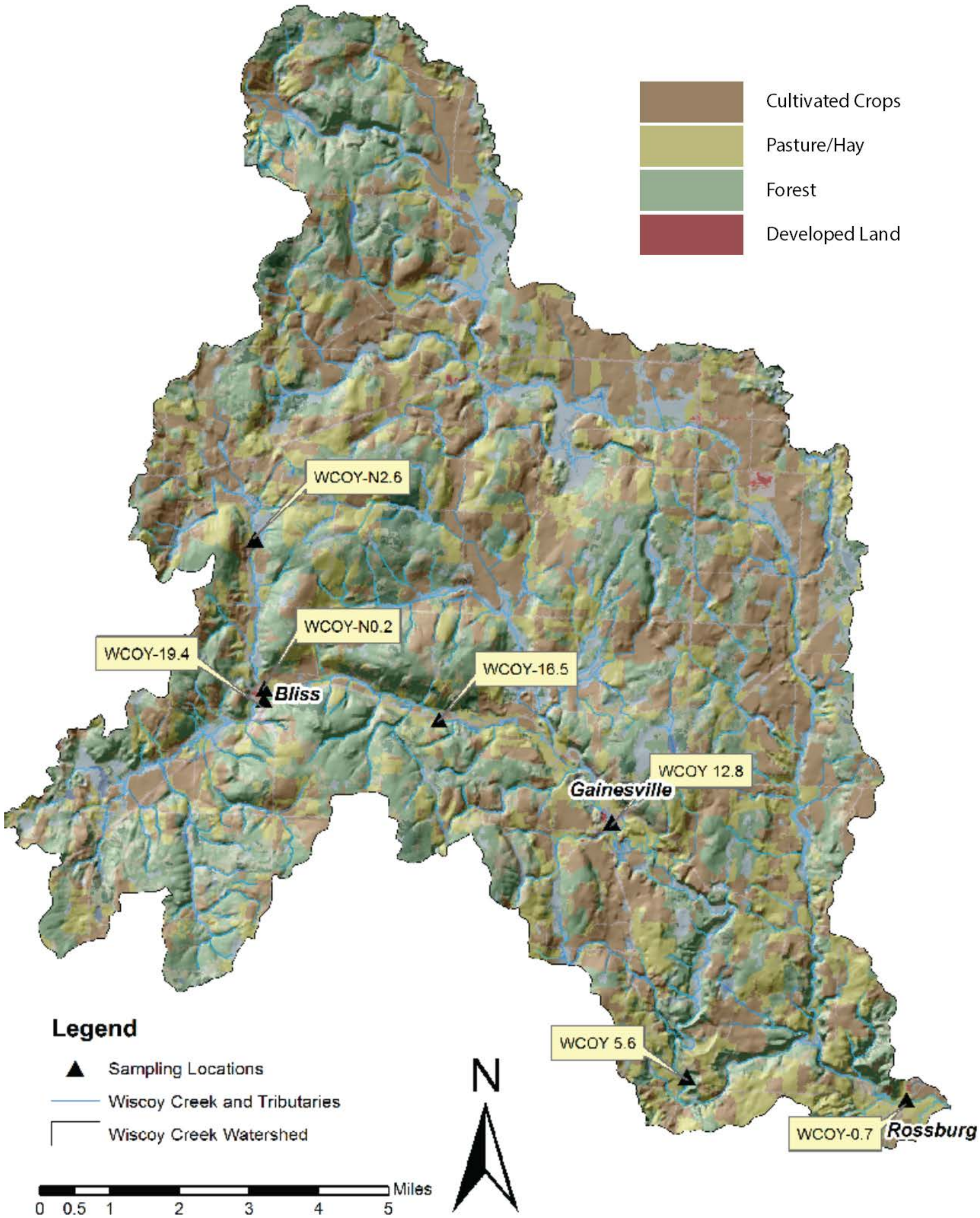


Figure 2. Site location map, North Branch Wiscoy Creek, Station N2.6.

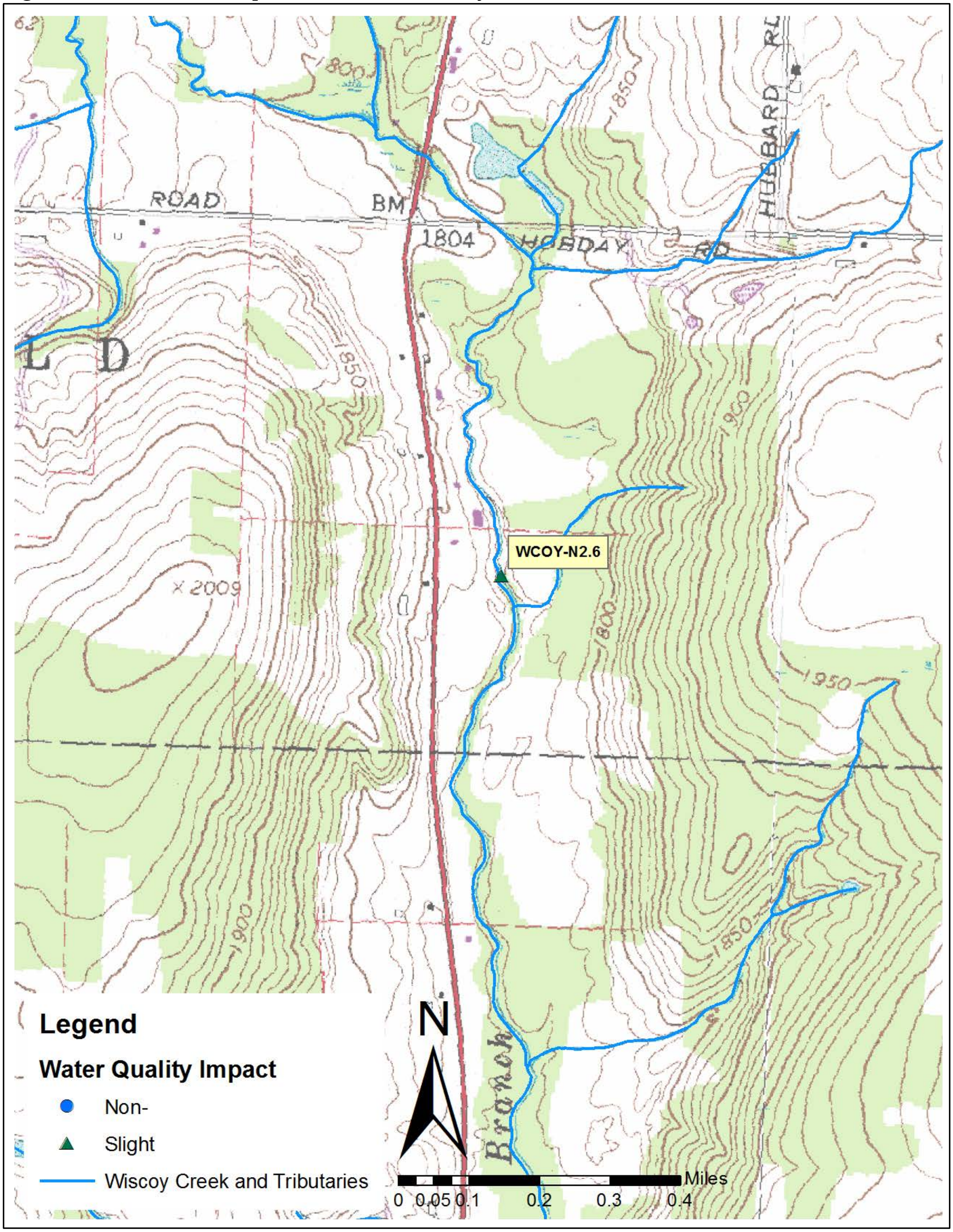


Figure 2a. Site location map, North Branch and Main-stem Wiscoy Creek, Stations N0.2, 19.4.

