New York State
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Division of Water

Shawangunk Kill
Biological Assessment

2007 Survey

New York State
Department of Environmental Conservation

BIOLOGICAL STREAM ASSESSMENT

Shawangunk Kill
Ulster and Orange Counties, New York
Lower Hudson River Basin

Survey dates: August 28, 2007
Report date: February 27, 2008

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Stream: Shawangunk Kill

Reach: Maple Glen to Ganahgote, NY

River Basin: Lower Hudson

Background:

The Stream Biomonitoring Unit sampled four stations along the Shawangunk Kill in Ulster and Orange counties, New York, on August 28, 2007. Sampling was conducted to collect baseline water-quality data on the kill, since it is a stream which supports many unique and rare habitats and wildlife for the region.

To characterize water quality based on benthic macroinvertebrate communities, a traveling kick sample was collected from riffle areas at each of four sites on the kill. Methods used are 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 100-specimen subsamples 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). Amount of expected variability of results is stated in Smith and Bode (2004). Table 4 provides a listing of sampling sites, and Table 5 provides a listing of all 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 the Shawangunk Kill ranged from non- to slightly impacted. Water quality worsened from a previous assessment of station 00. Suspected causes of impact are nonpoint source nutrient runoff from agricultural and developed lands within certain portions of the watershed.

2. Large portions of the watershed are predominately forested ($\geq$ 50% at all sites) with percent impervious surface cover well below the threshold of concern of $\geq$ 11%. However, agricultural land use is also a significant player in the ecology of the landscape ($\geq$ 20% at all sites).

3. Increased development and agricultural practices may be contributing substantial amounts of nonpoint source nutrient runoff in certain areas of the watershed, resulting in stream eutrophication. Results of the Nutrient Biotic Index for phosphorus as well as Impact Source Determination indicate that the disturbance responsible for slight impact at stations B and 00 is nonpoint source nutrient enrichment.

Discussion:

The Shawangunk Kill originates approximately 20 miles west of the Hudson River in the forested regions of the Shawangunk Ridge. From here it flows northeasterly for 35 miles until it joins with the Wallkill River, a major tributary to the Lower Hudson River. The Shawangunk Kill watershed is home to many unique, rare and threatened wildlife species and is considered a significant habitat complex (USFW 1997). The stream is classified as both A and B with some portions having trout standards (T) applied.

The Stream Biomonitoring Unit sampled the Shawangunk Kill on August 28, 2007 to document water quality in the stream, providing a baseline set of information in light of increased development pressure in the watershed. In addition, the data would provide a comparison with earlier collections. Previous sampling had been conducted on the stream at several sites. In 1997, one site (station 01), and in 2002, three sites (stations A, 00, and 01) were sampled. The sample collected in 1997 was field inspected and met all screening criteria for a determination of non-impacted water quality. The sample was not retained because an exceptional macroinvertebrate community was noted (Bode et al 2004). In 2002, all three sites were also field-assessed. In addition, the samples were processed in the laboratory to family level. Non-impacted water quality was assessed at all three sites (Bode et al 2004).

For the present study, one additional site was added to the three sampled in 2002, station B. The purpose of this site was to target possible development in the watershed, providing an upstream/downstream dataset (personal communication R. W. Bode). Results suggest non-impacted to slightly impacted water quality (Figure 1). A worsening from 2002 occurred at station 00 resulting in slight impact. Benthic macroinvertebrate communities at all sites were represented by mayflies, stoneflies and caddisflies. However, station B marked a shift from a community dominated by pollution intolerant stoneflies and mayflies at Station A to facultative riffle beetle and caddisfly species at the remaining sites.

Based on the Nutrient Biotic Index for phosphorus (NBI-P) (Figure 2, methods summarized in Appendix X) stations A, 00 and 01 were assessed as mesotrophic, while station B was assessed as eutrophic. Stations B and 00 had the highest NBI-P values suggesting the slight impact to water quality at these sites is likely caused by excessive nutrients, specifically phosphorus. Impact Source Determination (ISD) corroborates this, indicating benthic macroinvertebrate communities typical of areas of increased nonpoint source nutrient inputs at most stations (Table 3, methods summarized in Appendix XI).

Although the Shawangunk Kill watershed is predominately forested ($\geq$ 50% at all sites), agricultural land use is also a significant player in the ecology of the landscape ($\geq$ 20% at all sites) (Figure 3 and Table 2). In some areas, impervious surface cover (ISC) may also be contributing polluted runoff, although the levels are not of concern because they fall well below the percent of ISC ($\geq$ 11%) that might cause water-quality impairment (Schueler and Holland 2000; Bode et al 2006). Although above the decision threshold for use impairment at all sites (NYSDEC 2002), water quality at stations B and 00 (slight impact) deviates from the natural condition (non-impacted). The results of the NBI-P and ISD indicate the disturbance responsible for this deviation is nonpoint source nutrient enrichment. The disturbance appears to be at a scale large enough to cause eutrophication of certain portions of the Shawangunk Kill. Increased development pressure or more intensive agricultural practices in the watershed will likely cause continued declines in water quality.

Literature Cited

Bode, R. W., M. A. Novak, L. E. Abele, D. L. Heitzman, and A. J. Smith. 2002. *Quality Assurance Work Plan for Biological Stream Monitoring in New York State*. New York State Department of Environmental Conservation, Technical Report. 115 pages.

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NYSDEC. 2002. Consolidated *Assessment and Listing Methodology (CALM): Assessment Methodology*. www.dec.ny.gov/chemical/31296.html. New York State Department of Environmental Conservation, Division of Water, Water Assessment and Management, 625 Broadway, Albany NY, 12233-3502.

USFW. 1997. *Significant Habitats and Complexes of the New York Bight Watershed*. training.fws.gov/library/pubs5/begin.htm. United States Fish and Wildlife Service, Southern New England – New York Bight, Coastal Ecosystems Program, Charleston Rhode Island. Technical Report.

Figure 1. Biological Assessment Profile of index values, the Shawangunk Kill, 2007. Values are plotted on a normalized scale of water quality. The line connects the mean of the four values for each site, representing Species Richness, EPT richness, Hilsenhoff Biotic Index, Percent Model Affinity or Non Chironomidae, Oligochaeta richness. See Appendix IV for more complete explanation.
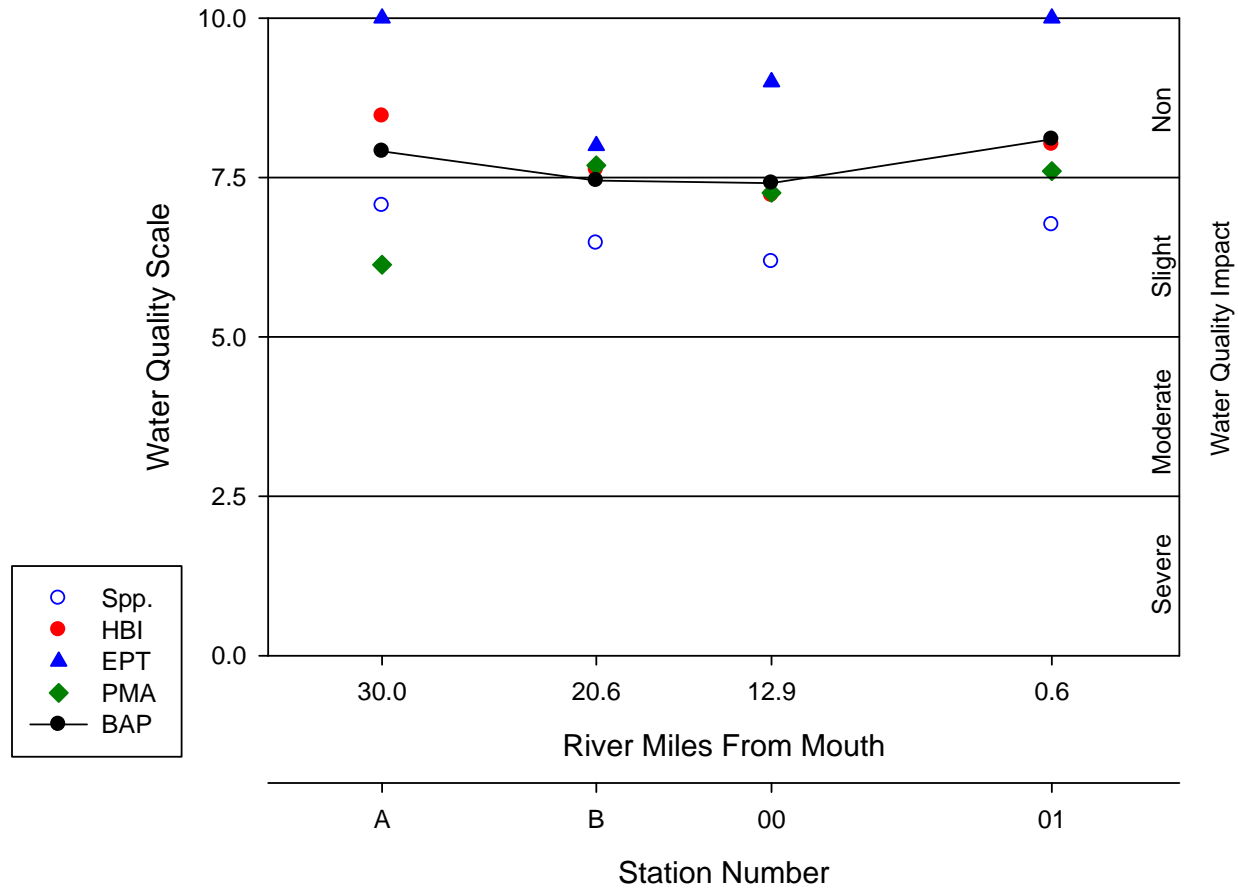
Table 1. Overview of field data.

