New York State
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Division of Water

Mohawk River (Utica)

Biological Assessment

2009 Survey

New York State
Department of Environmental Conservation

BIOLOGICAL ASSESSMENT

Mohawk River (Utica)
Oneida County, New York
Mohawk River Basin

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Alexander J. Smith
Brian T. Duffy
Diana L. Heitzman

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

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Stream: Mohawk River

River Basin: Mohawk River

Reach: Utica, NY - portions 12 and 13 of segment H-240

Background

At the request of Region 6 Division of Water staff, the Stream Biomonitoring Unit (SBU) sampled the Mohawk River, Oneida County, in the vicinity of Utica New York, between the months of June-September, 2009. Benthic macroinvertebrate communities were examined to characterize water quality and determine if biological impairment of aquatic communities occurred downstream of several sewer and stormwater outfalls.

Biological impairment criteria were evaluated. Artificial substrate samplers were deployed three times for a colonization period of five weeks at each of four sites on the main-stem of the Mohawk River. Details on the biological assessment methods used are described in Standard Operating Procedure #208-09: Biological Monitoring of Surface Waters in New York State (Smith et al. 2009), Biological Impairment Criteria (Bode et al. 1990), and appendices I and IX. 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 250-specimen subsample from each one.

Macroinvertebrate community parameters for multiplate samples used in the determination of biological impairment included: species richness, biotic index, EPT richness and species dominance. Water quality assessment was based on the Biological Assessment Profile score (BAP), a multi-metric index which is a method of plotting multiple index values on a common scale of water quality impact. The metrics included in calculating the BAP for multiplate samples are species richness, biotic index, EPT richness and diversity (see Appendices II and III). Table 1 provides a listing of sampling sites, and Table 4 provides a listing of all species collected in the present survey. This is followed by a laboratory data summary (Table 5).

Results and Conclusions

1. Biological impairment criteria suggest the macroinvertebrate community at Station 05A is impaired in relation to the upstream control site based on significant losses of sensitive taxa (EPT richness). The taxa found downstream of each outfall show that pollution is having a cumulative effect, compounding degradation and resulting in an assessment of impairment at the furthest downstream location.

2. Overall assessment of water quality using the Biological Assessment Profile indicates slightly impacted conditions at all sites including the upstream control station. However, analysis of individual metrics indicates substantial loss of sensitive species and a decline in biomass from the upstream to the most downstream site, resulting in a macroinvertebrate community that is substantially changed in composition and density at the sites below the combined sewer outfalls (CSOs) and storm sewer outfalls (SSOs).

Discussion

The Mohawk River in the area of Utica, NY (water index numbers H-240, portions 12 and 13) is presently listed as an impaired water body on both the 2010 New York State Section 303(d) List of Impaired Waters (NYSDEC 2010), and the 2003 Mohawk River Basin Waterbody Inventory and Priority Waterbodies List (NYSDEC 2003). Causes of impairment are attributed to floatables, pathogens and high dissolved oxygen demand. Sources of contaminants are combined sewer outfalls (CSOs) and storm sewer outfalls (SSOs) in addition to general urban and industrial/municipal sources (NYSDEC 2010).

The Stream Biomonitoring Unit (SBU) conducted sampling in the Mohawk River from June to September, 2009. Artificial substrate samplers were deployed three times each at four sites in portions 12 and 13 of segment H-240 of the Mohawk River to collect benthic macroinvertebrates (Table 1 and Figure 1). Samplers were deployed for a colonization period of five weeks following the methods outlined in Smith et al. (2009). Sampling locations were selected to assess the impacts of various CSOs and SSOs in this section of the river. An upstream control site was located above the influence of outfalls (Station 04) (Table 1 and Figure 1). Station 04A was located downstream of the Sauquoit Creek pump station SSO, Station 05 was located downstream of the Nail Creek outlet CSO, Station 05A was located downstream of the Railroad Interceptor outfall, Grace Creek Interceptor outfall, and the Oneida County WPCP outfall (Table 1 and Figure 1).

Application of Biological Impairment Criteria (Bode et al. 1990) indicates significant biological impairment occurring from the upstream to the most downstream location. Metric scores from the three multiplate samples at each downstream site (Stations 04A, 05, 05A) were compared to results from the upstream control site (Station 04), and impairment thresholds evaluated (Table 2). The threshold for EPT richness was exceeded, indicating impairment occurring in the reach between Stations 04 and 05A. The change in biotic index scores between these sites was significantly different (Table 2), approaching the threshold for impairment but not exceeding it. This supports a trend seen in the analysis of individual metrics. EPT richness and biotic index were the metrics most changed, suggesting the CSOs and SSO as the causes of impairment, since these metrics reflect inputs of sewage or other organic wastes. While significant biological impairment does not occur below just one of these discharges, the cumulative effect of the CSOs and SSO results in impairment at the most downstream site in the reach.

