BIOLOGICAL STREAM ASSESSMENT

Woodbury Creek
Orange County, New York
Lower Hudson River Basin

Survey date: May 8, 2007
Report date: June 8, 2007

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Stream: Woodbury Creek, Orange County, New York

Reach: Highland Mills to mouth at Moodna Creek, Mountainville, New York

River Basin: Lower Hudson

Background

The Stream Biomonitoring Unit sampled Woodbury Creek in Orange County, New York, on May 8, 2007. The purpose of the sampling was to assess overall water quality and compare it to the results of surveys in 2005, 2004 and 1987. An additional goal was to determine if nymphs of the stonefly *Amphinemura delosa*, an indicator of excellent water quality, were present in the stream, as they were in 1987, but not since then. Dick Manley of the Moodna Watershed Coalition, and local resident Mary Gross-Ferraro, assisted in the survey and provided additional information.

One traveling kick sample for macroinvertebrates was taken in a riffle area at each of six sites using methods described in the Quality Assurance document (Bode et al., 2002) and summarized in Appendix I. The contents of each sample were field-inspected, to determine major groups of organisms present, and then preserved in alcohol for laboratory inspection of a 100-specimen subsample from each site. 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). Expected variability of results is stated in Smith and Bode (2004). Table 4 provides a listing of sampling sites and Table 3 provides a listing of all macroinvertebrate species collected in the present survey. This is followed by macroinvertebrate data reports, including raw data from each site.

Results and Conclusions

1. Water quality in Woodbury Creek ranged from non-impacted to slightly impacted. Compared to 2005 results, water quality showed no appreciable change at the upstream sites, but did show an unexplained decline at the most downstream site.

2. The indicator stonefly *Amphinemura delosa* was found at one site in Woodbury Creek, and at two tributary sites. This species was designated in the 1987 report as a suitable indicator of future water quality in the creek. Its presence appears to be related primarily to salinity in Woodbury Creek. Increased salinity since 1987 has diminished the occurrence of viable populations of the species in the main stem of the creek. The less saline tributaries provide more favorable water quality for its larvae, and drift likely accounts for those found in the main stem.

3. Salinity in Woodbury Creek, as measured by specific conductance, was highest in 2005, and has decreased since then. Corrective measures undertaken by the Woodbury Commons mall in 2006-2007, including construction of a new salt storage facility and the use of sand/salt mixtures, have likely been responsible for lower salinity levels in Woodbury Creek.

Discussion

Woodbury Creek was previously sampled by the Stream Biomonitoring Unit in 1987, 2004 and 2005 at the same four sites used in the present survey (Novak et al., 1987; Bode et al., 2004; Bode et al., 2005). Sampling was conducted to identify and then track the source of high specific conductance in the stream. Salt-laden runoff from the Woodbury Commons Mall parking lot was identified as the primary source of high specific conductance in the stream.

Based on resident macroinvertebrate communities collected in the 2004 survey, water quality was assessed as moderately impacted at the upstream site and slightly impacted at the three downstream sites. Water quality at all sites in the 2004 sampling appeared worse compared to the results of the 1987 sampling. Elevated specific conductance in Woodbury Creek was cited as the greatest change in the stream since 1987, with a rise in conductance from 160 µmhos/cm in 1987 to 1226 µmhos/cm in 2004, a 766% increase. The 2005 survey found better conditions at Stations 01, 03, and 04, but more degraded conditions at Station 02 (Figure 3).

Water quality at the four main stem sites in the present survey ranged from slightly impacted to non-impacted (Figure 1). Station 01 was largely affected by slow current speed and pond-like conditions upstream, as in previous years. Station 02 at Quaker Meetinghouse appeared more impacted than in previous years, Station 03 appeared similar to previous years, and Station 04 appeared more impacted than in previous years.

Salt levels in Woodbury Creek, as measured by specific conductance, exhibit both annual and seasonal variation (Figure 3). Specific conductance data have been collected by Mr. Dick Manley, Moodna Creek Coalition, since 2004. Conductance levels were highest in 2005 and have decreased since then. Corrective measures undertaken by Woodbury Commons Mall in 2006-2007, including construction of a new salt storage facility and the use of sand/salt mixtures (pers. comm., Alex Feliciano, Woodbury Commons Facility Manager), have likely been partially responsible for lower conductance levels in Woodbury Creek.

Novak et al. (1987) noted, "The continued presence of *Amphinemura delosa*, an intolerant stonefly found in abundance at Station 02, will be a good indicator of high water quality." This stonefly was not found in the 2004 survey, but this species normally emerges as an adult in the spring and would not be expected to be found as a nymph in a July sampling. In order to determine whether *Amphinemura delosa* was still found at Station 02, follow-up sampling was conducted on May 5, 2005 to allow direct comparison to the 1987 data. No *Amphinemura delosa* were found at any site in that survey, either in the 100-organism subsamples or in supplementary scanning of entire samples. The status of *Amphinemura delosa* was therefore unresolved.

In the present survey, larvae of the stonefly *Amphinemura delosa* were found at three sites: Tributary 6 (Station WOOD-02A), Mineral Springs, and Station 02. It was found in low numbers at all these sites; only in Tributary 6 was it in sufficient numbers to appear in the 100-organism subsample. This is the first known collection of this species in the Woodbury Creek watershed since 1987, and shows that it has not been extirpated from the watershed.

In Woodbury Creek, we theorize that increased salinity from 1987 to 2005 greatly diminished the viability of populations in the main stem of the creek. Less saline tributaries such as Tributary 6 and Mineral Springs provide more favorable water quality for the larvae, and some larvae are likely carried downstream into the main stem. This may account for the occurrence of a few larvae at Woodbury Creek Station 02, which is located 0.4 mile downstream of the confluence of Tributary 6. It seems likely that continued decreases in salinity would allow the recolonization of stable populations of *Amphinemura delosa* in Woodbury Creek, while increases in salinity would further restrict its viability in the main stem.

An examination of the natural history of *Amphinemura delosa* reveals that it is considered to be a relatively scarce species with limited distribution (Earle, 2003). In the northeastern U.S., adults appear in May (Earle, 2003). The larvae feed on algae and detritus (Minshall, 1967) and frequent warmer, small streams (Ricker, 1952). The larvae are tolerant of acid mine drainage, iron and aluminum precipitate, natural acidity and acid precipitation, silt, and intermittent flow (Earle, unpublished). With adaptations to headwater conditions, nutrient enrichment and salinity naturally would be affecting the populations of *A. delosa*.

Nutrient enrichment, previously documented in the 2005 Woodbury Creek report, was again especially noted at Station 02, with an abundance of algae. The dissolved oxygen level of the stream at this site was supersaturated (134%), indicating high photosynthetic activity and probable night time oxygen deficits. The pH at this site was very high (8.8), and this also is probably caused by the photosynthetic activity of the abundant algae. Remarkably, these values for dissolved oxygen and pH are identical with those measured in 2005 at this site, attesting to identical conditions with regard to algae and nutrients. The Nutrient Biotic Index (NBI, see Appendix X), developed by Smith et al. (2007), showed eutrophic levels at Station 02, similar to the 2005 results (Figures 4 and 5). As stated in the 2005 report (Bode et al., 2005), effluents from the sewage treatment facilities of two developments in Highland Mills enter through tributaries between Stations 01 and 02, and are likely related to the greater evidence of nutrient enrichment at Station 02.

Water column samples taken during this survey were analyzed for total phosphorus, ammonium, calcium, chloride, dissolved organic carbon, magnesium, nitrate, nitrite, total dissolved nitrogen, organic monomeric aluminum, total aluminum, total monomeric aluminum, pH, potassium, silicon, specific conductance and sulfate. Total phosphorus (TP) level, at Woodbury Creek Station 02 and Tributary 6 Station 02A, exceeded the provisional nutrient guidance for aquatic life use impairment by phosphorus (Smith et al 2007). Station 02's location 0.4-mile downstream from the confluence of Tributary 6 indicates that Tributary 6 is the likely source of Station 02's high TP level. Nitrate values were elevated at all sites and exceeded provisional nutrient guidance for aquatic life use impairment by nitrate at Stations 02 and 02A. At Station 02A, nitrate values were roughly five times greater than guidance values (Smith et al 2007).

Non-impacted conditions were documented in Mineral Springs Brook. This station can be considered a reference site for the watershed, exhibiting an exemplary macroinvertebrate community (Figure 12). Clean-water mayflies and stoneflies were very abundant, and a young-of-the-year trout was also collected in the sample (Table 10). The influence of Mineral Springs Brook on Woodbury Creek water quality likely contributes to the non-impacted conditions documented at the next downstream site in Mountainville (Station 03).

The apparent decline in water quality at Station 04 in Mountainville compared to Station 03 is unexplained. This decline was also present in the 2004 and 2005 data, but to a lesser degree. Since less than one stream mile separates Stations 03 and 04, there are a limited number of possible sources of impact, however these sources remain unknown.

Woodbury Creek continues to be affected by three types of inputs which threaten its water quality: elevated salinity, nutrient enrichment and siltation. None of these substances has numerical standards and their effects are best monitored by the biological components of macroinvertebrates, fish and algae. Salinity, nutrient enrichment and siltation continue to be substantial burdens for a stream that is classified as trout spawning and carries sensitive species of mayflies and stoneflies. Any additional appreciable inputs into Woodbury Creek can be predicted to have detrimental effects that would result in further decline of the stream ecosystem.

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Figure 1. Biological Assessment Profiles of index values, Woodbury Creek, 2007. Values are plotted on normalized scales of water quality. The line represents the mean of the four values from each site for species richness (SPP), EPT richness (EPT), Hilsenhoff Biotic Index (HBI), and Percent Model Affinity (PMA). See Appendix IV for a more complete explanation.

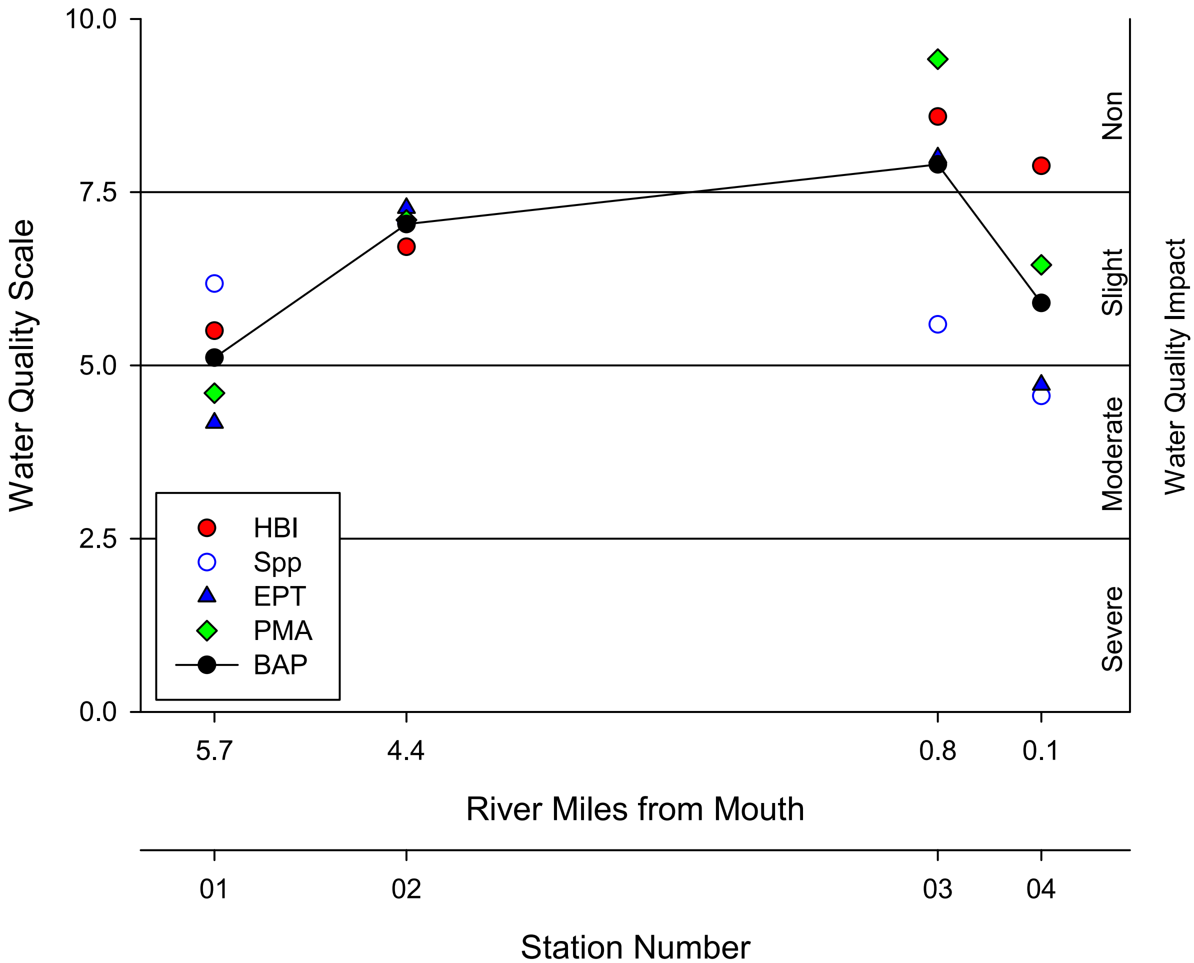


Figure 2. Biological Assessment Profiles of index values, Woodbury Creek, 1987-2007. Values are plotted on normalized scales of water quality. The lines represent the means for each of the sampling years of the four values from each site for species richness (SPP), EPT richness (EPT), Hilsenhoff Biotic Index (HBI), and Percent Model Affinity (PMA). See Appendix IV for a more complete explanation.

