New York State
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Division of Water

Wallkill River

Biological Assessment

2008 Survey

New York State
Department of Environmental Conservation

BIOLOGICAL STREAM ASSESSMENT

Wallkill River
Orange and Ulster Counties, New York
Lower Hudson River Basin

Survey date: July 15, 2008
Report date: May 13, 2011

Diana L. Heitzman
Alexander J. Smith
Brian Duffy

Stream Biomonitoring Unit
Bureau of Water Assessment and Management
Division of Water
NYS Department of Environmental Conservation
Albany, New York

Table of Contents

Stream: Wallkill River

River Basin: Lower Hudson River Basin

Reach: Liberty Corners to Tuthill, NY

Background

The Stream Biomonitoring Unit sampled seven stations on the Wallkill River in the reach between Liberty Corners and Tuthill, Orange and Ulster Counties, New York, on July 15, 2008. Sampling was conducted to assess general water quality, particularly in relation to nonpoint source agricultural inputs. In addition to the agricultural nature of this region, the Wallkill River passes through a number of small towns and villages as it travels north from New Jersey until it reaches its confluence with the Rondout Creek. Municipal wastewater discharges enter the river at a number of locations; the largest of these inputs occur in Middletown, Wallkill, Montgomery, Walden, Shawangunk, Gardiner, and New Paltz.

To characterize water quality based on benthic macroinvertebrate communities, a traveling kick sample was collected from riffle areas at each of the seven sites on the Wallkill River. 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 were: species richness, biotic index, EPT richness, Percent Model Affinity (PMA) and NCO richness (see Appendices II and III). Amount of expected variability of results is stated in Smith and Bode (2004). In addition, the Nutrient Biotic Index (NBI) (Smith et al. 2007) was used to evaluate impacts to the aquatic community resulting from nitrogen and phosphorus inputs to the river. Table 3 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 was found to be slightly impacted at each of the seven stations on the Wallkill River. Water quality at all sites varied little from the previous survey of the Wallkill River in 1994.

2. There are still agricultural impacts in the Wallkill River, extending downstream from the “black dirt” area, resulting in slightly impacted water quality.

Discussion

The Wallkill River flows 94 miles north from its source, Lake Mohawk in Sparta, New Jersey, through two states and three counties, to Ulster County, NY where it enters the Hudson River. Lake Mohawk is a man-made lake surrounded by a golf course and urban development. In New York State, the region historically known as the "black dirt" area (a truck-farming region whose primary crop is onions) extends from the New Jersey line to Pellets Island (Station 03), a distance of about 10 river miles. As the river flows north, there are several small dams, more agriculture, and a number of small towns. These features of the watershed may contribute pollutants to the Wallkill, such as nutrients, siltation, or pesticides.

Together with the Rondout Creek, the Wallkill is part of one of the largest tributary complexes to the Hudson River. Besides its significant natural resource values, the Wallkill River has long been a source of active and passive outdoor recreation for area residents.

On July 15, 2008, macroinvertebrate samples were collected from seven sites on the Wallkill River in Orange and Ulster Counties, NY. These data were collected to assess overall water quality in this area, which has not been compiled since 1994. (Bode et al, 1994). There is also regional concern about whether discharges from wastewater treatment plants along the river's corridor are affecting the water quality of the Wallkill River. These systems are found in Middletown, Wallkill, Montgomery, Walden, Shawangunk, and Gardiner.

Results of the 2008 SBU sampling found conditions of slightly impaired water quality at all seven sites (Figure 1). Impact Source Determination (ISD) identified possible municipal/industrial influences at Stations 03 and 05, as well as domestic wastes at Station 05. Enrichment impacts of development and agriculture are evident in the water quality assessments of both 1994 and 2008. There were no differences seen in the biological communities above and below any of the wastewater discharges to the Wallkill River. The biological condition of the Wallkill River continues to reflect the land cover and land uses of this watershed and has not varied much since the 1994 survey.

The Nutrient Biotic Index (NBI) (Smith et al. 2007) suggests conditions resulting from excess phosphorus (NBI-P) and nitrogen (NBI-N) (Figure 4) at all sites except for Stations 08 and 10. Impact Source Determination (ISD) identified nutrient enrichment, as well as sewage and municipal/industrial inputs, as the source of water-quality impacts (Table 4). As this is a highly agricultural watershed, these results are not unexpected and are consistent with the biological assessment of 1994. Agricultural practices commonly change hydrology and increase sedimentation through erosion, nutrient loading, riparian reduction and altered land cover (Allan 2004).

Specific conductance increased an average of 24% from 1994 to 2008 (Table 2), is an ongoing concern in tributaries to the Hudson River (Novak and Bode, 2004). Future studies should monitor possible increases in this water quality parameter.

Literature Cited

Allan, J. D. 2004. Landscapes and Riverscapes: The Influence of Land Use on Stream Ecosystems. Annual Review of Ecology, Evolution and Systematics 35: 257-84.

Bode, R. W., M. A. Novak, L. E. Abele. 1994. Biological Stream Assessment of Wallkill River, Orange and Ulster Counties, New York. New York State Department of Environmental Conservation, Technical Report, 59 pages.

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.

Novak, M.A., 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.

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.

Wallkill River Watershed Conservation and Management Plan, 2007, Orange County Soil and Water Conservation District

Figure 1. Biological Assessment Profile (BAP) of index values, Wallkill River, Orange and Ulster Counties, 2008. Values are plotted on a normalized scale of water quality. The BAP represents the mean of the four values for each site, representing species richness (Spp), EPT richness, Hilsenhoff Biotic Index (HBI), and Percent Model Affinity (PMA), or Non Chironomidae, Oligochaeta (NCO) richness (for Station 01). See Appendix IV for a more complete explanation.

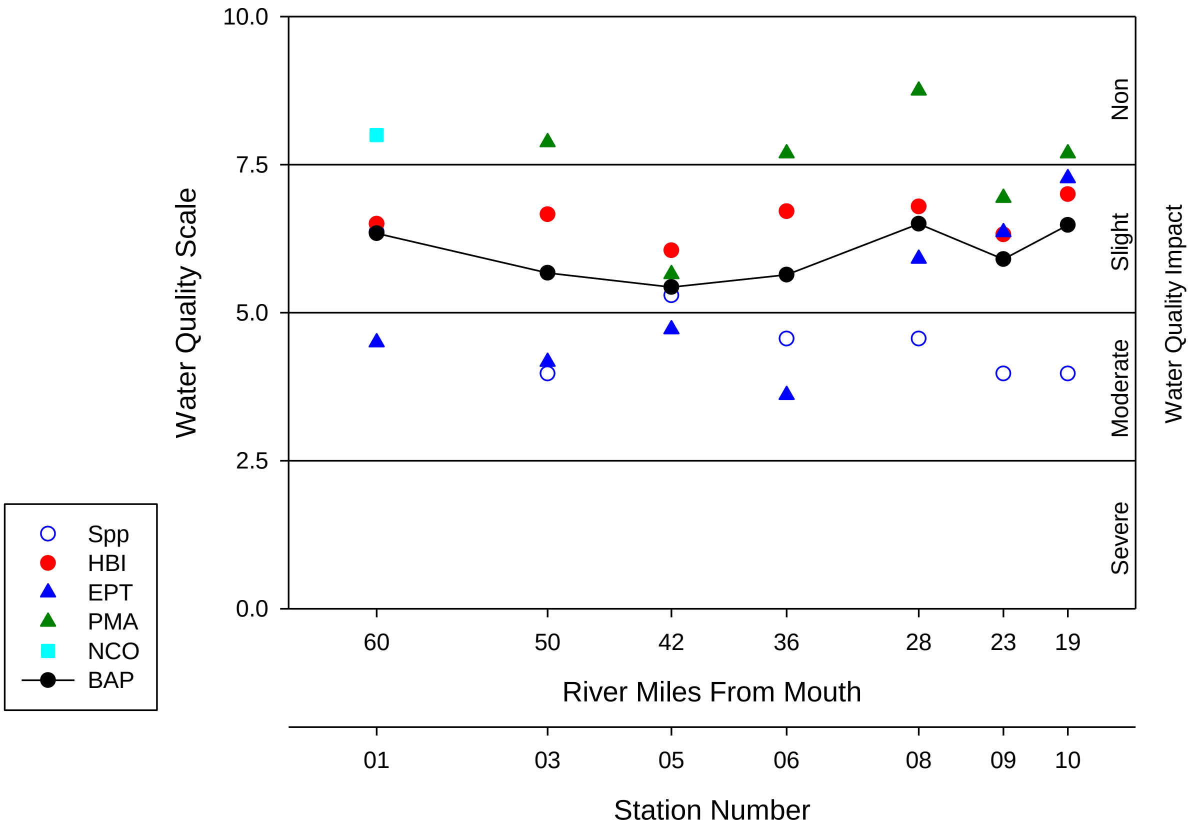


Figure 1a. Biological Assessment Profile (BAP) of index values, Wallkill River, Orange and Ulster Counties, 1994 and 2008.

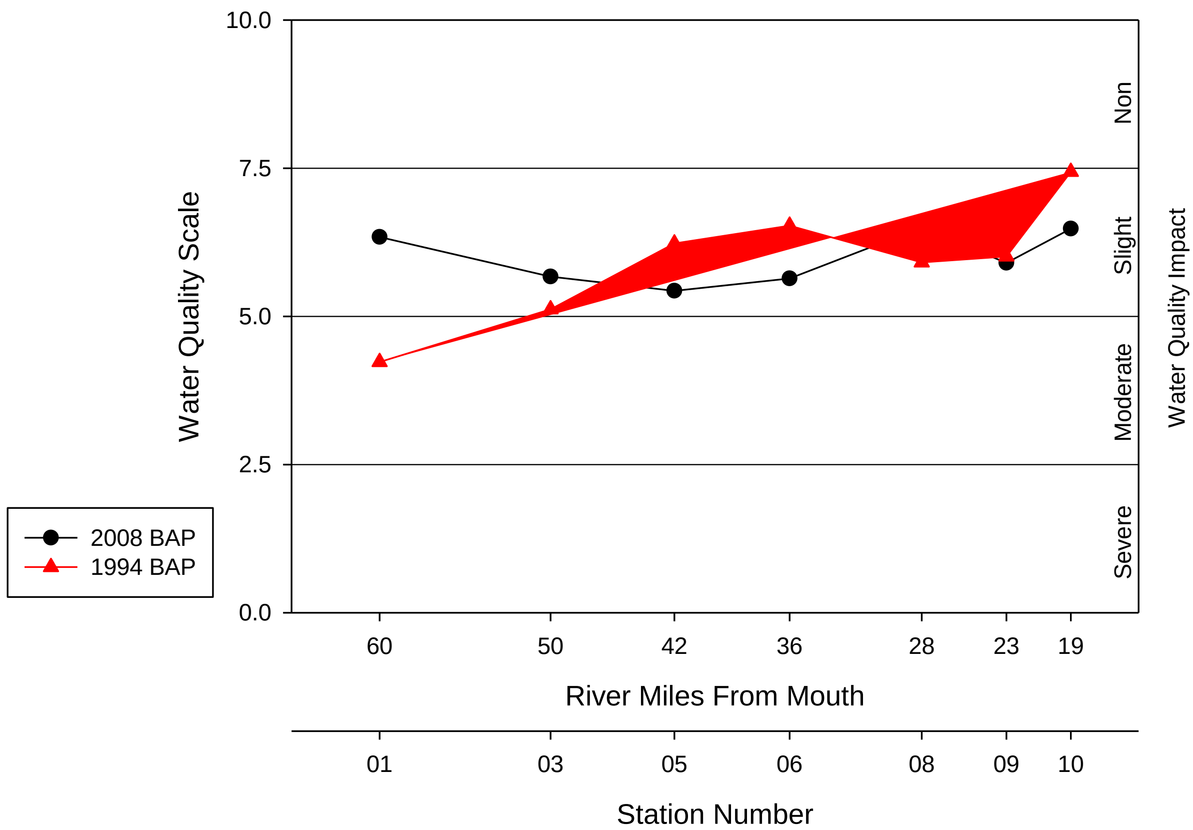


Table 1. Overview of Field Data

Location	Station	Depth (meters)	Width (meters)	Current (cm/sec)	Canopy (%)	Embedd (%)	Temp (˚C)	Cond. (µmol/cm)	pH (units)	DO (mg/l)
WALK	01	0.3	12	Slack	25	-	26.0	560	8.0	7.93
WALK	03	0.3	10	80	25	10	25.9	542	8.1	8.2
WALK	05	0.2	15	91	10	30	26.8	573	8.4	12.2
WALK	06	0.2	40	143	10	50	25.6	582	8.2	9.65
WALK	08	0.2	30	41	10	50	26.7	587	8.7	7.3
WALK	09	0.4	30	56	10	50	24.6	580	8.5	7.74
WALK	10	0.2	25	21	10	40	25.8	553	8.6	6.99

Table 2. Conductivity Values 1994 and 2008

Location	Station	1994 Cond. (µmol/cm)	2008 Cond. (µmol/cm)
WALK	01	422	560
WALK	03	438	542
WALK	05	498	573
WALK	06	487	582
WALK	08	473	587
WALK	09	460	580
WALK	10	450	553

Table 3. Station Locations for the Wallkill River, Orange and Ulster Counties, 2008.