Location	Station	Depth (meters)	Width (meters)	Current (cm/sec)	Canopy (%)	Embed. (%)	Temp. ^{O}C	Cond. (μmol/cm)	pH (units)	DO (mg/l)	DO Sat. (%)
GUNK	A	0.1	10	100	80	20	19	351	6.9	9.0	100
GUNK	B	0.2	15	100	20	30	21	333	7.6	8.2	91
GUNK	00	0.1	30	100	30	15	23	331	8.5	9.7	113
GUNK	01	0.2	15	125	10	10	26	289	8.7	8.3	102

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Figure 2. Nutrient Biotic Index values for Phosphorus (NBI-P) and Nitrogen (NBI-N). NBI values are plotted on a scale of eutrophication from oligotrophic to eutrophic. Index values greater than 6.0 indicate water quality impairment due to cultural eutrophication and are indicative of sites where aquatic life use is likely to be effected. See Appendix X for a detailed explanation of the index.
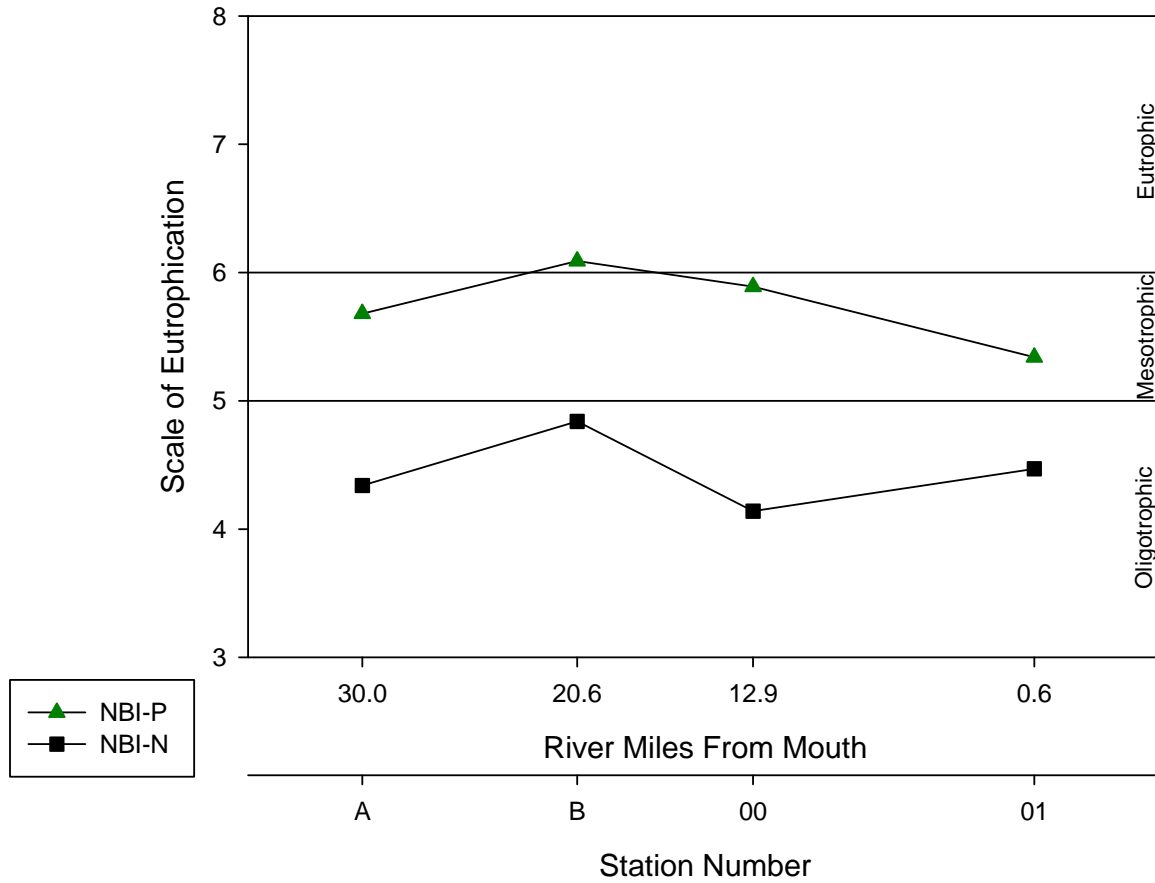
Figure 3. Percent land cover for major land use types within the Shawangunk Kill watershed samples. Land cover data was generated using the 2006 National Land Cover dataset.
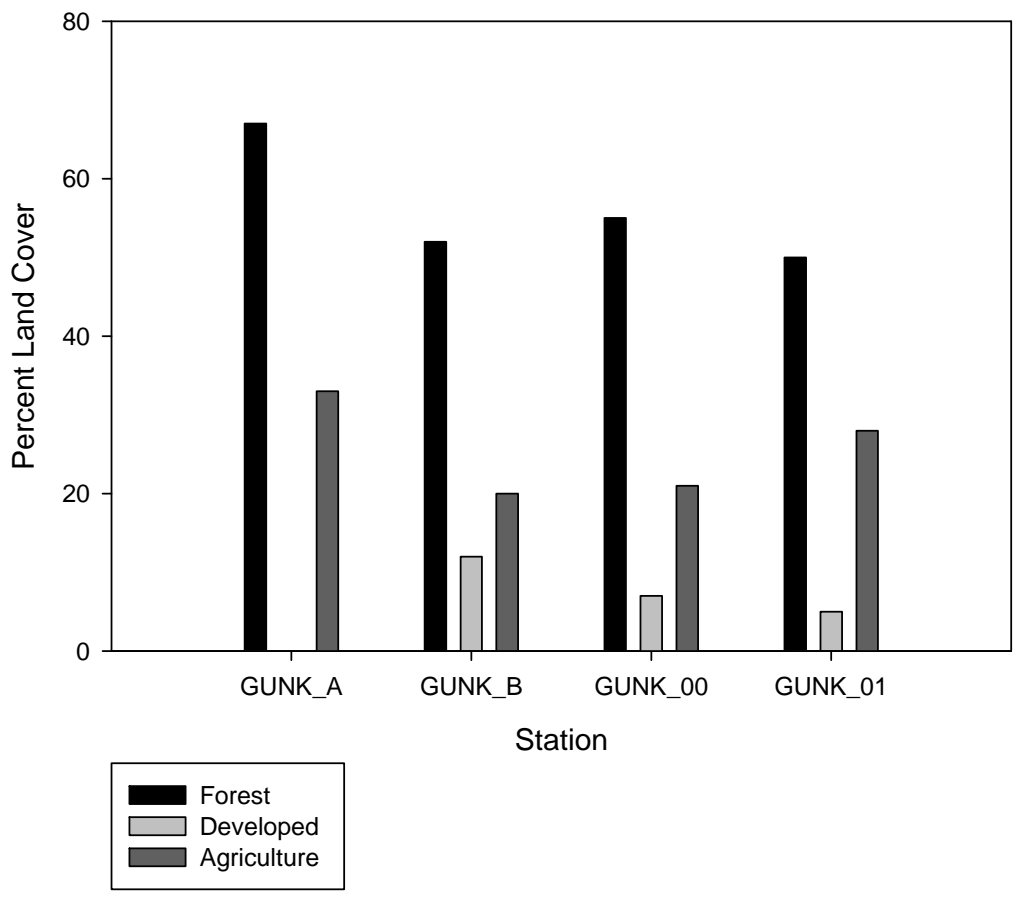
Table 2. Summary of percent land cover results:

Station	Forest	Developed	Agriculture	Impervious Surface
GUNK-A	67	0	33	0
GUNK-B	52	12	20	4
GUNK-00	55	7	21	2
GUNK-01	50	5	28	1

Table 3. Impact Source Determination (ISD), Shawangunk Kill, 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	GUNK-A	GUNK-B	GUNK-00	GUNK-01
Natural: minimal human disturbance	51	55	58	65
Nutrient Enriched: mostly nonpoint, agricultural	44	59	58	51
Toxic: industrial, municipal, or urban runoff	24	39	55	43
Organic: sewage effluent, animal wastes	33	34	45	40
Complex: municipal/industrial	19	29	48	40
Siltation	37	45	51	47
Impoundment	31	48	52	50

Summary of ISD results

Station	Community Type
GUNK-A	Natural
GUNK-B	Nutrient Enriched
GUNK-00	Natural / Enriched
GUNK-01	Natural

Table 4. Station locations for the Shawangunk Kill, Ulster and Orange counties, New York, 2007.