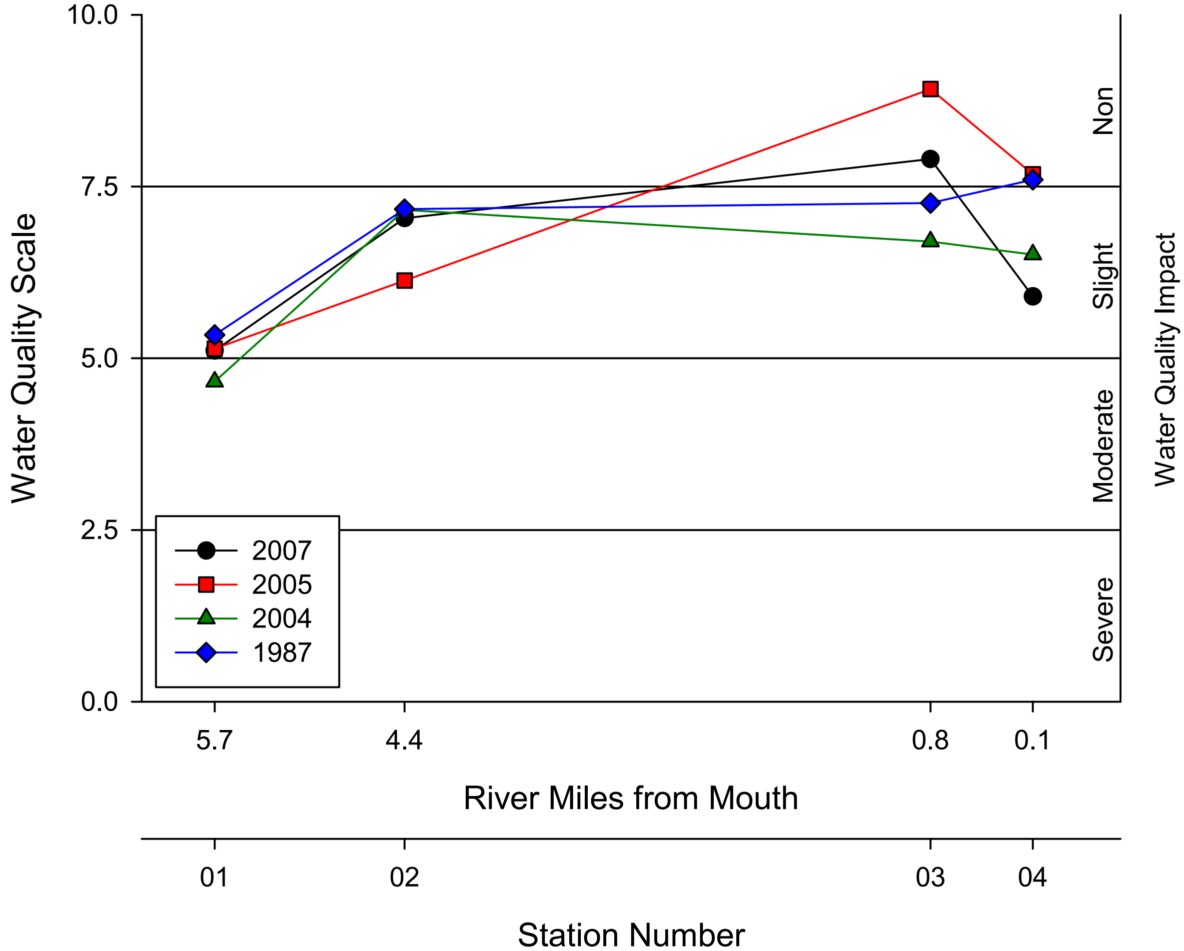


Table 1. Overview of field data

Location	Station	Depth	Width	Current	Canopy	Embed.	Temp.	Cond.	pH	DO	%Sat.
WOOD	01	0.3	5.0	67	60	30	12	760	6.7	7.6	71
WOOD	02	0.2	8.0	100	80	30	13	605	8.8	14	134
WOOD	03	0.2	15.0	120	60	40	14	432	8.0	11.4	110
WOOD	04	0.2	15.0	100	50	30	14	430	8.5	11.9	115
WOOD	02A	0.2	4.0	80	80	20	12	462	7.8	12.1	114
MNRL	04	0.1	5.0	100	20	30	13	198	7.5	11.2	107

Figure 3. Specific conductance in Woodbury Creek during A) 2005 B) 2006 and C) 2007, courtesy of Mr. Dick Manley, Moodna Creek Coalition. The red line represents the level of concern for biological impairment of 800 µsiemens/cm.

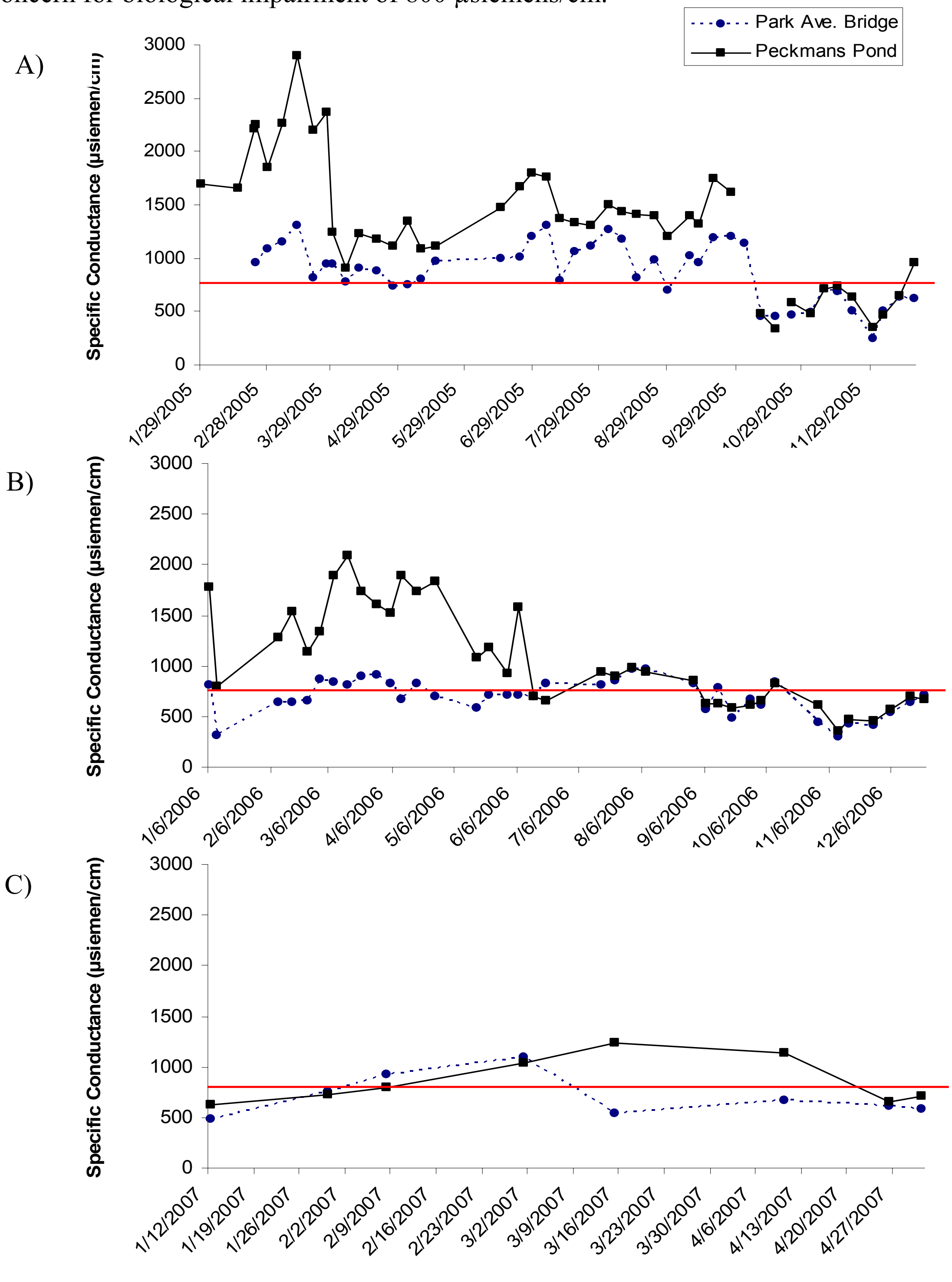


Table 2. Impact Source Determintation (ISD), Woodbury Creek, 2007. Numbers represent percent similarity to community type models for each impact category. Highest similarities at each station are shaded. Similarities less than 50% are less conclusive. Highest numbers represent probable type of impact. See Appendix XI for further explanation.

Community Type	Station Number					
	WOOD-01	WOOD-02	WOOD-03	WOOD-04	Trib 6 WOOD-2A	Mineral Springs MNRL-04
Natural: minimal human disturbance	29	41	52	27	33	43
Nutrient Enrichment: mostly nonpoint, agricultural	31	42	36	31	34	14
Toxic: industrial, municipal, or urban run-off	41	38	27	20	15	42**
Organic: sewage effluent, animal wastes	27	43	31	22	24	14
Complex: municipal/industrial	31	36	28	15	20	12
Siltation	32	44	40	28	28	27
Impoundment	40	50*	42	48*	29	13

Summary of ISD results

Station	Community Type
WOOD-1	Toxic / Impoundment
WOOD-2	Siltation / Organic / Nutrients / Natural
WOOD-3	Natural
WOOD-4	Nutrients / Siltation / Natural
WOOD-2A	Nutrients
MNRL-04	Natural

*Designations of impoundment effects considered spurious.
**Designation of toxic effects at this site considered spurious

Figure 4. Nutrient Biotic Index values for Phosphorus (NBI-P). NBI values are plotted on a scale of eutrophication from oligotrophic to eutrophic. See Appendix X for a detailed explanation of the index.