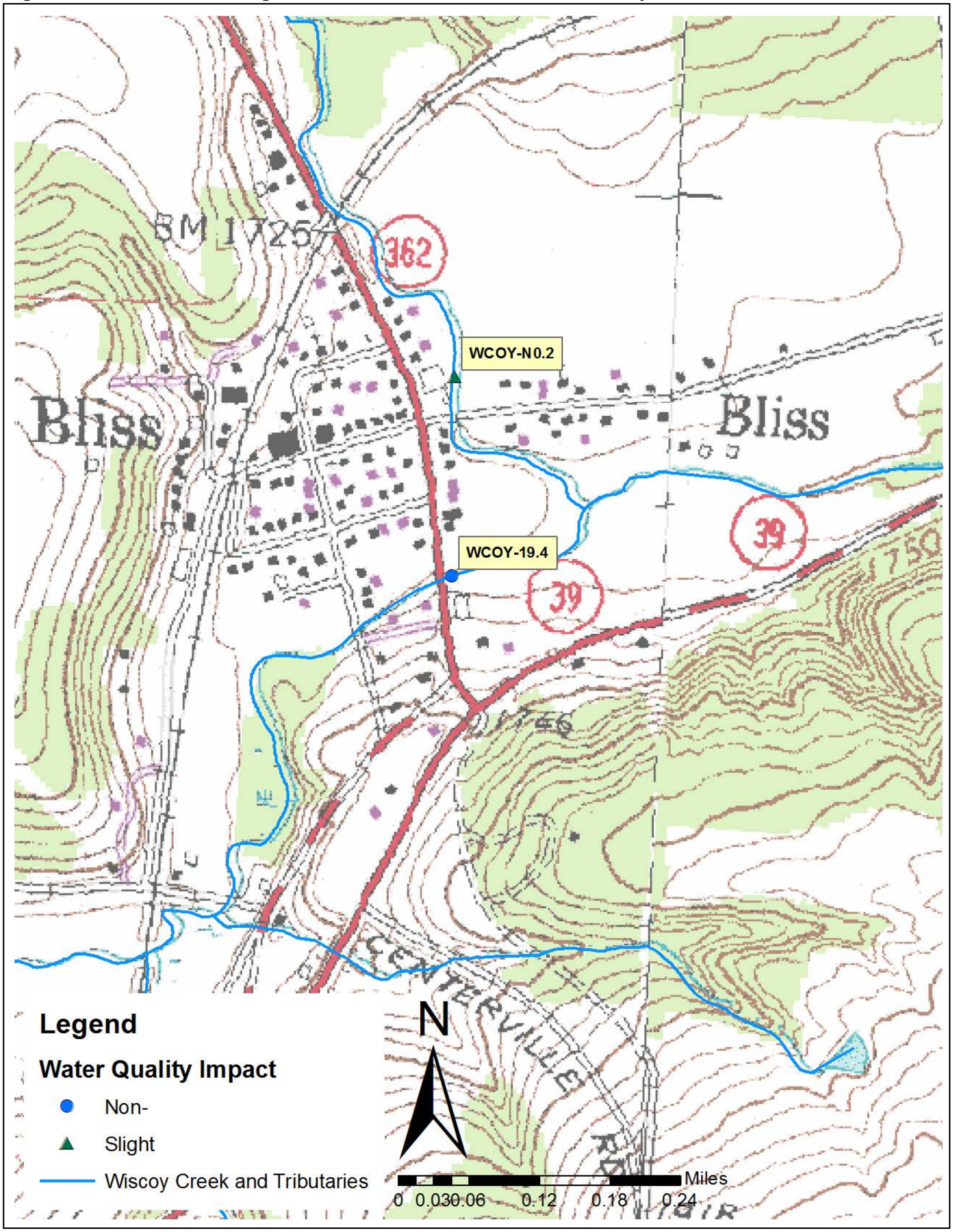


Figure 2b. Site location map, Wiscoy Creek, Station 16.5.

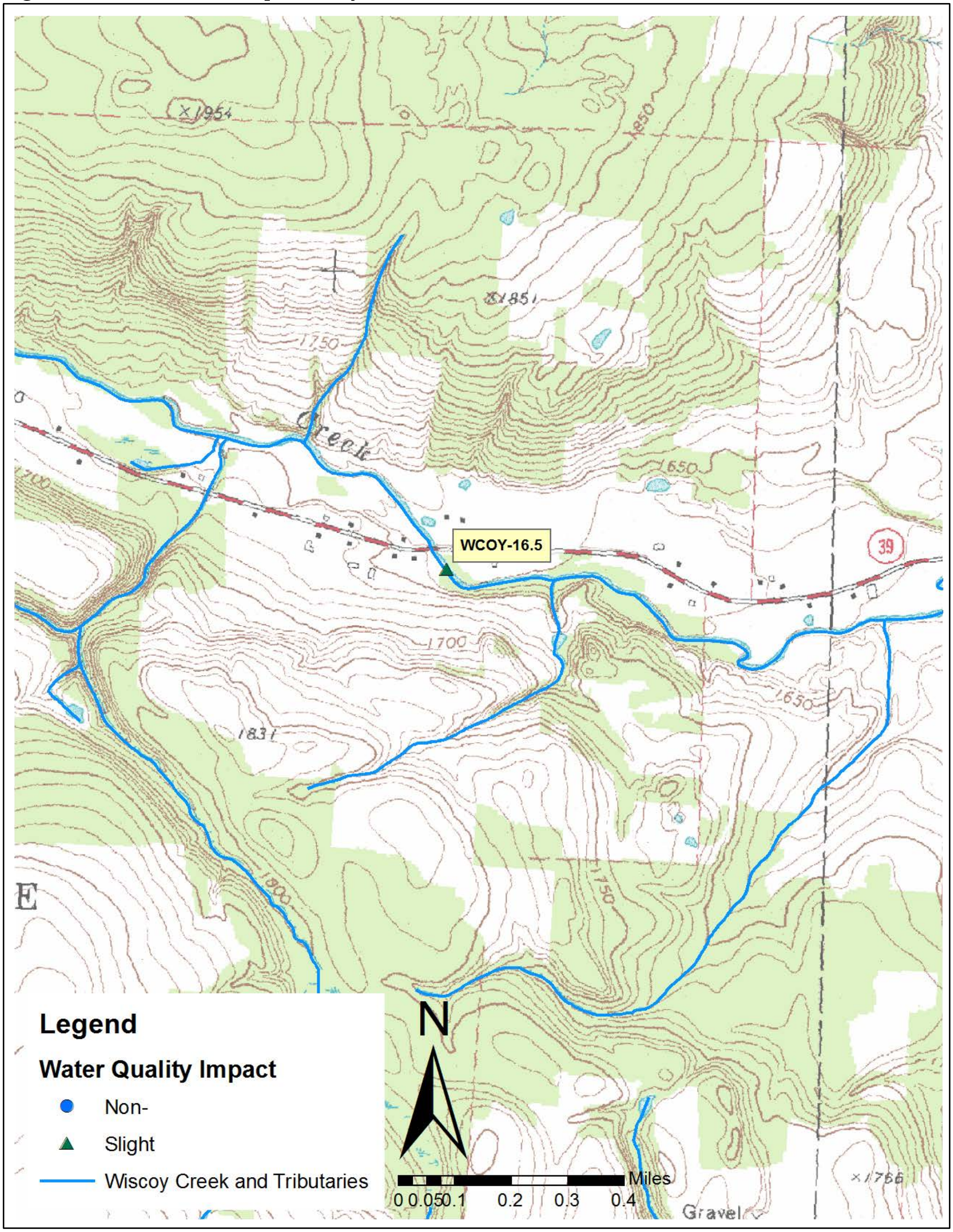


Figure 2c. Site location map, Wiscoy Creek, Station 12.8.

