New York State
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Division of Water

Monhagen Brook

Biological Assessment

2004 Survey

New York State
Department of Environmental Conservation

George E. Pataki, *Governor*

MONHAGEN BROOK
BIOLOGICAL ASSESSMENT

Lower Hudson River Basin
Orange County, New York

Survey date: July 29, 2004
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CONTENTS

Stream: Monhagen Brook, Orange County, New York

Reach: above and below Middletown, New York

Drainage basin: Lower Hudson River

Background:

The Stream Biomonitoring Unit sampled Monhagen Brookin Orange County, New York, on July 29, 2004. Sampling was done to determine the condition of resident benthic macroinvertebrate communities in Monhagen Brook, assess current water quality, and compare with previous sampling results. In riffle areas at four sites, a traveling kick sample for macroinvertebrates was taken, using methods described in the Quality Assurance document (Bode et al., 2002) and sumn1arized in Appendix 1. 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 includes 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 2 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 Monhagen Brook was slightly impacted to moderately impacted. Primary causes of impact were nutrient enrichment, urban runoff, and unknown discharges.

2. Compared to the results of the 1992 sampling, water quality was similar. The rising level of chlorides, reflected by specific conductance which increased 253% from 1986 to 2004, is an ongoing concern in the creek.

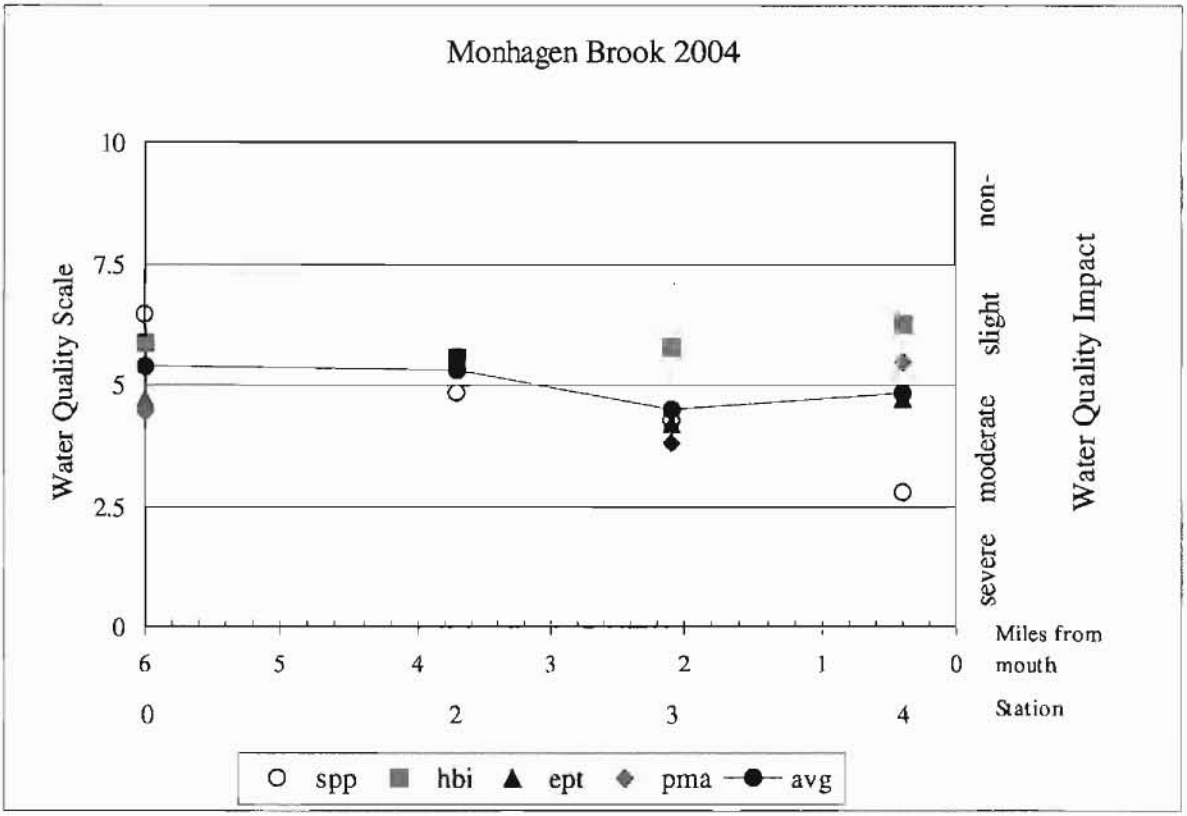
Discussion

Monhagen Brook originates from a small pond on the western outskirts of Middletown, New York. It flows east and south through Middletown before entering the Wallkill River east of the city, approximately 8 stream miles from its origin. The stream is classified as C, which denotes fishing as the best use. Most of the stream is 5 meters wide and 0.2 meters deep.

Monhagen Brook was previously sampled by the NYSDEC Avon Pollution Investigations Unit In 1972 (Cooper et al., 1973, as part of a Wallkill River survey), and by the NYSDEC Stream Biomonitoring Unit in 1986 (Bode et al., 1986) and 1992 (Bode et al., 1993). In the 1972 survey, all three sites downstream of the Middletown Sewage Treatment Plant were assessed as severely impacted. These sites correspond to Stations 2-4 in the present survey. In the 1986 survey, five sites were sampled, including the four sites used in the present survey. The four sites used in the present survey were assessed as severely impacted in 1986. Urban runoff was the likely cause of impact at the upstream site and the discharge of the Middletown Sewage Treatment Plant degraded conditions at Stations 2-4. In 1989, the treatment plant was upgraded and the effluent was rerouted to the Wallkill River. When Monhagen Brook was re-sampled by the Stream Biomonitoring Unit in 1992, water quality assessments reflected improvements resulting from the rerouting of sewage effluent. Water quality was moderately impacted at all sites except the most downstream. site (Station 4), which was within the range of slight impact.