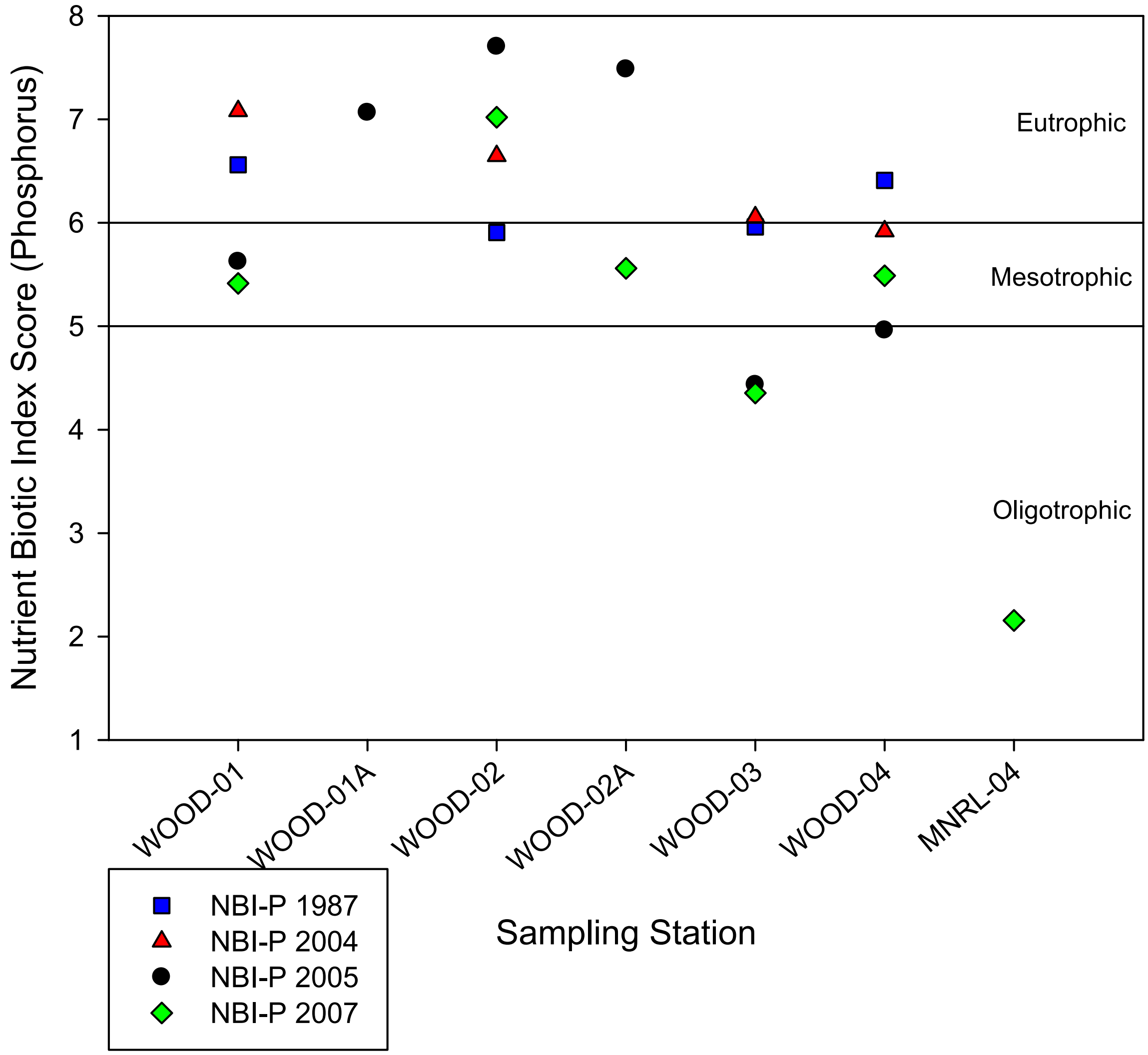


Figure 5. Nutrient Biotic Index values for Nitrogen (NBI-N). NBI values are plotted on a scale of eutrophication from oligotrophic to eutrophic. See Appendix X for a detailed explanation of the index.

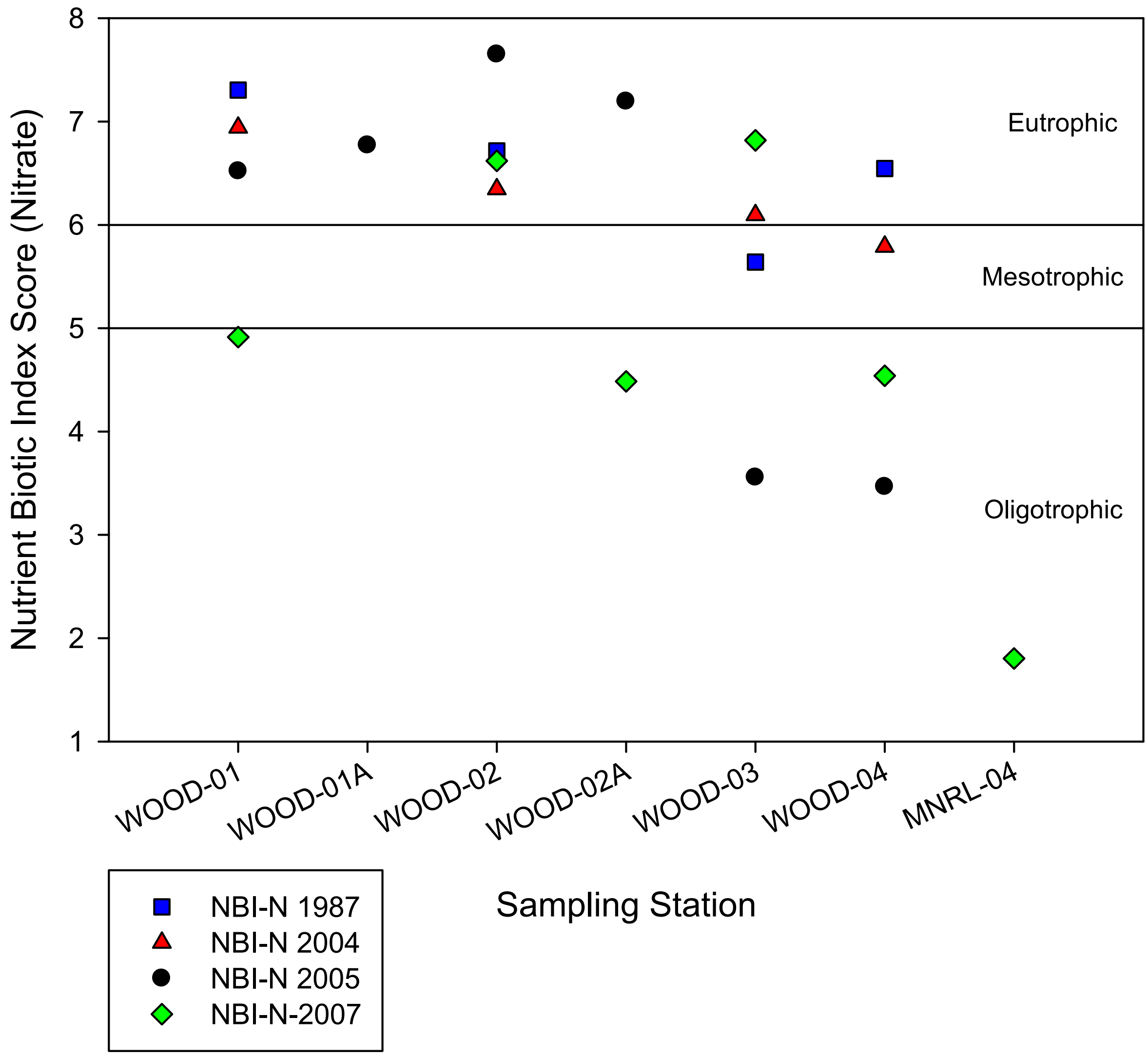


Figure 6. Watershed overview map.

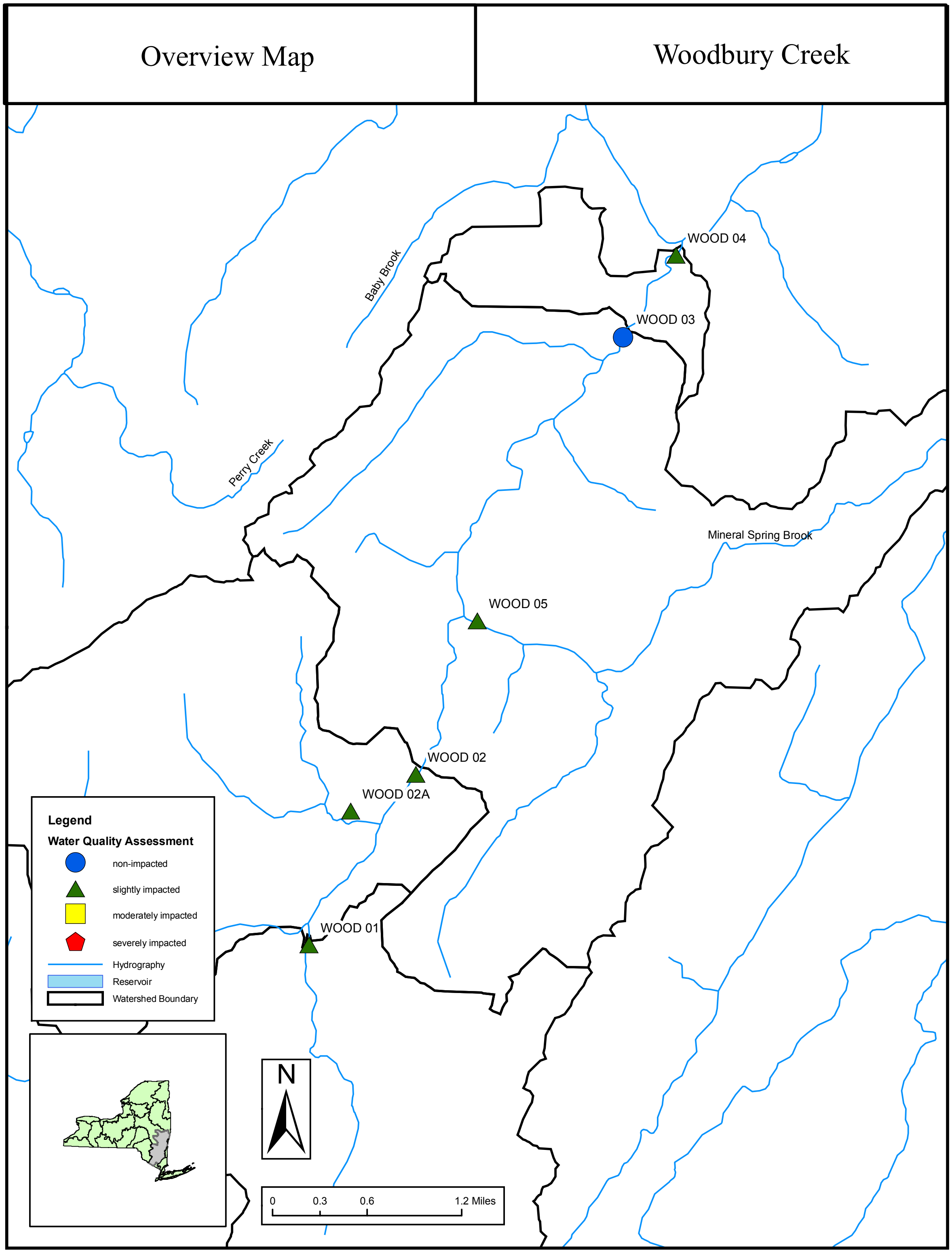


Figure 7. Map of Station 01.

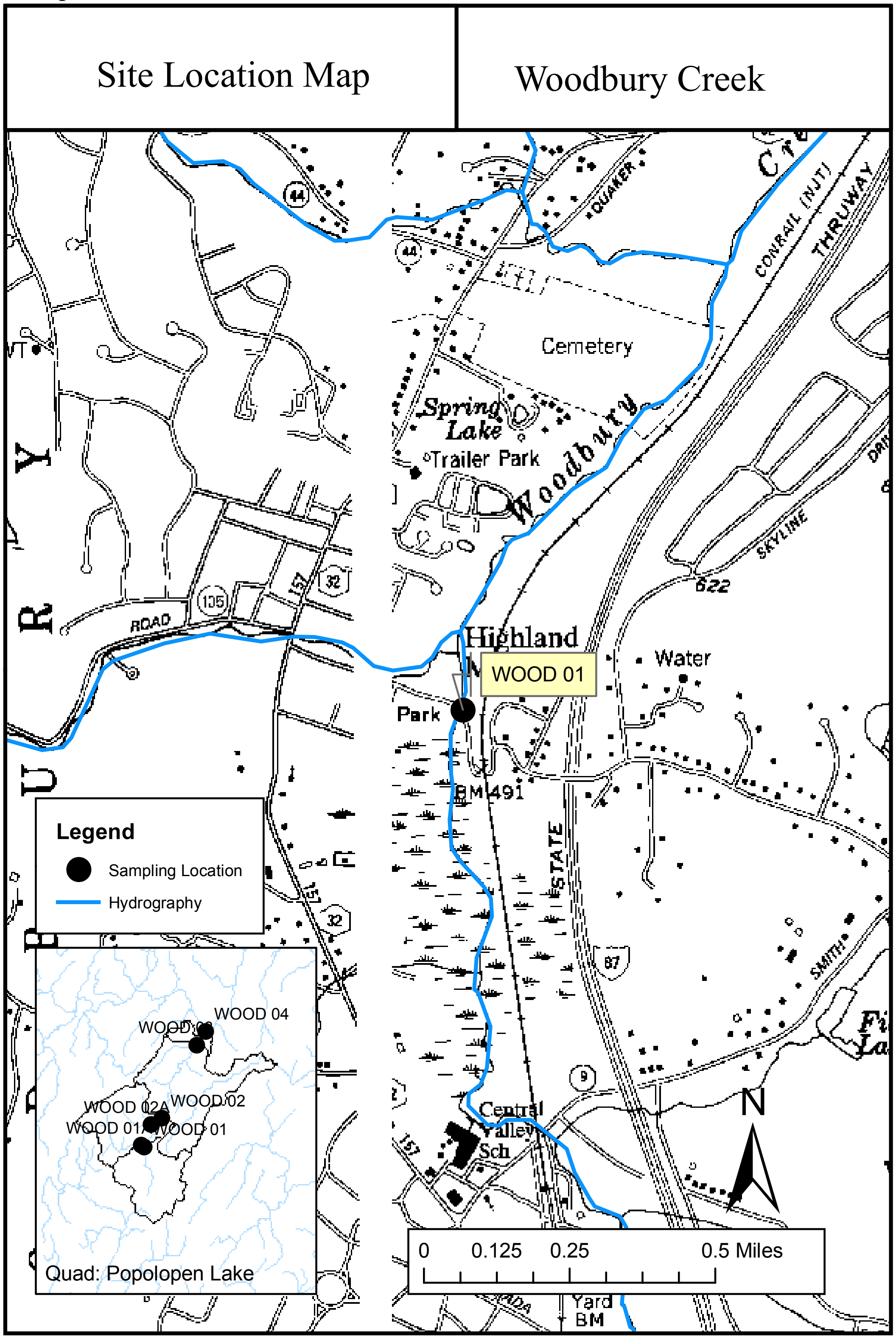


Figure 8. Map of Station 02.