Based on standardized biological assessment methods (Smith et al 2009), water quality was assessed as slightly impacted at all four sites (Figure 2). These results were determined by calculating the Biological Assessment Profile Score (BAP) a multi-metric index that uses species richness, biotic index, EPT richness and diversity (Figure 2) (Appendix II) to make an overall assessment of water quality. The variability in BAP scores between sites is within expected limits of variation, so the assessment of slight impact at all four sites is accurate for the general assessment methodology.

However, analysis of individual metrics indicates loss of sensitive species and a decline in density from the upstream to the most downstream site, and a divergence between metrics of pollution tolerance (EPT richness and biotic index) and species evenness (species richness and species diversity) (Figure 2). The macroinvertebrate community becomes more diverse downstream, but sensitive taxa are lost and replaced by pollution tolerant species, seen in the loss of EPT taxa and the increase in the biotic index.

In addition, macroinvertebrate population density declines downstream (Figure 3). The decline in density is correlated with increases in specific conductance and declines in water transparency as indicated by the decreasing depth of secchi disk water clarity readings (Figure 3 and Table 3). The input of nutrients and organics from the outfalls should result in an increase in density (Smith et al. 2007) as the community is released from nutrient limitation. Instead, the decline of density suggests additional pollutants of a toxic nature may be present in this reach.

The macroinvertebrate community is substantially changed in composition and density at the sites below the CSOs and SSOs (Stations 04A-05A) compared to the upstream location. The loss of sensitive taxa and replacement with pollution tolerant organisms suggests the addition of measurable pollution. The response of the community downstream of each outfall reflects a cumulative effect with compounding degradation until the community is assessed as impaired at the furthest downstream location. The loss of density in this reach of the river is an alarming indication of how much the community changes.

Continued monitoring of this reach is needed, especially as efforts to limit the effects of CSO and SSO discharges and improve water quality are performed. Monitoring will provide the necessary information about the effectiveness of these efforts.

This study only presents information about the invertebrate community in the upper portions of the water column. Based on reconnassaince surveys in May 2009, in which SBU staff collected ponar bottom dredge samples in the study reach for field inspection of organisms, there is concern that benthic (bottom) sediments in this reach of river may be grossly contaminated, and aquatic life greatly impacted. However, because of the perceived toxic and harmful nature of the contaminants in the sediments, the SBU was unable to collect samples of aquatic organisms. Therefore, the SBU recommends that a survey of the aquatic life in the benthic sediments of this reach be undertaken. This survey should also include the analysis of invertebrate tissues for accumulating contaminants. Frequent sampling for water chemistry, or sampling for water chemistry during weather or other events that cause high discharge, should accompany the benthic sediments survey to begin to relate water chemistry information to aquatic life in this stretch of river.

References

Bode, R. W., M. A. Novak and L. E. Abele. 1990. Biological Impairment Criteria for Flowing Waters in New York State. New York State Department of Environmental Conservation, Albany, New York. Technical Report, 110 pages.

NYSDEC. 2003. Mohawk River Basin Waterbody Inventory and Priority Waterbodies List. New York State Department of Environmental Conservation, Albany, New York. Technical Report, 370 pages.

NYSDEC. 2010. 2010 Section 303(d) List of Impaired Waters. New York State Department of Environmental Conservation, Albany, New York. Technical Report, 44 pages.

Smith, A. J., D. L. Heitzman and B. T. Duffy. 2009. Standard Operating Procedure: Biological Monitoring of Surface Waters in New York State. New York State Department of Environmental Conservation, Albany, New York. Technical Report, 159 pages.

Smith, A.J., R.W. Bode, M.A. Novak, L.E. Abele and D.L. Heitzman. 2006. A Nutrient Biotic Index (NBI) for use with benthic macroinvertebrate communities and its relationship with surface water nutrient concentrations in flowing waters. New York State Deptartment of Environmental Conservation, Albany, New York. Technical Report, 72 pages.

Table 1. Station Locations for the Mohawk River, Oneida County, NY, 2009. Site photographs are in order of their listing in the table.