Station   Location

GUNK-A   Maple Glen, NY
Above Meyers Road bridge site
Latitude: 41° 30' 41"
Longitude: 74° 28' 19"

GUNK - A

GUNK-B   Above Burlingham, NY
Above Larson Road bridge
Latitude: 41° 34' 44"
Longitude: 74° 23' 45"

GUNK-00   Below Pine Bush, NY
Above Hardenburg Road bridge
Latitude: 41° 37' 09"
Longitude: 74° 17' 40"
No photograph available

GUNK-01   Ganahgote, NY
Above County Route 9 bridge
Latitude: 41° 41' 11"
Longitude: 74° 10' 29"
No photograph available

GUNK - B

Figure 4. Watershed overview map, Shawangunk Kill, Ulster and Orange counties, NY.

| Overview Map | Shawangunk Kill |

Legend

Water Quality Assessment

- 🔵 non-impacted
- 🔺 slightly impacted
- 🟨 moderately impacted
- 🔴 severely impacted
- Hydrography
- Watershed Boundary

N

0   2   4   8 Miles
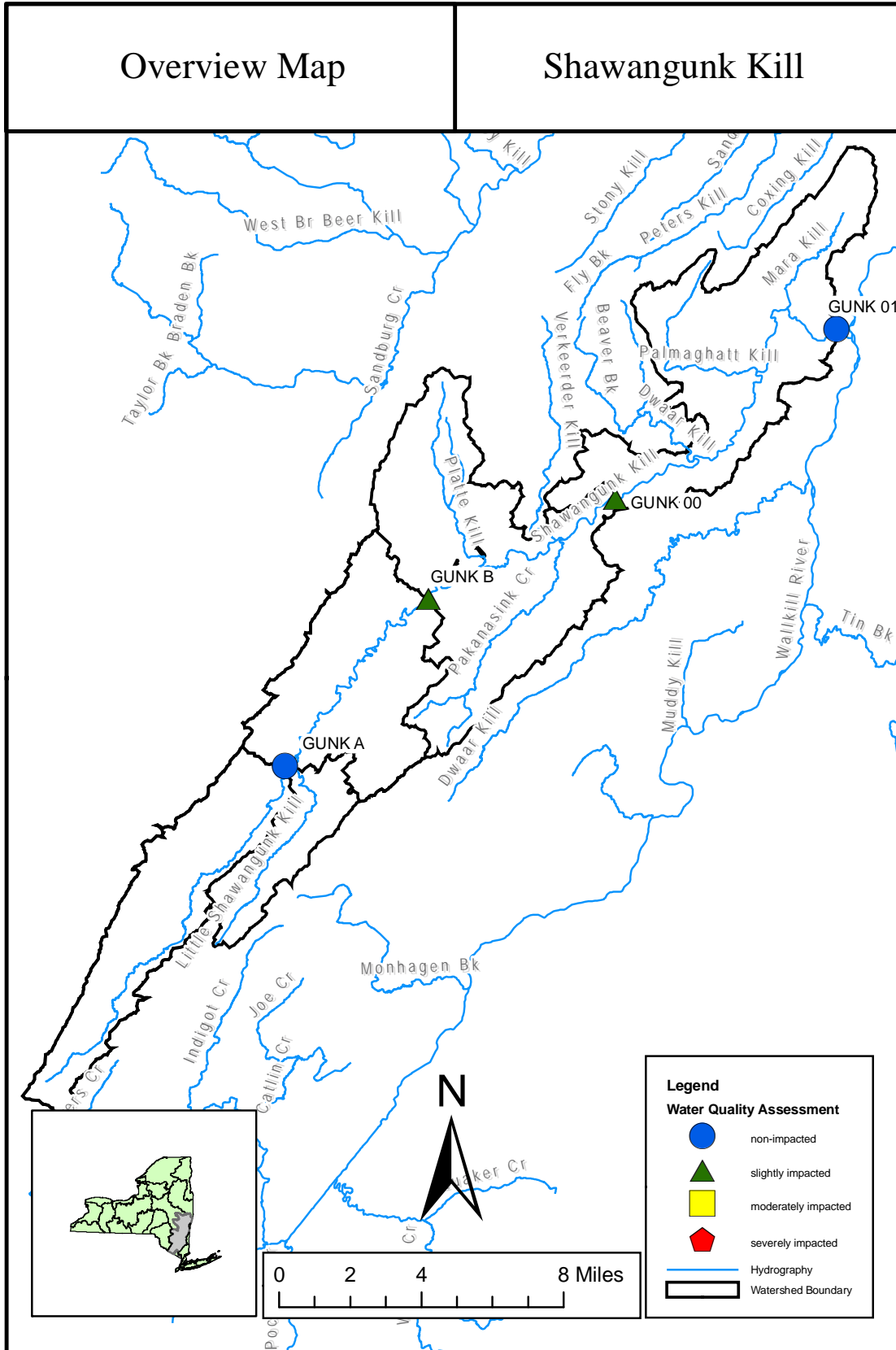
Figure 5. Map of Shawangunk Kill station A

Site Location Map	Shawangunk Kill

GUNK A

Legend
● Sampling Location
— Hydrography

GUNK 01
GUNK 00
GUNK B
GUNK A

Quad: Wurtsboro

0   0.05 0.1   0.2 Miles

N
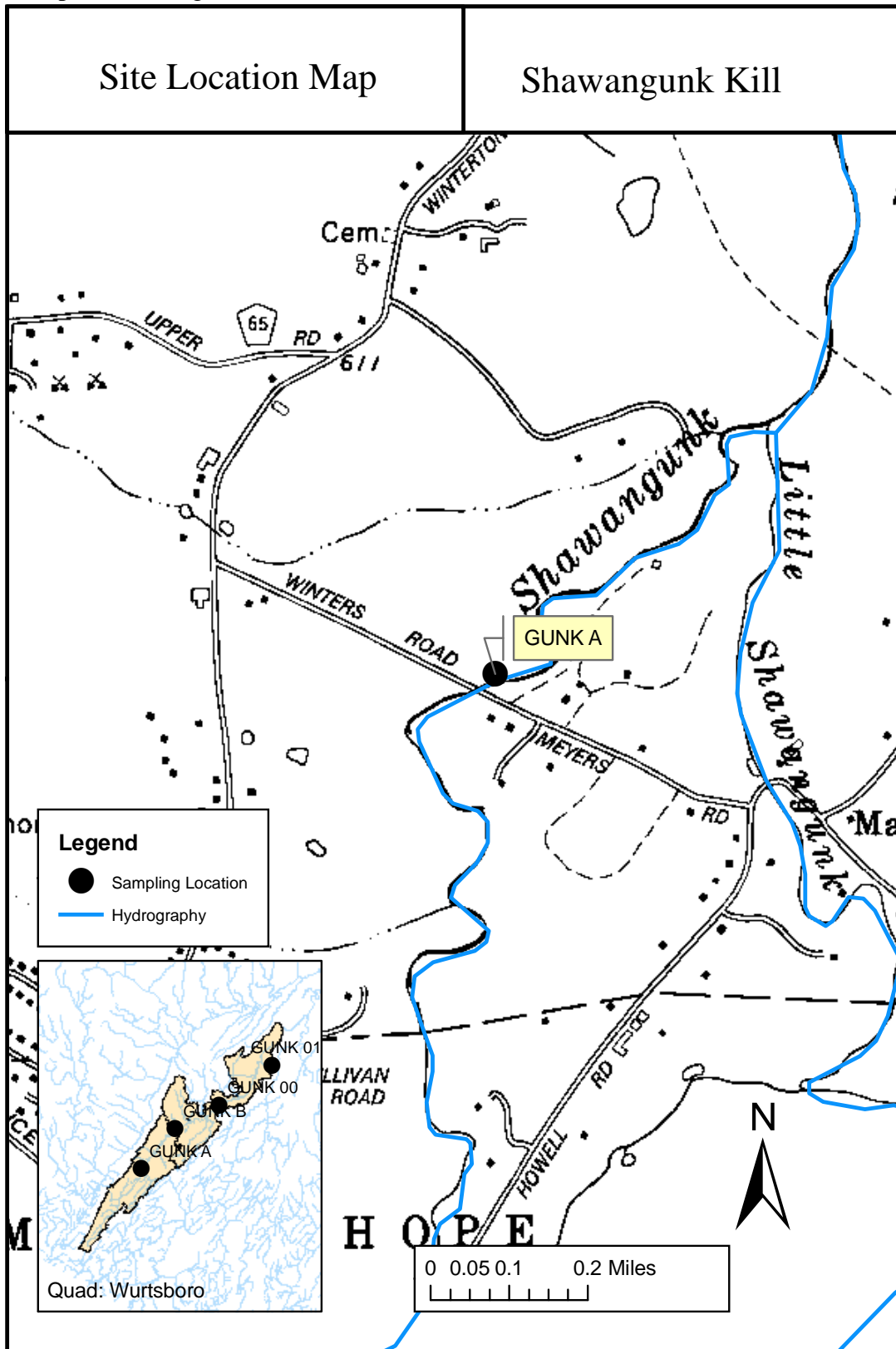
Figure 6. Map of Shawangunk Kill station B