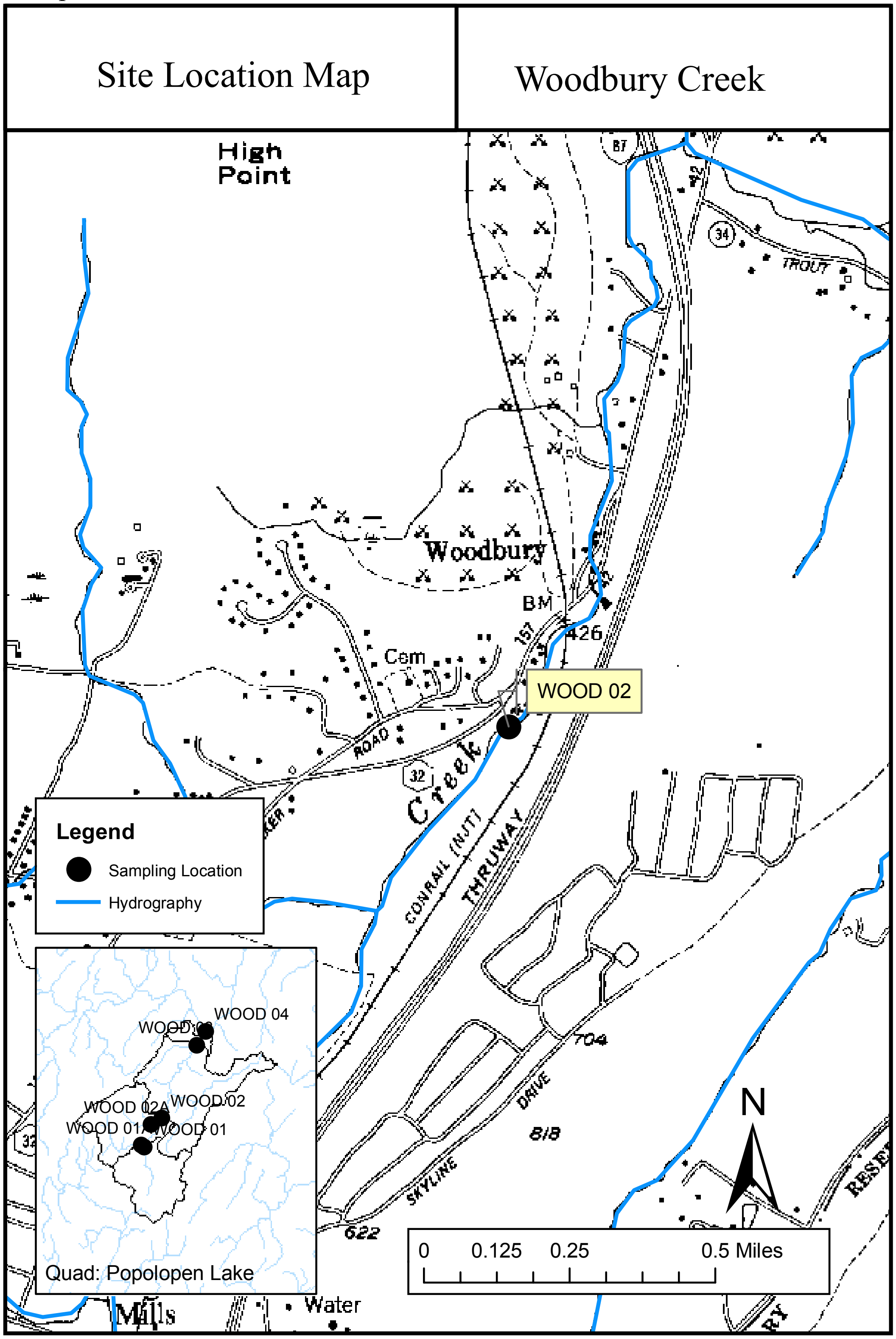


Figure 9. Map of Station 03.

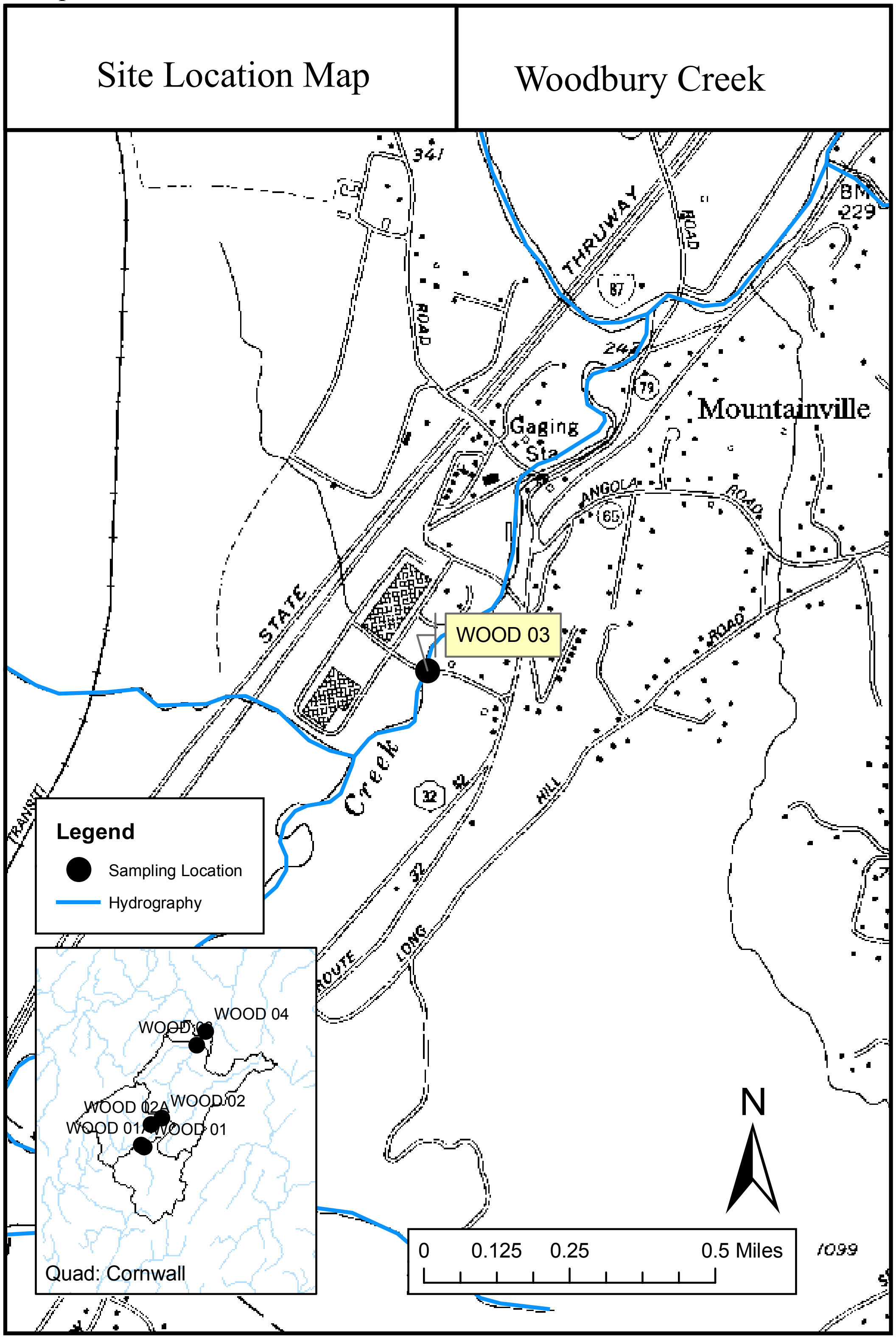


Figure 10. Map of Station 04.

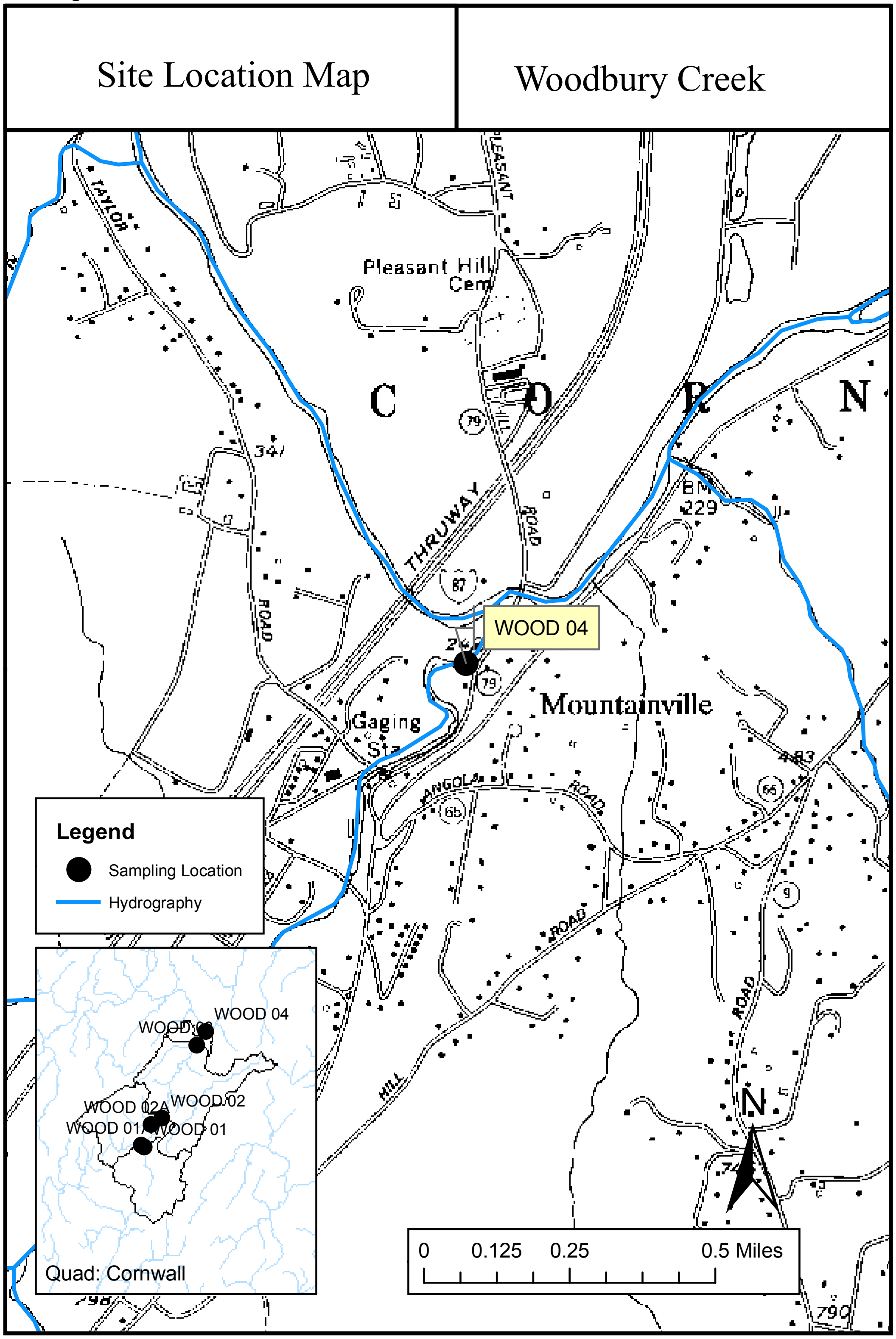


Figure 11. Map of Tributary #6, Station 02A.