Station	Location
MOHK-04 Mohawk River	Utica 500 meters above Sauquoit Creek Pump Station SSO Latitude: 43.126665 Longitude: -75.269205
MOHK -04A Mohawk River	Utica 300 meters below Sauquoit Creek Pump Station SSO Latitude: 43.125275 Longitude: -75.263828
MOHK -05 Mohawk River	Utica 350 meters below Utica CSO, Nail Creek Outlet Latitude: 43.11109 Longitude: -75.23672
MOHK -05A Mohawk River	Utica 350 meters below CSOs at Railroad Interceptor (076), Grace Creek Interceptor (077), and Oneida Co. WPCP (001) Latitude: 43.101992 Longitude: -75.19032

no photo available

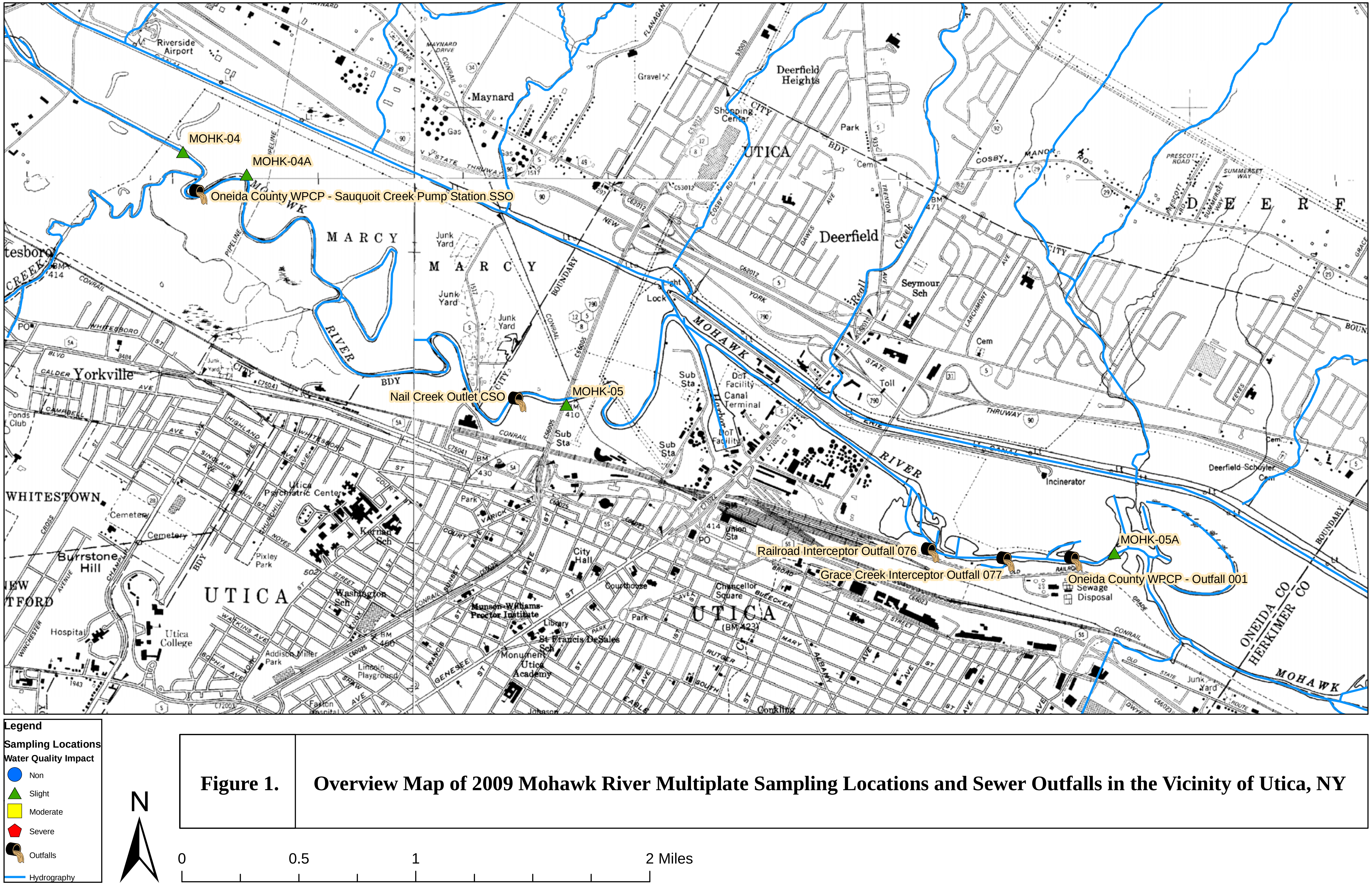


Figure 1.	**Overview Map of 2009 Mohawk River Multiplate Sampling Locations and Sewer Outfalls in the Vicinity of Utica, NY**