Site Location Map	Shawangunk Kill

GUNK B

Legend

● Sampling Location

— Hydrography

GUNK 01

GUNK 00

GUNK B

GUNK A

Quad: Wurtsboro

N

0   0.1   0.2   0.4 Miles
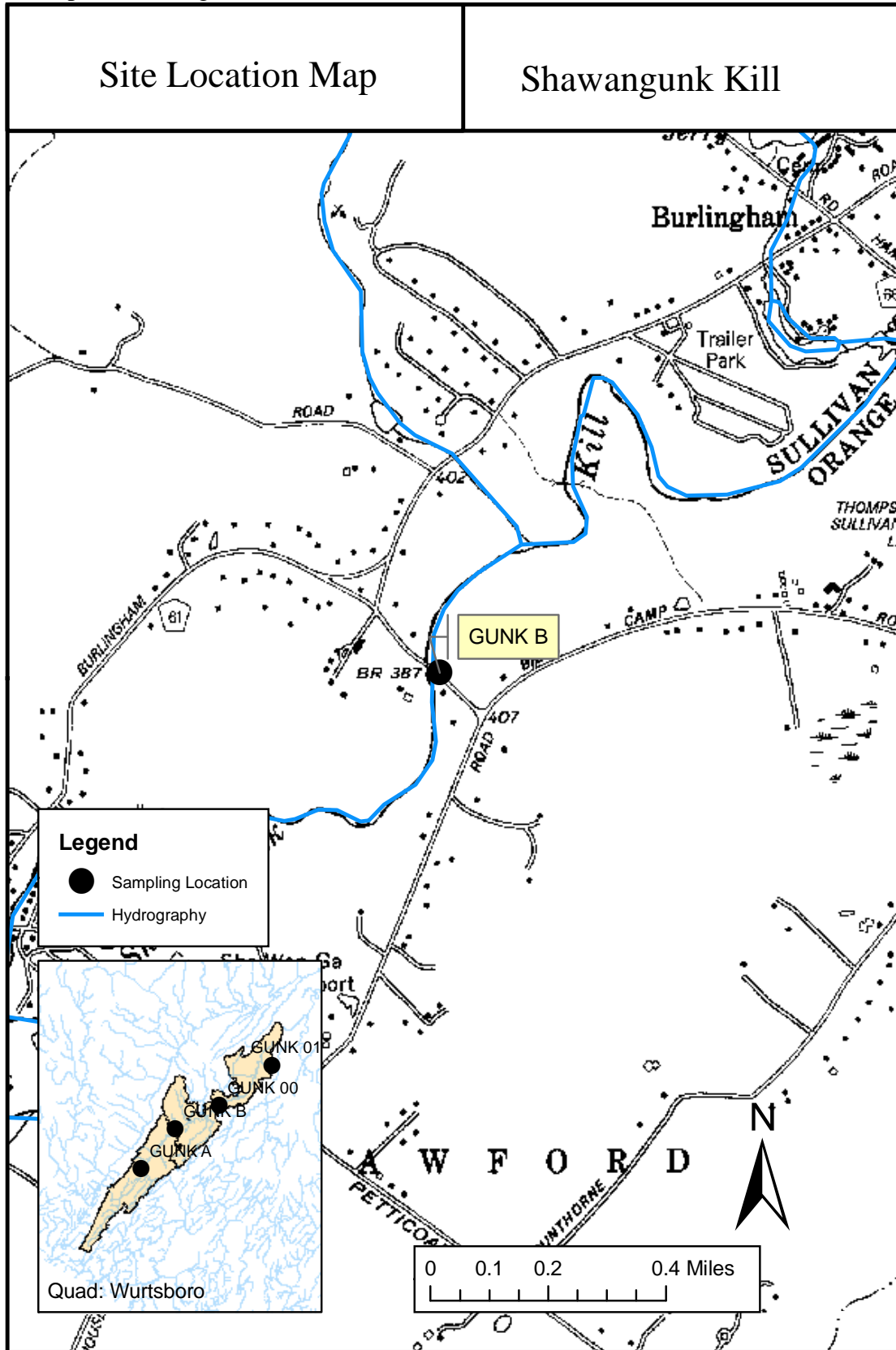
Figure 7. Map of Shawangunk Kill station 00

Site Location Map	Shawangunk Kill

GUNK 00

Legend
● Sampling Location
— Hydrography

GUNK 01
GUNK 00
GUNK B
GUNK A

Quad: Pine Bush

Pine Bush
(BM 396)