Station	Location		
WALK-01	Liberty Corners, NY Oil City Road River Mile: 59.8 Latitude: 41.28788 Longitude: -74.53436	
WALK-03	Pelletts Island, NY CR 37 bridge River Mile: 49.7 Latitude: 41.38103 Longitude: -74.41300	
WALK -05	Crystal Run, NY 100 m above Scotchtown Ave. bridge River Mile: 42.4 Latitude: 41.44907 Longitude: -74.33331	

Table 3a. Station Locations for the Wallkill River, Orange and Ulster Counties, 2008.

Station	Location	
WALK -06	Montgomery, NY 20 m below SR 211 bridge River Mile: 35.6 Latitude: 41.50285 Longitude: -74.26375	
WALK -08	Walden, NY 50 m below Oak St bridge River Mile: 27.8 Latitude: 41.56492 Longitude: -74.19319	
WALK -09	Galeville, NY 10 m above Galeville Rd bridge River Mile: 22.8 Latitude: 41.63535 Longitude: -74.18869	
WALK -10	Tuthill, NY Jellystone Campground 20 m above Shawangunk confluence River Mile: 19.0 Latitude: 41.68306 Longitude: -74.16429	

Figure 2. Overview Map, Wallkill River, Orange and Ulster Counties.

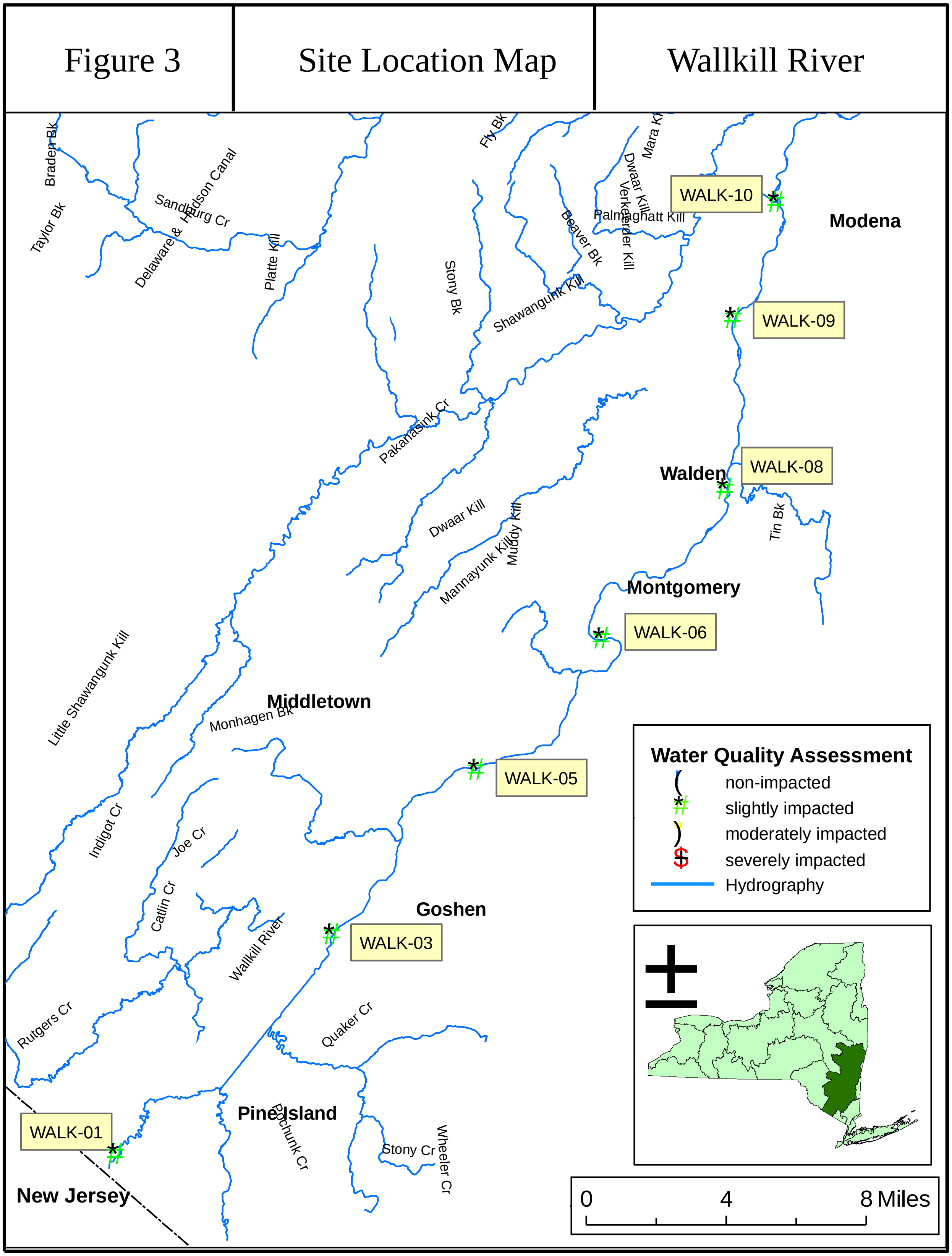


Figure 3. Site Location Map, Wallkill River, Station 01

Site Location Map	Wallkill River

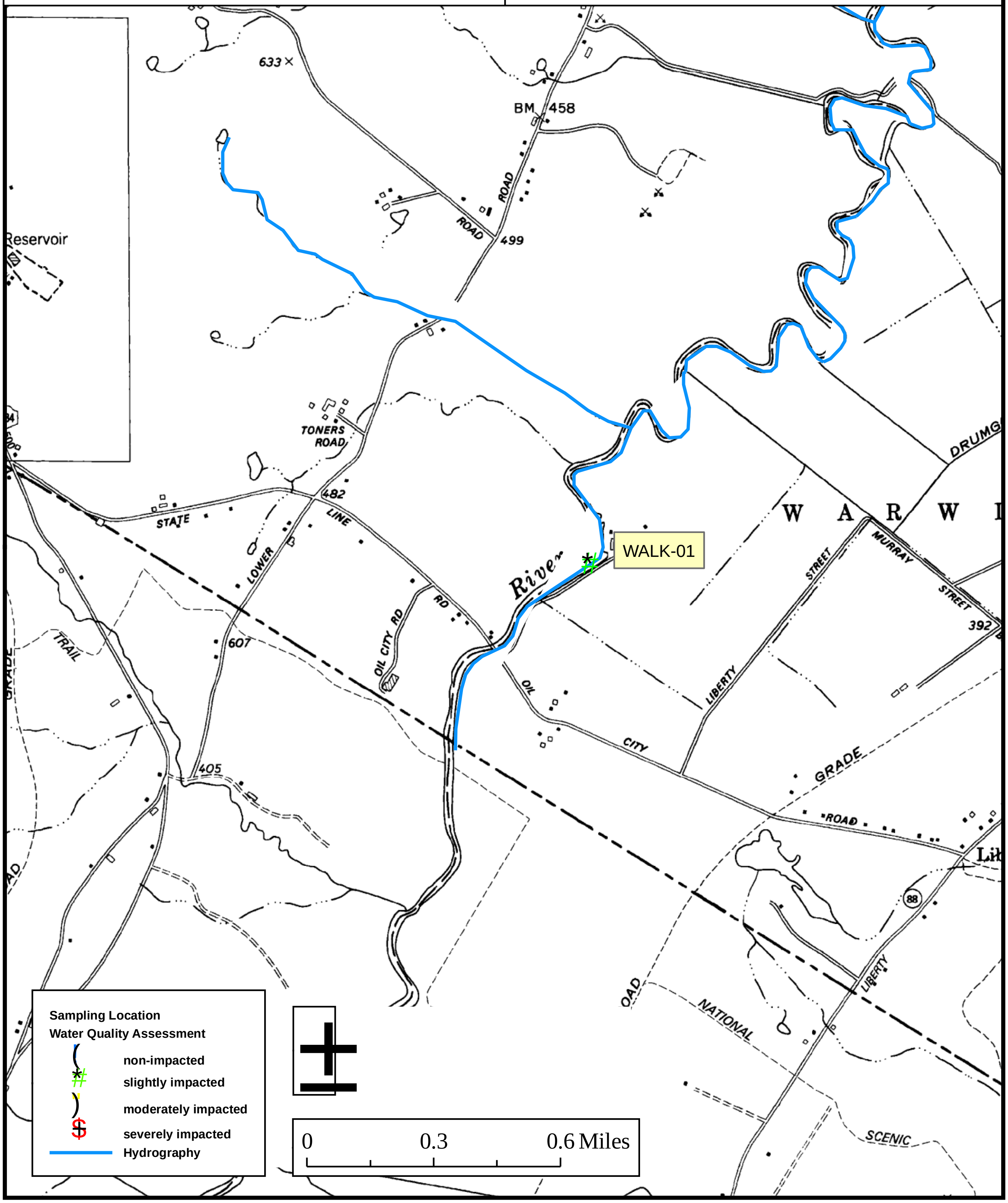


Figure 3a. Site Location Map, Wallkill River, Station 03

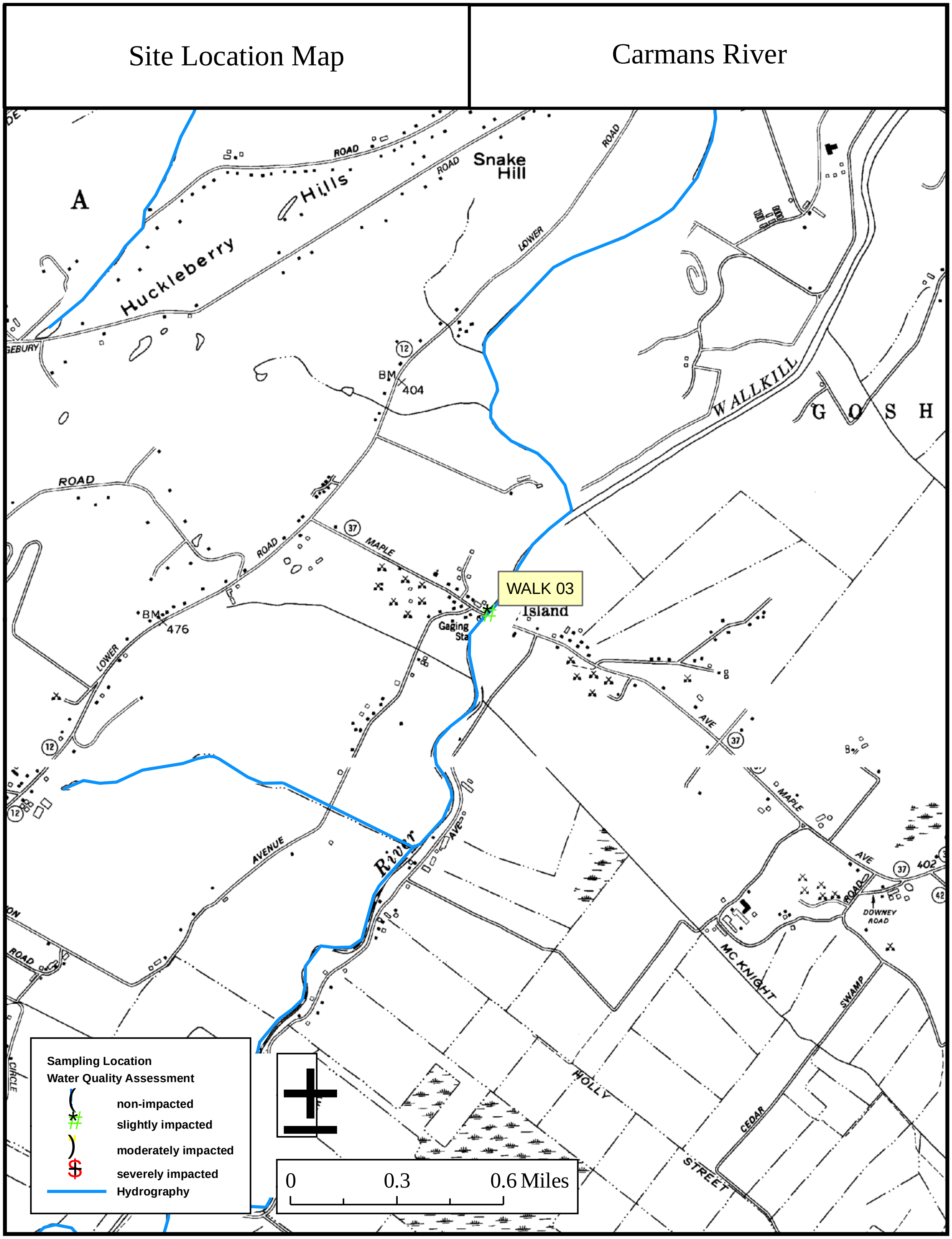


Figure 3b. Site Location Map, Wallkill River, Station 05

Site Location Map	Wallkill River

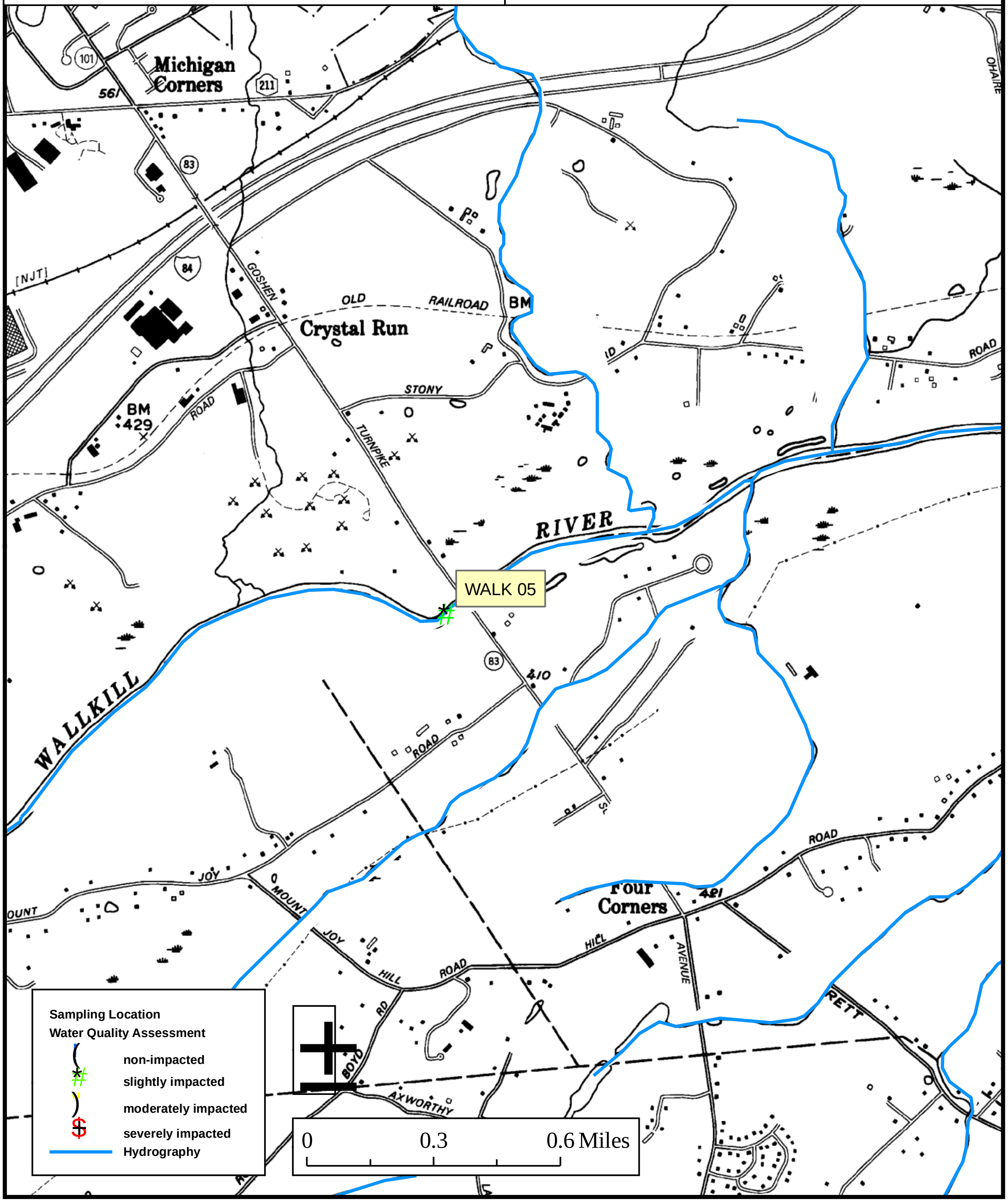


Figure 3c. Site Location Map, Wallkill River, Station 06

Site Location Map	Wallkill River

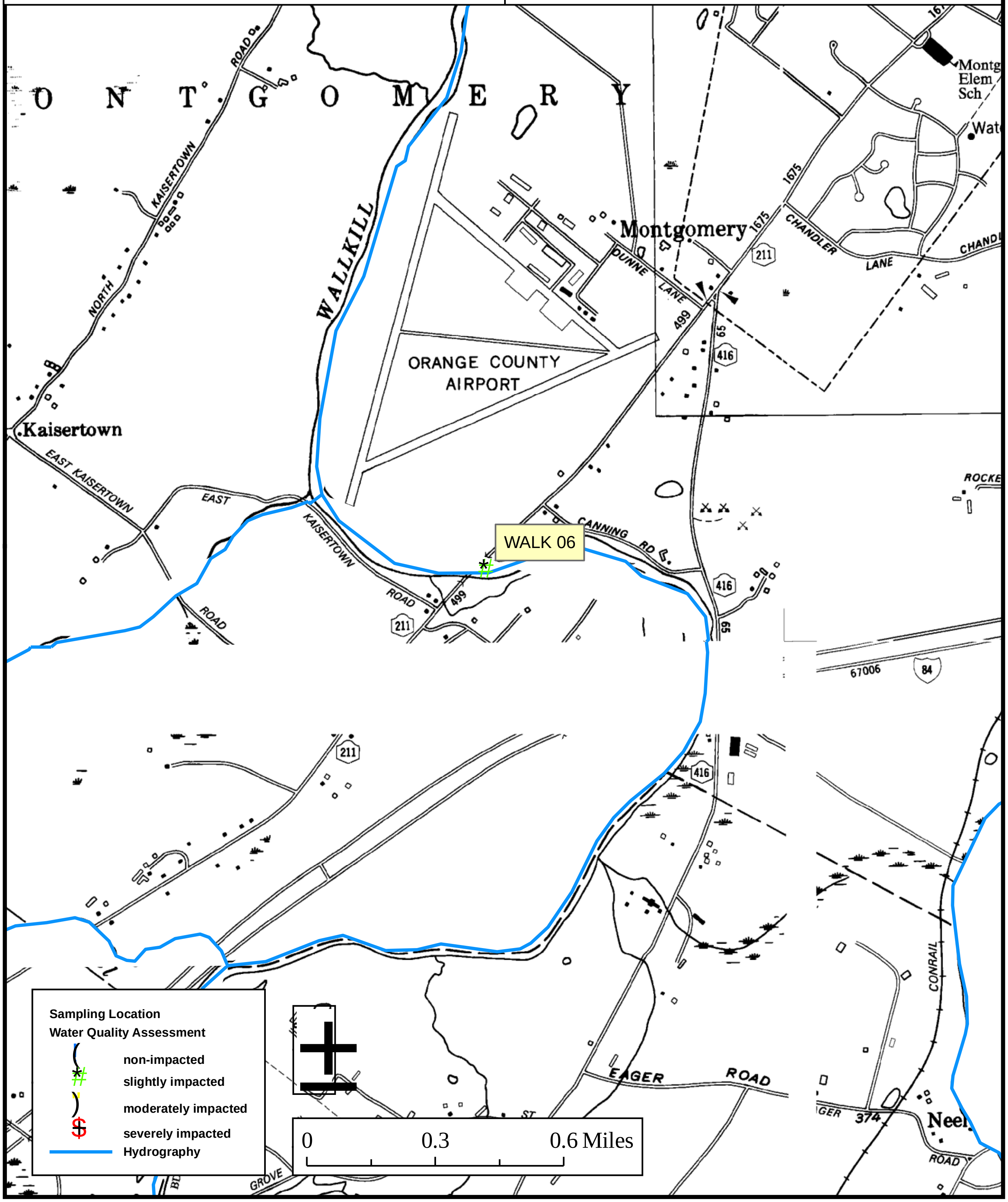


Figure 3d. Site Location Map, Wallkill River, Station 08

Site Location Map	Wallkill River

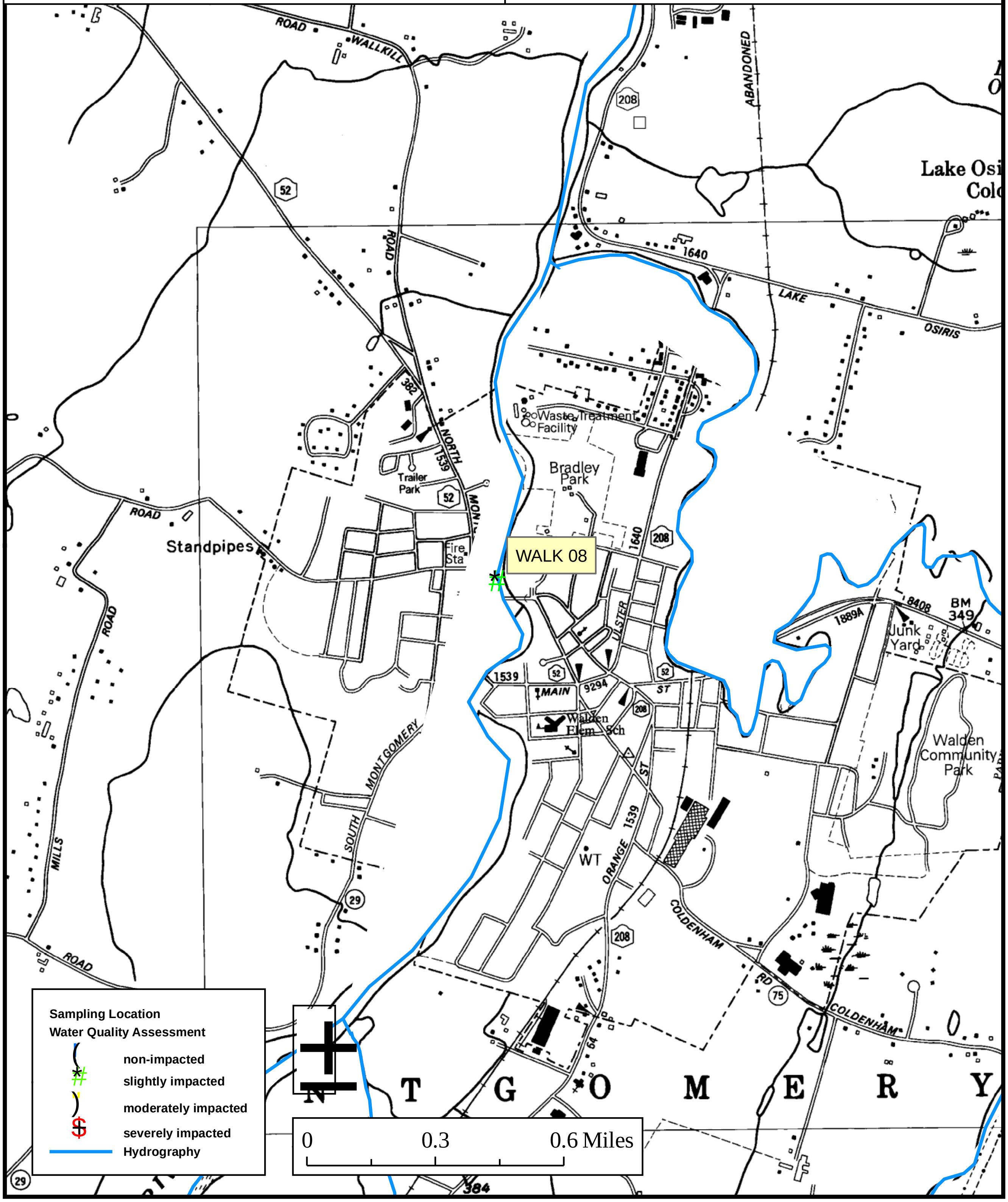


Figure 3e. Site Location Map, Wallkill River, Station 09