Table 2. Mean Metric Scores for Each Station based on the three samples collected at each location. For each station downstream of station 04 (04A, 05, and 05A) the difference in metric values (parentheses) and P-values from the Student's T-test are given. For multiplate samples, violation of one or more criteria for the following parameters indicates provisional impairment Biotic index (HBI): +1.5, EPT: -4, Species richness (Spp.): -8, and Species dominance (Spp. Dom): +15. Impaired sites (gray) violate at least one of these thresholds and result in a Student's T-test of $P \leq 0.05$ (as in Bode et al., 1990).

Station	Average Metric Scores			
	Spp.	HBI	EPT	Spp. Dom
04	27	5.70	10	39
04A	28 (+1)	6.05 (+.35)	8 (-2)	32 (-7)
P	0.119	0.051	0.548	0.566
05	27 (0)	6.51 (+.81)	6 (-4)	26 (-13)
P	1.0	0.077	0.109	0.284
05A	32 (+5)	6.99 (+1.29)	4 (-6)	23 (-16)
P	0.119	0.006	0.049	0.172

Figure 2. Biological Assessment Profile (BAP) of Index Values, Mohawk River, 2009. Values are plotted on a normalized scale of water quality. Water quality scores for each station are the mean of the values from the three replicates at each site, representing species richness, EPT richness, Hilsenhoff Biotic Index and diversity. See Appendix IV for a more complete explanation.