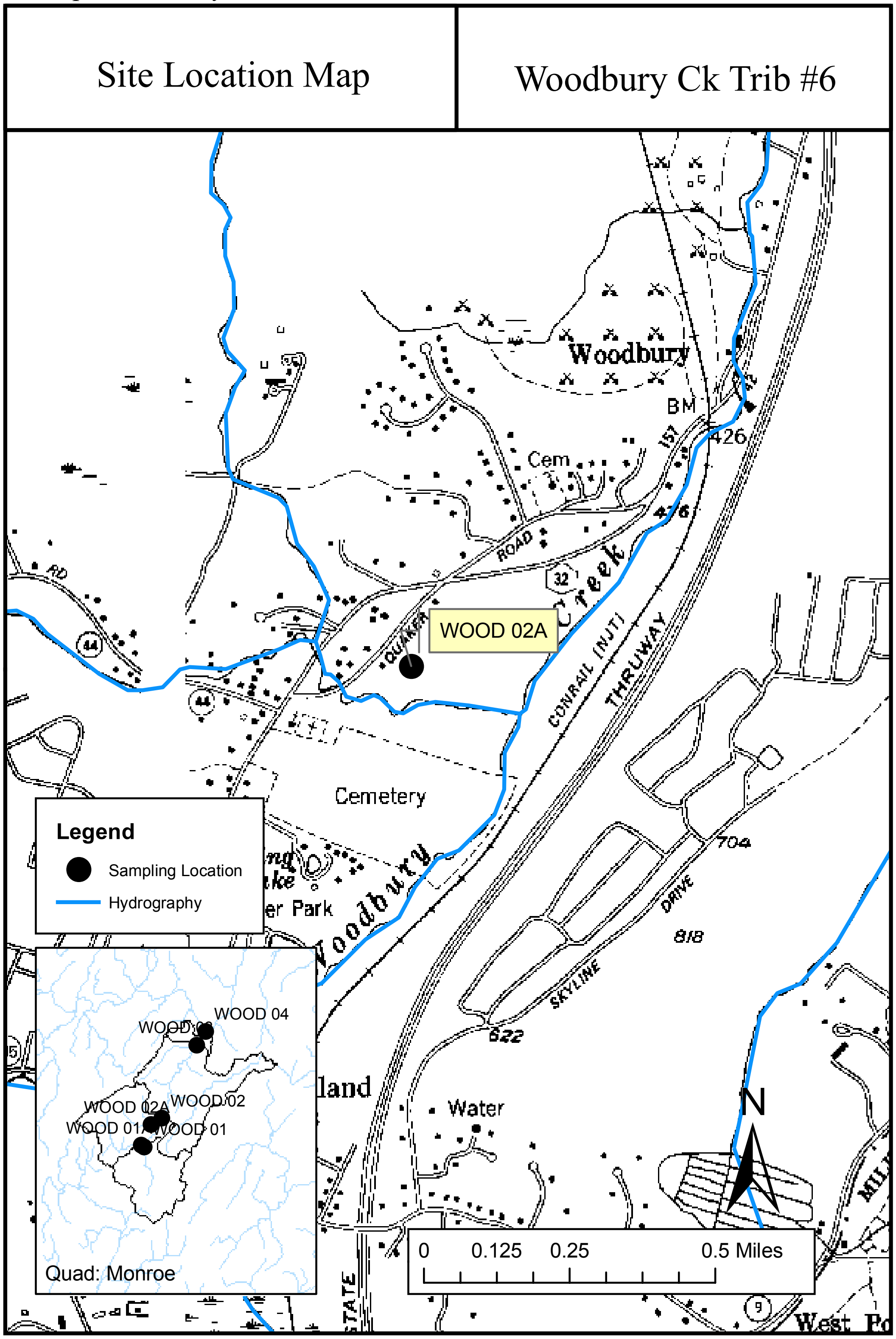


Figure 12. Map of Mineral Springs Brook, Station 04.

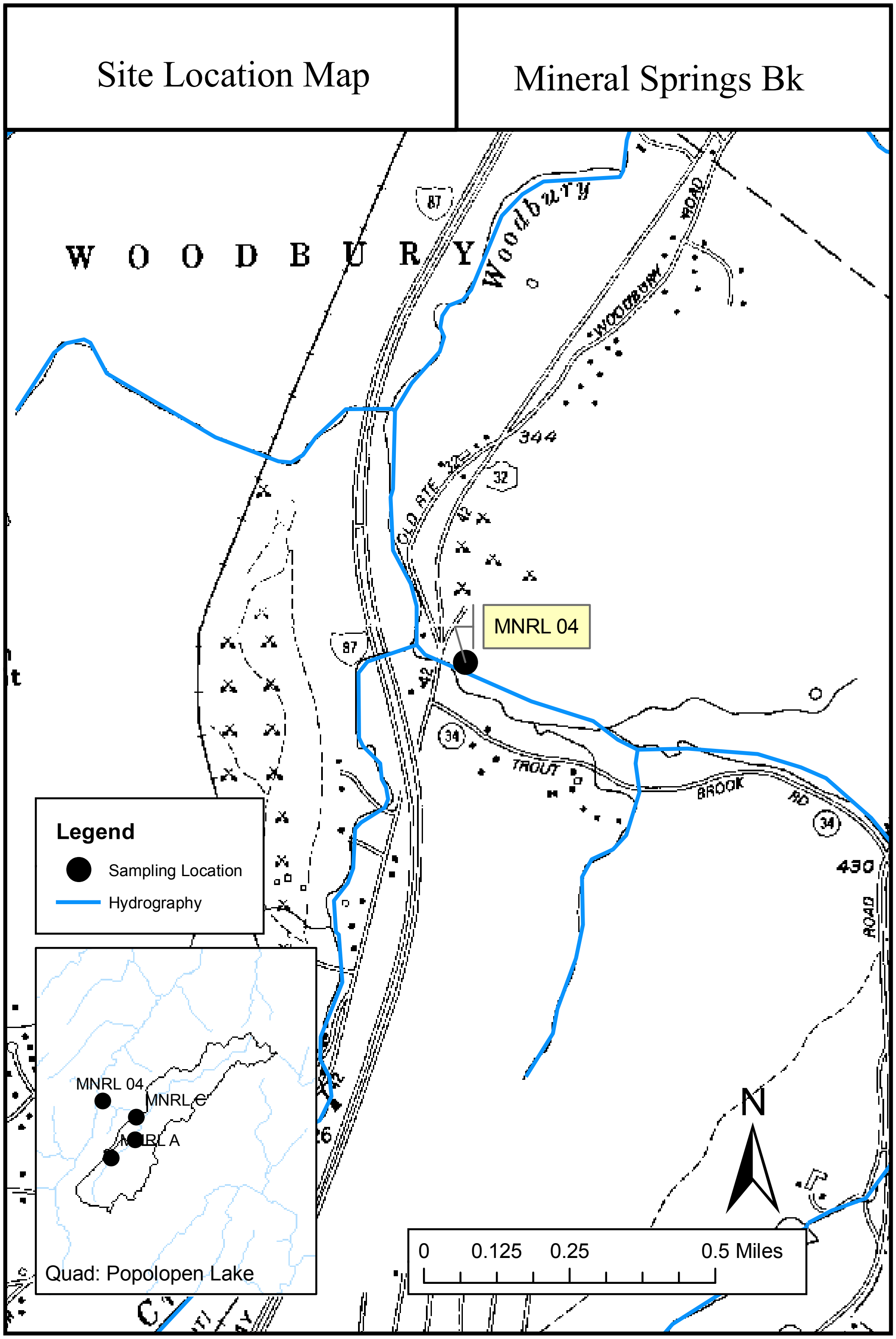


Table 4. Macroinvertebrate Species Collected in Woodbury Creek and Tributaries, Orange County, New York, 2007.

NEMERTEA
- Tetrastemmatidae
  - *Prostoma graecense*

PLATYHELMINTHES
- TURBELLARIA
  - Undetermined Turbellaria

ANNELIDA
- OLIGOCHAETA
  - TUBIFICIDA
    - Enchytraeidae
      - Undetermined Enchytraeidae
    - Naididae
      - *Nais bretscheri*
      - *Nais variabilis*

MOLLUSCA
- GASTROPODA
  - Lymnaeidae
    - Undetermined Lymnaeidae
  - Planorbidae
    - Undetermined Planorbidae
- PELECYPODA
  - Sphaeriidae
    - *Pisidium sp.*

ARTHROPODA
- CRUSTACEA
  - ISOPODA
    - Asellidae
      - *Caecidotea communis*
      - *Caecidotea sp.*
  - AMPHIPODA
    - Gammaridae
      - *Gammarus sp.*

INSECTA
- EPHEMEROPTERA
  - Baetidae
    - *Baetis brunneicolor*
    - *Baetis tricaudatus*
    - *Baetis* sp.
  - Heptageniidae
    - *Cinygmula subaequalis*
    - *Epeorus (Iron) sp.*
    - *Leucrocuta sp.*
    - *Rhithrogena sp.*
  - Ephemerellidae
    - *Ephemerella subvaria*
    - *Eurylophella temporalis*
    - Undetermined Ephemerellidae
- PLECOPTERA
  - Nemouridae
    - *Amphinemura delosa*
  - Perlidae
    - *Acroneuria abnormis*
    - *Acroneuria carolinensis*
    - *Paragnetina media*
    - *Perlesta sp.*
  - Chloroperlidae
    - *Sweltsa* sp.
  - Perlodidae
    - *Isoperla* sp.
- COLEOPTERA
  - Psephenidae
    - *Psephenus herricki*
  - Elmidae
    - *Dubiraphia bivittata*
    - *Stenelmis crenata*
- MEGALOPTERA
  - Corydalidae
    - *Nigronia serricornis*
  - Sialidae
    - *Sialis* sp.
- TRICHOPTERA
  - Philopotamidae
    - *Chimarra aterrima?*
    - *Dolophilodes sp.*
  - Polycentropodidae
    - *Polycentropus* sp.
  - Hydropsychidae
    - *Cheumatopsyche sp.*
    - *Hydropsyche betteni*
    - *Hydropsyche bronta*
    - *Hydropsyche slossonae*
    - *Hydropsyche sparna*
  - Rhyacophilidae
    - *Rhyacophila fuscula*
- DIPTERA
  - Tipulidae
    - *Antocha sp.*
    - *Hexatoma* sp.
    - *Tipula sp.*
  - Empididae
    - *Hemerodromia sp.*
    - *Wiedemannia* sp.
  - Simuliidae
    - *Prosimulium magnum*
    - *Simulium venustum*
    - *Simulium vittatum*
    - *Simulium sp.*

Table 4. Macroinvertebrate Species Collected (Cont'd.)

Chironomidae

Thienemannimyia gr. spp.
Diamesa sp.
Cricotopus vierriensis
Cricotopus sp.
Eukiefferiella claripennis gr.
Eukiefferiella pseudomontana gr.
Orthocladius obumbratus
Orthocladius (Euorthocladius.) sp.
Parametriocnems lundbecki
Cryptochironomus fulvus gr.
Polypedilum aviceps
Polypedilum flavum
Polypedilum illinoense
Cladotanytarsus sp.
Micropsectra sp.
Tanytarsus glabrescens gr.

Table 3. Station locations for Woodbury Creek. Orange County, New York, 2007.