Site Location Map	Wallkill River

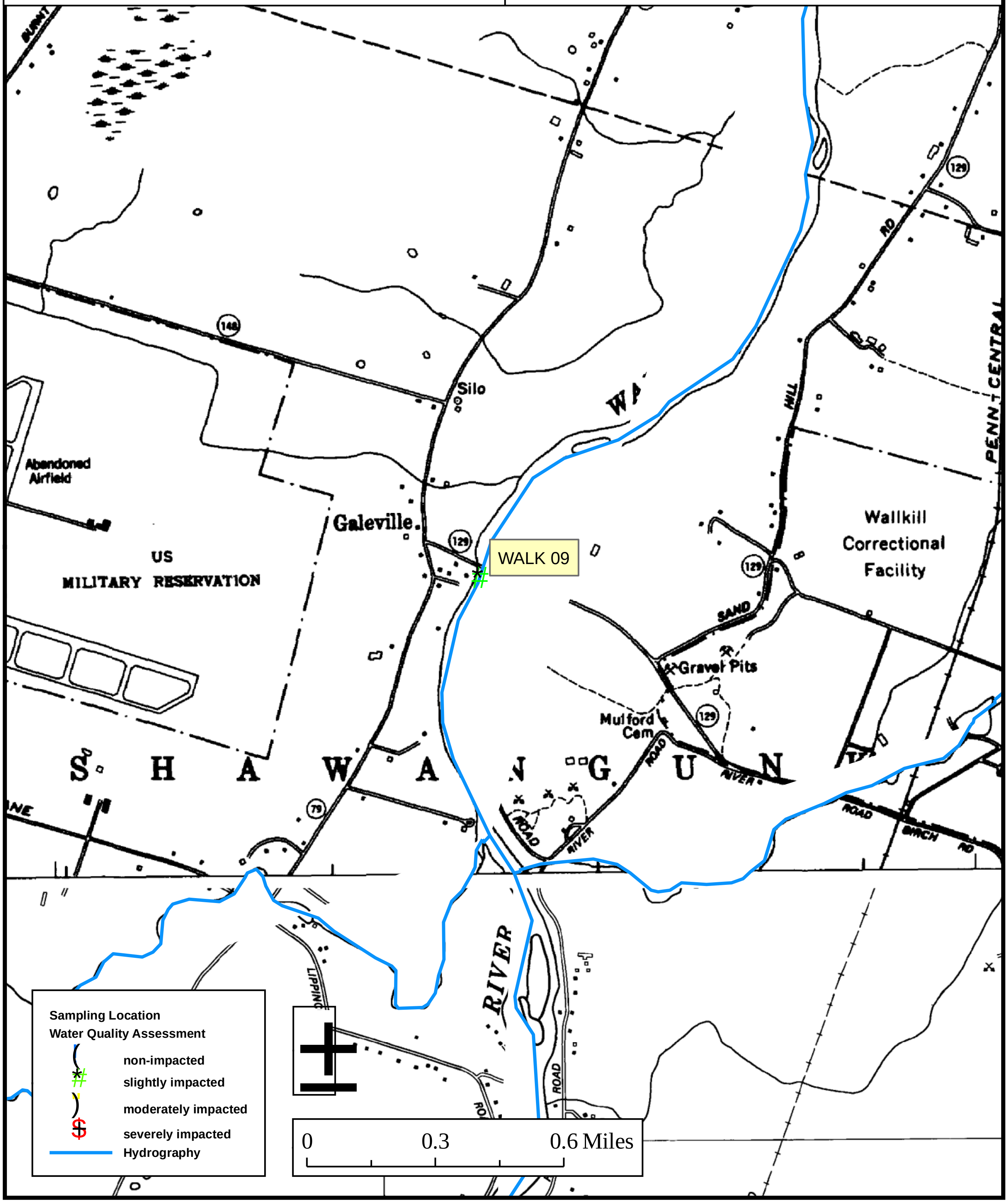


Figure 3f. Site Location Map, Wallkill River, Station 10

Site Location Map	Wallkill River

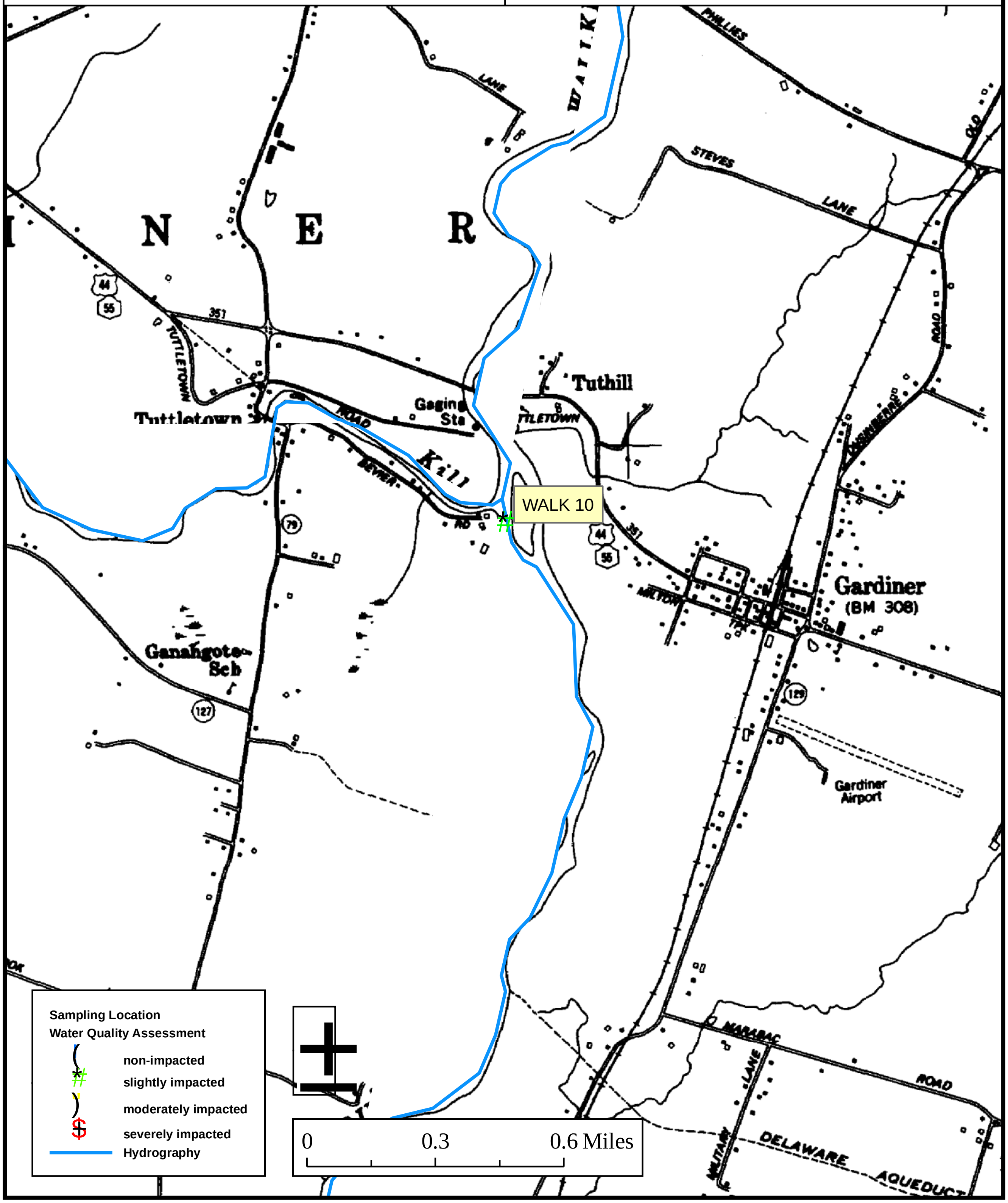
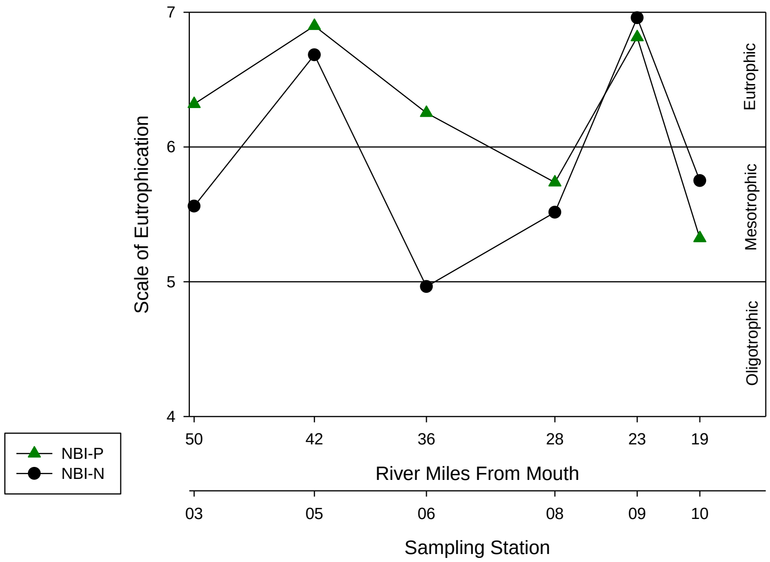
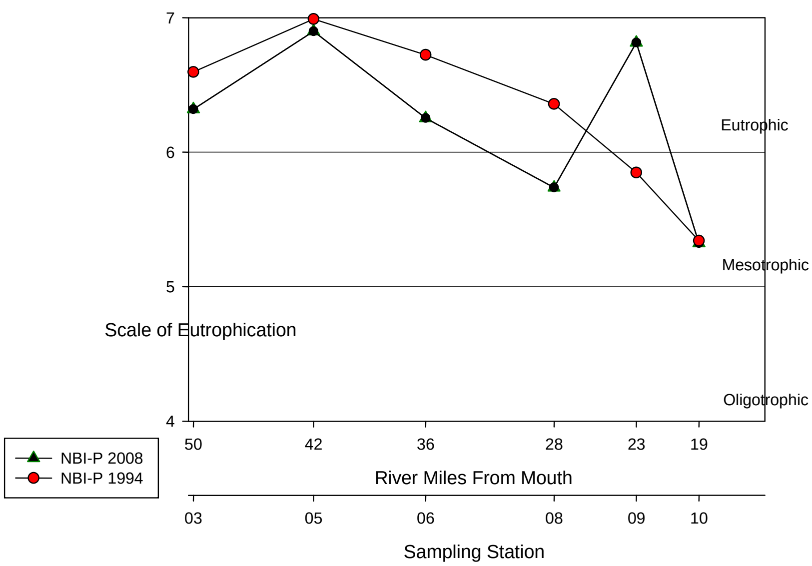


Figure 4. A. Nutrient Biotic Index Values for Phosphorus (NBI-P) and Nitrogen (NBI-N) for the 2008 survey. NBI values are plotted on a scale of eutrophication from oligotrophic to eutrophic.
B. Comparison of NBI-P values from 1994 and 2008. See Appendix X for a detailed explanation of the index. Station 01 is not included due to non-comparable habitat and sampling methods.



A



B

Table 4. Impact Source Determination (ISD), Wallkill River, Orange and Ulster Counties, 2008. Numbers represent percent similarity to community type models for each impact category. Highest similarities at each station are shaded. Similarities less than 50% are less conclusive. Highest numbers represent probable stressor(s) to the community. See Appendix XI for further explanation.

Community Type	Station						
	01	03	05	06	08	09	10
Natural: minimal human disturbance	16	48	46	49	49	52	37
Nutrient Enrichment: mostly nonpoint, agricultural	13	56	56	69	52	56	34
Toxic: industrial, municipal, or urban run-off	18	51	57	51	43	44	31
Organic: sewage effluent, animal wastes	19	58	68	50	49	41	30
Complex: municipal/industrial	48	68	67	49	46	50	27
Siltation	28	55	61	57	56	56	47
Impoundment	46	66	58	62	46	50	35

Note: Impact Source Determinations (ISD) are intended as supplemental data to the macroinvertebrate community assessments.

Table 5. Macroinvertebrate Species Collected in Wallkill River, Orange and Ulster Counties, 2008.