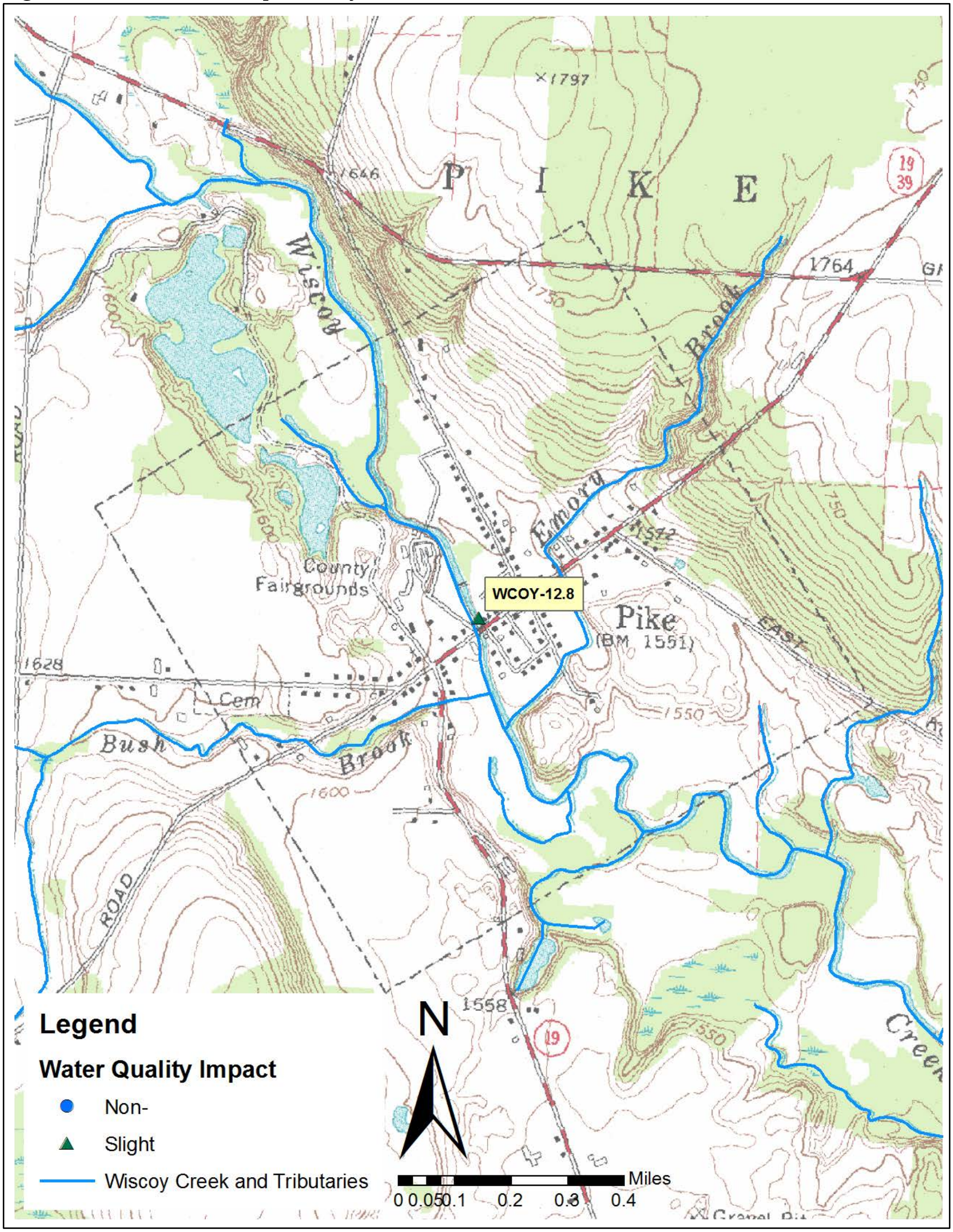


Figure 2d. Site location map, Wiscoy Creek, Station 5.6.