In the present sampling, water quality in Monhagen Brook ranged from slightly impacted to moderately impacted (Figure 1). At the most upstream site (Station 0), the stream was littered with a large amount of refuse, equipment parts, and urban debris -- conditions similar to those documented in the 1986 study. Water quality was in the range of slight impact, with Impact Source Determination indicating possible effects of nutrient enrichment, toxic inputs, organic wastes, and impoundment (Table 1). At the downstream edge of Middletown (Station 2), the macroinvertebrate metrics were similar to those at upstream sites, although specific conductance had increased by 25%. At the two downstream sites (Stations 3-4), macroinvertebrate metrics worsened slightly and water quality was assessed as moderately impacted. Impact Source Determination again indicated a range of causes, but nutrient enrichment and urban runoff likely continued to exert an influence on the biota. Since 1986, water quality in Monhagen Brook appears to have improved upstream as well as downstream of the Middletown Sewage Treatment Plant (Figure 2). The 1989 upgrade of the plant and rerouting the discharge to the Wallkill River is the obvious source of downstream improvement from conditions found in the 1972 and 1986 samplings. A cause for the improvement of the stream at Station 0 is not identified by the 2004 survey, since urban runoff still affects water quality in the stream. As in 1992, conditions still decline downstream from Station 2 to the mouth. The rising level of chlorides, as measured by specific conductance which increased an average of 253% from 1986 to 2004 (Table 2), is an ongoing concern in the creek. This trend has recently been noted in many streams in the Hudson River basin (Novak and Bode, 2004) and calls for continued monitoring.

Figures1-2. Biological Assessment Profiles of Index Values, Monhagen Brook. Values are plotted on a normalized scale of water quality. Averages are shown for each year of sampling.



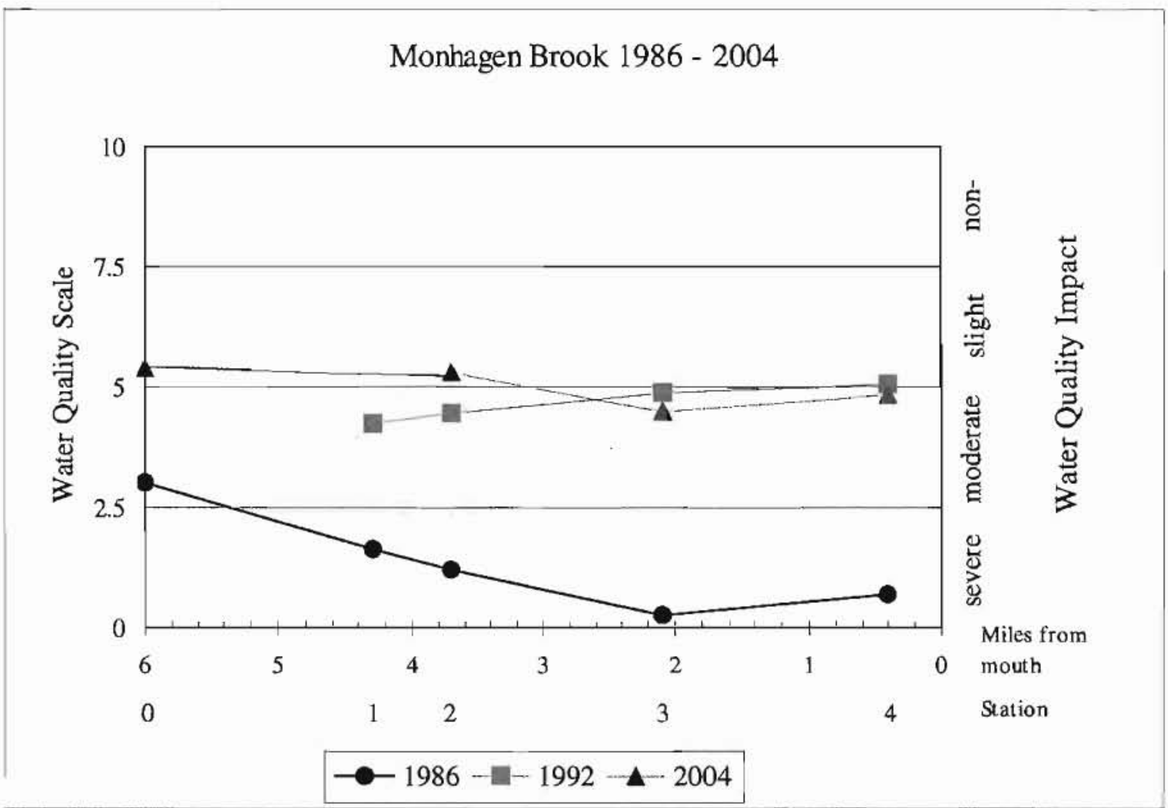


Table 1. Impact Source Determination, Monhagen Brook, 2004. Numbers represent similarity to macroinvertebrate community type nl0dels for each impact category. The highest similarities at each station are highlighted. Similarities less than 50% are less conclusive. Highest numbers represent probable type of impact. See Appendix X for further explanation.

	Station			
Community Type	MONH-0	MONH-2	MONH-3	MONH-4
Natural: minimal human impacts	30	38	28	46
Nutrient additions; mostly nonpoint, agricultural	47	49	57	58
Toxic: industrial, municipal, or urban run-off	45	47	44	69
Organic: sewage effluent, animal wastes	50	45	54	44
Complex: municipal/industrial	50	57	59	58
Siltation	44	40	40	43
Impoundment	47	49	60*	58

STATION	COMMUNITY TYPE
MONH-0	Nutrients, toxics, organics, impoundments
MONH-2	Complex
MONH-3	Complex, nutrients, organics
MONH-4	Toxics

* Indications of impoundment considered spurious

Table 2. Specific conductance in Monhagen Brook, in μmhos

STATION	DATE		
	June 1986	Aug 1992	July 2004
MONH-00	266	-	816
MONH-01	338	658	-
MONH-02	469	672	1026
MONH-03	483	644	1088
MONH-04	420	727	1071

Literature Cited:

Bode, R. W., M. A. Novak, L. E. Abele, D. L. Heitzlnan, 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.

Bode, R. W., M. A. Novak, and L. E. Abele. 1986. Rapid biological stream assessment, Monhagen Brook. New York State Department of Environmental Conservation, Technical Report, 12 pages.

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Cooper, A. L., and G. N. Neuderfer. 1973. A macroinvertebrate study of the Wallkill River. New York State Department of Environmental Conservation, Technical Report, 50 pages.

Novak, M.A., and R. W. Bode. 2004. Thirty-year trends in water quality of Hudson River tributaries. Conference: Rising Salt Concentrations in Tributaries of the Hudson River Estuary. Hudson River Environmental Society, 2004.

Smith, A. J., and R. W. Bode. 2004. Analysis of variability in New York State benthic macroinvertebrate samples. New York State Department of Environmental Conservation, Technical Report, 43 pages.

Overview of field data

At the sites sampled on July 29, 2004, Monhagen Brook was 3-5 meters wide, 0.2 meters deep, and had current speeds of 80-100 cm/sec in riffles. Dissolved oxygen was 7.9-9.0 mg/l, specific conductance was 816-1088 μmhos, pH was 7.5-7.9 and temperature was 20-23 °C (68-73 °F). Measurements for each site are found on the field data summary sheets.