Town of Crawford Park

N

0   0.1   0.2   0.4 Miles
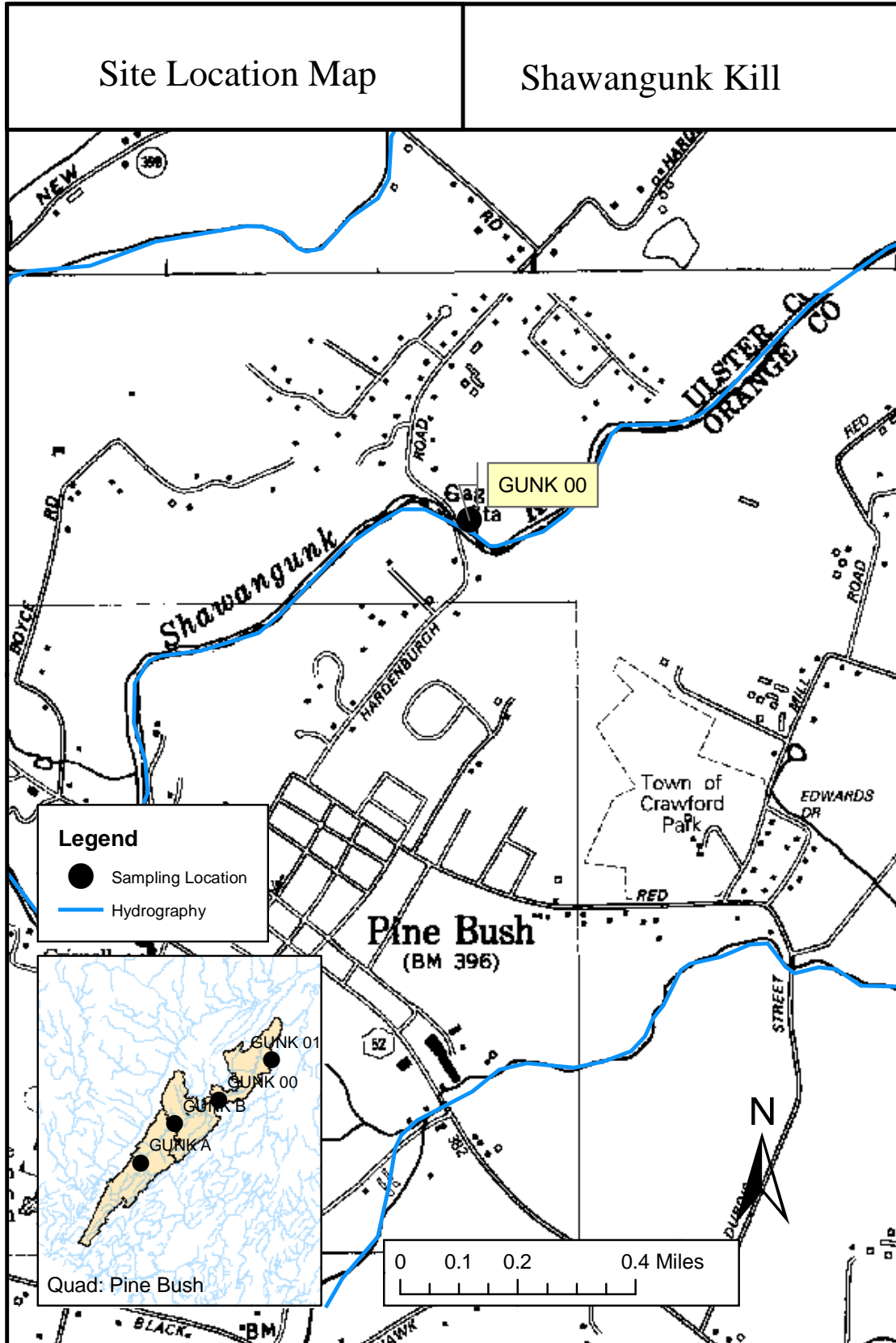
Figure 8. Map of Shawangunk Kill station 01
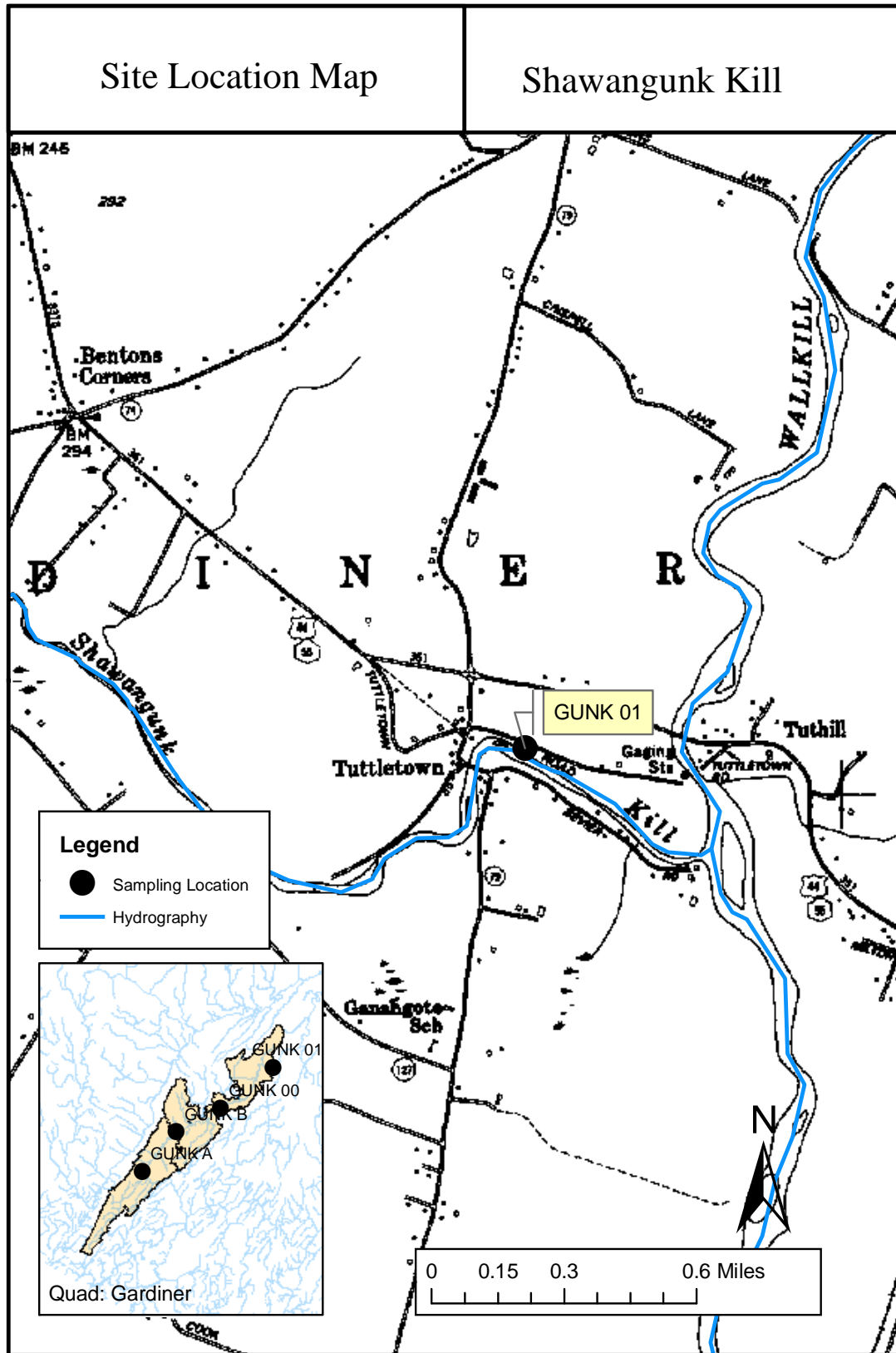
Table 5. Macroinvertebrate species collected in the Shawangunk Kill, Ulster and Orange counties, NY, 2007.

ARTHROPODA
 CRUSTACEA
 DECAPODA
 Cambaridae
  Cambarus sp.

 INSECTA
 EPHEMEROPTERA
 Isonychiidae
  Isonychia bicolor
 Baetidae
  Acentrella sp.
  Baetis flavistriga
  Baetis intercalaris
 Heptageniidae
  Epeorus (Iron) sp.
  Heptagenia sp.
  Leucrocuta sp.
  Stenonema terminatum
  Stenonema sp.
 Ephemerellidae
  Serratella deficiens
 Caenidae
  Caenis sp.
 Ephemeridae
  Ephemera guttulata

 PLECOPTERA
 Perlidae
  Acroneuria abnormis
  Agnetina capitata
  Paragnetina immarginata
  Paragnetina media

 COLEOPTERA
 Psephenidae
  Psephenus herricki
 Elmidae
  Optioservus trivittatus
  Stenelmis concinna
  Stenelmis crenata

 MEGALOPTERA
 Corydalidae
  Nigronia serricornis
 Sialidae
  Sialis sp.

 TRICHOPTERA
 Philopotamidae
  Chimarra aterrima?
  Chimarra obscura
 Psychomyiidae
  Psychomyia flavida
 Hydropsychidae
  Cheumatopsyche sp.
  Hydropsyche betteni
  Hydropsyche bronta
  Hydropsyche morosa
  Hydropsyche phalerata
  Hydropsyche sparna
 Rhyacophilidae
  Rhyacophila fuscula
 Glossosomatidae
  Glossosoma sp.
 Hydroptilidae
  Leucotrichia sp.
 Brachycentridae
  Brachycentrus appalachia

 LEPIDOPTERA
 Pyralidae
  Petrophila sp.

 DIPTERA
 Tipulidae
  Antocha sp.
 Simuliidae
  Simulium jenningsi
  Simulium tuberosum
 Athericidae
  Atherix sp.
 Empididae
  Hemerodromia sp.
 Chironomidae
  Diamesa sp.
  Cardiocladius obscurus
  Cricotopus bicinctus
  Cricotopus vierriensis
 Nanocladius sp.
  Orthocladius dubitatus
  Parametriocnemus sp.
  Tvetenia vitracies
  Polypedilum aviceps
  Polypedilum flavum

Table 6. Macroinvertebrate Data Reports (MDR)

STREAM SITE: Shawangunk Kill, Station A
LOCATION: Orange County, NY
DATE: 8/28/2007
SAMPLE TYPE: Kick
SUBSAMPLE: 100 organisms

ARTHROPODA
 INSECTA
  EPHEMEROPTERA

	Isonychiidae	*Isonychia bicolor*	1
	Heptageniidae	*Epeorus* (Iron) sp.	6
		Leucrocuta sp.	1
		Stenonema terminatum	3
	Ephemeridae	*Ephemera guttulata*	7
PLECOPTERA	Perlidae	*Acroneuria abnormis*	3
		Agnetina capitata	1
		Paragnetina immarginata	1
		Paragnetina media	13
COLEOPTERA	Psephenidae	*Psephenus herricki*	7
	Elmidae	*Optioservus trivittatus*	8
		Stenelmis concinna	2
		Stenelmis crenata	12
MEGALOPTERA	Corydalidae	*Nigronia serricornis*	2
	Sialidae	*Sialis* sp.	1
TRICHOPTERA	Philopotamidae	*Chimarra aterrima*?	2
	Hydropsychidae	*Hydropsyche morosa*	8
		Hydropsyche sparna	1
	Rhyacophilidae	*Rhyacophila fuscula*	3
	Glossosomatidae	*Glossosoma* sp.	1
	Brachycentridae	*Brachycentrus appalachia*	1
DIPTERA	Athericidae	*Atherix* sp.	13
	Chironomidae	*Diamesa* sp.	1
		Parametriocnemus sp.	1
		Polypedilum aviceps	1

SPECIES RICHNESS: 25
BIOTIC INDEX: 3.5
EPT RICHNESS: 15
MODEL AFFINITY: 56
ASSESSMENT: non

Description: The sample was collected above Meyers Rd. bridge in Maple Glen, NY. The site was surrounded by a thick, vegetated riparian area creating dense canopy cover keeping water temperature lower than other sites. The in-stream substrate was represented by a good mixture of rock, rubble, gravel, and sand. The invertebrate community comprised many clean water mayflies, stoneflies, and caddisflies and water quality was assessed as non-impacted.