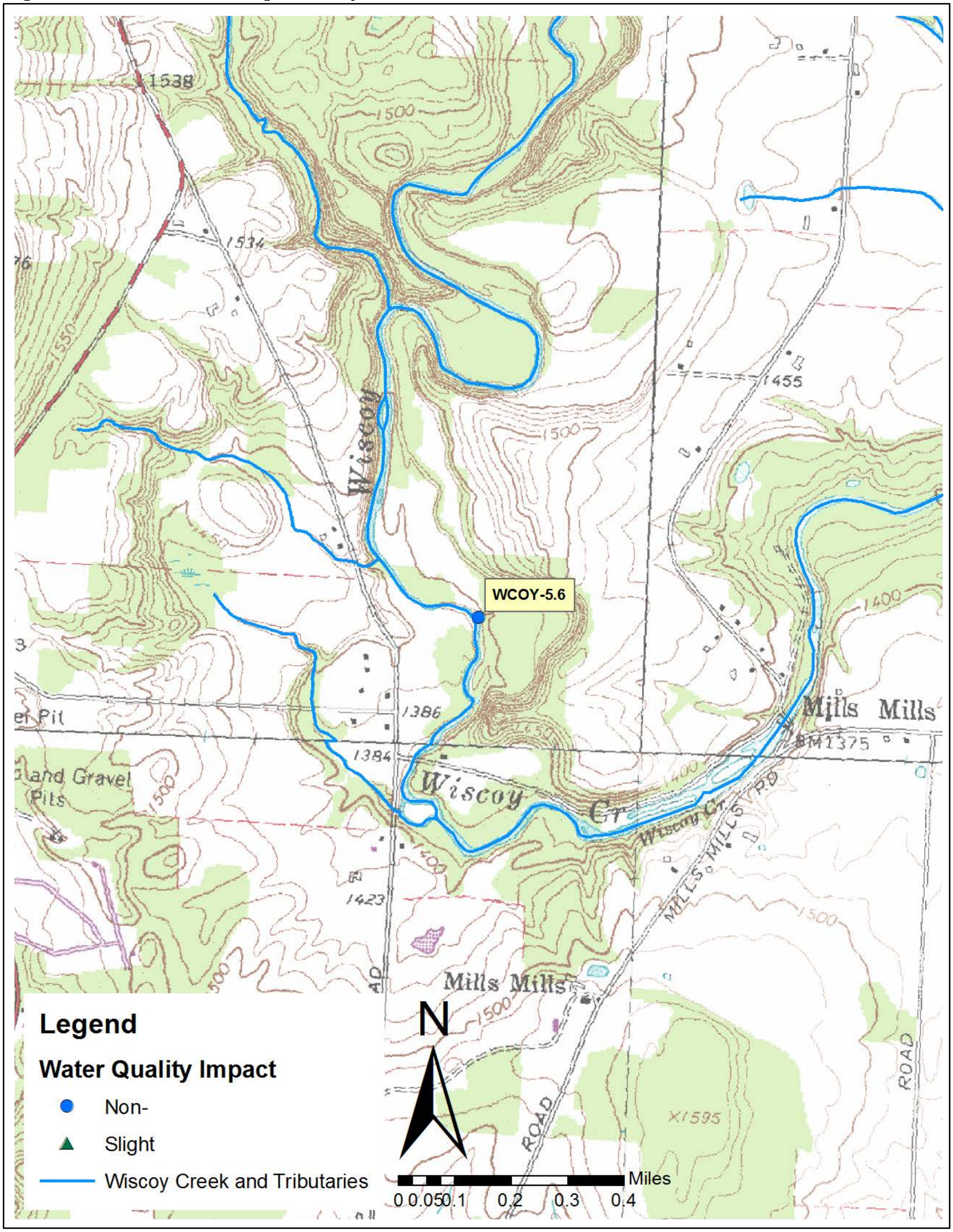


Figure 2e. Site location map, Wiscoy Creek, Station 0.7.

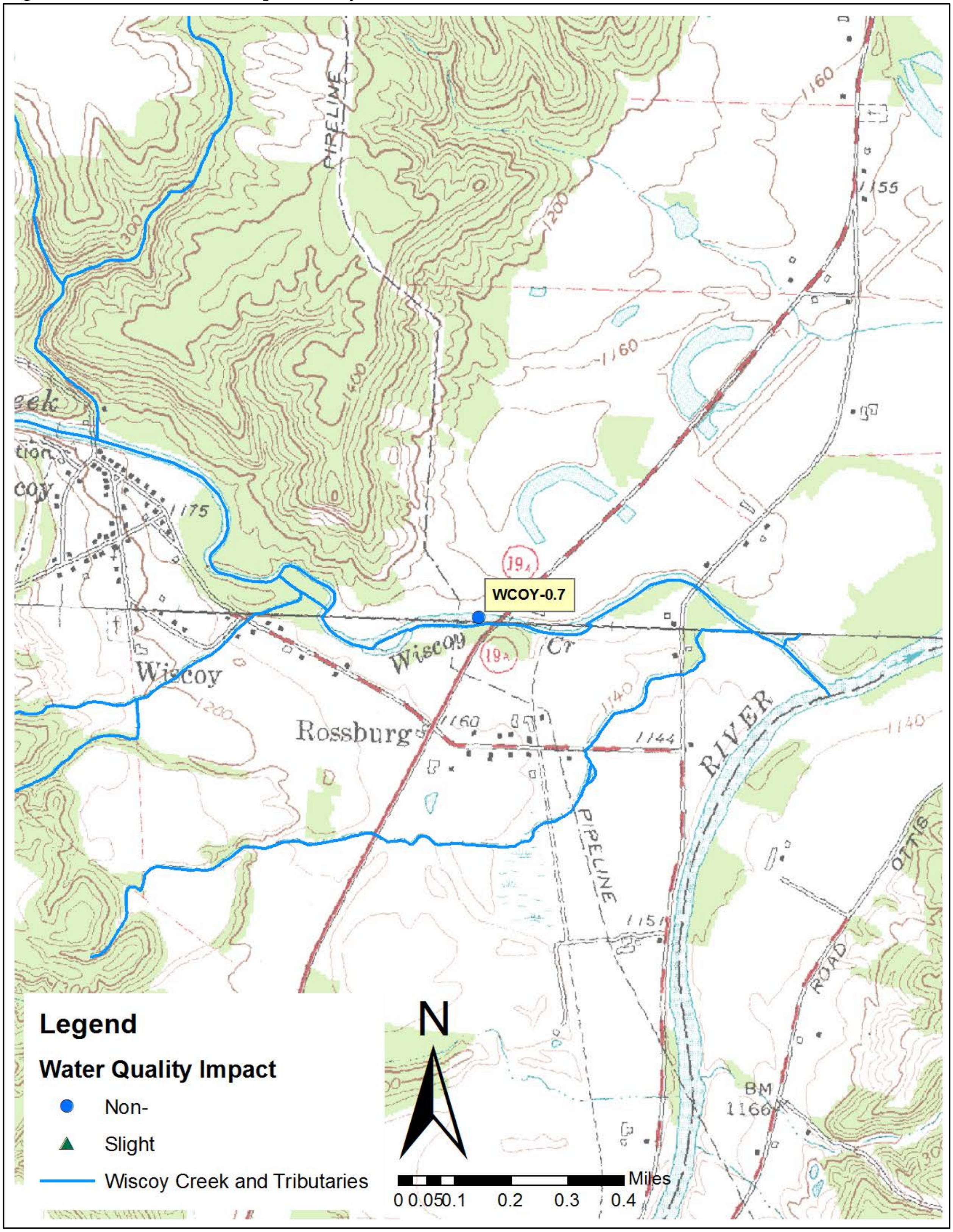


Table 1. Survey locations on Wiscoy Creek, 2014.

WCOY-N2.6	Bliss, NY	
	End of Northern Angler Footpath	
	Latitude:	42.612217
	Longitude:	-78.257547

WCOY-N0.2	Bliss, NY	
	At E. Main Street	
	Latitude:	42.581083
	Longitude:	-78.253293

WCOY-19.4	Bliss, NY	
	At SR. 362/ Pearl St.	
	Latitude:	42.5784
	Longitude:	-78.253208

WCOY-16.5	Bliss, NY	
	100 m below SR 39 Bridge	
	Latitude:	42.575887
	Longitude:	-78.203773

Table 1 Cont'd. Survey locations on Wiscoy Creek.

WCOY-12.8	Pike, NY 100 m above Rt. 19 Bridge Latitude: 42.555873 Longitude: -78.154238		
WCOY-5.6	Fillmore, NY Ukrainian American Work Camp Latitude: 42.503362 Longitude: -78.130467		
WCOY-0.7	Rossburg, NY 50 m above Rt. 19A Bridge Latitude: 42.500167 Longitude: -78.068532		