Table 3. Station Locations for Monhagen Brook, Orange County, NY

STATION	LOCATION
00	Middletown, New York Below Route 17M bridge Latitude/Longitude 41° 26' 53"; 74° 25' 50" 6.0 stream miles above mouth
02	Middletown, New York Below Dolsontown Road bridge Latitude/Longitude 41° 25' 21"; 74° 25' 40" 3.7 stream miles above mouth
03	Middletown, New York Above McVeigh Road bridge Latitude/Longitude 41° 25' 19"; 74° 24' 21" 2.1 stream miles above mouth
04	Middletown, New York Above Co. Rte. 50 (Golf Links Rd. bridge) Latitude/Longitude 41° 26' 24"; 74° 22' 48" 0.4 stream miles above mouth

Figure 3 | Site Location Map | Monhagen Brook

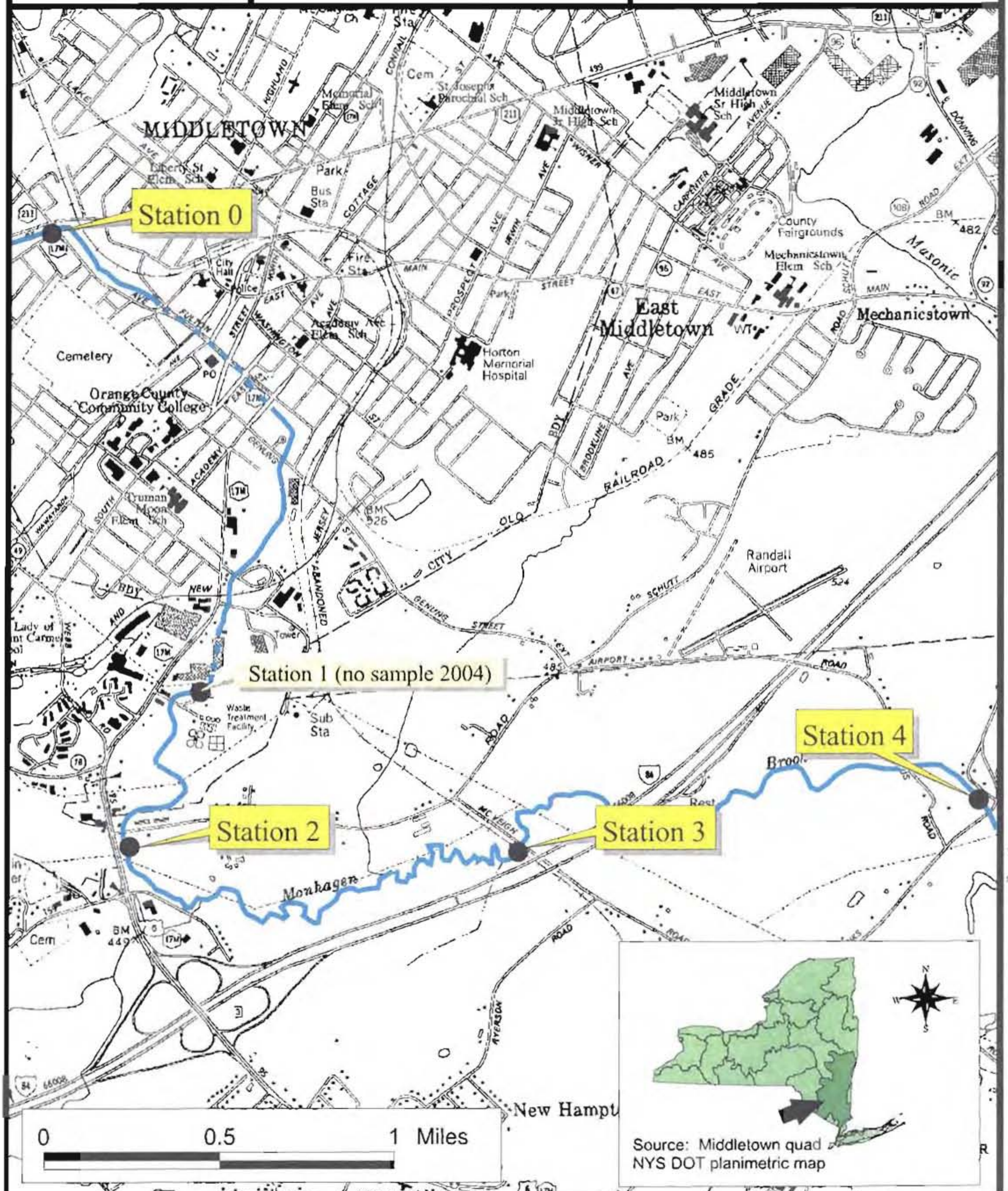


Table 4. Macroinvertebrate Species Collected in Monhagen Brook, Orange County, NY, 2004.

PLATYHELMINTHES
TURBELLARIA
Planariidae
Undetermined Turbellaria
ANNELIDA
OLIGOCHAETA
TUBIFICIDA
Enchytraeidae
Undetermined Enchytraeidae
Tubificidae
Undet. Tubificidae w/ cap. setae
Undet. Tubificidae w/o cap. setae
HIRUDINEA
Glossiphoniidae
Undetermined Hirudinea
MOLLUSCA
PELECYPODA
Sphaeriidae
Undetermined Sphaeriidae
ARTHROPODA
CRUSTACEA
ISOPODA
Asellidae
Caecidotea racovitzai
Caecidotea sp.
AMPHIPODA
Gammaridae
Gammarus sp.
DECAPODA
Cambaridae
Undetermined Cambaridae
INSECTA
EPHEMEROPTERA
Baetidae
Baetis flavistriga
Baetis intercalaris
COLEOPTERA
Elmidae
Optioservus fastiditus
Stenelmis crenata
Stenelmis sp.
TRICHOPTERA
Philopotamidae
Chimarra aterrima?
Hydropsychidae
Cheumatopsyche sp.
Hydropsyche betteni
Hydropsyche bronta
Hydropsyche morosa
Hydropsyche sp.
Hydroptilidae
Hydroptila consimilis

DIPTERA
Tipulidae
Antocha sp.
Simuliidae
Simulium aureum
Simulium tuberosum
Simulium sp.
Empididae
Hemerodromia sp.
Chironomidae
Thienemannimyia gr. spp.
Diamesa sp.
Cricotopus bicinctus
Cricotopus tremulus
Cricotopus vierriensis
Parametriocnemus lundbecki
Microtendipes rydalensis gr.
Polypedilum aviceps
Polypedilum illinoense
Polypedilum flavum
Polypedilum scalaenum gr.
Undetermined Chironomini
Rheotanytarsus exiguus gr.
Tanytarsus guerlus gr.