STREAM SITE: Shawangunk Kill, Station B
LOCATION: Ulster County, NY
DATE: 8/28/2007
SAMPLE TYPE: Kick
SUBSAMPLE: 100 organisms

ARTHROPODA
 CRUSTACEA
  DECAPODA

| | | Cambaridae | *Cambarus* sp. | 1 |

INSECTA
 EPHEMEROPTERA

EPHEMEROPTERA	Isonychiidae	*Isonychia bicolor*	14
	Baetidae	*Acentrella* sp.	1
		Baetis intercalaris	1
	Heptageniidae	*Stenonema terminatum*	5
	Caenidae	*Caenis* sp.	2

| PLECOPTERA | Perlidae | *Acroneuria abnormis* | 1 |
| | | *Paragnetina media* | 8 |

COLEOPTERA	Psephenidae	*Psephenus herricki*	1
	Elmidae	*Optioservus trivittatus*	11
		Stenelmis crenata	23

| MEGALOPTERA | Corydalidae | *Nigronia serricornis* | 4 |

TRICHOPTERA	Philopotamidae	*Chimarra aterrima*?	4
	Hydropsychidae	*Hydropsyche betteni*	1
		Hydropsyche bronta	5
		Hydropsyche morosa	5

DIPTERA	Tipulidae	*Antocha* sp.	3
	Athericidae	*Atherix* sp.	2
	Chironomidae	*Cricotopus bicinctus*	1
		Cricotopus vierriensis	2
		Nanocladius sp.	1
		Orthocladius dubitatus	2
		Polypedilum flavum	2

SPECIES RICHNESS: 23
BIOTIC INDEX: 4.3
EPT RICHNESS: 11
MODEL AFFINITY: 66
ASSESSMENT: slight

Description: The sample was collected above the Larson Rd. bridge just outside of Burlingham, NY. Water quality was assessed as slightly impacted at this station. Water temperature increased slightly while canopy cover decreased significantly, and a greater amount of silt was present on the substrate. The number of stoneflies present diminished and the community became dominated by riffle beetles indicative of increased nutrient concentrations.

STREAM SITE:	Shawangunk Kill, Station 00
LOCATION:	Orange/Ulster Counties, NY
DATE:	8/28/2007
SAMPLE TYPE:	Kick
SUBSAMPLE:	100 organisms

ARTHROPODA
 INSECTA
  EPHEMEROPTERA

	Isonychiidae	*Isonychia bicolor*	7
	Baetidae	*Acentrella* sp.	3
		Baetis intercalaris	11
	Heptageniidae	*Stenonema* sp.	5
PLECOPTERA	Perlidae	*Acroneuria abnormis*	1
		Paragnetina media	8
COLEOPTERA	Psephenidae	*Psephenus herricki*	2
	Elmidae	*Optioservus trivittatus*	3
		Stenelmis crenata	10
TRICHOPTERA	Philopotamidae	*Chimarra aterrima*?	1
		Chimarra obscura	2
	Psychomyiidae	*Psychomyia flavida*	2
	Hydropsychidae	*Cheumatopsyche* sp.	7
		Hydropsyche morosa	14
		Hydropsyche sparna	4
	Hydroptilidae	*Leucotrichia* sp.	8
DIPTERA	Simuliidae	*Simulium jenningsi*	2
	Chironomidae	*Cardiocladius obscurus*	1
		Cricotopus vierriensis	1
		Orthocladius dubitatus	2
		Tvetenia vitracies	1
		Polypedilum flavum	5

SPECIES RICHNESS:	22
BIOTIC INDEX:	4.7
EPT RICHNESS:	13
MODEL AFFINITY:	63
ASSESSMENT:	slight

Description: The sample was collected below Pine Bush, NY, just above the Hardenburg Rd. bridge. The benthic macroinvertebrate community at this station was very similar to that of station B, although caddisflies became slightly more dominant here. Water quality was assessed as slightly impacted.

STREAM SITE: Shawangunk Kill, Station 01
LOCATION: Ulster County, NY
DATE: 8/28/2007
SAMPLE TYPE: Kick
SUBSAMPLE: 100 organisms

ARTHROPODA
  INSECTA
    EPHEMEROPTERA

	Isonychiidae	*Isonychia bicolor*	5
	Baetidae	*Acentrella* sp.	7
		Baetis flavistriga	2
		Baetis intercalaris	4
	Heptageniidae	*Heptagenia* sp.	1
		Leucrocuta sp.	14
		Stenonema sp.	3
	Ephemerellidae	*Serratella deficiens*	2
PLECOPTERA	Perlidae	*Paragnetina media*	1
COLEOPTERA	Psephenidae	*Psephenus herricki*	5
	Elmidae	*Optioservus trivittatus*	6
		Stenelmis crenata	9
TRICHOPTERA	Philopotamidae	*Chimarra aterrima*?	3
		Chimarra obscura	11
	Hydropsychidae	*Hydropsyche betteni*	4
		Hydropsyche morosa	2
		Hydropsyche phalerata	2
		Hydropsyche sparna	1
	Hydroptilidae	*Leucotrichia* sp.	12
LEPIDOPTERA	Pyralidae	*Petrophila* sp.	1
DIPTERA	Simuliidae	*Simulium tuberosum*	1
	Empididae	*Hemerodromia* sp.	1
	Chironomidae	*Cardiocladius obscurus*	1
		Polypedilum flavum	2

SPECIES RICHNESS:	24
BIOTIC INDEX:	3.9
EPT RICHNESS:	16
MODEL AFFINITY:	65
ASSESSMENT:	non

Description: The sample for this station was collected just above the County Rte. 9 bridge in Ganahgote, NY. Water quality was assessed as non-impacted. The macroinvertebrate community had a higher percentage of pollution intolerant mayflies here than at the previous two upstream stations. However, caddisflies and riffle beetles preferring high nutrient concentrations were still well represented in the community.

Table 6. Laboratory data summary, the Shawangunk Kill, Ulster and Orange counties, NY, 2007.

LABORATORY DATA SUMMARY				
STREAM NAME: Shawangunk Kill				
DATE SAMPLED: 8/28/2007				
SAMPLING METHOD: Kick				
LOCATION	GUNK	GUNK	GUNK	GUNK
STATION	A	B	00	01
DOMINANT SPECIES / %CONTRIBUTION / TOLERACE / COMMON NAME				
1.	Paragnetina media 13 % intolerant stonefly	Stenelmis crenata 23 % facultative beetle	Hydropsyche morosa 14 % facultative caddisfly	Leucrocuta sp. 14 % intolerant mayfly
2. Intolerant = not tolerant of poor water quality	Atherix sp. 13 % intolerant snipe fly	Isonychia bicolor 14 % intolerant mayfly	Baetis intercalaris 11 % facultative mayfly	Leucotrichia sp. 12 % facultative caddisfly
3. Facultative = occurring over a wide range of water quality	Stenelmis crenata 12 % facultative beetle	Optioservus trivittatus 11 % intolerant beetle	Stenelmis crenata 10 % facultative beetle	Chimarra obscura 11 % intolerant caddisfly
4. Tolerant = tolerant of poor water quality	Hydropsyche morosa 8 % facultative caddisfly	Paragnetina media 8 % intolerant stonefly	Paragnetina media 8 % intolerant stonefly	Stenelmis crenata 9 % facultative beetle
5.	Optioservus trivittatus 8 % intolerant beetle	Stenonema terminatum 5 % intolerant mayfly	Leucotrichia sp. 8 % facultative caddisfly	Acentrella sp. 7 % intolerant mayfly
% CONTRIBUTION OF MAJOR GROUPS (NUMBER OF TAXA IN PARENTHESIS)				
Chironomidae (midges)	3 (3.0)	8 (5.0)	10 (5.0)	3 (2.0)
Trichoptera (caddisflies)	16 (6.0)	15 (4.0)	38 (7.0)	35 (7.0)
Ephemeroptera (mayflies)	18 (5.0)	23 (5.0)	26 (4.0)	38 (8.0)
Plecoptera (stoneflies)	18 (4.0)	9 (2.0)	9 (2.0)	1 (1.0)
Coleoptera (beetles)	29 (4.0)	35 (3.0)	15 (3.0)	20 (3.0)
Oligochaeta (worms)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Mollusca (clams and snails)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Crustacea (crayfish, scuds, sowbugs)	0 (0.0)	1 (1.0)	0 (0.0)	0 (0.0)
Other insects (odonates, diptera)	16 (3.0)	9 (3.0)	2 (1.0)	3 (3.0)
Other (Nemertea, Platyhelminthes)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
SPECIES RICHNESS	25	23	22	24
BIOTIC INDEX	3.54	4.38	4.72	3.98
EPT RICHNESS	15	11	13	16
PERCENT MODEL AFFINITY	56	66	63	65
FIELD ASSESSMENT	VG	VG	G	VG
OVERALL ASSESSMENT	non-impacted	slightly impacted	slightly impacted	non-impacted

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Table 7. Field data summaries, the Shawangunk Kill, Ulster and Orange counties, NY, 2007.