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

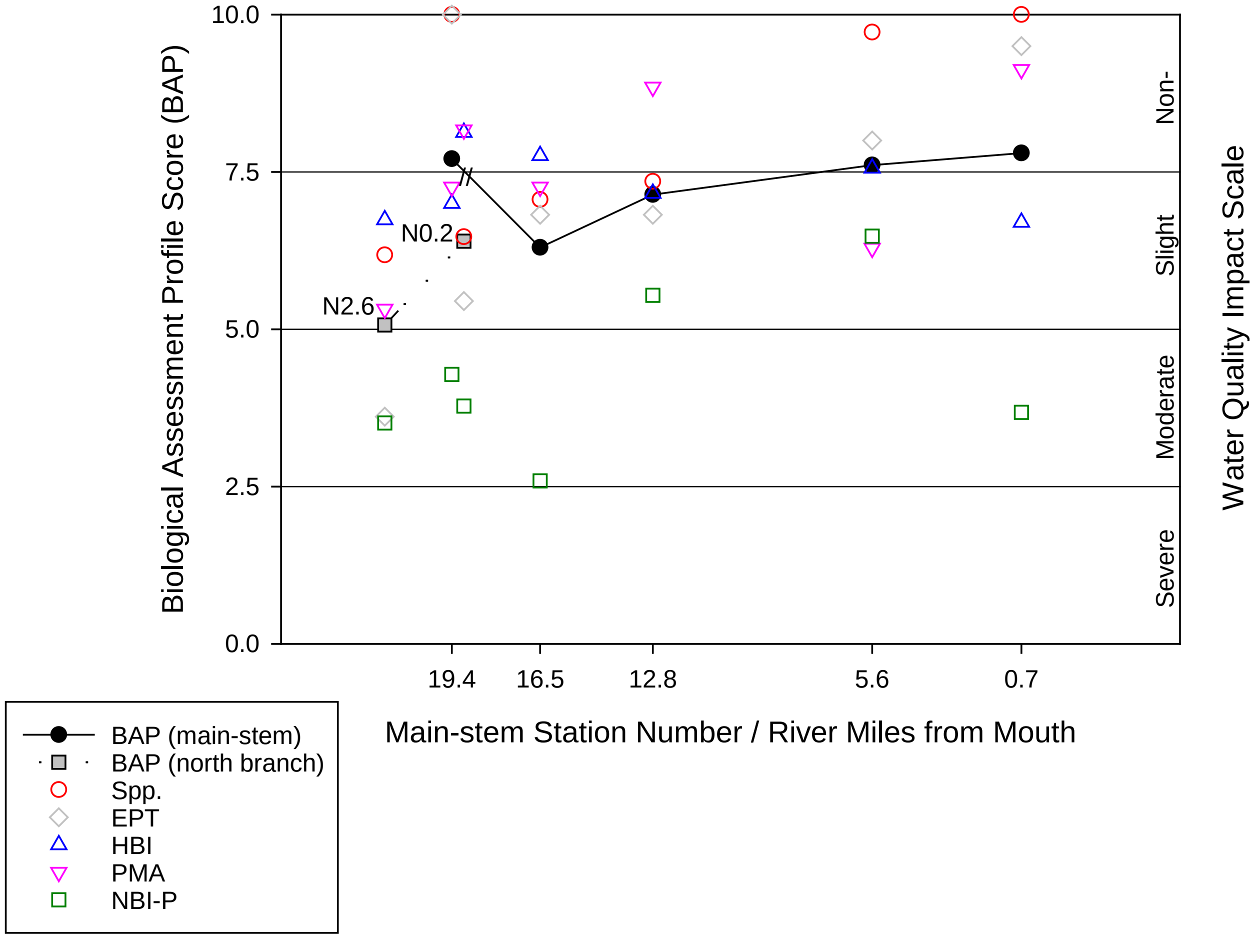


Table 2. Summary of Impact Source Determination (ISD) results for Wiscoy Creek, 2014. Category abbreviations are Mun./Ind.= Municipal/Industrial sources, Non-point = Non-point source nutrient runoff, Sew./An. Wastes = Sewage effluent and animal waste sources. Further detail on ISD is found in Appendix X. Shaded values represent ≥50% similarity to ISD model communities indicating a significant result. Values ≤50% represent inconclusive results.

Station	Mun./Ind.	Non-point	Sew./An. Wastes	Siltation	Toxic
WCOY-N2.6	47	29	57	40	38
WCOY-N0.2	27	38	27	34	33
WCOY-19.4	29	49	42	49	31
WCOY-16.5	18	39	24	30	22
WCOY-12.8	8	13	8	8	8
WCOY-5.6	24	37	40	41	19
WCOY-0.7	33	43	39	44	35

Figure 4. Pebble count analysis from Wiscoy Creek, 2014.

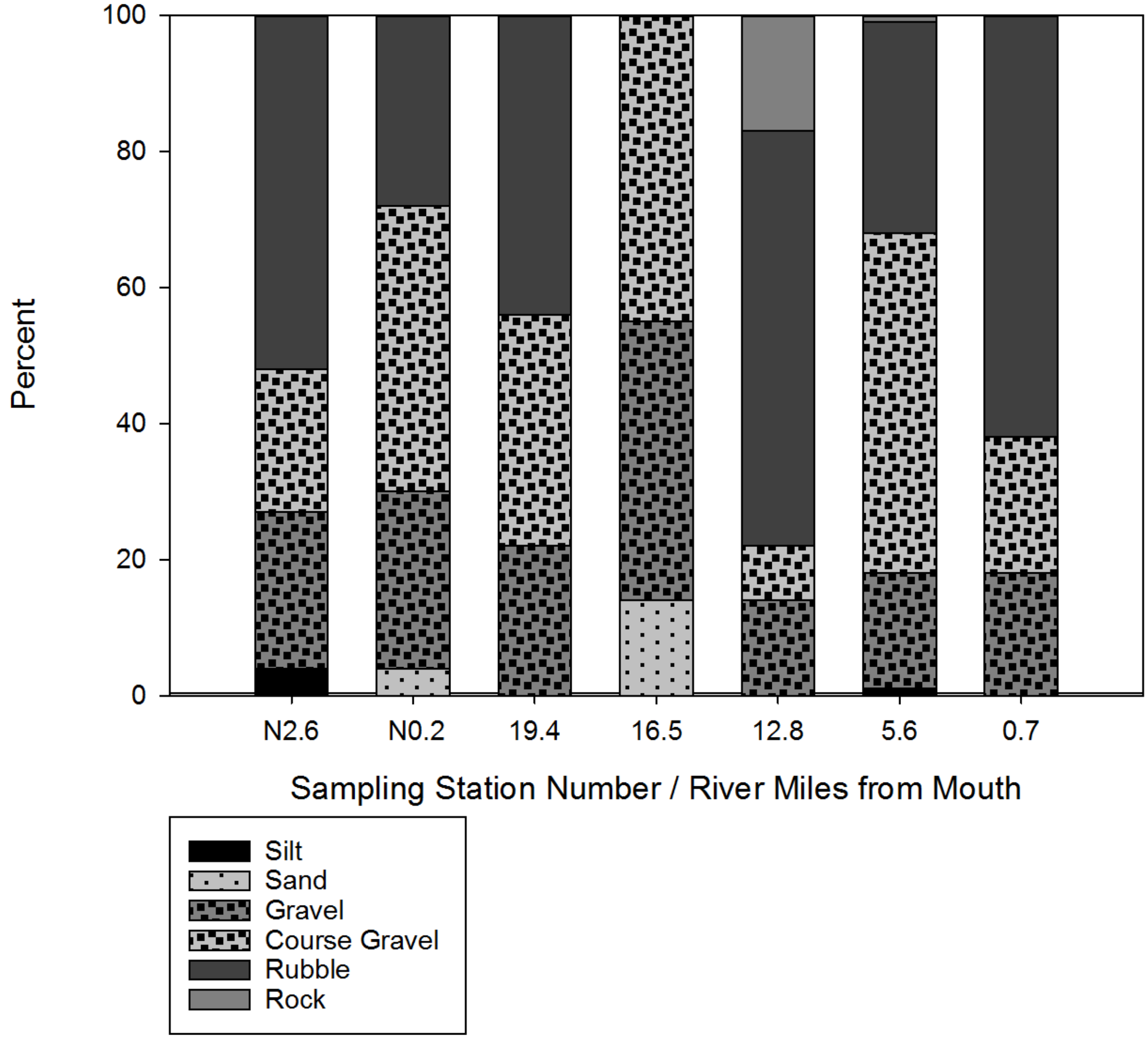


Table 3. Summary of substrate particle sizes recorded from pebble counts in Wiscoy Creek, 2014. Values are calculated as a proportion of the total from a random count of 100 pebbles in the stream reach. Coarse Gravel is abbreviated as C. Gravel.