ANNELIDA
OLIGOCHAETA
LUMBRICULIDA
Lumbriculidae
Undetermined Lumbriculidae

TUBIFICIDA
Tubificidae
Branchiura sowerbyi
Undet. Tubificidae w/o cap. setae

HIRUDINEA
RHYNCHOBDELLIDA
Undetermined Hirudinea

MOLLUSCA
GASTROPODA
BASOMMATOPHORA
Ancylidae
Ferrissia sp.

PELECYPODA
VENEROIDEA
Sphaeriidae
Pisidium sp.
Sphaerium sp.

ARTHROPODA
CRUSTACEA
AMPHIPODA
Gammaridae
Gammarus sp.
Talitridae
Hyalella sp.

DECAPODA
Cambaridae
Undetermined Cambaridae

INSECTA
EPHEMEROPTERA
Baetidae
Baetis intercalaris
Centroptilum sp.
Heptageniidae
Leucrocuta sp.
Stenacron interpunctatum
Stenonema exiguum
Stenonema mediopunctatum
Stenonema terminatum
Leptohyphidae
Tricorythodes sp.
Caenidae
Caenis sp.

HEMIPTERA
Corixidae
Undetermined Corixidae

COLEOPTERA
Psephenidae
Psephenus herricki
Elmidae
Ancyronyx variegatus
Dubiraphia vittata
Macronychus glabratus
Optioservus sp.
Promoresia elegans
Stenelmis crenata
Stenelmis sp.

TRICHOPTERA
Philopotamidae
Chimarra obscura
Hydropsychidae
Cheumatopsyche sp.
Hydropsyche betteni
Hydropsyche bronta
Hydropsyche morosa
Hydroptilidae
Hydroptila sp.
Leptoceridae
Oecetis sp.

LEPIDOPTERA
Pyralidae
Petrophila sp.

DIPTERA
Ceratopogonidae
Undetermined Ceratopogonidae
Simuliidae
Simulium aureum
Simulium jenningsi
Simulium vittatum
Empididae
Hemerodromia sp.
Chironomidae
Procladius sp.
Thienemannimyia gr. spp.
Cricotopus bicinctus
Cricotopus sp.
Nanocladius sp.
Orthocladius sp.
Dicrotendipes neomodestus
Dicrotendipes sp.
Glyptotendipes sp.
Parachironomus sp.
Polypedilum aviceps
Polypedilum flavum
Polypedilum illinoense
Tribelos/Endochironomus/Phaenopsectra Co
Cladotanytarsus sp.
Rheotanytarsus sp.
Tanytarsus sp.