FIELD DATA SUMMARY				
STREAM NAME: Shawangunk Kill	DATE SAMPLED: 8/28/2007			
REACH:				
FIELD PERSONNEL INVOLVED: Bode/Smith				
STATION	A	B	00	01
ARRIVAL TIME AT STATION	11:00	12:00	1:10	2:00
LOCATION	GUNK	GUNK	GUNK	GUNK
PHYSICAL CHARACTERISTICS				
Width (meters)	10	15	30	15
Depth (meters)	0.1	0.2	0.1	0.2
Current speed (cm per sec.)	100	100	100	125
Substrate (%)				
Rock (>25.4 cm, or bedrock)	10	10		20
Rubble (6.35 - 25.4 cm)	40	40	40	40
Gravel (0.2 - 6.35 cm)	30	20	30	20
Sand (0.06 - 2.0 mm)	10	10	20	10
Silt (0.004 - 0.06 mm)	10	20	10	10
Embeddedness (%)	20	30	15	10
CHEMICAL MEASUREMENTS				
Temperature (°C)	19	21	23	26
Specific Conductance (umhos)	351	333	331	289
Dissolved Oxygen (mg/l)	9	8.2	9.7	8.3
pH	6.9	7.6	8.5	8.7
BIOLOGICAL ATTRIBUTES				
Canopy (%)	80	20	30	10
Aquatic Vegetation				
Algae - suspended				
Algae - attached,filamentous	X	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		X	X
Megaloptera (dobsonflies, damselflies)	X	X	X	X
Odonata (dragonflies, damselflies)				
Chironomidae (midges)	X			
Simuliidae (black flies)				
Decapoda (crayfish)	X	X	X	X
Gammaridae (scuds)				
Mollusca (snails, clams)				
Oligochaeta (worms)				
Other				
FAUNAL CONDITION	VG	VG	G	VG

Appendix I. Biological Methods for Kick Sampling

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

B. <u>Site Selection</u>: 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. <u>Sampling</u>: 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. <u>Sample Sorting and Subsampling:</u> 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. <u>Organism Identification</u>: 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. <u>Species Richness</u>: 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; less than 11, severely impacted.

2. <u>EPT Richness</u>: the total number of species of mayflies (<u>E</u>phemeroptera), stoneflies (<u>P</u>lecoptera), and caddisflies (<u>T</u>richoptera) 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. <u>Hilsenhoff Biotic Index</u>: 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. <u>Percent Model Affinity</u>: 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. <u>Nutrient Biotic Index</u>: 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 (BAP); Conversion of Index Values to a Common 10-Scale

The Biological Assessment Profile 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.

Water Quality Scale	SPP	HBI	EPT	PMA	NBI	Water Quality Impact
10.0	35	2.0	15	90	3.0	None
7.5	26	4.5	10	64	5.0	Slight
5.0	18	6.5	5	49	6.0	Moderate
2.5	10	8.5	1	35	7.0	Severe
0.0	5	10.0	0	20	8.0	
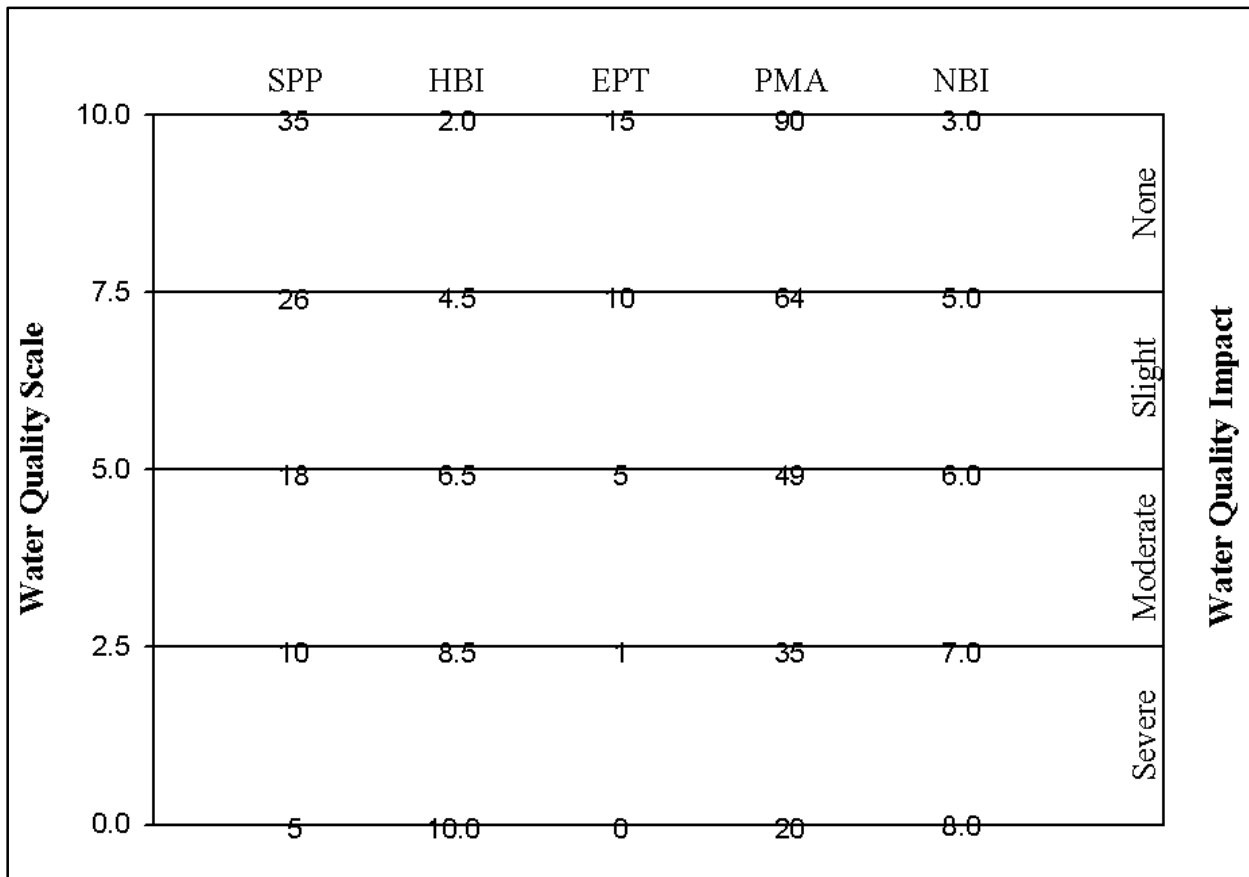
Appendix IV-B. Biological Assessment Profile: Plotting Values

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:
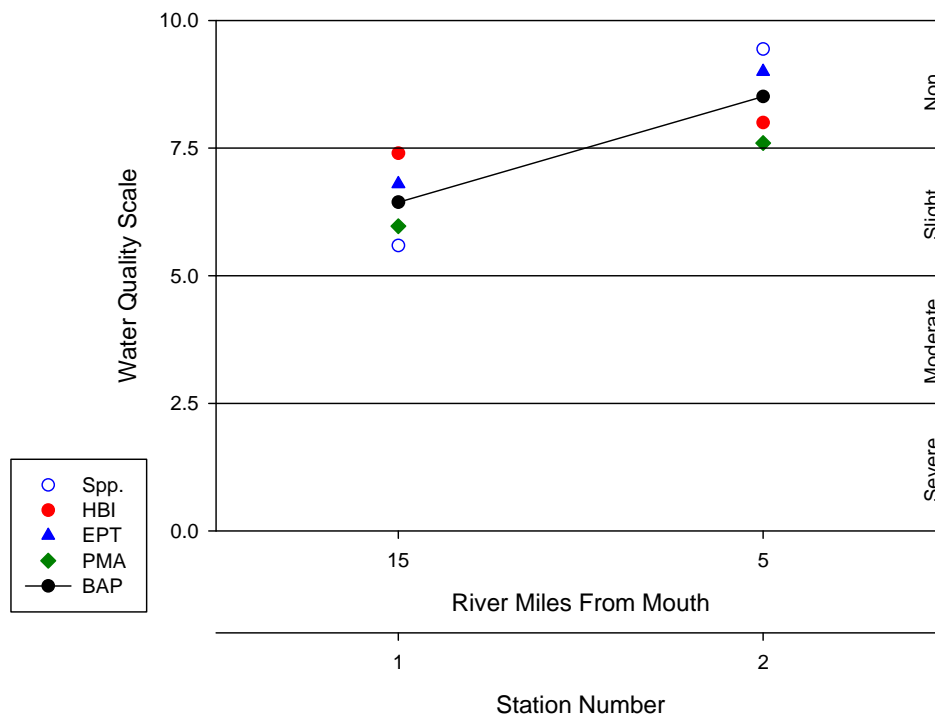
Appendix V. Water Quality Assessment Criteria