Station	Silt	Sand	Gravel	C. Gravel	Rubble	Rock
WCOY-N2.6	0.04	0.00	0.23	0.21	0.53	0.00
WCOY-N0.2	0.00	0.04	0.26	0.42	0.28	0.00
WCOY-19.4	0.00	0.00	0.22	0.34	0.44	0.00
WCOY-16.5	0.00	0.14	0.41	0.45	0.00	0.00
WCOY-12.8	0.00	0.00	0.14	0.08	0.61	0.17
WCOY-5.6	0.01	0.00	0.17	0.50	0.31	0.01
WCOY-0.7	0.00	0.00	0.18	0.20	0.62	0.00

Figure 5. Habitat assessment scores for each sampling location on Wiscoy Creek, 2014.

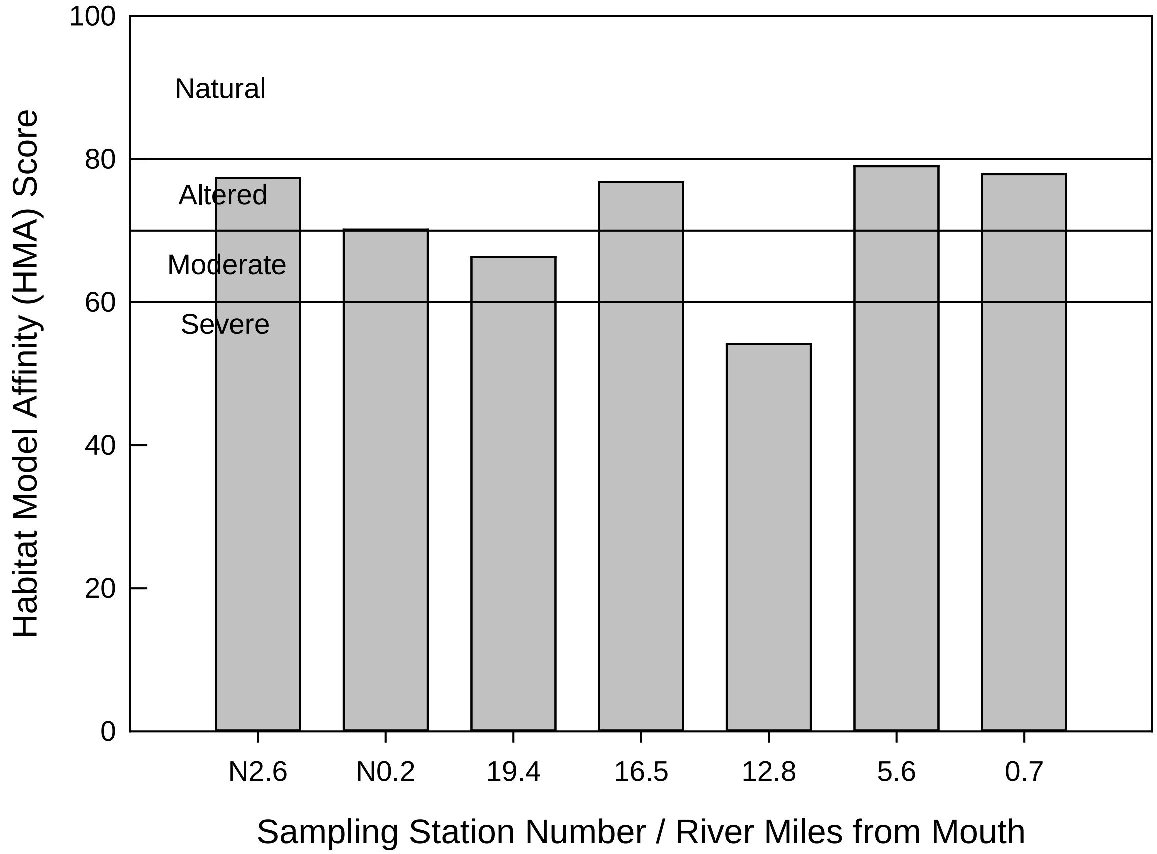


Table 4. Summary of physical habitat attribute scores* used in calculating the Habitat Model Affinity (Figure 4) at locations on Wiscoy Creek, 2014.

Station	Epi. Cover	Embed.	Vel/Dep Reg.	Sed. Dep.	Flow Satus	Chan. Alt.	Rif. Freq.	Bank Stab.	Bank Veg.	Rip. Width
WCOY-N2.6	7	13	17	11	18	18	13	18	14	11
WCOY-N0.2	6	14	10	14	18	15	15	16	12	7
WCOY-19.4	10	16	6	12	18	15	14	15	11	3
WCOY-16.5	16	6	17	7	18	15	17	16	16	11
WCOY-12.8	8	5	17	10	18	3	17	14	6	0
WCOY-5.6	12	14	16	17	18	17	17	12	10	10
WCOY-0.7	11	9	17	9	18	16	17	12	16	16

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

Table 5. Macroinvertebrate species collected in Wiscoy Creek, 2014.

Genus species	Location - Station						
	WCOY N2.6	WCOY N0.2	WCOY 19.4	WCOY 16.5	WCOY 12.8	WCOY 5.6	WCOY 0.7
Acentrella sp.			3		12		6
Acentrella turbida						2	
Agnetina capitata		2	1				
Antocha sp.			1			1	
Atherix sp.					2		1
Baetis flavistriga	2		3				1
Baetis intercalaris			1	3	3	1	3
Baetis tricaudatus	3	25	1	8	12	2	23
Brillia flavifrons							1
Caecidotea communis	3						
Caenis sp.						1	1
Ceraclea sp.		1					
Ceratopsyche bronta			4	1			3
Ceratopsyche morosa					3		2
Ceratopsyche slossonae		1	1				
Ceratopsyche sp.					3		1
Ceratopsyche sparna							1
Cheumatopsyche sp.		2		1	3	2	2
Conchapelopia sp.	1	1				3	1
Cricotopus bicinctus	3	1				1	
Cricotopus sp.		1					2
Cricotopus tremulus gr.	1						
Cricotopus trifascia gr.	1	1			1		
Cryptochironomus fulvus gr.			1				
Diamesa sp.			1				
Dolophilodes sp.	1	8		2			
Drunella cornutella						1	
Ephemera guttulata			2				
Eukiefferiella sp.				1		1	
Gammarus sp.	20	2					
Hemerodromia sp.			3				
Hexatoma sp.				6	2	1	
Hydroporus sp.			1				
Isonychia sp.						1	
Leucrocuta sp.			1	1			
Maccaffertium mediopunctatum			1				
Maccaffertium terminatum			1				
Micropsectra dives gr.	26	7				7	1
Microtendipes pedellus gr.	1	1	16	2	3	12	4
Microtendipes rydalensis gr.		1	1		2	1	2