Table 6. Macroinvertebrate Data Report (MDR), Station 01

STREAM SITE: Wallkill River, Station 01
LOCATION: Liberty Corners, NY
DATE: 7/15/2008
SAMPLE TYPE: Kick, Sandy Streams
SUBSAMPLE: 100

MOLLUSCA			
PELECYPODA			
VENEROIDEA			
	Sphaeriidae	*Sphaerium sp.*	2
ARTHROPODA			
CRUSTACEA			
AMPHIPODA	Gammaridae	*Gammarus sp.*	40
INSECTA			
EPHEMEROPTERA	Baetidae	*Centroptilum sp.*	2
	Heptageniidae	*Stenacron interpunctatum*	4
HEMIPTERA	Corixidae	Undetermined Corixidae	14
COLEOPTERA	Elmidae	*Ancyronyx variegatus*	1
		Dubiraphia vittata	11
		Macronychus glabratus	1
		Stenelmis sp.	1
TRICHOPTERA	Hydropsychidae	*Hydropsyche bronta*	1
DIPTERA	Ceratopogonidae	Undetermined Ceratopogonidae	1
	Chironomidae	*Procladius sp.*	2
		Dicrotendipes sp.	2
		Parachironomus sp.	1
		Polypedilum flavum	2
		Tribelos/Endochironomus/Phaenopsectra Co	9
		Cladotanytarsus sp.	1
		Rheotanytarsus sp.	2
		Tanytarsus sp.	3
		SPECIES RICHNESS:	19
		BIOTIC INDEX:	6.1
		EPT RICHNESS:	3
		MODEL AFFINITY:	47
		ASSESSMENT:	slt

DESCRIPTION: 30m above State Line Rd. bridge. Site was 0.4 miles upstream of location sampled in 1994, due to private property issues. Substrate is mostly sand and silt, also deep and slow; habitat restrictions.

Table 6a. Macroinvertebrate Data Report (MDR), Station 03

STREAM SITE: Wallkill River, Station 03
LOCATION: Pellets Island, NY
DATE: 7/15/2008
SAMPLE TYPE: Kick
SUBSAMPLE: 100

ANNELIDA			
OLIGOCHAETA			
LUMBRICULIDA			
	Lumbriculidae	Undetermined Lumbriculidae	2
ARTHROPODA			
INSECTA			
EPHEMEROPTERA	Baetidae	*Baetis intercalaris*	22
COLEOPTERA	Elmidae	*Optioservus sp.*	1
		Stenelmis crenata	5
TRICHOPTERA	Hydropsychidae	*Cheumatopsyche sp.*	40
		Hydropsyche betteni	1
	Hydroptilidae	*Hydroptila sp.*	1
DIPTERA	Simuliidae	*Simulium aureum*	1
		Simulium jenningsi	9
	Chironomidae	*Thienemannimyia gr. spp.*	3
		Cricotopus bicinctus	2
		Orthocladius sp.	2
		Dicrotendipes neomodestus	1
		Polypedilum flavum	4
		Rheotanytarsus sp.	6
		SPECIES RICHNESS:	15
		BIOTIC INDEX:	5.17
		EPT RICHNESS:	4
		MODEL AFFINITY:	68
		ASSESSMENT:	slt

DESCRIPTION: Sampled under bridge near the left bank.

Table 6b. Macroinvertebrate Data Report (MDR), Station 05

DATE: 7/15/2008
SAMPLE TYPE: Kick
SUBSAMPLE: 100

ANNELIDA			
HIRUDINEA			
RHYNCHOBDELLIDA			
		Undetermined Hirudinea	3
ARTHROPODA			
CRUSTACEA			
AMPHIPODA	Talitridae	*Hyalella sp.*	1
INSECTA			
EPHEMEROPTERA	Baetidae	*Baetis intercalaris*	9
	Heptageniidae	*Stenonema terminatum*	1
COLEOPTERA	Elmidae	*Promoresia elegans*	1
		Stenelmis crenata	14
TRICHOPTERA	Hydropsychidae	*Cheumatopsyche sp.*	23
		Hydropsyche betteni	6
		Hydropsyche bronta	7
DIPTERA	Simuliidae	*Simulium aureum*	1
	Empididae	*Hemerodromia sp.*	1
	Chironomidae	*Thienemannimyia gr. spp.*	5
		Cricotopus bicinctus	1
		Cricotopus sp.	5
		Nanocladius sp.	1
		Polypedilum aviceps	1
		Polypedilum flavum	2
		Polypedilum illinoense	5
		Rheotanytarsus sp.	11
		Tanytarsus sp.	2
		SPECIES RICHNESS:	20
		BIOTIC INDEX:	5.73
		EPT RICHNESS:	5
		MODEL AFFINITY:	56
		ASSESSMENT:	slt

DESCRIPTION: 100 m above Scotchtown Rd. bridge; wastewater smell at this site.

Table 6c. Macroinvertebrate Data Report (MDR), Station 06

STREAM SITE:	Wallkill River, Station 06
LOCATION:	Montgomery, NY
DATE:	7/15/2008
SAMPLE TYPE:	Kick
SUBSAMPLE:	100

ARTHROPODA			
CRUSTACEA			
AMPHIPODA			
	Gammaridae	*Gammarus sp.*	1
	Talitridae	*Hyalella sp.*	3
INSECTA			
EPHEMEROPTERA	Baetidae	*Baetis intercalaris*	12
	Heptageniidae	*Stenonema terminatum*	4
COLEOPTERA	Elmidae	*Promoresia elegans*	1
		Stenelmis crenata	12
TRICHOPTERA	Hydropsychidae	*Cheumatopsyche sp.*	20
DIPTERA	Simuliidae	*Simulium jenningsi*	24
		Simulium vittatum	2
	Chironomidae	*Thienemannimyia gr. spp.*	2
		Cricotopus bicinctus	2
		Cricotopus sp.	1
		Glyptotendipes sp.	1
		Polypedilum flavum	1
		Polypedilum illinoense	2
		Rheotanytarsus sp.	1
		SPECIES RICHNESS:	17
		BIOTIC INDEX:	5.13
		EPT RICHNESS:	3
		MODEL AFFINITY:	66
		ASSESSMENT:	slt

DESCRIPTION: 20 m below Rt. 211 bridge, next to Orange County Airport

Table 6d. Macroinvertebrate Data Report (MDR), Station 08

STREAM SITE: Wallkill River, Station 08
LOCATION: Walden, NY
DATE: 7/15/2008
SAMPLE TYPE: Kick
SUBSAMPLE: 100

ANNELIDA			
OLIGOCHAETA			
TUBIFICIDA			
	Tubificidae	Undet. Tubificidae w/o cap. setae	1
MOLLUSCA			
GASTROPODA			
BASOMMATOPHORA	Ancylidae	*Ferrissia sp.*	2
ARTHROPODA			
CRUSTACEA			
AMPHIPODA	Gammaridae	*Gammarus sp.*	2
DECAPODA	Cambaridae	Undetermined Cambaridae	1
INSECTA			
EPHEMEROPTERA	Baetidae	*Baetis intercalaris*	6
	Heptageniidae	*Stenacron interpunctatum*	10
		Stenonema mediopunctatum	5
		Stenonema terminatum	17
COLEOPTERA	Psephenidae	*Psephenus herricki*	1
	Elmidae	*Ancyronyx variegatus*	1
		Optioservus sp.	3
		Stenelmis crenata	3
TRICHOPTERA	Philopotamidae	*Chimarra obscura*	2
	Hydropsychidae	*Cheumatopsyche sp.*	28
		Hydropsyche morosa	2
LEPIDOPTERA	Pyralidae	*Petrophila sp.*	3
DIPTERA	Chironomidae	*Thienemannimyia gr. spp.*	8
		Polypedilum flavum	5
		SPECIES RICHNESS:	18
		BIOTIC INDEX:	5.12
		EPT RICHNESS:	7
		MODEL AFFINITY:	78
		ASSESSMENT:	slt

DESCRIPTION: 50 m below Oak St. bridge

Table 6e. Macroinvertebrate Data Report (MDR), Station 09

STREAM SITE:	Wallkill River, Station 09
LOCATION:	Galeville, NY
DATE:	7/15/2008
SAMPLE TYPE:	Kick
SUBSAMPLE:	100

MOLLUSCA			
PELECYPODA			
VENEROIDEA			
	Sphaeriidae	*Pisidium sp.*	1
		Sphaerium sp.	1
ARTHROPODA			
CRUSTACEA			
AMPHIPODA	Gammaridae	*Gammarus sp.*	25
INSECTA			
EPHEMEROPTERA	Baetidae	*Baetis intercalaris*	11
	Heptageniidae	*Leucrocuta sp.*	2
		Stenacron interpunctatum	12
		Stenonema mediopunctatum	2
		Stenonema terminatum	1
	Leptohyphidae	*Tricorythodes sp.*	1
COLEOPTERA	Elmidae	*Macronychus glabratus*	3
		Stenelmis crenata	24
TRICHOPTERA	Hydropsychidae	*Cheumatopsyche sp.*	10
		Hydropsyche bronta	5
DIPTERA	Chironomidae	*Thienemannimyia gr. spp.*	1
		Polypedilum flavum	1
		SPECIES RICHNESS:	15
		BIOTIC INDEX:	5.44
		EPT RICHNESS:	8
		MODEL AFFINITY:	61
		ASSESSMENT:	slt

DESCRIPTION: 10 m above Galeville Rd. bridge

Table 6f. Macroinvertebrate Data Report (MDR), Station 10

STREAM SITE: Wallkill River, Station 10
LOCATION: Tuthill, NY
DATE: 7/15/2008
SAMPLE TYPE: Kick
SUBSAMPLE: 100

ANNELIDA			
OLIGOCHAETA			
TUBIFICIDA			
	Tubificidae	*Branchiura sowerbyi*	2
ARTHROPODA			
CRUSTACEA			
AMPHIPODA	Gammaridae	*Gammarus sp.*	8
INSECTA			
EPHEMEROPTERA	Baetidae	*Baetis intercalaris*	4
	Heptageniidae	*Leucrocuta sp.*	14
		Stenacron interpunctatum	26
		Stenonema exiguum	1
		Stenonema mediopunctatum	7
		Stenonema terminatum	6
	Leptohyphidae	*Tricorythodes sp.*	1
	Caenidae	*Caenis sp.*	4
COLEOPTERA	Elmidae	*Stenelmis crenata*	21
TRICHOPTERA	Hydropsychidae	*Cheumatopsyche sp.*	3
	Leptoceridae	*Oecetis sp.*	1
LEPIDOPTERA	Pyralidae	*Petrophila sp.*	1
DIPTERA	Chironomidae	*Thienemannimyia gr. spp.*	1
		SPECIES RICHNESS:	15
		BIOTIC INDEX:	4.9
		EPT RICHNESS:	10
		MODEL AFFINITY:	66
		ASSESSMENT:	slt

DESCRIPTION: Jellystone Park campground-20 m above Shawangunk Kill confluence.

Table 7. Laboratory Data Summary, Wallkill River, Orange and Ulster Counties, 2008.

LABORATORY DATA SUMMARY				
STREAM NAME: Wallkill River				
DATE SAMPLED: 7/15/2008				
SAMPLING METHOD: Kick, Sandy Streams				
LOCATION	WALK	WALK	WALK	
STATION	01	03	05	
DOMINANT SPECIES / %CONTRIBUTION / TOLERACE / COMMON NAME				
Tolerance Definitions:	1. Gammarus sp. 40 % facultative scud	Cheumatopsyche sp. 40 % facultative caddisfly	Cheumatopsyche sp. 23 % facultative caddisfly	
Intolerant = not tolerant of poor water quality	2. Undetermined Corixidae 14 % facultative boatman	Baetis intercalaris 22 % facultative mayfly	Stenelmis crenata 14 % facultative beetle	
Facultative = occurring over a wide range of water quality	3. Dubiraphia vittata 11 % facultative beetle	Simulium jenningsi 9 % intolerant black fly	Rheotanytarsus sp. 11 % facultative midge	
Tolerant = tolerant of poor water quality	4. Tribelos/Endochironomus/Phaenopsectra Co 9 % tolerant midge	Rheotanytarsus sp. 6 % facultative midge	Baetis intercalaris 9 % facultative mayfly	
	5. Stenacron interpunctatum 4 % facultative mayfly	Stenelmis crenata 5 % facultative beetle	Hydropsyche bronta 7 % facultative caddisfly	
% CONTRIBUTION OF MAJOR GROUPS (NUMBER OF TAXA IN PARENTHESIS)				
Chironomidae (midges)	22 (8.0)	18 (6.0)	33 (9.0)	
Trichoptera (caddisflies)	1 (1.0)	42 (3.0)	36 (3.0)	
Ephemeroptera (mayflies)	6 (2.0)	22 (1.0)	10 (2.0)	
Plecoptera (stoneflies)	0 (0.0)	0 (0.0)	0 (0.0)	
Coleoptera (beetles)	14 (4.0)	6 (2.0)	15 (2.0)	
Oligochaeta (worms)	0 (0.0)	2 (1.0)	0 (0.0)	
Mollusca (clams and snails)	2 (1.0)	0 (0.0)	0 (0.0)	
Crustacea (crayfish, scuds, sowbugs)	40 (1.0)	0 (0.0)	1 (1.0)	
Other insects (odonates, diptera)	15 (2.0)	10 (2.0)	2 (2.0)	
Other (Nemertea, Platyhelminthes)	0 (0.0)	0 (0.0)	1 (0.0)	
SPECIES RICHNESS	19	15	20	
BIOTIC INDEX	6.1	5.17	5.73	
EPT RICHNESS	3	4	5	
PERCENT MODEL AFFINITY	47	68	56	
FIELD ASSESSMENT	Good	Good	Good	
OVERALL ASSESSMENT	slightly impacted	slightly impacted	slightly impacted	

Table 7a. Laboratory Data Summary, Wallkill River, Orange and Ulster Counties, 2008.