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
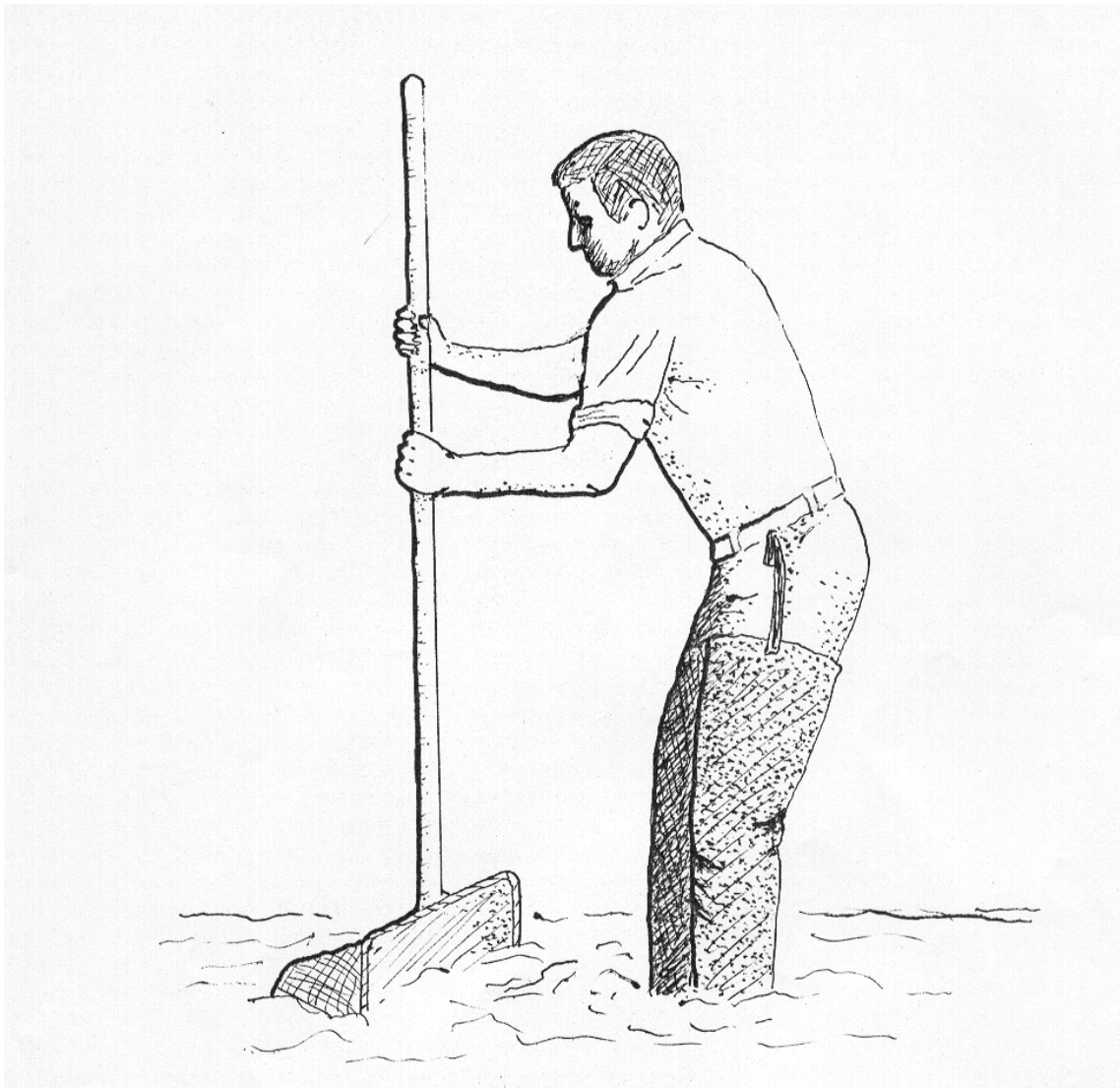
← current

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 that Usually Indicate 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

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Appendix VII. B. Aquatic Macroinvertebrates that Usually Indicate Poor Water Quality

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

MIDGES

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

BLACK FLIES

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

WORMS

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

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

SOWBUGS

Appendix 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

<u>Anthropogenic</u>: caused by human actions

<u>Assessment</u>: a diagnosis or evaluation of water quality

<u>Benthos</u>: organisms occurring on or in the bottom substrate of a waterbody

<u>Bioaccumulate</u>: accumulate contaminants in the tissues of an organism

<u>Biomonitoring</u>: the use of biological indicators to measure water quality

<u>Community</u>: a group of populations of organisms interacting in a habitat

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

<u>Electrofishing</u>: sampling fish by using electric currents to temporarily immobilize them, allowing capture

<u>EPT richness</u>: the number of species of mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera)in a sample or subsample

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

<u>Fauna</u>: the animal life of a particular habitat

<u>Impact</u>: a change in the physical, chemical, or biological condition of a waterbody

<u>Impairment</u>: a detrimental effect caused by an impact

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

<u>Intolerant</u>: unable to survive poor water quality

<u>Longitudinal trends</u>: upstream-downstream changes in water quality in a river or stream

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

<u>Multiplate</u>: multiple-plate sampler, a type of artificial substrate sampler of aquatic macroinvertebrates

<u>Organism</u>: a living individual

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

<u>Rapid bioassessment</u>: 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

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

<u>Species richness</u>: the number of macroinvertebrate species in a sample or subsample

<u>Station</u>: a sampling site on a waterbody

<u>Survey</u>: a set of samplings conducted in succession along a stretch of stream

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

<u>Tolerant</u>: able to survive poor water quality

Appendix X. Methods for Calculation of the Nutrient Biotic Index

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

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

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

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 Nutrient Biotic Indices

TAXON	TP T-Value	NO3 T-Value
Acentrella sp.	5	5
Acerpenna pygmaea	0	4
Acroneuria abnormis	0	0
Acroneuria sp.	0	0
Agnetina capitata	3	6
Anthopotamus sp.	4	5
Antocha sp.	8	6
Apatania sp.	3	4
Atherix sp.	8	5
Baetis brunneicolor	1	5
Baetis flavistriga	7	7
Baetis intercalaris	6	5
Baetis sp.	6	3
Baetis tricaudatus	8	9
Brachycentrus appalachia	3	4
Caecidotea racovitzai	6	2
Caecidotea sp.	7	9
Caenis sp.	3	3
Cardiocladius obscurus	8	6
Cheumatopsyche sp.	6	6
Chimarra aterrima?	2	3
Chimarra obscura	6	4
Chimarra socia	4	1
Chimarra sp.	2	0
Chironomus sp.	9	6
Cladotanytarsus sp.	6	4
Corydalus cornutus	2	2
Cricotopus bicinctus	7	6
Cricotopus tremulus gr.	8	9
Cricotopus trifascia gr.	9	9
Cricotopus vierriensis	6	5
Cryptochironomus fulvus gr.	5	6
Diamesa sp.	10	10
Dicranota sp.	5	10
Dicrotendipes neomodestus	10	4
Dolophilodes sp.	4	3
Drunella cornutella	4	4
Ectopria nervosa	10	9
Epeorus (Iron) sp.	0	0
Ephemerella sp.	4	4
Ephemerella subvaria	4	1
Ephoron leukon?	1	1
Eukiefferiella devonica gr.	9	9
Ferrissia sp.	9	5
Gammarus sp.	8	9
Glossosoma sp.	6	0
Goniobasis livescens	10	10
Helicopsyche borealis	1	2
Hemerodromia sp.	5	6
Heptagenia sp.	0	0
Hexatoma sp.	0	1
Hydropsyche betteni	7	9

TAXON	TP T-Value	NO3 T-Value
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
Undet. Enchytraeidae	7	8
Undet. Ephemerellidae	3	6
Undetermined Gomphidae	2	0
Undet. Heptageniidae	5	2

TAXON	TP T-Value	NO3 T-Value
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

<div align="center">NATURAL</div>

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

NONPOINT NUTRIENTS, PESTICIDES

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

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

	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