Macroinvertebrate Data Reports: Raw Data

STREAM SITE:	Monhagen Brook	Station 0
LOCATION:	Middletown, New York	Below Route 17M bridge
DATE:	29 July 2004	
SAMPLE TYPE:	Kick sample	
SUBSAMPLE:	100 individuals	

PLATYHELMINTHES			
TURBELLARIA			
	Planariidae	Undetermined Turbellaria	1
ANNELIDA			
OLIGOCHAETA			
TUBIFICIDA	Enchytraeidae	Undetermined Enchytraeidae	1
	Tubificidae	Undet. Tubificidae w/ cap. setae	1
HIRUDINEA			
	Glossiphoniidae	Undetermined Hirudinea	1
ARTHROPODA			
CRUSTACEA			
ISOPODA	Asellidae	*Caecidotea racovitzai*	5
AMPHIPODA	Gammaridae	*Gammarus sp.*	1
INSECTA			
EPHEMEROPTERA	Baetidae	*Baetis intercalaris*	2
COLEOPTERA	Elmidae	*Stenelmis sp.*	2
TRICHOPTERA	Philopotamidae	*Chimarra aterrima?*	1
	Hydropsychidae	*Cheumatopsyche sp.*	12
		Hydropsyche betteni	16
		Hydropsyche sp.	4
DIPTERA	Tipulidae	*Antocha sp.*	1
	Simuliidae	*Simulium aureum*	6
		Simulium tuberosum	10
	Empididae	*Hemerodromia sp.*	6
	Chironomidae	*Thienemannimyia gr. spp.*	10
		Diamesa sp.	8
		Microtendipes rydalensis gr.	1
		Polypedilum aviceps	1
		Polypedilum illinoense	2
		Polypedilum flavum	7
		Tanytarsus guerlus gr.	1

SPECIES RICHNESS:	23 (good)
BIOTIC INDEX:	5.83 (good)
EPT RICHNESS:	5 (poor)
MODEL AFFINITY:	46 (poor)
ASSESSMENT:	slightly impacted

DESCRIPTION: This site was 1.8 miles downstream of the source pond at the headwaters of Monhagen Brook. The stream is in an urban area, and was littered with a large amounts of refuse. The macroinvertebrate community was dominated by filter-feeding caddisflies, midges, and black flies. Based on the metrics, water quality was assessed as slightly impacted.

Macroinvertebrate Data Reports: Raw Data

STREAM SITE:	Monhagen Brook	Station 02
LOCATION:	Middletown, New York	Below Dolsontown Road bridge
DATE:	29 July 2004	
SAMPLE TYPE:	Kick sample	
SUBSAMPLE:	100 individuals	

ANNELIDA			
OLIGOCHAETA			
TUBIFICIDA	Tubificidae	Undet. Tubificidae w/o cap. setae	1
HIRUDINEA			
	Glossiphoniidae	Undetermined Hirudinea	1
ARTHROPODA			
CRUSTACEA			
ISOPODA	Asellidae	*Caecidotea sp.*	1
INSECTA			
EPHEMEROPTERA	Baetidae	*Baetis intercalaris*	22
COLEOPTERA	Elmidae	*Stenelmis crenata*	1
TRICHOPTERA	Hydropsychidae	*Cheumatopsyche sp.*	6
		Hydropsyche betteni	28
		Hydropsyche morosa	2
		Hydropsyche sp.	3
	Hydroptilidae	*Hydroptila consimilis*	20
DIPTERA	Simuliidae	*Simulium sp.*	1
	Empididae	*Hemerodromia sp.*	3
	Chironomidae	*Thienemannimyia gr. spp.*	3
		Cricotopus bicinctus	2
		Cricotopus tremulus gr.	2
		Polypedilum illinoense	2
		Polypedilum scalaenum gr.	1
		Undetermined Chironomini	1

SPECIES RICHNESS:	18 (poor)
BIOTIC INDEX:	6.06 (good)
EPT RICHNESS:	6 (good)
MODEL AFFINITY:	51 (good)
ASSESSMENT:	slightly impacted

DESCRIPTION: This site was downstream of the Middletown downtown area. The habitat was considered acceptable for riffle kick sampling. The macroinvertebrate community was heavily dominated by filter-feeding caddisflies. Water quality was assessed as slightly impacted, similar to upstream Station 0.

Macroinvertebrate Data Reports: Raw Data

STREAM SITE:	Moodna Brook	Station 03
LOCATION:	Middletown, New York	Above McVeigh Road bridge
DATE:	29 July 2004	
SAMPLE TYPE:	Kick sample	
SUBSAMPLE:	100 individuals	

PLATYHELMINTHES			
TURBELLARIA			
	Planariidae	Undetermined Turbellaria	2
ANNELIDA			
OLIGOCHAETA			
TUBIFICIDA	Tubificidae	Undet. Tubificidae w/o cap. setae	1
ARTHROPODA			
CRUSTACEA			
ISOPODA	Asellidae	*Caecidotea racovitzai*	1
INSECTA			
EPHEMEROPTERA	Baetidae	*Baetis flavistriga*	3
		Baetis intercalaris	1
COLEOPTERA	Elmidae	*Optioservus fastiditus*	1
		Stenelmis sp.	3
TRICHOPTERA	Hydropsychidae	*Cheumatopsyche sp.*	35
		Hydropsyche betteni	33
DIPTERA	Tipulidae	*Antocha sp.*	2
	Empididae	*Hemerodromia sp.*	2
	Chironomidae	*Thienemannimyia gr. spp.*	1
		Cricotopus bicinctus	1
		Cricotopus vierriensis	1
		Polypedilum flavum	4
		Rheotanytarsus exiguus gr.	9

SPECIES RICHNESS:	16 (poor)
BIOTIC INDEX:	5.88 (good)
EPT RICHNESS:	4 (poor)
MODEL AFFINITY:	42 (poor)
ASSESSMENT:	moderately impacted

DESCRIPTION: The kick sample was taken just upstream of the McVeigh Road bridge. The macroinvertebrate community was heavily dominated by filter-feeding caddisflies, as at upstream sites. Three of the four metrics worsened compared to upstream Station 2 and water quality was assessed as moderately impacted.