LABORATORY DATA SUMMARY				
STREAM NAME: Wallkill River				
DATE SAMPLED: 7/15/2008				
SAMPLING METHOD: Kick				
LOCATION	WALK	WALK	WALK	WALK
STATION	06	08	09	10
DOMINANT SPECIES / %CONTRIBUTION / TOLERACE / COMMON NAME				
Tolerance Definitions:	1. Simulium jenningsi 24 % intolerant black fly	Cheumatopsyche sp. 28 % facultative caddisfly	Gammarus sp. 25 % facultative scud	Stenacron interpunctatum 26 % facultative mayfly
Intolerant = not tolerant of poor water quality	2. Cheumatopsyche sp. 20 % facultative caddisfly	Stenonema terminatum 17 % intolerant mayfly	Stenelmis crenata 24 % facultative beetle	Stenelmis crenata 21 % facultative beetle
Facultative = occurring over a wide range of water quality	3. Baetis intercalaris 12 % facultative mayfly	Stenacron interpunctatum 10 % facultative mayfly	Stenacron interpunctatum 12 % facultative mayfly	Leucrocuta sp. 14 % intolerant mayfly
Tolerant = tolerant of poor water quality	4. Stenelmis crenata 12 % facultative beetle	Thienemannimyia gr. spp. 8 % facultative midge	Baetis intercalaris 11 % facultative mayfly	Gammarus sp. 8 % facultative scud
	5. Rheotanytarsus sp. 11 % facultative midge	Baetis intercalaris 6 % facultative mayfly	Cheumatopsyche sp. 10 % facultative caddisfly	Stenonema mediopunctatum 7 % intolerant mayfly
% CONTRIBUTION OF MAJOR GROUPS (NUMBER OF TAXA IN PARENTHESIS)				
Chironomidae (midges)	21 (8.0)	13 (2.0)	2 (2.0)	1 (1.0)
Trichoptera (caddisflies)	20 (1.0)	32 (3.0)	15 (2.0)	4 (2.0)
Ephemeroptera (mayflies)	16 (2.0)	38 (4.0)	29 (6.0)	63 (8.0)
Plecoptera (stoneflies)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Coleoptera (beetles)	13 (2.0)	8 (4.0)	27 (2.0)	21 (1.0)
Oligochaeta (worms)	0 (0.0)	1 (1.0)	0 (0.0)	2 (1.0)
Mollusca (clams and snails)	0 (0.0)	2 (1.0)	2 (2.0)	0 (0.0)
Crustacea (crayfish, scuds, sowbugs)	4 (2.0)	3 (2.0)	25 (1.0)	8 (1.0)
Other insects (odonates, diptera)	26 (2.0)	3 (1.0)	0 (0.0)	1 (1.0)
Other (Nemertea, Platyhelminthes)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
SPECIES RICHNESS	17	18	15	15
BIOTIC INDEX	5.13	5.12	5.44	4.9
EPT RICHNESS	3	7	8	10
PERCENT MODEL AFFINITY	66	78	61	66
FIELD ASSESSMENT	Good	Good	Good	Good
OVERALL ASSESSMENT	slightly impacted	slightly impacted	slightly impacted	slightly impacted

Table 8. Field Data Summary, Wallkill River, Orange and Ulster Counties, 2008.

FIELD DATA SUMMARY				
STREAM NAME: Wallkill River	**DATE SAMPLED:** 7/15/2008			
REACH: Liberty Corners to Tuthill				
FIELD PERSONNEL INVOLVED: Heitzman/Wright/Anderson				
STATION	01	03	05	
ARRIVAL TIME AT STATION	6:00	5:10	4:00	
LOCATION	WALK	WALK	WALK	
PHYSICAL CHARACTERISTICS				
Width (meters)	12	10	15	
Depth (meters)	0.3	0.3	0.2	
Current speed (cm per sec.)	SLACK	80	91	
Substrate (%)				
Rock (>25.4 cm, or bedrock)	5	20	20	
Rubble (6.35 - 25.4 cm)		20	30	
Gravel (0.2 - 6.35 cm)	25	40	30	
Sand (0.06 - 2.0 mm)	30	10	10	
Silt (0.004 - 0.06 mm)	30	10	10	
Embeddedness (%)		10	30	
CHEMICAL MEASUREMENTS				
Temperature (Celsius)	26	25.9	26.8	
Specific Conductance (umhos)	560	542	573	
Dissolved Oxygen (mg/l)	7.93	8.2	12.2	
pH	8	8.1	8.4	
BIOLOGICAL ATTRIBUTES				
Canopy (%)	25	25	10	
Aquatic Vegetation				
Algae - suspended	X	X	X	
Algae - attached, filamentous		X	X	
Algae - diatoms		10	20	
Macrophytes or moss				
Occurrence of Macroinvertebrates				
Ephemeroptera (mayflies)	X	X	X	
Plecoptera (stoneflies)				
Trichoptera (caddisflies)		X	X	
Coleoptera (beetles)		X	X	
Megaloptera (dobsonflies, damselflies)				
Odonata (dragonflies, damselflies)				
Chironomidae (midges)				
Simuliidae (black flies)				
Decapoda (crayfish)			X	
Gammaridae (scuds)	X			
Mollusca (snails, clams)		X		
Oligochaeta (worms)				
Other	X		X	
FAUNAL CONDITION	Good	Good	Good	

Table 8a. Field Data Summary, Wallkill River, Orange and Ulster Counties, 2008.

FIELD DATA SUMMARY				
STREAM NAME: Wallkill River	**DATE SAMPLED:** 7/15/2008			
REACH: Liberty Corners to Tuthill				
FIELD PERSONNEL INVOLVED: Heitzman/Wright/Anderson				
STATION	06	08	09	10
ARRIVAL TIME AT STATION	1:10	11:45	10:50	9:55
LOCATION	WALK	WALK	WALK	WALK
PHYSICAL CHARACTERISTICS				
Width (meters)	40	30	30	25
Depth (meters)	0.2	0.2	0.4	0.2
Current speed (cm per sec.)	143	41	56	21
Substrate (%)				
Rock (>25.4 cm, or bedrock)	10	20	30	10
Rubble (6.35 - 25.4 cm)	30	30	20	30
Gravel (0.2 - 6.35 cm)	30	10	10	10
Sand (0.06 - 2.0 mm)	20	30	30	30
Silt (0.004 - 0.06 mm)	10	10	10	20
Embeddedness (%)	50	50	50	40
CHEMICAL MEASUREMENTS				
Temperature (Celsius)	25.6	26.7	24.6	25.8
Specific Conductance (umhos)	582	587	580	553
Dissolved Oxygen (mg/l)	9.65	7.3	7.74	6.99
pH	8.2	8.7	8.5	8.6
BIOLOGICAL ATTRIBUTES				
Canopy (%)	10	10	10	10
Aquatic Vegetation				
Algae - suspended	X			
Algae - attached, filamentous	X	X	X	X
Algae - diatoms	75	50	10	30-40
Macrophytes or moss				
Occurrence of Macroinvertebrates				
Ephemeroptera (mayflies)	X	X	X	X
Plecoptera (stoneflies)				
Trichoptera (caddisflies)	X	X	X	X
Coleoptera (beetles)	X	X	X	X
Megaloptera (dobsonflies, damselflies)				
Odonata (dragonflies, damselflies)				
Chironomidae (midges)		X		
Simuliidae (black flies)	X			
Decapoda (crayfish)		X	X	
Gammaridae (scuds)	X		X	
Mollusca (snails, clams)	X		X	
Oligochaeta (worms)				X
Other		X		X
FAUNAL CONDITION	Good	Good	Good	Good

Appendix I. Biological Methods for Kick Sampling

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

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

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

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

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

Appendix II. Macroinvertebrate Community Parameters

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

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

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

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

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

Appendix III. Levels of Water Quality Impact in Streams

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

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

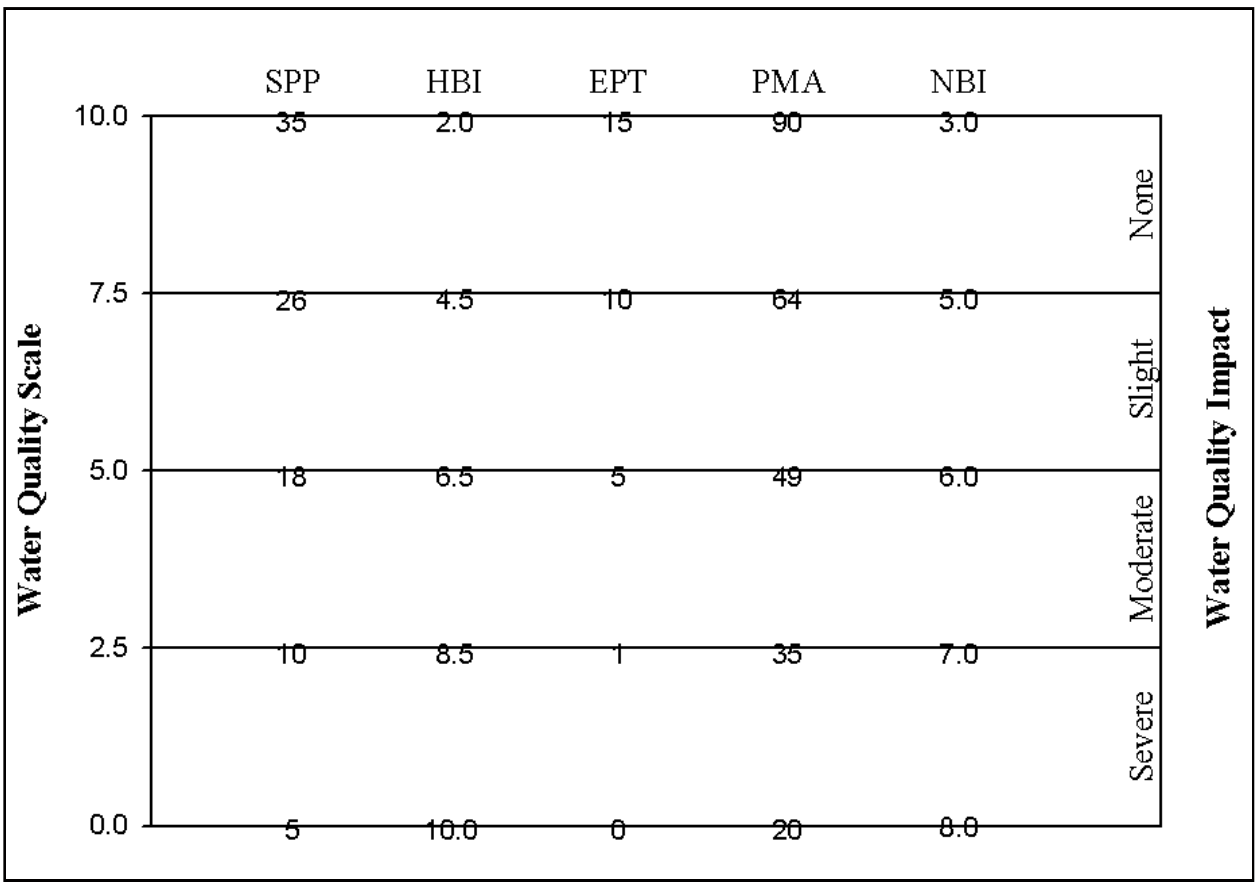
2. *Slightly impacted*: Indices reflect good water quality. The macroinvertebrate community is slightly but significantly altered from the pristine state. Species richness is usually 19-26. Mayflies and stoneflies may be restricted, with EPT richness values of 6-10. The biotic index value is 4.51-6.50.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

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

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

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

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



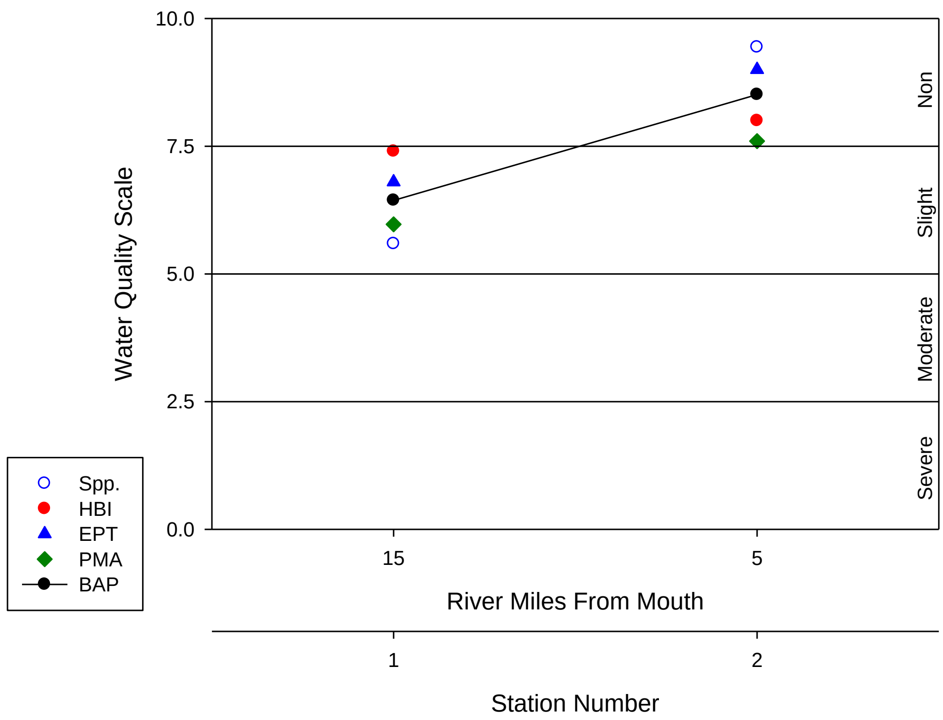
Appendix IV-B. Biological Assessment Profile: Plotting Values