STATION	LOCATION	
01	Highland Mills, New York Below Park Avenue bridge Latitude/Longitude 41^{o} 20' 41"; 74^{o} 07' 16" 5.7 stream miles above mouth Photograph facing upstream	
02	Quaker Meetinghouse, New York Off Route 32 pull-off Latitude/Longitude 41^{o} 21' 31"; 74^{o} 06' 33" 4.4 stream miles above mouth Photograph facing upstream	
03	Mountainville, New York Below Industry Drive bridge Latitude/Longitude 41^{o} 24' 01"; 74^{o} 04' 54" 0.8 stream mile above mouth Photograph facing upstream	
04	Mountainville, New York Off Pleasant Hill Road Latitude/Longitude 41^{o} 24' 28"; 74^{o} 04' 31" 0.1 stream mile above mouth Photograph facing upstream	

Table 3 cont'd. Station locations for Woodbury Creek. Orange County, New York, 2007

WOOD-2A

Unnamed Tributary 6
Highland Mills, New York
Latitude/Longitude 41° 21' 22"; 74° 07' 05"
10 meters below Hazard Road bridge
Photograph facing upstream

MNRL-03

Mineral Springs
Woodbury, New York
Latitude/Longitude 41° 22' 27"; 74° 06' 02"
10 meters above Route 32 bridge
Photograph facing upstream

Table 5. Macroinvertebrate Data Report (MDR), Station 01

STREAM SITE:	Woodbury Creek, Station 01
LOCATION:	Orange County, NY
DATE:	05/08/07
SAMPLE TYPE:	Kick
SUBSAMPLE:	100 organisms

MOLLUSCA			
PELECYPODA			
VENEROIDEA			
	Sphaeriidae	*Pisidium* sp.	3
ARTHROPODA			
CRUSTACEA			
ISOPODA	Asellidae	*Caecidotea communis*	10
AMPHIPODA	Gammaridae	*Gammarus* sp.	1
INSECTA			
PLECOPTERA	Perlidae	*Perlesta* sp.	2
	Perlodidae	*Isoperla* sp.	2
COLEOPTERA	Elmidae	*Dubiraphia bivittata*	3
MEGALOPTERA	Sialidae	*Sialis* sp.	1
TRICHOPTERA	Polycentropodidae	*Polycentropus* sp.	2
	Hydropsychidae	*Cheumatopsyche* sp.	8
DIPTERA	Tipulidae	*Antocha* sp.	1
	Simuliidae	*Simulium venustum*	10
		Simulium vittatum	1
	Chironomidae	*Thienemannimyia* gr. spp.	8
		Cricotopus vierriensis	2
		Cricotopus sp.	4
		Orthocladius obumbratus	11
		Cryptochironomus fulvus gr.	1
		Polypedilum flavum	2
		Cladotanytarsus sp.	1
		Micropsectra sp.	17
		Tanytarsus glabrescens gr.	7
		Tanytarsus guerlus gr.	3
		SPECIES RICHNESS:	22
		BIOTIC INDEX:	6.1
		EPT RICHNESS:	4
		MODEL AFFINITY:	47
		ASSESSMENT:	slight

DESCRIPTION: The macroinvertebrate community appeared similar to that found in previous years, dominated by midges, black flies and sowbugs. Stoneflies were also present. Filamentous algae was abundant on the stream rocks, and freshwater sponges were also found on many rocks. Overall, water quality was assessed as slightly impacted.

Table 6. Macroinvertebrate Data Report (MDR), Station 02

STREAM SITE:	Woodbury Creek, Station 02
LOCATION:	Orange County, NY
DATE:	05/08/07
SAMPLE TYPE:	Kick
SUBSAMPLE:	100 organisms

ANNELIDA			
OLIGOCHAETA			
TUBIFICIDA			
	Naididae	*Nais bretscheri*	26
ARTHROPODA			
INSECTA			
EPHEMEROPTERA	Ephemerellidae	*Ephemerella subvaria*	4
		Eurylophella temporalis	1
PLECOPTERA	Perlidae	*Acroneuria abnormis*	1
		Paragnetina media	1
COLEOPTERA	Psephenidae	*Psephenus herricki*	6
	Elmidae	*Stenelmis crenata*	8
TRICHOPTERA	Philopotamidae	*Chimarra aterrima*?	1
	Polycentropodidae	*Polycentropus* sp.	1
	Hydropsychidae	*Cheumatopsyche* sp.	4
		Hydropsyche betteni	1
		Hydropsyche bronta	1
	Rhyacophilidae	*Rhyacophila fuscula*	2
DIPTERA	Tipulidae	*Antocha* sp.	2
	Simuliidae	*Prosimulium magnum*	1
		Simulium venustum	10
		Simulium vittatum	1
	Empididae	*Hemerodromia* sp.	2
	Chironomidae	*Diamesa* sp.	9
		Eukiefferiella pseudomontana gr.	6
		Orthocladius (Euorthoclad.) sp.	2
		Orthocladius obumbratus	4
		Polypedilum aviceps	2
		Polypedilum illinoense	2
		Cladotanytarsus sp.	2
		SPECIES RICHNESS:	25
		BIOTIC INDEX:	5.13
		EPT RICHNESS:	10
		MODEL AFFINITY:	62
		ASSESSMENT:	slight

DESCRIPTION: Dissolved oxygen and pH were very high at this site, apparently reflecting high rates of photosynthesis. Stream rocks were covered with large amounts of filamentous algae. The Nutrient Biotic Index for phosphorus was in the eutrophic range. The facultative worm *Nais bretscheri* was dominant. Mayflies and stoneflies were present but not numerous. Overall, water quality was assessed as slightly impacted.

Table 7. Macroinvertebrate Data Report (MDR), Station 03

STREAM SITE:	Woodbury Creek, Station 03
LOCATION:	Orange County, NY
DATE:	05/08/07
SAMPLE TYPE:	Kick
SUBSAMPLE:	100 organisms

ANNELIDA			
OLIGOCHAETA			
TUBIFICIDA			
	Naididae	*Nais bretscheri*	3
ARTHROPODA			
INSECTA			
EPHEMEROPTERA	Baetidae	*Baetis brunneicolor*	1
	Heptageniidae	*Epeorus* (Iron) sp.	1
		Leucrocuta sp.	1
		Rhithrogena sp.	1
	Ephemerellidae	Undetermined Ephemerellidae	40
PLECOPTERA	Perlidae	*Acroneuria carolinensis*	1
		Perlesta sp.	1
	Chloroperlidae	*Sweltsa* sp.	2
COLEOPTERA	Elmidae	*Stenelmis crenata*	7
TRICHOPTERA	Philopotamidae	*Chimarra aterrima*?	1
	Hydropsychidae	*Hydropsyche slossonae*	14
		Hydropsyche sparna	3
DIPTERA	Simuliidae	*Simulium venustum*	8
	Empididae	*Hemerodromia* sp.	3
		Wiedemannia sp.	3
	Chironomidae	*Diamesa* sp.	2
		Parametriocnemus lundbecki	1
		Polypedilum aviceps	6
		Polypedilum flavum	1
		SPECIES RICHNESS:	20
		BIOTIC INDEX:	3.41
		EPT RICHNESS:	11
		MODEL AFFINITY:	84
		ASSESSMENT:	non

DESCRIPTION: The sample was taken approximately 40 meters downstream of the Industry Drive bridge in Mountainville. Many stream rocks were covered with a coating of brown algae. The kick sample yielded a large number of clean-water mayflies and stoneflies. Overall, water quality was assessed as non-impacted.

Table 8. Macroinvertebrate Data Report (MDR), Station 04

STREAM SITE: Woodbury Creek, Station 04
LOCATION: Orange County, NY
DATE: 05/08/07
SAMPLE TYPE: Kick
SUBSAMPLE: 100 organisms

ARTHROPODA			
INSECTA			
EPHEMEROPTERA			
	Baetidae	*Baetis tricaudatus*	2
	Heptageniidae	*Epeorus* (Iron) sp.	2
	Ephemerellidae	*Ephemerella subvaria*	16
COLEOPTERA	Psephenidae	*Psephenus herricki*	3
	Elmidae	*Dubiraphia bivittata*	1
		Stenelmis crenata	4
MEGALOPTERA	Corydalidae	*Nigronia serricornis*	1
TRICHOPTERA	Hydropsychidae	*Hydropsyche slossonae*	1
	Rhyacophilidae	*Rhyacophila fuscula*	1
DIPTERA	Tipulidae	*Antocha* sp.	1
	Simuliidae	*Prosimulium magnum*	5
		Simulium venustum	40
	Empididae	*Hemerodromia* sp.	3
		Wiedemannia sp.	2
	Chironomidae	*Diamesa* sp.	2
		Orthocladius obumbratus	13
		Polypedilum aviceps	3
		SPECIES RICHNESS:	17
		BIOTIC INDEX:	4.12
		EPT RICHNESS:	5
		MODEL AFFINITY:	58
		ASSESSMENT:	slight

DESCRIPTION: The kick sample was taken off Pleasant Hill Road in Mountainville, approximately 200 meters upstream of the confluence with Moodna Creek. The sample had less biomass than that taken at upstream Station-3, and all metrics were worse. Black fly larvae dominated the macroinvertebrate community. Overall, water quality was assessed as slightly impacted.

Table 9. Macroinvertebrate Data Report (MDR), Station 02A

STREAM SITE: Woodbury Ck Trib #6, Station 02A
LOCATION: Orange County, NY
DATE: 05/08/07
SAMPLE TYPE: Kick
SUBSAMPLE: 100 organisms

NEMERTEA			
ENOPLA			
HOPLONEMERTEA			
	Tetrastemmatidae	*Prostoma graecense*	1
ANNELIDA			
OLIGOCHAETA			
TUBIFICIDA	Enchytraeidae	Undetermined Enchytraeidae	1
	Naididae	*Nais variabilis*	2
MOLLUSCA			
GASTROPODA			
BASOMMATOPHORA	Lymnaeidae	Undetermined Lymnaeidae	2
	Planorbidae	Undetermined Planorbidae	1
ARTHROPODA			
INSECTA			
EPHEMEROPTERA	Ephemerellidae	*Ephemerella subvaria*	1
		Eurylophella temporalis	2
PLECOPTERA	Nemouridae	*Amphinemura delosa*	3
COLEOPTERA	Psephenidae	*Psephenus herricki*	1
TRICHOPTERA	Philopotamidae	*Chimarra aterrima*?	1
		Dolophilodes sp.	2
	Hydropsychidae	*Cheumatopsyche* sp.	7
	Rhyacophilidae	*Rhyacophila fuscula*	1
DIPTERA	Tipulidae	*Antocha* sp.	1
	Simuliidae	*Prosimulium magnum*	10
	Empididae	*Hemerodromia* sp.	3
		Wiedemannia sp.	6
	Chironomidae	*Diamesa* sp.	13
		Eukiefferiella claripennis gr.	1
		Orthocladius (Euorthoclad.) sp.	1
		Orthocladius obumbratus	6
		Polypedilum flavum	6
		Micropsectra sp.	28
		SPECIES RICHNESS:	23
		BIOTIC INDEX:	5.33
		EPT RICHNESS:	7
		MODEL AFFINITY:	50
		ASSESSMENT:	slight

DESCRIPTION: The sampling site was on the Woodbury Creek unnamed tributary known as Tributary 6, 10 meters downstream of the Hazzard Road bridge in Highland Mills. Large stoneflies were found in the sample, but biomass was very low, and few mayflies were present. All metrics were within the range of slightly impacted water quality.

Table 10. Macroinvertebrate Data Report (MDR), Mineral Springs Brook, Station 04

STREAM SITE:	Mineral Springs Bk, Station 04
LOCATION:	Orange County, NY
DATE:	05/08/07
SAMPLE TYPE:	Kick
SUBSAMPLE:	100 organisms

PLATYHELMINTHES			
TURBELLARIA			
TRICLADIDA			
		Undetermined Turbellaria	1
ARTHROPODA			
INSECTA			
EPHEMEROPTERA	Baetidae	*Baetis tricaudatus*	3
	Heptageniidae	*Cinygmula subaequalis*	21
		Epeorus (Iron) sp.	40
	Leptophlebiidae	*Paraleptophlebia* sp.	1
	Ephemerellidae	*Ephemerella subvaria*	15
PLECOPTERA	Perlidae	*Paragnetina media*	1
	Chloroperlidae	*Sweltsa* sp.	8
	Perlodidae	*Isoperla* sp.	1
TRICHOPTERA	Hydropsychidae	*Hydropsyche slossonae*	4
	Rhyacophilidae	*Rhyacophila fuscula*	1
DIPTERA	Tipulidae	*Hexatoma* sp.	1
		Tipula sp.	1
	Simuliidae	*Simulium* sp.	1
	Empididae	*Hemerodromia* sp.	2
		SPECIES RICHNESS:	15
		BIOTIC INDEX:	1.28
		EPT RICHNESS:	10
		MODEL AFFINITY:	56
		ASSESSMENT:	non

DESCRIPTION: This site on Mineral Springs Brook was located 10 meters upstream of Route 32 in Woodbury, approximately 100 meters upstream of the confluence with Woodbury Creek. The sample had a very high number of individuals, mostly clean-water mayflies and stoneflies. Due to high numbers of mayflies in the subsample, the original Percent Model Affinity value of 56 was adjusted to 95 to reflect the number of mayflies exceeding the model. Overall, water quality was assessed as non-impacted.

Table 11. Laboratory data summary, Woodbury Creek, Orange county, NY, 2007.