Macroinvertebrate Data Reports: Raw Data

STREAM SITE:	Monhagen Brook	Station 04
LOCATION:	Middletown, New York	Above Golf Links Road (County Route 50)
DATE:	29 July 2004	
SAMPLE TYPE:	Kick sample	
SUBSAMPLE:	100 individuals	

MOLLUSCA			
PELECYPODA			
	Sphaeriidae	Undetermined Sphaeriidae	2
ARTHROPODA			
CRUSTACEA			
ISOPODA	Asellidae	*Caecidotea racovitzai*	16
DECAPODA	Cambaridae	Undetermined Cambaridae	2
INSECTA			
EPHEMEROPTERA	Baetidae	*Baetis flavistriga*	17
COLEOPTERA	Elmidae	*Stenelmis crenata*	19
TRICHOPTERA	Philopotamidae	*Chimarra aterrima?*	19
	Hydropsychidae	*Cheumatopsyche sp.*	3
		Hydropsyche betteni	13
		Hydropsyche bronta	4
DIPTERA	Chironomidae	*Parametriocnemus lundbecki*	1
		Polypedilum flavum	4

SPECIES RICHNESS:	11 (poor)
BIOTIC INDEX:	5.50 (good)
EPT RICHNESS:	5 (poor)
MODEL AFFINITY:	52 (good)
ASSESSMENT:	moderately impacted

DESCRIPTION: Riffle habitat was good at this site, but the macroinvertebrate community was very limited. Filter-feeding caddisflies and algal-scraping riffle beetles were dominant. Based on the metrics, water quality was assessed as moderately impacted.

FIELD DATA SUMMARY				
STREAM NAME: Monhagen Brook		DATE SAMPLED: 7/29/2004		
REACH: Middletown				
FIELD PERSONNEL INVOLVED: Smith, Bode, Abele				
STATION	00	02	03	04
ARRIVAL TIME AT STATION	1:45	2:30	2:35	3:30
LOCATION	Rte 17M bridge	DOLSONTOWN Rd	McVeigh Rd bridge	Co. Rte. 50
PHYSICAL CHARACTERISTICS				
Width (meters)	3	5	5	5
Depth (meters)	0.2	0.2	0.2	.2
Current speed (cm per sec.)	80	80	100	80
Substrate (%)				
Rock (>25.4 cm, or bedrock)	10	10	10	10
Rubble (6.35 - 25.4 cm)	40	30	40	40
Gravel (0.2 – 6.35 cm)	20	30	30	20
Sand (0.06 – 2.0 mm)	10	20	10	20
Silt (0.004 – 0.06 mm)	20	10	10	10
Embeddedness (%)	20	25	25	40
CHEMICAL MEASUREMENTS				
Temperature (° C)	20	23	22	22
Specific Conductance (umhos)	816	1026	1088	1071
Dissolved Oxygen (mg/l)	9.0	8.1	7.9	8.6
pH	7.6	7.7	7.5	7.9
BIOLOGICAL ATTRIBUTES				
Canopy (%)	90	10	25	75
Aquatic Vegetation				
algae – suspended				
algae – attached, filamentous			present	
algae - diatoms		present	abundant	abundant
macrophytes or moss		present		
Occurrence of Macroinvertebrates				
Ephemeroptera (mayflies)		x		x
Plecoptera (stoneflies)				
Trichoptera (caddisflies)	x	x	x	x
Coleoptera (beetles)		x		x
Megaloptera(dobsonflies, alderflies)				
Odonata (dragonflies, damselflies)				
Chironomidae (midges)	x		x	x
Simuliidae (black flies)				
Decapoda (crayfish)		x	x	x
Gammaridae (scuds)			x	
Mollusca (snails, clams)				
Oligochaeta (worms)			x	x
Other	x	x	x	
FAUNAL CONDITION	poor	good	poor	good

LABORATORY DATA SUMMARY				
STREAM NAME: Monhagen Brook	DRAINAGE: 13			
DATE SAMPLED: 7/29/2004	COUNTY: Orange			
SAMPLING METHOD: Traveling Kick				
STATION	00	02	03	04
LOCATION	Middletown	Middletown	below Middletown	below Middletown
DOMINANT SPECIES/%CONTRIBUTION/TOLERANCE/COMMON NAME				
1.	*Hydropsyche betteni*	*Hydropsyche betteni*	*Cheumatopsyche sp.*	*Stenelmis crenata*
	16 %	28 %	35 %	19 %
	facultative	facultative	facultative	facultative
	caddisfly	caddisfly	caddisfly	beetle
2.	*Cheumatopsyche sp.*	*Baetis intercalaris*	*Hydropsyche betteni*	*Chimarra aterrima?*
Intolerant = not tolerant of poor	12 %	22 %	33 %	19 %
water quality	facultative	facultative	facultative	intolerant
	caddisfly	mayfly	caddisfly	caddisfly
3.	*Simulium tuberosum*	*Hydroptila consimilis*	*Rheotanytarsus exiguus gr.*	*Baetis flavistriga*
Facultative = occurring over a	10 %	20 %	9 %	17 %
wide range of water quality	intolerant	facultative	facultative	intolerant
	black fly	caddisfly	midge	mayfly
4.	*Thienemannimyia gr. spp.*	*Cheumatopsyche sp.*	*Polypedilum flavum*	*Caecidotea racovitzai*
Tolerant = tolerant of poor	10 %	6 %	4 %	16 %
water quality	facultative	facultative	facultative	tolerant
	midge	caddisfly	midge	sowbug
5.	*Diamesa sp.*	*Hydropsyche sp.*	*Baetis flavistriga*	*Hydropsyche betteni*
	8 %	3 %	3 %	13 %
	facultative	intolerant	intolerant	facultative
	midge	caddisfly	mayfly	caddisfly
% CONTRIBUTION OF MAJOR GROUPS (NUMBER OF TAXA IN PARENTHESES)				
Chironomidae (midges)	30.0 (7.0)	11.0 (6.0)	16.0 (5.0)	5.0 (2.0)
Trichoptera (caddisflies)	33.0 (4.0)	59.0 (5.0)	68.0 (2.0)	39.0 (4.0)
Ephemeroptera (mayflies)	2.0 (1.0)	22.0 (1.0)	4.0 (2.0)	17.0 (1.0)
Plecoptera (stoneflies)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)
Coleoptera (beetles)	2.0 (1.0)	1.0 (1.0)	4.0 (2.0)	19.0 (1.0)
Oligochaeta (worms)	2.0 (2.0)	1.0 (1.0)	1.0 (1.0)	0.0 (0.0)
Mollusca (clams and snails)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	2.0 (1.0)
Crustacea (crayfish, scuds, sowbugs)	6.0 (2.0)	1.0 (1.0)	1.0 (1.0)	18.0 (2.0)
Other insects (odonates, diptera)	23.0 (4.0)	4.0 (2.0)	4.0 (2.0)	0.0 (0.0)
Other (Nemertea, Platyhelminthes)	2.0 (2.0)	1.0 (1.0)	2.0 (1.0)	0.0 (0.0)
SPECIES RICHNESS	23	18	16	11
BIOTIC INDEX	5.83	6.06	5.88	5.5
EPT RICHNESS	5	6	4	5
PERCENT MODEL AFFINITY	46	51	42	52
FIELD ASSESSMENT	moderate	slight	moderate	moderate
OVERALL ASSESSMENT	slight	slight	moderate	moderate