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

Example data:

	Station 1		Station 2	
	metric value	10-scale value	metric value	10-scale value
Species richness	20	5.59	33	9.44
Hilsenhoff Biotic Index	5.00	7.40	4.00	8.00
EPT richness	9	6.80	13	9.00
Percent Model Affinity	55	5.97	65	7.60
Average		6.44 (slight)		8.51 (non-)

Sample BAP plot:



Appendix V. Water Quality Assessment Criteria

Non-Navigable Flowing Waters

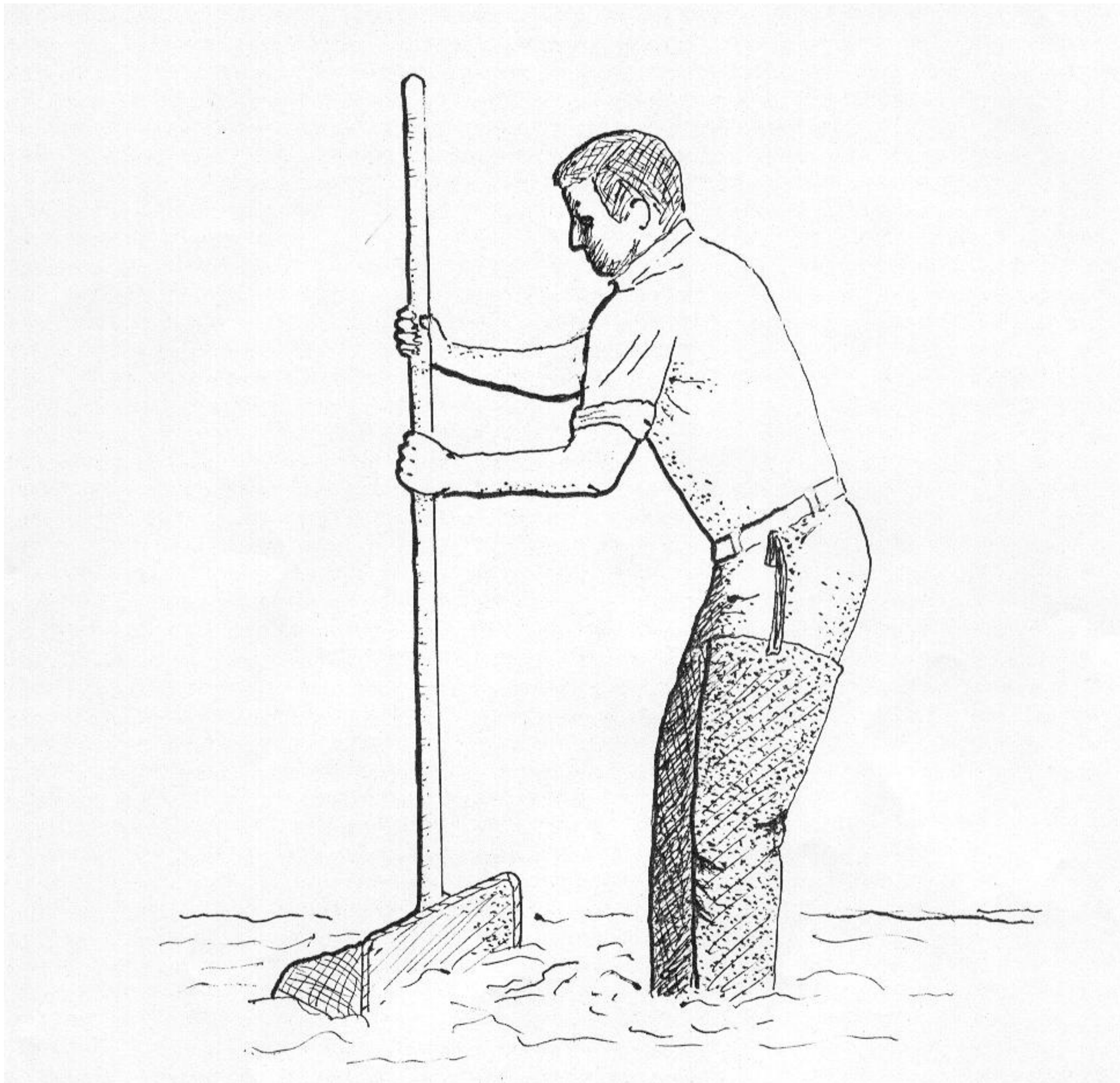
	Species Richness	Hilsenhoff Biotic Index	EPT Value	Percent Model Affinity*	Diversity **
Non-Impacted	>26	0.00-4.50	>10	>64	>4
Slightly Impacted	19-26	4.51-6.50	6-10	50-64	3.01-4.00
Moderately Impacted	11-18	6.51-8.50	2-5	35-49	2.01-3.00
Severely Impacted	0-10	8.51-10.00	0-1	<35	0.00-2.00

* 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 Usually Indicative of Good Water Quality

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

MAYFLIES

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

STONEFLIES

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

CADDISFLIES

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

BEETLES

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

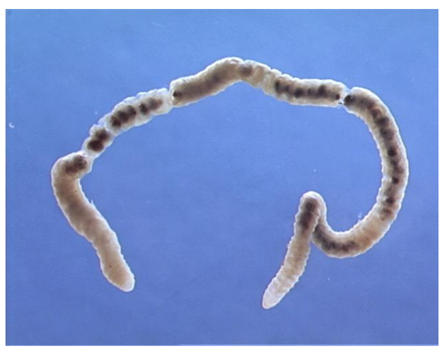
Midges are the most common aquatic flies. The larvae occur in almost any aquatic situation. Many species are very tolerant to pollution. Large, red midge larvae called "bloodworms" indicate organic enrichment. Other midge larvae filter plankton, indicating nutrient enrichment when numerous.

MIDGES

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

BLACK FLIES

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



WORMS

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

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

SOWBUGS

Appendix VIII. The Rationale of Biological Monitoring

Biological monitoring refers to the use of resident benthic macroinvertebrate communities as indicators of water quality. Macroinvertebrates are larger-than-microscopic invertebrate animals that inhabit aquatic habitats; freshwater forms are primarily aquatic insects, worms, clams, snails, and crustaceans.

Concept:
Nearly all streams are inhabited by a community of benthic macroinvertebrates. The species comprising the community each occupy a distinct niche defined and limited by a set of environmental requirements. The composition of the macroinvertebrate community is thus determined by many factors, including habitat, food source, flow regime, temperature, and water quality. The community is presumed to be controlled primarily by water quality if the other factors are determined to be constant or optimal. Community components which can change with water quality include species richness, diversity, balance, abundance, and presence/absence of tolerant or intolerant species. Various indices or metrics are used to measure these community changes. Assessments of water quality are based on metric values of the community, compared to expected metric values.

Advantages:
The primary advantages to using macroinvertebrates as water quality indicators are that they:

- are sensitive to environmental impacts
- are less mobile than fish, and thus cannot avoid discharges
- can indicate effects of spills, intermittent discharges, and lapses in treatment
- are indicators of overall, integrated water quality, including synergistic effects
- are abundant in most streams and are relatively easy and inexpensive to sample
- are able to detect non-chemical impacts to the habitat, e.g. siltation or thermal changes
- are vital components of the aquatic ecosystem and important as a food source for fish
- are more readily perceived by the public as tangible indicators of water quality
- can often provide an on-site estimate of water quality
- can often be used to identify specific stresses or sources of impairment
- can be preserved and archived for decades, allowing for direct comparison of specimens
- bioaccumulate many contaminants, so that analysis of their tissues is a good monitor of toxic substances in the aquatic food chain

Limitations:
Biological monitoring is not intended to replace chemical sampling, toxicity testing, or fish surveys. Each of these measurements provides information not contained in the others. Similarly, assessments based on biological sampling should not be taken as being representative of chemical sampling. Some substances may be present in levels exceeding ambient water quality criteria, yet have no apparent adverse community impact.

Appendix IX. Glossary

Anthropogenic: caused by human actions

Assessment: a diagnosis or evaluation of water quality

Benthos: organisms occurring on or in the bottom substrate of a waterbody

Bioaccumulate: accumulate contaminants in the tissues of an organism

Biomonitoring: the use of biological indicators to measure water quality

Community: a group of populations of organisms interacting in a habitat

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

Electrofishing: sampling fish by using electric currents to temporarily immobilize them, allowing capture

EPT richness: the number of taxa of mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) in a sample or subsample

Eutrophic: high nutrient levels normally leading to excessive biological productivity

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

Fauna: the animal life of a particular habitat

Impact: a change in the physical, chemical, or biological condition of a waterbody

Impairment: a detrimental effect caused by an impact

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

Intolerant: unable to survive poor water quality

Longitudinal trends: upstream-downstream changes in water quality in a river or stream

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

Mesotrophic: intermediate nutrient levels (between oligotrophic and eutrophic) normally leading to moderate biological productivity

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

Non Chironomidae/Oligochaeta (NCO) richness: the number of taxa neither belonging to the family Chironomidae nor the subclass Oligochaeta in a sample or subsample

Oligotrophic: low nutrient levels normally leading to unproductive biological conditions

Organism: a living individual

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

Rapid bioassessment: a biological diagnosis of water quality using field and laboratory analysis designed to allow assessment of water quality in a short turn-around time; usually involves kick sampling and laboratory subsampling of the sample

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

Species richness: the number of macroinvertebrate taxa in a sample or subsample

Station: a sampling site on a waterbody

Survey: a set of samplings conducted in succession along a stretch of stream

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

Tolerant: able to survive poor water quality

Trophic: referring to productivity

Appendix X. Methods for Calculation of the Nutrient Biotic Index

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

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

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

Where ***a*** is equal to the number of individuals for each taxon, ***b*** is the taxon's tolerance value, and ***c*** is the total number of individuals in the sample for which tolerance values have been assigned.

Classification of NBI Scores: NBI scores have been placed on a scale of eutrophication with provisional boundaries between stream trophic status.

Index	Oligotrophic	Mesotrophic	Eutrophic
NBI-P	< 5.0	> 5.0 - 6.0	> 6.0
NBI-N	< 4.5	> 4.5 - 6.0	> 6.0

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
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
Polypedilum aviceps	5	7
Polypedilum flavum	9	7
Polypedilum illinoense	10	7
Polypedilum laetum	7	6
Polypedilum scalaenum gr.	10	6
Potthastia gaedii gr.	9	10
Promoresia elegans	10	10
Prostoma graecense	2	7
Psephenus herricki	10	9
Psephenus sp.	3	4

NBI tolerance values (cont'd)

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

TAXON	TP T-Value	NO3 T-Value
Synorthocladius nr. semivirens	6	9
Tanytarsus glabrescens gr.	5	6
Tanytarsus guerlus gr.	5	5
Thienemannimyia gr. spp.	8	8
Tipula sp.	10	10
Tricorythodes sp.	4	9
Tvetenia bavarica gr.	9	10
Tvetenia vitracies	7	6
Undet. Tubificidae w/ cap. setae	10	8
Undet. Tubificidae w/o cap. setae	7	7
Undetermined Cambaridae	6	5
Undet. Ceratopogonidae	8	9
Undet. Enchytraeidae	7	8
Undet. Ephemerellidae	3	6
Undetermined Gomphidae	2	0
Undet. Heptageniidae	5	2
Undetermined Hirudinea	9	10
Undetermined Hydrobiidae	6	7
Undetermined Hydroptilidae	5	2
Undet. Limnephilidae	3	4
Undet. Lumbricina	8	8
Undet. Lumbriculidae	5	6
Undetermined Perlidae	5	7
Undetermined Sphaeriidae	10	8
Undetermined Turbellaria	8	6
Zavrelia sp.	9	9

Appendix XI. Impact Source Determination Methods and Community Models

Definition: Impact Source Determination (ISD) is the procedure for identifying types of impacts that exert deleterious effects on a waterbody. While the analysis of benthic macroinvertebrate communities has been shown to be an effective means of determining severity of water quality impacts, it has been less effective in determining what kind of pollution is causing the impact. ISD uses community types or models to ascertain the primary factor influencing the fauna.