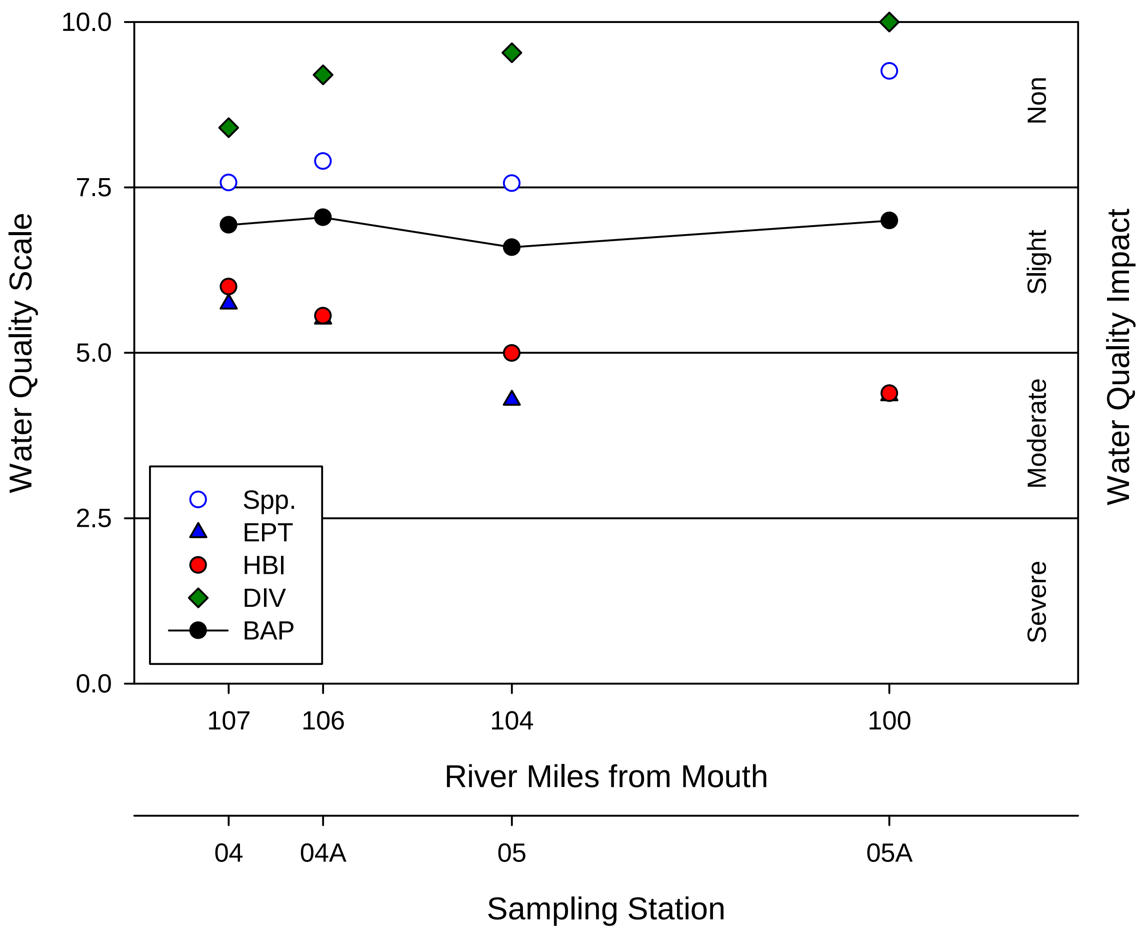


Table 3. Overview of Field Data collected from the Mohawk River, 2009. Values represent means from the three replicates collected at each site.

Station	Temperature °C	Specific Conductance (µmhos/cm)	pH	Dissolved Oxygen (mg/L)	Percent Oxygen Saturation (%)	Secchi Depth (meters)
04	20	402	7.7	7.4	82	1.4
04A	20	452	7.8	7.6	84	1.3
05	21	462	7.8	8.6	96	1.1
05A	20	484	7.6	7.4	82	0.8

Figure 3. Relationship Between Mean Specific Conductance, Secchi depth, and Number of Individuals in the Mohawk River, Oneida County, 2009.