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 meters 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 the dislodged organisms are carried into the net. Sampling is continued for a specified time and for a specified distance in the stream. Rapid assessment sampling specifies sampling five minutes for a distance of five meters. The net contents 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 stereo microscope 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 is 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.

MACROINVERTEBRATE COMMUNITY PARAMETERS

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

3. Hilsnhoff Biotic index is a measure of the tolerance of the organisms in the 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 purposes of characterizing species' tolerance, intolerant = 0-4, facultative = 5-7, and tolerant = 8-10. 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 the Quality Assurance document (Bode et al., 1996). Ranges for the levels of impact are: 0-4.50, non-impacted; 4.5 1-6.50, slightly impacted; 6.5 1-8.50, moderately impacted; and 8.51 - 10.00, severely impacted.

4. Percent Model Affinity is a measure of similarity to a model non-impacted community based on percent abundance in seven major macroinvertebrate groups (Novak and Bode, 1992). Percent 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.

Bode, R.W., M.A. Novak, and L.E. Abele. 1996. Quality assurance work plan for biological stream monitoring in New York State. NY S DEC technical report, 89 pp.

Hilsenhoff, W. L. 1987. An improved biotic index of organic stream pollution. The Great Lakes Entomologist 20(1): 31-39.

Lenat, D. R. 1987. Water quality assessment using a new qualitative collection method for freshwater benthic macroinvertebrates. North Carolina DEM Tech. Report. 12 pp.

Novak, M.A., and R. W. Bode. 1992. Percent model affinity: a new measure of macroinvertebrate community composition. J. N. Am. Benthol. Soc. 11(1):80-85.

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 Macroinvertebrate Community Parameters Appendix*). 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-organism 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. 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.

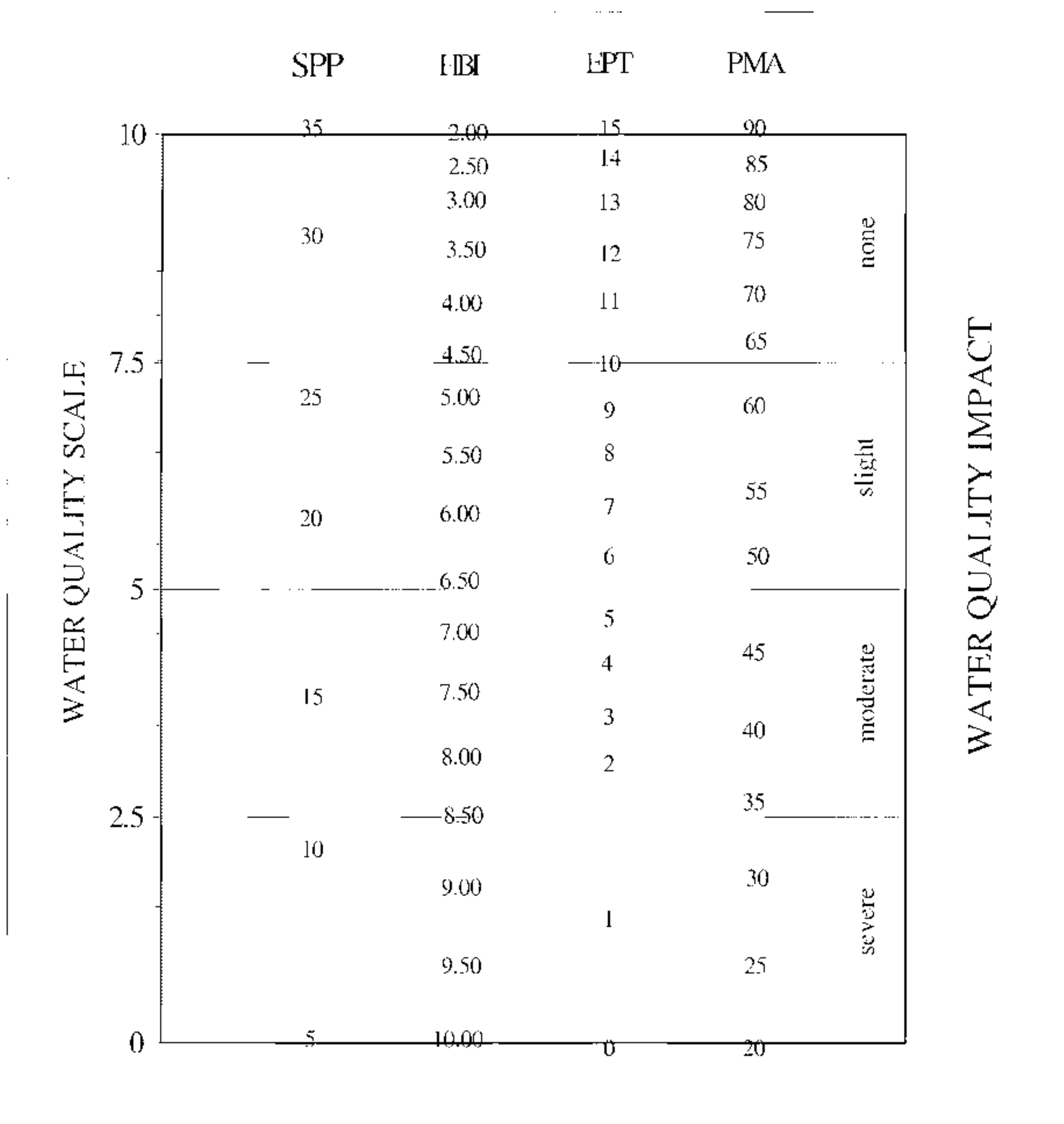
2. *Slightly impacted* Indices reflect good water quality. The macroinvertebrate community is slightly but significantly altered from the pristine state. Species richness usually is 19-26. Mayflies and stoneflies may be restricted, with EPT richness values of 6-10. The biotic index value is 4.51-6.50. Percent model affinity is 50-64. 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 usually is 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. The percent model affinity value is 35-49. 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 less. 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. 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.