Development of methods: The method found to be most useful in differentiating impacts in New York State streams was the use of community types based on composition by family and genus. It may be seen as an elaboration of Percent Model Affinity (Novak and Bode, 1992), which is based on class and order. A large database of macroinvertebrate data was required to develop ISD methods. The database included several sites known or presumed to be impacted by specific impact types. The impact types were mostly known by chemical data or land use. These sites were grouped into the following general categories: agricultural nonpoint, toxic-stressed, sewage (domestic municipal), sewage/toxic, siltation, impoundment, and natural. Each group initially contained 20 sites.Cluster analysis was then performed within each group, using percent similarity at the family or genus level. Within each group, four clusters were identified. Each cluster was usually composed of 4-5 sites with high biological similarity. From each cluster, a hypothetical model was then formed to represent a model cluster community type; sites within the cluster had at least 50 percent similarity to this model. These community type models formed the basis for ISD (see tables following). The method was tested by calculating percent similarity to all the models and determining which model was the most similar to the test site. Some models were initially adjusted to achieve maximum representation of the impact type. New models are developed when similar communities are recognized from several streams.

Use of the ISD methods: Impact Source Determination is based on similarity to existing models of community types (see tables following). The model that exhibits the highest similarity to the test data denotes the likely impact source type, or may indicate "natural," lacking an impact. In the graphic representation of ISD, only the highest similarity of each source type is identified. If no model exhibits a similarity to the test data of greater than 50 percent, the determination is inconclusive. The determination of impact source type is used in conjunction with assessment of severity of water quality impact to provide an overall assessment of water quality.

Limitations: These methods were developed for data derived from subsamples of 100-organisms each that are taken from traveling kick samples of New York State streams. Application of these methods for data derived from other sampling methods, habitats, or geographical areas would likely require modification of the models.

ISD Models

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

ISD Models (cont'd)

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

ISD Models (cont'd)

	MUNICIPAL/INDUSTRIAL								TOXIC					
	A	B	C	D	E	F	G	H	A	B	C	D	E	F
PLATYHELMINTHES	-	40	-	-	-	5	-	-	-	-	-	-	5	-
OLIGOCHAETA	20	20	70	10	-	20	-	-	-	10	20	5	5	15
HIRUDINEA	-	5	-	-	-	-	-	-	-	-	-	-	-	-
GASTROPODA	-	-	-	-	-	5	-	-	-	5	-	-	-	5
SPHAERIIDAE	-	5	-	-	-	-	-	-	-	-	-	-	-	-
ASELLIDAE	10	5	10	10	15	5	-	-	10	10	-	20	10	5
GAMMARIDAE	40	-	-	-	15	-	5	5	5	-	-	-	5	5
Isonychia	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BAETIDAE	5	-	-	-	5	-	10	10	15	10	20	-	-	5
HEPTAGENIIDAE	5	-	-	-	-	-	-	-	-	-	-	-	-	-
LEPTOPHLEBIIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EPHEMERELLIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Caenis/Tricorythodes	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PLECOPTERA	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Psephenus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Optioservus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Promoresia	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenelmis	5	-	-	10	5	-	5	5	10	15	-	40	35	5
PHILOPOTAMIDAE	-	-	-	-	-	-	-	40	10	-	-	-	-	-
HYDROPSYCHIDAE	10	-	-	50	20	-	40	20	20	10	15	10	35	10
HELICOPSYCHIDAE/ BRACHYCENTRIDAE/ RHYACOPHILIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SIMULIIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Simulium vittatum	-	-	-	-	-	-	20	10	-	20	-	-	-	5
EMPIDIDAE	-	5	-	-	-	-	-	-	-	-	-	-	-	-
CHIRONOMIDAE														
Tanypodinae	-	10	-	-	5	15	-	-	5	10	-	-	-	25
Cardiocladius	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cricotopus/ Orthocladius	5	10	20	-	5	10	5	5	15	10	25	10	5	10
Eukiefferiella/ Tvetenia	-	-	-	-	-	-	-	-	-	-	20	10	-	-
Parametriocnemus	-	-	-	-	-	-	-	-	-	-	-	5	-	-
Chironomus	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polypedilum aviceps	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polypedilum (all others)	-	-	-	10	20	40	10	5	10	-	-	-	-	5
Tanytarsini	-	-	-	10	10	-	5	-	-	-	-	-	-	5
TOTAL	100	100	100	100	100	100	100	100	100	100	100	100	100	100

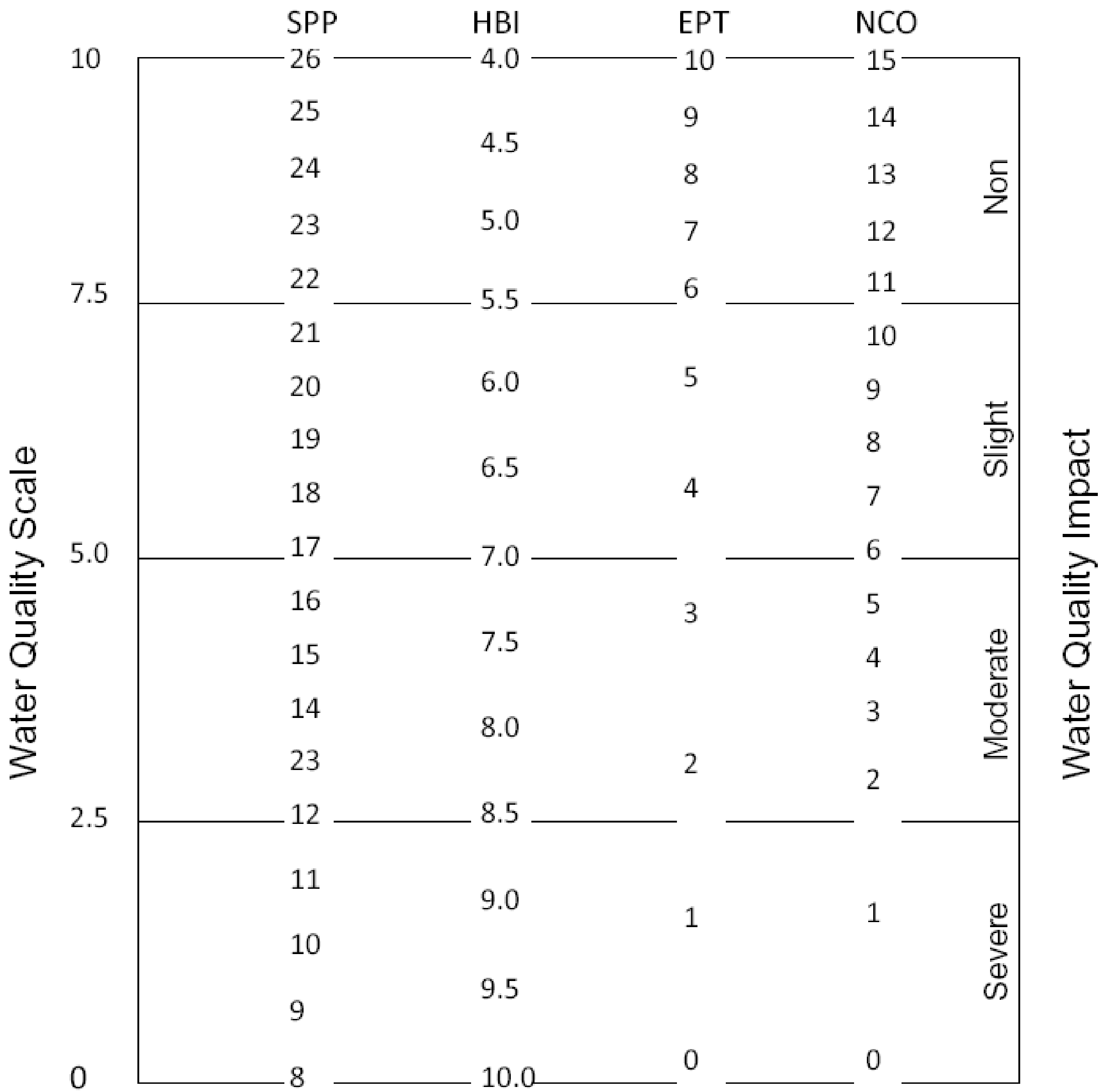
ISD Models (cont'd)

	SEWAGE EFFLUENT, ANIMAL WASTES									
	A	B	C	D	E	F	G	H	I	J
PLATYHELMINTHES	-	-	-	-	-	-	-	-	-	-
OLIGOCHAETA	5	35	15	10	10	35	40	10	20	15
HIRUDINEA	-	-	-	-	-	-	-	-	-	-
GASTROPODA	-	-	-	-	-	-	-	-	-	-
SPHAERIIDAE	-	-	-	10	-	-	-	-	-	-
ASELLIDAE	5	10	-	10	10	10	10	50	-	5
GAMMARIDAE	-	-	-	-	-	10	-	10	-	-
Isonychia	-	-	-	-	-	-	-	-	-	-
BAETIDAE	-	10	10	5	-	-	-	-	5	-
HEPTAGENIIDAE	10	10	10	-	-	-	-	-	-	-
LEPTOPHLEBIIDAE	-	-	-	-	-	-	-	-	-	-
EPHEMERELLIDAE	-	-	-	-	-	-	-	-	5	-
Caenis/Tricorythodes	-	-	-	-	-	-	-	-	-	-
PLECOPTERA	-	-	-	-	-	-	-	-	-	-
Psephenus	-	-	-	-	-	-	-	-	-	-
Optioservus	-	-	-	-	-	-	-	-	5	-
Promoresia	-	-	-	-	-	-	-	-	-	-
Stenelmis	15	-	10	10	-	-	-	-	-	-
PHILOPOTAMIDAE	-	-	-	-	-	-	-	-	-	-
HYDROPSYCHIDAE	45	-	10	10	10	-	-	10	5	-
HELICOPSYCHIDAE/ BRACHYCENTRIDAE/ RHYACOPHILIDAE	-	-	-	-	-	-	-	-	-	-
SIMULIIDAE	-	-	-	-	-	-	-	-	-	-
Simulium vittatum	-	-	-	25	10	35	-	-	5	5
EMPIDIDAE	-	-	-	-	-	-	-	-	-	-
CHIRONOMIDAE										
Tanypodinae	-	5	-	-	-	-	-	-	5	5
Cardiocladius	-	-	-	-	-	-	-	-	-	-
Cricotopus/ Orthocladius	-	10	15	-	-	10	10	-	5	5
Eukiefferiella/ Tvetenia	-	-	10	-	-	-	-	-	-	-
Parametriocnemus	-	-	-	-	-	-	-	-	-	-
Chironomus	-	-	-	-	-	-	10	-	-	60
Polypedilum aviceps	-	-	-	-	-	-	-	-	-	-
Polypedilum (all others)	10	10	10	10	60	-	30	10	5	5
Tanytarsini	10	10	10	10	-	-	-	10	40	-
TOTAL	100	100	100	100	100	100	100	100	100	100

ISD Models (cont'd)

	SILTATION					IMPOUNDMENT									
	A	B	C	D	E	A	B	C	D	E	F	G	H	I	J
PLATYHELMINTHES	-	-	-	-	-	-	10	-	10	-	5	-	50	10	-
OLIGOCHAETA	5	-	20	10	5	5	-	40	5	10	5	10	5	5	-
HIRUDINEA	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-
GASTROPODA	-	-	-	-	-	-	-	10	-	5	5	-	-	-	-
SPHAERIIDAE	-	-	-	5	-	-	-	-	-	-	-	-	5	25	-
ASELLIDAE	-	-	-	-	-	-	5	5	-	10	5	5	5	-	-
GAMMARIDAE	-	-	-	10	-	-	-	10	-	10	50	-	5	10	-
Isonychia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BAETIDAE	-	10	20	5	-	-	5	-	5	-	-	5	-	-	5
HEPTAGENIIDAE	5	10	-	20	5	5	5	-	5	5	5	5	-	5	5
LEPTOPHLEBIIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EPHEMERELLIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Caenis/Tricorythodes	5	20	10	5	15	-	-	-	-	-	-	-	-	-	-
PLECOPTERA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Psephenus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
Optioservus	5	10	-	-	-	-	-	-	-	-	-	-	-	5	-
Promoresia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stenelmis	5	10	10	5	20	5	5	10	10	-	5	35	-	5	10
PHILOPOTAMIDAE	-	-	-	-	-	5	-	-	5	-	-	-	-	-	30
HYDROPSYCHIDAE	25	10	-	20	30	50	15	10	10	10	10	20	5	15	20
HELICOPSYCHIDAE/ BRACHYCENTRIDAE/ RHYACOPHILIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-
SIMULIIDAE	5	10	-	-	5	5	-	5	-	35	10	5	-	-	15
EMPIDIDAE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CHIRONOMIDAE															
Tanypodinae	-	-	-	-	-	-	5	-	-	-	-	-	-	-	-
Cardiocladius	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cricotopus/ Orthocladius	25	-	10	5	5	5	25	5	-	10	-	5	10	-	-
Eukiefferiella/ Tvetenia	-	-	10	-	5	5	15	-	-	-	-	-	-	-	-
Parametriocnemus	-	-	-	-	-	5	-	-	-	-	-	-	-	-	-
Chironomus	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polypedilum aviceps	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polypedilum (all others)	10	10	10	5	5	5	-	-	20	-	-	5	5	5	5
Tanytarsini	10	10	10	10	5	5	10	5	30	-	-	5	10	10	5
TOTAL	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100

Appendix XII. Biological Assessment Profile of Slow, Sandy Streams.



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