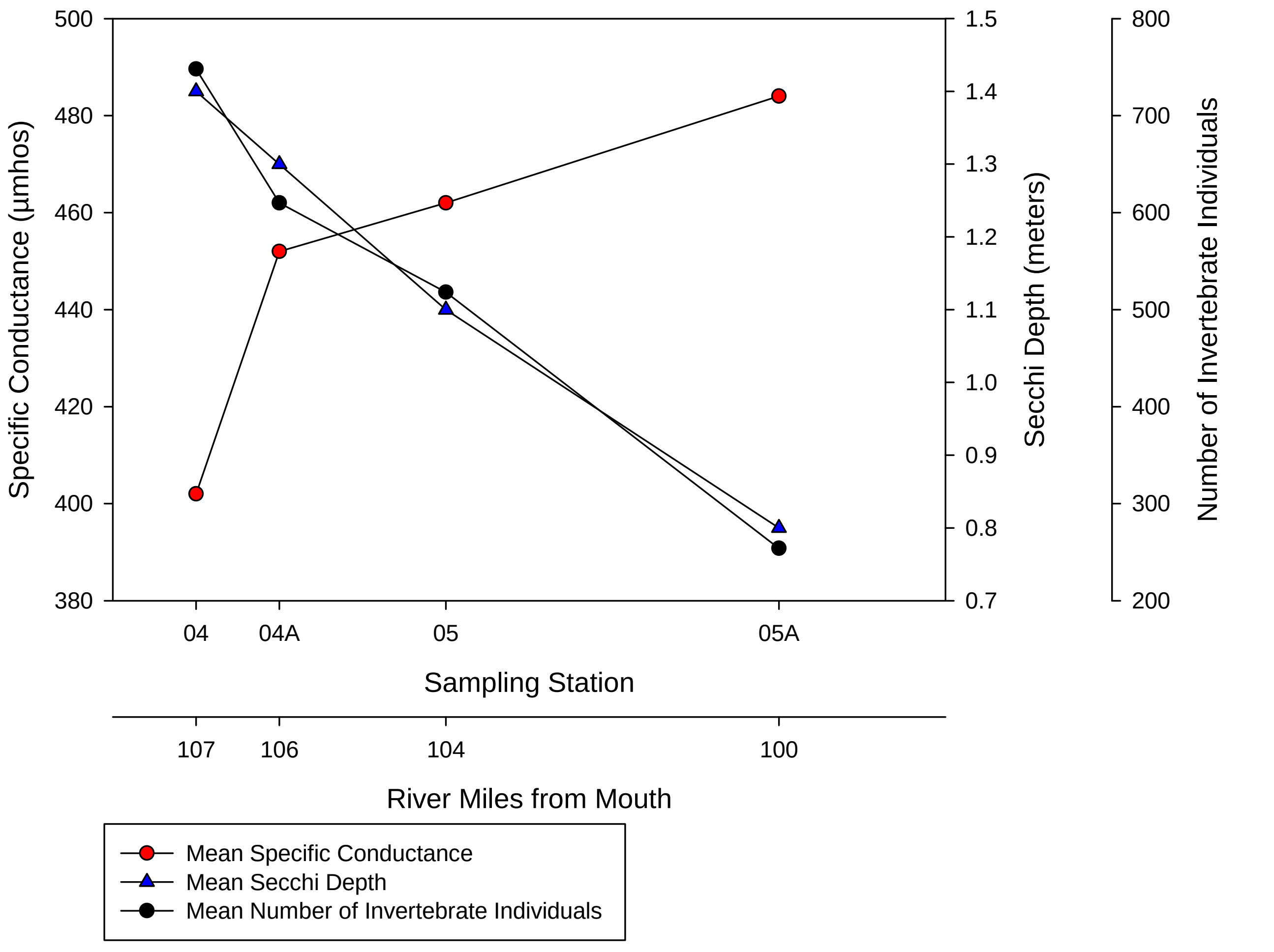


Table 4. Macroinvertebrate Species Collected in the Mohawk River, Oneida County, 2009.

PLATYHELMINTHES
TURBELLARIA
TRICLADIDA

Undetermined Turbellaria

ANNELIDA
OLIGOCHAETA
TUBIFICIDA
Tubificidae
Undet. Tubificidae w/o cap. setae
Naididae
Nais communis
Stylaria lacustris
Undetermined Naididae

MOLLUSCA
GASTROPODA
BASOMMATOPHORA
Physidae
Physella sp.
Lymnaeidae
Undetermined Lymnaeidae
Planorbidae
Undetermined Planorbidae
Ancylidae
Ferrissia sp.

ARTHROPODA
CRUSTACEA
AMPHIPODA
Gammaridae
Gammarus tigrinus
Gammarus sp.

INSECTA
EPHEMEROPTERA
Baetidae
Baetis flavistriga
Baetis intercalaris
Baetis tricaudatus
Plauditus sp.
Baetidae
Procloeon sp.
Baetidae
Undetermined Baetidae
Heptageniidae
Stenacron carolina
Stenacron interpunctatum
Stenonema femoratum
Stenonema terminatum
Stenonema sp.
Undetermined Heptageniidae
Ephemerellidae
Serratella sp.
Undetermined Ephemerellidae
Leptohyphidae
Tricorythodes sp.

ODONATA
Coenagrionidae
Undetermined Coenagrionidae

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

TRICHOPTERA
Philopotamidae
Chimarra obscura
Psychomyiidae
Psychomyia sp.
Polycentropodidae
Cyrnellus sp.
Neureclipsis sp.
Dipseudopsidae
Phylocentropus sp.
Hydropsychidae
Cheumatopsyche sp.
Hydropsyche betteni
Hydropsyche bidens
Hydropsyche bronta
Hydropsyche morosa
Hydropsyche scalaris
Hydropsyche slossonae
Hydropsyche sp.

DIPTERA
Tipulidae
Antocha sp.
Ceratopogonidae
Undetermined Ceratopogonidae
Simuliidae
Simulium vittatum
Simulium sp.
Empididae
Hemerodromia sp.
Chironomidae
Ablabesmyia mallochi
Ablabesmyia sp.
Procladius sp.
Thienemannimyia gr. spp.
Brillia sp.
Corynoneura sp.
Cricotopus bicinctus
Cricotopus sp.
Nanocladius distinctus
Nanocladius sp.
Orthocladius annectens
Parakiefferiella sp.
Parametriocnemus sp.
Rheocricotopus robacki
Thienemanniella sp.
Chironomus sp.
Cryptochironomus sp.
Dicrotendipes lucifer
Dicrotendipes modestus
Dicrotendipes neomodestus
Glyptotendipes sp.
Harnischia curtilamellata
Microtendipes pedellus gr.
Nilothauma sp.
Parachironomus sp.
Paralauterborniella sp.
Phaenopsectra flavipes
Phaenopsectra sp.
Polypedilum fallax gr.
Polypedilum flavum
Polypedilum halterale gr.
Polypedilum illinoense
Polypedilum scalaenum gr.
Stenochironomus sp.
Stictochironomus sp.

Tribelos/Endochironomus/Phaenopsectra Co
Xenochironomus xenolabis
Cladotanytarsus sp.
Micropsectra polita
Micropsectra sp.
Paratanytarsus sp.
Rheotanytarsus exiguus gr.
Stempellinella sp.
Sublettea coffmani
Sublettea sp.
Tanytarsus glabrescens gr.
Tanytarsus guerlus gr.
Tanytarsus sp.