Genus species	Location - Station						
	WCOY N2.6	WCOY N0.2	WCOY 19.4	WCOY 16.5	WCOY 12.8	WCOY 5.6	WCOY 0.7
Nais bretscheri					2		1
Nais sp.				1			
Nixe (Nixe) sp.					2	9	1
Ophidonais serpentina	7						
Ophiogomphus sp.				1		2	
Optioservus fastiditus	10		1				1
Optioservus ovalis		18		40		6	
Optioservus sp.			7		8		10
Optioservus trivittatus			1			2	1
Pagastia orthogonia	8	19		1		2	1
Paragnetina media							1
Paraleptophlebia sp.			3				
Parametriocnemus sp.			1	1	7		
Plauditus sp.							1
Polypedilum aviceps	2	3	4	10	12	12	2
Polypedilum flavum			1		1	3	2
Polypedilum tritum		1					
Pristina sp.					1		
Prodiamesa olivacea	1						
Psephenus herricki			2			1	1
Psilotreta sp.			1				
Rheocricotopus robacki		1			2	1	
Rheotanytarsus exiguus gr.	1			1		2	
Rheotanytarsus pellucidus						1	
Rheotanytarsus sp.							1
Serratella deficiens				2	1	1	2
Simulium sp.	1			1		1	
Stempellinella sp.				1	1	2	1
Stenacron sp.			1				
Stenelmis crenata			14				5
Sublettea coffmani		1	1				1
Synorthocladius sp.					1		
Tanytarsus curticornis gr.			4	7	9	8	7
Tanytarsus glabrescens gr.						6	2
Tanytarsus sp.			10				
Thienemanniella xena							1
Thienemannimyia gr. spp.			1				
Tricorythodes sp.			1		3	2	
Tubifex	4						
Tvetenia bavarica gr.	1			2	3	1	
Tvetenia vitracies		1		1			2

Genus species	Location - Station						
	WCOY N2.6	WCOY N0.2	WCOY 19.4	WCOY 16.5	WCOY 12.8	WCOY 5.6	WCOY 0.7
Undet. Tubificidae w/ cap. setae	2						
Undet. Tubificidae w/o cap. setae	1						
Undetermined Cambaridae				1			
Undetermined Enchytraeidae		1	1				1
Undetermined Ephemerellidae						1	
Undetermined Heptageniidae			1				
Undetermined Hydropsychidae				4			
Undetermined Lumbricina			2				
Undetermined Nemertea					1		
Undetermined Perlidae				1			
Undetermined Pisidiidae		1					

Table 6. Summary of field measured physical and chemical attributes from each sampling location on Wiscoy Creek, 2014.

Station	Depth (m)	Width (m)	Current (cm/sec)	Embed. (%)	Temp. (°C)	Conduct. (µmhos)	pH	DO (mg/L)	DO Sat. (%)
WCOY-N2.6	0.1	4	40	~	14.9	498	7.9	8.9	89
WCOY-N0.2	0.1	4	40	30	15.1	470	8.2	9.4	94
WCOY-19.4	0.1	4	30	25	19.9	371	8.2	8.8	97
WCOY-16.5	0.2	5	50	50	16.9	429	8.1	8.8	90
WCOY-12.8	0.2	10	50	60	16.2	422	8.2	9.4	96
WCOY-5.6	0.3	10	50	50	17.6	429	8.4	9.9	100
WCOY-0.7	0.3	15	60	60	19.0	434	8.4	9.4	102

Appendix I. Biological Methods for Kick Sampling

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

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

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

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

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

Appendix II. Macroinvertebrate Community Parameters

1. Species Richness: the total number of species or taxa found in a sample. For subsamples of 100-organisms each that are taken from kick samples, expected ranges in most New York State streams are: greater than 26, non-impacted; 19-26, slightly impacted; 11-18, moderately impacted, and less than 11, severely impacted.

2. EPT Richness: the total number of species of mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) found in an average 100-organisms subsample. These are considered to be clean-water organisms, and their presence is generally correlated with good water quality (Lenat, 1987). Expected assessment ranges from most New York State streams are: greater than 10, non-impacted; 6-10, slightly impacted; 2-5, moderately impacted, and 0-1, severely impacted.

3. Hilsenhoff Biotic Index: a measure of the tolerance of organisms in a sample to organic pollution (sewage effluent, animal wastes) and low dissolved oxygen levels. It is calculated by multiplying the number of individuals of each species by its assigned tolerance value, summing these products, and dividing by the total number of individuals. On a 0-10 scale, tolerance values range from intolerant (0) to tolerant (10). For the purpose of characterizing species' tolerance, intolerant = 0-4, facultative = 5-7, and tolerant = 8-10. Tolerance values are listed in Hilsenhoff (1987). Additional values are assigned by the NYS Stream Biomonitoring Unit. The most recent values for each species are listed in Quality Assurance document, Bode et al. (2002). Impact ranges are: 0-4.50, non-impacted; 4.51-6.50, slightly impacted; 6.51-8.50, moderately impacted, and 8.51-10.00, severely impacted.

4. Percent Model Affinity: a measure of similarity to a model, non-impacted community based on percent abundance in seven major macroinvertebrate groups (Novak and Bode, 1992). Percentage abundances in the model community are: 40% Ephemeroptera; 5% Plecoptera; 10% Trichoptera; 10% Coleoptera; 20% Chironomidae; 5% Oligochaeta; and 10% Other. Impact ranges are: greater than 64, non-impacted; 50-64, slightly impacted; 35-49, moderately impacted, and less than 35, severely impacted.

5. Nutrient Biotic Index: a measure of stream nutrient enrichment identified by macroinvertebrate taxa. It is calculated by multiplying the number of individuals of each species by its assigned tolerance value, summing these products, and dividing by the total number of individuals with assigned tolerance values. Tolerance values ranging from intolerant (0) to tolerant (10) are based on nutrient optima for Total Phosphorus (listed in Smith, 2005). Impact ranges are: 0-5.00, non-impacted; 5.01-6.00, slightly impacted; 6.01-7.00, moderately impacted, and 7.01-10.00, severely impacted.