LABORATORY DATA SUMMARY				
STREAM NAME: Woodbury Creek				
DATE SAMPLED: 05/08/07				
SAMPLING METHOD: Kick				
LOCATION	WOOD	WOOD	WOOD	WOOD
STATION	01	02	03	04
DOMINANT SPECIES / %CONTRIBUTION / TOLERACE / COMMON NAME				
1.	Micropsectra sp. 17 % facultative midge	Nais bretscheri 26 % facultative worm	Undetermined Ephemerellidae 40 % intolerant mayfly	Simulium venustum 40 % facultative black fly
2. Intolerant = not tolerant of poor water quality	Orthocladius obumbratus 11 % facultative midge	Simulium venustum 10 % facultative black fly	Hydropsyche slossonae 14 % intolerant caddisfly	Ephemerella subvaria 16 % intolerant mayfly
3. Facultative = occurring over a wide range of water quality	Caecidotea communis 10 % tolerant sowbug	Diamesa sp. 9 % facultative midge	Simulium venustum 8 % facultative black fly	Orthocladius obumbratus 13 % facultative midge
4. Tolerant = tolerant of poor water quality	Simulium venustum 10 % facultative black fly	Stenelmis crenata 8 % facultative beetle	Stenelmis crenata 7 % facultative beetle	Prosimulium magnum 5 % intolerant black fly
5.	Cheumatopsyche sp. 8 % facultative caddisfly	Psephenus herricki 6 % intolerant beetle	Polypedilum aviceps 6 % facultative midge	Stenelmis crenata 4 % facultative beetle
%CONTRIBUTION OF MAJOR GROUPS (NUMBER OF TAXA IN PARENTHESIS)				
Chironomidae (midges)	56 (10.0)	27 (7.0)	10 (4.0)	18 (3.0)
Trichoptera (caddisflies)	10 (2.0)	10 (6.0)	18 (3.0)	2 (2.0)
Ephemeroptera (mayflies)	0 (0.0)	5 (2.0)	44 (5.0)	20 (3.0)
Plecoptera (stoneflies)	4 (2.0)	2 (2.0)	4 (3.0)	0 (0.0)
Coleoptera (beetles)	3 (1.0)	14 (2.0)	7 (1.0)	8 (3.0)
Oligochaeta (worms)	0 (0.0)	26 (1.0)	3 (1.0)	0 (0.0)
Mollusca (clams and snails)	3 (1.0)	0 (0.0)	0 (0.0)	0 (0.0)
Crustacea (crayfish, scuds, sowbugs)	11 (2.0)	0 (0.0)	0 (0.0)	0 (0.0)
Other insects (odonates, diptera)	13 (4.0)	16 (5.0)	14 (3.0)	52 (6.0)
Other (Nemertea, Platyhelminthes)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
SPECIES RICHNESS	22	25	20	17
BIOTIC INDEX	6.1	5.13	3.41	4.12
EPT RICHNESS	4	10	11	5
PERCENT MODEL AFFINITY	47	62	84	58
FIELD ASSESSMENT	Good	Very Good	Very Good	Very Good
OVERALL ASSESSMENT	slightly impacted	slightly impacted	non-impacted	slightly impacted

Table 11 cont'd. Laboratory data summary

LABORATORY DATA SUMMARY				
STREAM NAME: Woodbury Creek				
DATE SAMPLED: 05/08/07				
SAMPLING METHOD: Kick				
LOCATION	WOOD	MNRL		
STATION	02A	04		
DOMINANT SPECIES / %CONTRIBUTION / TOLERACE / COMMON NAME				
1.	Micropsectra sp. 28 % facultative midge	Epeorus (Iron) sp. 40 % intolerant mayfly		
2. Intolerant = not tolerant of poor water quality	Diamesa sp. 13 % facultative midge	Cinygmula subaequalis 21% intolerant mayfly		
3. Facultative = occurring over a wide range of water quality	Prosimulium magnum 10 % Intolerant blackfly	Ephemerella subvaria 15 % Intolerant mayfly		
4. Tolerant = tolerant of poor water quality	Cheumatopsyche sp. 7 % facultative caddisfly	Sweltsa sp. 8 % intolerant stonefly		
5.	Wiedemania sp. 6 % facultative dance fly	Hydropsyche slossonae 4 % intolerant caddisfly		
% CONTRIBUTION OF MAJOR GROUPS (NUMBER OF TAXA IN PARENTHESIS)				
Chironomidae (midges)	55 (6.0)	0 (0.0)		
Trichoptera (caddisflies)	11 (4.0)	5 (2.0)		
Ephemeroptera (mayflies)	3 (2.0)	80 (5.0)		
Plecoptera (stoneflies)	3 (1.0)	10 (3.0)		
Coleoptera (beetles)	1 (1.0)	0 (0.0)		
Oligochaeta (worms)	3 (2.0)	0 (0.0)		
Mollusca (clams and snails)	3 (2.0)	0 (0.0)		
Crustacea (crayfish, scuds, sowbugs)	0 (0.0)	0 (0.0)		
Other insects (odonates, diptera)	20 (4.0)	5 (4.0)		
Other (Nemertea, Platyhelminthes)	1 (1.0)	1 (1.0)		
SPECIES RICHNESS	23	15		
BIOTIC INDEX	5.33	1.28		
EPT RICHNESS	7	10		
PERCENT MODEL AFFINITY	50	56		
FIELD ASSESSMENT	Good	Very Good		
OVERALL ASSESSMENT	Slightly impacted	Slightly impacted		

Table 12. Field data summary, Woodbury Creek, Orange county, NY, 2007.

FIELD DATA SUMMARY				
STREAM NAME: Woodbury Creek	**DATE SAMPLED:** 05/08/07			
REACH:				
FIELD PERSONNEL INVOLVED: Abele/Bode/Smith				
STATION	01	02	03	04
ARRIVAL TIME AT STATION	9:00	10:45	12:15	12:50
LOCATION	WOOD	WOOD	WOOD	WOOD
PHYSICAL CHARACTERISTICS				
Width (meters)	5	8	15	15
Depth (meters)	0.3	0.2	0.2	0.2
Current speed (cm per sec.)	67	100	120	100
Substrate (%)				
Rock (>25.4 cm, or bedrock)	10	0	10	0
Rubble (6.35 - 25.4 cm)	30	30	40	0
Gravel (0.2 - 6.35 cm)	30	40	20	0
Sand (0.06 - 2.0 mm)	20	20	10	0
Silt (0.004 - 0.06 mm)	10	10	20	0
Embeddedness (%)	30	30	40	30
CHEMICAL MEASUREMENTS				
Temperature (°C)	12.2	13.2	13.6	13.9
Specific Conductance (umhos)	760	605	432	430
Dissolved Oxygen (mg/l)	7.6	14	11.4	11.9
pH	6.7	8.8	8.08	8.5
BIOLOGICAL ATTRIBUTES				
Canopy (%)	60	80	60	50
Aquatic Vegetation				
Algae - suspended				
Algae - attached,filamentous	X			X
Algae - diatoms	X		X	X
Macrophytes or moss				
Occurrence of Macroinvertebrates				
Ephemeroptera (mayflies)	X	X	X	X
Plecoptera (stoneflies)	X	X	X	X
Trichoptera (caddisflies)	X	X	X	X
Coleoptera (beetles)		X		
Megaloptera (dobsonflies, damselflies)		X		X
Odonata (dragonflies, damselflies)	X			
Chironomidae (midges)	X	X		
Simuliidae (black flies)				
Decapoda (crayfish)	X			
Gammaridae (scuds)	X			
Mollusca (snails, clams)	X			
Oligochaeta (worms)				
Other				
FAUNAL CONDITION	Good	Very Good	Very Good	Very Good

Table 12 cont'd. Field data summary.

FIELD DATA SUMMARY				
STREAM NAME: Woodbury Creek	DATE SAMPLED: 05/08/07			
REACH:				
FIELD PERSONNEL INVOLVED: Abele/Bode/Smith				
STATION	02A	04		
ARRIVAL TIME AT STATION	10:00	11:30		
LOCATION	WOOD	MNRL		
PHYSICAL CHARACTERISTICS				
Width (meters)	4	5		
Depth (meters)	0.2	0.1		
Current speed (cm per sec.)	80	100		
Substrate (%)				
Rock (>25.4 cm, or bedrock)	20	0		
Rubble (6.35 - 25.4 cm)	20	10		
Gravel (0.2 - 6.35 cm)	20	50		
Sand (0.06 - 2.0 mm)	20	20		
Silt (0.004 - 0.06 mm)	10	20		
Embeddedness (%)	20	30		
CHEMICAL MEASUREMENTS				
Temperature (°C)	12.3	13.3		
Specific Conductance (umhos)	462	198		
Dissolved Oxygen (mg/l)	12.1	11.2		
pH	7.8	7.58		
BIOLOGICAL ATTRIBUTES				
Canopy (%)	80	20		
Aquatic Vegetation				
Algae - suspended				
Algae - attached, filamentous				
Algae - diatoms	X	X		
Macrophytes or moss				
Occurrence of Macroinvertebrates				
Ephemeroptera (mayflies)	X	X		
Plecoptera (stoneflies)	X	X		
Trichoptera (caddisflies)	X	X		
Coleoptera (beetles)				
Megaloptera (dobsonflies, damselflies)				
Odonata (dragonflies, damselflies)				
Chironomidae (midges)	X	X		
Simuliidae (black flies)				
Decapoda (crayfish)	X			
Gammaridae (scuds)				
Mollusca (snails, clams)				
Oligochaeta (worms)				
Other		X		
FAUNAL CONDITION	Good	Very Good		

Table 13a-c. Water chemistry summary tables for Woodbury Creek and Mineral Springs Brook

Table 13A. Total phosphorus (TP), Nitrate (NO_3^-), Ammonium (NH_4), Nitrite, (NO_2^-), Total Dissolved Nitrogen (TDN), and Sulfate (SO_4^{2-})

Station	TP (mg/l)	NO_3^- (mg/l)	NH4 (µmoles/l)	NO_2^- (µmoles/l)	TDN (µmoles/l)	SO_4^{2-} (µmoles/l)
WOOD-01	0.018	0.622	0.630	-1.309	34.126	108.596
WOOD-02	0.067	1.147	0.348	-1.274	36.825	125.103
WOOD-03	0.005	0.509	0.310	-1.279	22.890	136.488
WOOD-04	0.005	0.435	0.207	-1.305	20.036	139.392
WOOD-02A	0.140	5.004	1.390	1.207	109.817	119.303
MNRL-01	0.006	0	2.600	-1.435	17.216	105.078

Table 13B. Acid Neutralizing Capacity (ANC), Organic Monomeric Aluminum (OMA), Total Aluminum (TA), Total Monomeric Aluminum (TMA), Dissolved Organic Carbon (DOC)

Station	ANC (µeq/l)	OMA (µmoles/l)	TA (µmoles/l)	TMA (µmoles/l)	DOC (µmoles/l)
WOOD-01	2429.261	-0.271	1.358	1.180	284.241
WOOD-02	1824.073	-0.499	2.126	0.815	241.387
WOOD-03	1442.185	-0.653	2.963	0.494	153.665
WOOD-04	1436.005	-0.662	3.382	0.533	155.829
WOOD-02A	814.688	-0.666	1.782	0.238	161.491
MNRL-01	786.482	-0.734	0.703	0.147	120.885

Table 13C. Calcium (Ca), Chloride (Cl), Magnesium (Mg), Potassium (K), Silicon (Si), Sodium (Na)

Station	Ca (µmoles/l)	Cl (µmoles/l)	Mg (µmoles/l)	K (µmoles/l)	Si (µmoles/l)	Na (µmoles/l)
WOOD-01	948.491	5101.268	506.690	25.087	27.000	3951.296
WOOD-02	833.230	4291.612	374.551	31.468	11.249	3166.960
WOOD-03	671.227	2509.239	252.481	22.927	38.912	2010.429
WOOD-04	682.408	2482.234	252.403	23.311	36.397	2009.688
WOOD-02A	594.743	3032.608	237.478	40.845	43.890	2281.283
MNRL-01	386.844	774.753	107.677	14.638	85.512	764.693

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.