Biological Assessment Profile: Conversion of Index values to 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 four indices, defined in the Macroinvertebrate Community Parameter Appendix, 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.



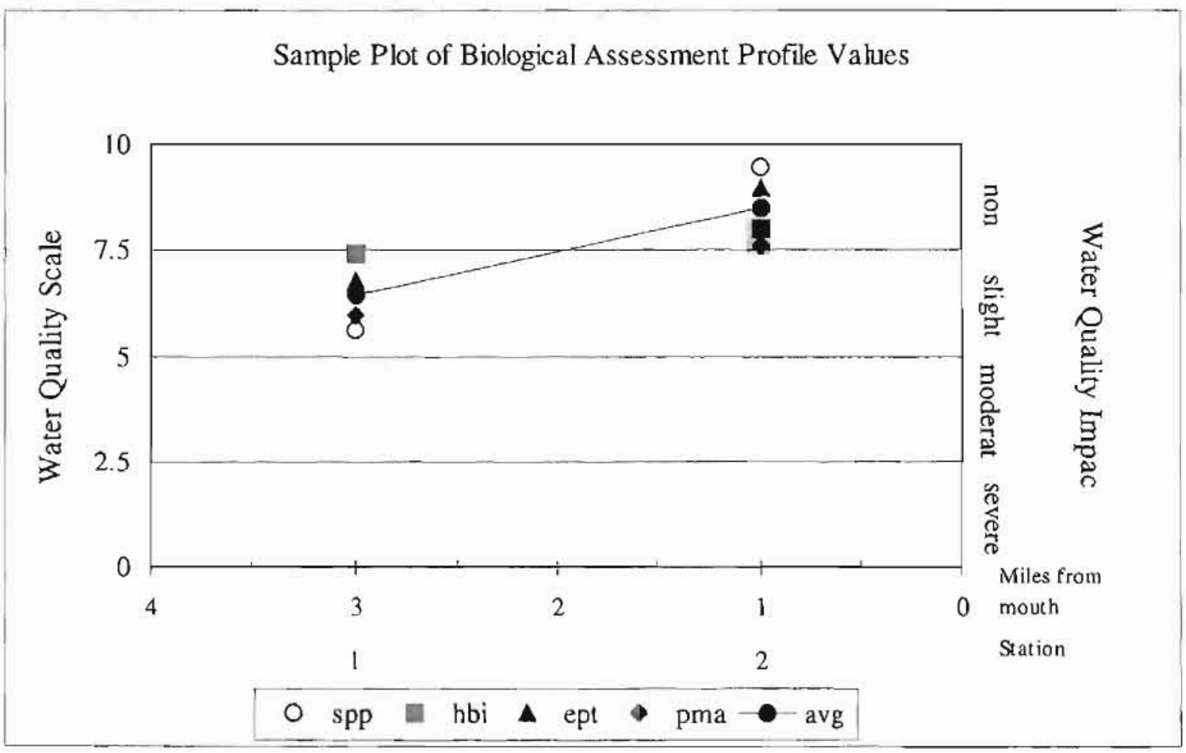
Biological Assessment Profile: Plotting Values

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-)

Table IV-B. Sample Plot of Biological Assessment Profile values



Water Quality Assessment Criteria

Water Quality Assessment Criteria for Non-Navigable Flowing Waters

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

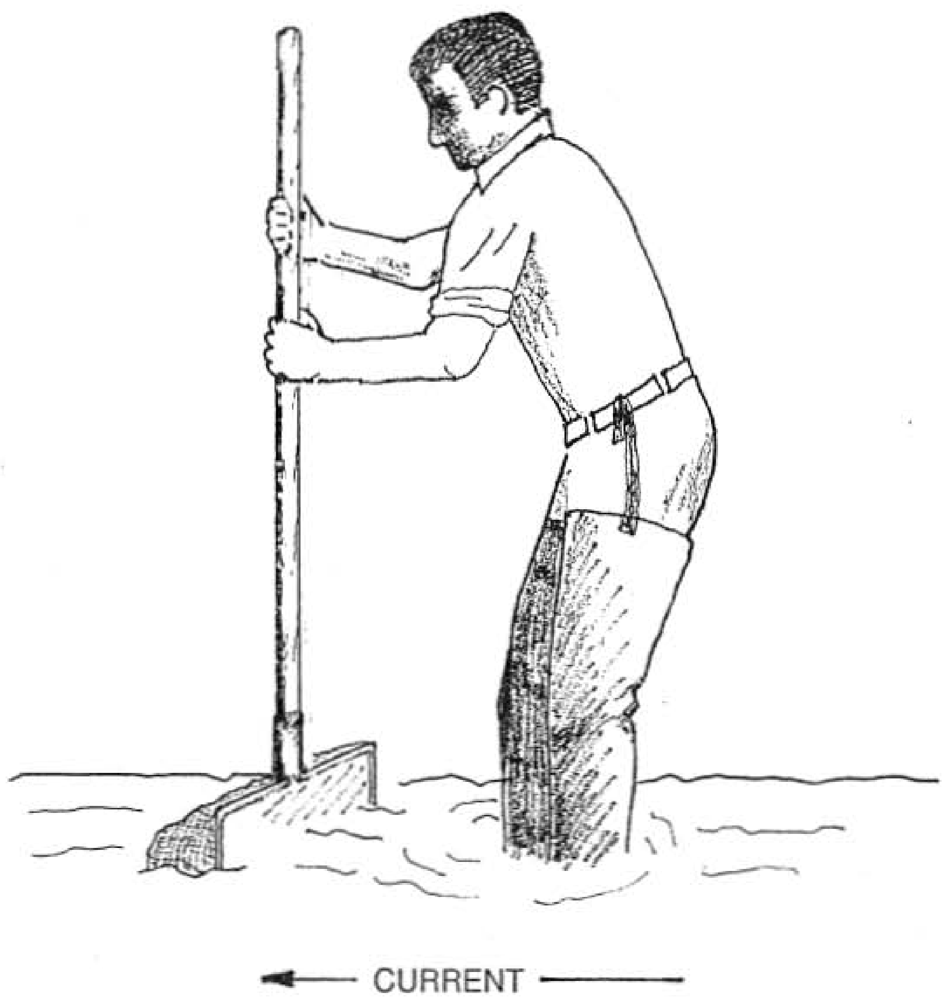
Percent model affinity criteria are used for traveling kick samples but not for multiplate samples.
* Diversity criteria are used for multiplate samples but not for traveling kick samples.