Appendix III. Levels of Water Quality Impact in Streams

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

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

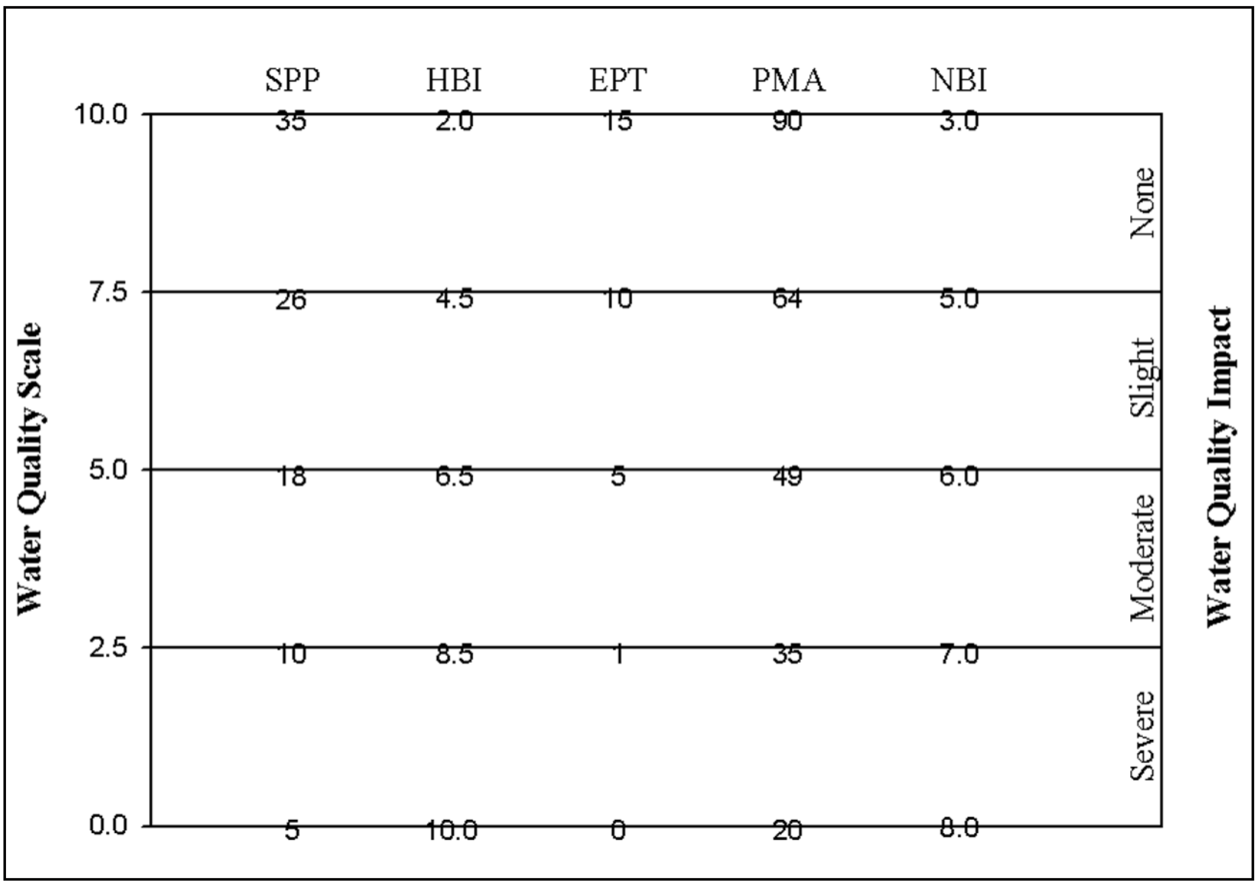
2. *Slightly impacted*: Indices reflect good water quality. The macroinvertebrate community is slightly but significantly altered from the pristine state. Species richness is usually 19-26. Mayflies and stoneflies may be restricted, with EPT richness values of 6-10. The biotic index value is 4.51-6.50.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

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

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

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

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



Appendix IV-B. Biological Assessment Profile: Plotting Values

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

Example data:

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

Appendix V. Water Quality Assessment Criteria

Non-Navigable Flowing Waters

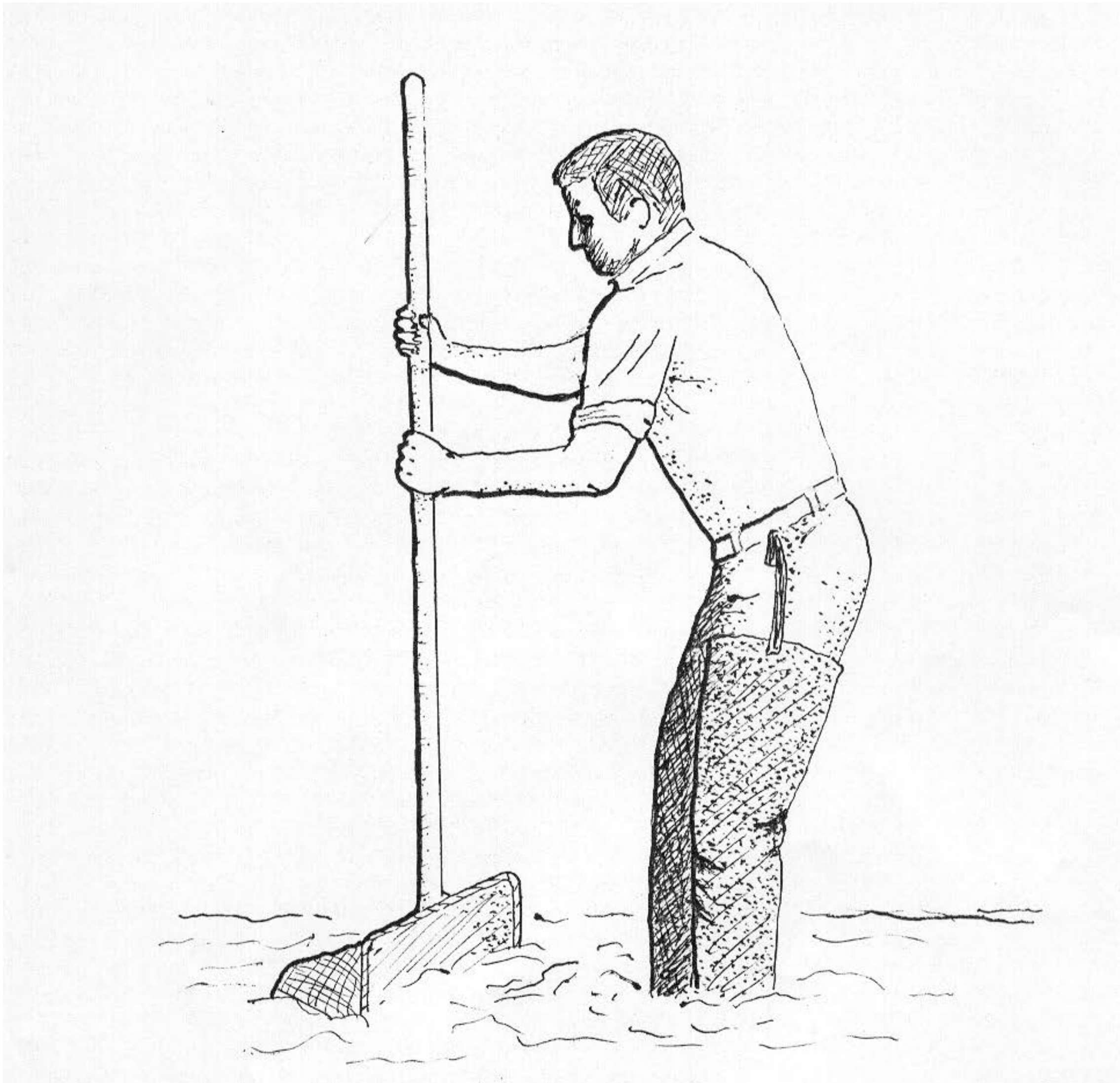
	Species Richness	Hilsenhoff Biotic Index	EPT Value	Percent Model Affinity*	Nutrient Biotic Index
Non-Impacted	>26	0.00-4.50	>10	>64	<5.00
Slightly Impacted	19-26	4.51-6.50	6-10	50-64	5.01-6.00
Moderately Impacted	11-18	6.51-8.50	2-5	35-49	6.01-7.00
Severely Impacted	0-10	8.51-10.00	0-1	<35	>7.01

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

Navigable Flowing Waters

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

Appendix VI. The Traveling Kick Sample



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

⟵ current

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

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

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

MAYFLIES

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

STONEFLIES

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

CADDISFLIES

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

BEETLES

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

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

MIDGES

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

BLACK FLIES

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

more common, though

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