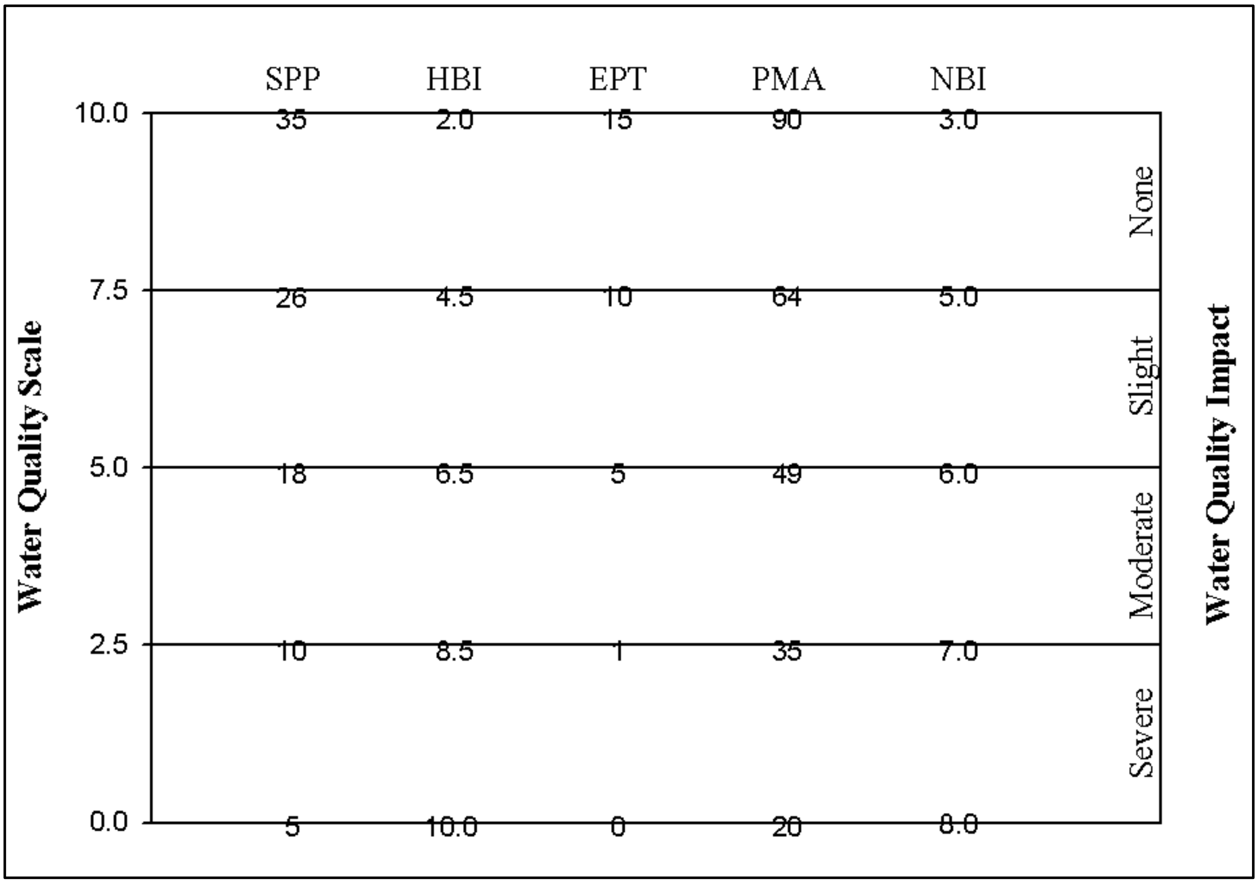
2. *Slightly impacted*: Indices reflect good water quality. The macroinvertebrate community is slightly but significantly altered from the pristine state. Species richness is usually 19-26. Mayflies and stoneflies may be restricted, with EPT richness values of 6-10. The biotic index value is 4.51-6.50.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

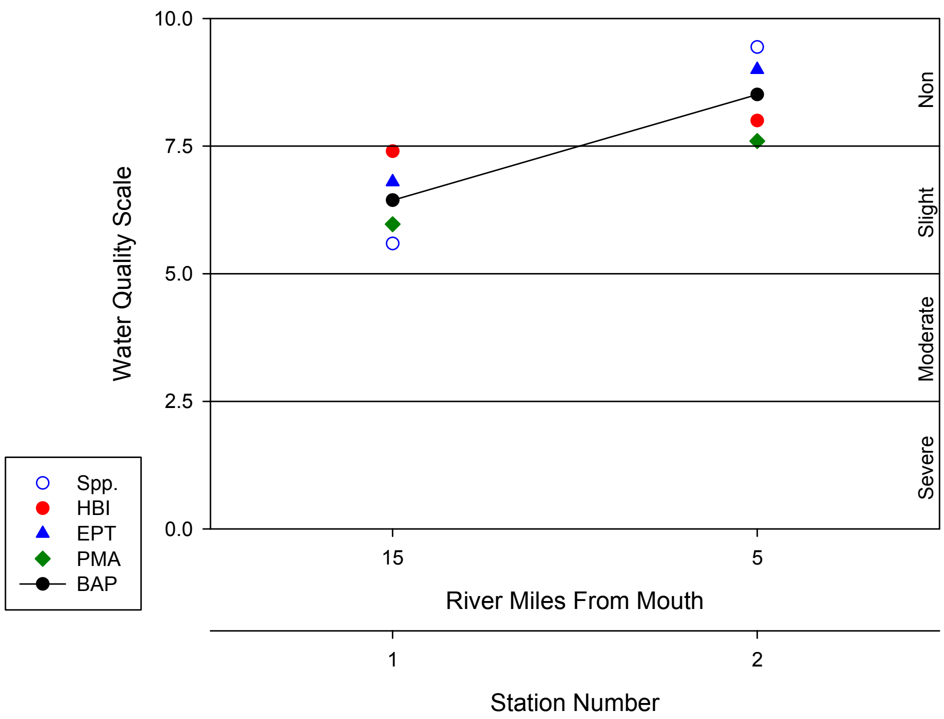
To plot survey data:

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
Average		6.44 (slight)		8.51 (non-)

Sample BAP plot:



Appendix V. Water Quality Assessment Criteria

Non-Navigable Flowing Waters

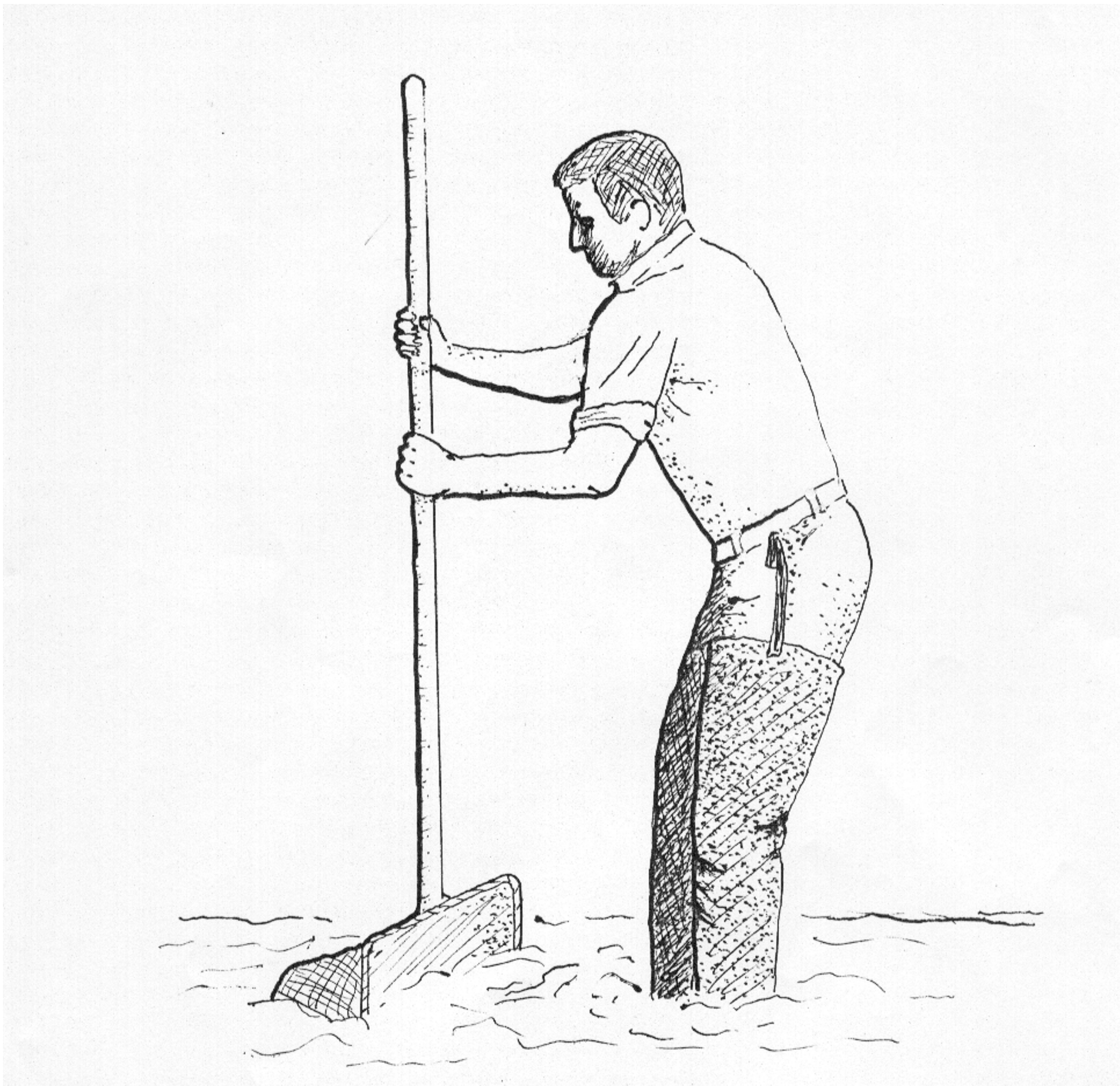
	Species Richness	Hilsenhoff Biotic Index	EPT Value	Percent Model Affinity*	Diversity **
Non-Impacted	>26	0.00-4.50	>10	>64	>4
Slightly Impacted	19-26	4.51-6.50	6-10	50-64	3.01-4.00
Moderately Impacted	11-18	6.51-8.50	2-5	35-49	2.01-3.00
Severely Impacted	0-10	8.51-10.00	0-1	<35	0.00-2.00

* Percent model affinity criteria 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 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 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 species of mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera)in a sample or subsample

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

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

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 species 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 State: ecosystem productivity

Appendix X. Methods for Calculation of the Nutrient Biotic Index

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

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

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

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

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

TAXON	TP T-Value	NO3 T-Value
Hexatoma sp.	0	1
Hydropsyche betteni	7	9
Hydropsyche bronta	7	6
Hydropsyche morosa	5	1
Hydropsyche scalaris	3	3
Hydropsyche slossonae	6	10
Hydropsyche sp.	5	4
Hydropsyche sparna	6	7
Hydroptila consimilis	9	10
Hydroptila sp.	6	6
Hydroptila spatulata	9	8
Isonychia bicolor	5	2
Lepidostoma sp.	2	0
Leucotrichia sp.	6	2
Leucrocuta sp.	1	3
Macrostemum carolina	7	2
Macrostemum sp.	4	2
Micrasema sp. 1	1	0
Micropsectra dives gr.	6	9
Micropsectra polita	0	7
Micropsectra sp.	3	1
Microtendipes pedellus gr.	7	7
Microtendipes rydalensis gr.	2	1
Nais variabilis	5	0
Neoperla sp.	5	5
Neureclipsis sp.	3	1
Nigronia serricornis	10	8
Nixe (Nixe) sp.	1	5
Ophiogomphus sp.	1	3
Optioservus fastiditus	6	7
Optioservus ovalis	9	4
Optioservus sp.	7	8
Optioservus trivittatus	7	6
Orthocladius nr. dentifer	3	7
Pagastia orthogonia	4	8
Paragnetina immarginata	1	2
Paragnetina media	6	3
Paragnetina sp.	1	6
Paraleptophlebia mollis	2	1
Paraleptophlebia sp.	2	3
Parametriocnemus lundbecki	8	10
Paratanytarsus confusus	5	8
Pentaneura sp.	0	1
Petrophila sp.	5	3
Phaenopsectra dyari?	4	5
Physella sp.	8	7
Pisidium sp.	8	10
Plauditus sp.	2	6
Polycentropus sp.	4	2

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

TAXON	TP T-Value	NO3 T-Value
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.

Impact Source Determination 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

Impact Source Determination Models

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

Impact Source Determination Models

	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

Impact Source Determination Models

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

Impact Source Determination Models

	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 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. 800 µmhos/cm corresponds to ~170 mg/L chlorides, ~510 parts per million Total Dissolved Solids, and ~0.51 parts per thousand salinity.

References:

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U.S. EPA. 1995. Drinking water regulations and health advisories. U.S. Environmental Protection Agency, Office of Water, Washington, D.C., 11 pages.