Water Quality Assessment Criteria for Navigable Flowing Waters

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

Appendix VI.

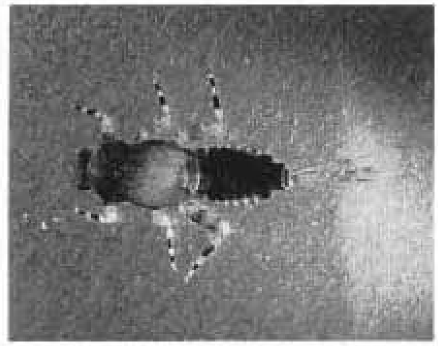
THE TRAVELING KICK SAMPLE



Rocks and sediment in the stream riffle are dislodged by foot upstream of a net; dislodged organisms are carried by the current in the net. Sampling is continued for a specified time, gradually moving downstream to cover a specified distance.

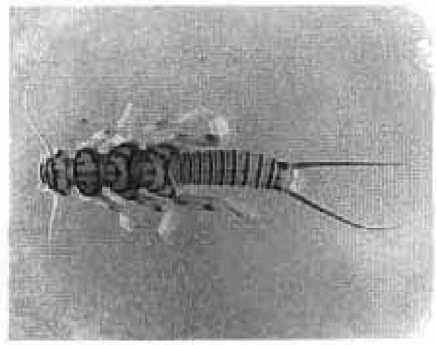
AQUATIC MACROINVERTEBRATES THAT USUALLY INDICATE GOOD WATER QUALITY

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.



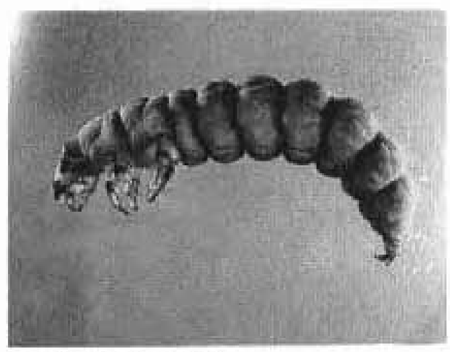
MAYFLIES

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.



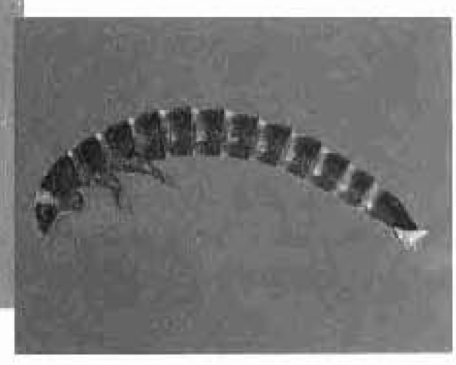
STONEFLIES

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 and water pennies. Most of these require a swift current and an adequate supply of oxygen, and are generally considered clean-water indicators.



BEETLES

AQUATIC MACROINVERTEBRATES THAT USUALLY INDICATE POOR WATER QUALITY

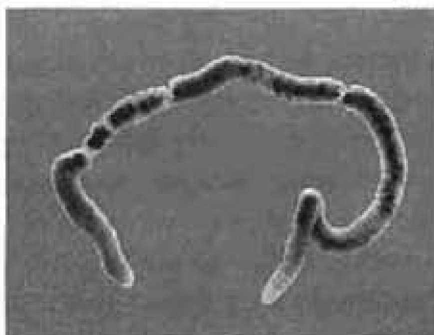
Midges are the most common aquatic flies. The larvae occur in almost any aquatic situation. Many species are very tolerant to pollution. Large, red midge larvae called "bloodworms" indicate organic enrichment. Other midge larvae filter plankton, indicating nutrient enrichment when numerous.

MIDGES

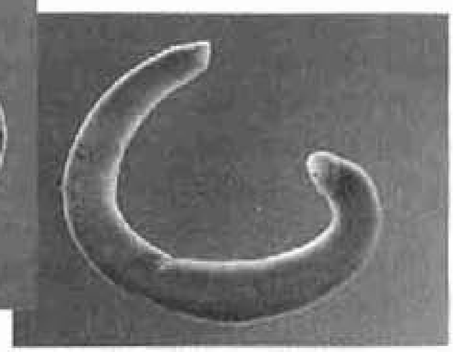
Black fly larvae have specialized structures for filtering plankton and bacteria from the water, and require a strong current. Some species are tolerant of organic enrichment and toxic contaminants, while others are intolerant of pollutants.

BLACK FLIES

The segmented worms include the leeches and the small aquatic earthworms. 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.

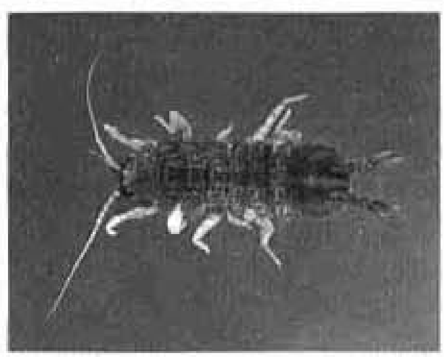


WORMS



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

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:

1) they are sensitive to environmental impacts
2) they are less mobile than fish, and thus cannot avoid discharges
3) they can indicate effects of spills, intermittent discharges, and lapses in treatment
4) they are indicators of overall, integrated water quality, including synergistic effects and substances lower than detectable limits
5) they are abundant in most streams and are relatively easy and inexpensive to sample
6) they are able to detect non-chemical impacts to the habitat, e.g. siltation or thermal changes
7) they are vital components of the aquatic ecosystem and important as a food source for fish
8) they are more readily perceived by the public as tangible indicators of water quality
9) they can often provide ail on-site estimate of water quality
10) they can often be used to identify specific stresses or sources of impairment
11) they can be preserved and archived for decades, allowing for direct comparison of specimens
12) they 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.

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

EPT richness: the number of species of mayflies (**E**phemeroptera), stoneflies (**P**lecoptera), and caddisflies (**Tr**ichoptera) 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 time; usually involves kick sampling and laboratory subsampling of the sample

Riffle: wadeable stretch of stream usually having a rubble bottom and sufficient current to break the water surface; 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

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