Table 5. Laboratory Data Summary, Mohawk River, Oneida County, NY, 2009.

STATION	*MOHK-04*	*MOHK-04*	*MOHK-04*
Date	7/23/2009	8/28/2009	10/01/2009
Five Most Dominant Species and Percent Contribution to the Sample	*Tanytarsus glabrescens* gr. (57%) *Thienemannimyia* gr. spp. (10%) *Neureclipsis* sp. (4%) *Sublettea* sp. (4%) *Cheumatopsyche* sp. (3%)	*Tanytarsus glabrescens* gr. (26%) *Cheumatopsyche* sp. (18%) *Rheotanytarsus exiguus* gr. (14%) *Hydropsyche scalaris* (5%) *Dicrotendipes neomodestus* (5%)	*Cheumatopsyche* sp. (33%) *Neureclipsis* sp. (15%) *Thienemannimyia* gr. spp. (13%) *Stenonema terminatum* (5%) *Chimarra obscura* (4%)
Percent Contribution of Major Taxonomic Groups			
Chironomidae	87	58	30
Trichoptera	7	29	57
Ephemeroptera	2	10	6
Plecoptera	0	0	0
Coleoptera	2	2	3
Oligochaeta	0	0	0
Mollusca	0	.3	0
Crustacea	1	.4	2
Other Insects	1	.3	2
Other Inverts.	0	0	0
Water Quality Assessment Metric Scores			
Species Richness	26	31	23
Biotic Index	5.88	5.61	5.62
EPT Richness	8	14	8
Diversity	2.67	3.57	3.37
BAP Score	5.71	8.63	6.45
Total Individuals	814	1106	325
OverallAssessment	Slightly impacted	Non-impacted	Slightly impacted

Table 5a. Laboratory Data Summary, Mohawk River, Oneida County, NY, 2009.

STATION	*MOHK-04A*	*MOHK-04A*	*MOHK-04A*
Date	7/23/2009	8/28/2009	10/01/2009
Five Most Dominant Species and Percent Contribution to the Sample	*Tanytarsus glabrescens gr.* (41%)	*Tanytarsus glabrescens gr.* (33%)	*Neureclipsis sp.* (22%)
	Cheumatopsyche sp. (16%)	*Rheotanytarsus exiguus gr.* (11%)	*Thienemannimyia gr. spp.* (20%)
	Thienemannimyia gr. spp. (11%)	*Cheumatopsyche sp.* (10%)	*Cheumatopsyche sp.* (15%)
	Polypedilum flavum (6%)	*Dicrotendipes neomodestus* (7%)	*Dicrotendipes neomodestus* (10%)
	Neureclipsis sp. (5%)	*Polypedilum flavum* (6%)	*Stenacron interpunctatum* (3%)
Percent Contribution of Major Taxonomic Groups			
Chironomidae	73	75	48
Trichoptera	22	15	41
Ephemeroptera	1	5	7
Plecoptera	0	0	0
Coleoptera	1	2	0
Oligochaeta	0	0	0
Mollusca	0	1	0
Crustacea	3	1	3
Other Insects	0	1	0
Other Inverts.	0	0	1
Water Quality Assessment Metric Scores			
Species Richness	22	31	30
Biotic Index	5.88	6.09	6.19
EPT Richness	4	8	12
Diversity	3.02	3.67	3.65
BAP Score	5.93	7.07	8.13
Total Individuals	622	682	528
OverallAssessment	Slightly impacted	Slightly impacted	Non-impacted

Table 5b. Laboratory Data Summary, Mohawk River, Oneida County, NY, 2009.

STATION	*MOHK-05*	*MOHK-05*	*MOHK-05*
Date	7/23/2009	8/28/2009	10/01/2009
Five Most Dominant Species and Percent Contribution to the Sample	*Tanytarsus glabrescens* gr. (33%) *Cheumatopsyche sp.* (17%) *Thienemannimyia gr. spp.* (13%) *Rheotanytarsus exiguus gr.* (9%) *Paralauterborniella sp.* (4%)	*Tanytarsus glabrescens* gr. (26%) *Dicrotendipes neomodestus* (13%) *Polypedilum illinoense* (10%) *Cheumatopsyche sp.* (9%) *Polypedilum flavum* (6%)	*Dicrotendipes neomodestus* (18%) *Chironomus sp.* (15%) *Cheumatopsyche sp.* (15%) *Neureclipsis sp.* (2%) *Thienemannimyia gr. spp.* (7%)
Percent Contribution of Major Taxonomic Groups			
Chironomidae	76	79	59
Trichoptera	20	14	28
Ephemeroptera	1	2	4
Plecoptera	0	0	0
Coleoptera	1	3	1
Oligochaeta	0	0	0
Mollusca	0	1	1
Crustacea	2	0	6
Other Insects	0	1	1
Other Inverts.	0	0	0
Water Quality Assessment Metric Scores			
Species Richness	22	33	25
Biotic Index	5.97	6.45	7.1
EPT Richness	5	7	5
Diversity	3.22	3.93	3.7
BAP Score	6.29	6.98	6.51
Total Individuals	630	734	189
OverallAssessment	Slightly impacted	Slightly impacted	Slightly impacted

Table 5c. Laboratory Data Summary, Mohawk River, Oneida County, NY, 2009.

STATION	*MOHK-05A*	*MOHK-05A*	*MOHK-05A*
Date	7/23/2009	8/28/2009	10/01/2009
Five Most Dominant Species and Percent Contribution to the Sample	*Gammarus tigrinus* (25%) *Cryptochironomus sp.* (12%) *Thienemannimyia gr. spp.* (7%) *Polypedilum illinoense* (6%) *Polypedilum scalaenum gr.* (6%)	*Cheumatopsyche sp.* (20%) *Chironomus sp.* (11%) *Rheotanytarsus exiguus gr.* (9%) *Polypedilum illinoense* (7%) *Tribelos/Endochironomus/Phaenopsectra Co* (7%)	*Dicrotendipes neomodestus* (23%) *Dicrotendipes lucifer* (13%) *Chironomus sp.* (13%) *Stylaria lacustris* (8%) *Thienemannimyia gr. spp.* (8%)
Percent Contribution of Major Taxonomic Groups			
Chironomidae	68	66	75
Trichoptera	3	22	8
Ephemeroptera	1	1	1
Plecoptera	0	0	0
Coleoptera	1	2	0
Oligochaeta	0	1	11
Mollusca	2	1	1
Crustacea	25	6	2
Other Insects	0	1	1
Other Inverts.	0	0	1
Water Quality Assessment Metric Scores			
Species Richness	29	34	34
Biotic Index	6.69	6.86	7.43
EPT Richness	8	4	5
Diversity	3.97	4.2	3.9
BAP Score	6.81	7.11	7.07
Total Individuals	182	269	310
OverallAssessment	Slightly impacted	Slightly impacted	Slightly impacted

Appendix I. Biological Methods for Multiplate Sampling

Multiplates are a type of artificial-substrate sampling device developed by Hester and Dendy (1962). They are used in flowing waters too deep for kick sampling. Artificial substrates collect a macroinvertebrate sample by providing a substrate for macroinvertebrate colonization for a fixed exposure period, after which the sampler is retrieved and the attached organisms are harvested. The use of artificial substrate samplers allows the comparison of results from different locations and times by providing uniformity of substrate type, depth and exposure period. The multiplate macroinvertebrate community is influenced more by water quality than by stream bottom conditions.

<u>Site selection</u>:

Sites should have comparable current speed to both upstream and downstream sites to the degree possible. The specific sampling location is preferably a pool or run, rather than a riffle. Samplers should be placed in the main current, not in peripheral near-shore areas. In navigable waters, samplers should be placed at the edge of the actual navigation channel to avoid interference with boat traffic. If navigation buoys are available near the desired sampling site, these are usually chosen for the sampler location.

<u>Sampler construction</u>:

The sampler design is 3 square hardboard plates, separated by spacers, mounted on a turnbuckle. Three square plates of tempered hardboard (smooth on both sides) are cut to the size of 6 inches (15 cm) on each side. A 1/4-inch hole is drilled through the center of each. Four square spacers of 1/8-inch tempered hardboard are cut to the size of 1 inch on each side. A 1/4-inch hole is drilled through the center of each. Three of the spacers are glued together to form a triple spacer, with the sides and holes aligned. The plates and spacers are mounted on a No. 13 aluminum turnbuckle. The top plates are separated by the single spacer, and the bottom plates are separated by the triple spacer. A washer is placed above the top plate and below the bottom plate. Both the top and bottom eyebolts of the turnbuckle are tightened securely to prevent loosening during exposure. The total exposed surface area of the sampler is 0.14 square meters (1.55 square feet).

<u>Sampler placement</u>:

Two sampling units are placed at each site during routine monitoring to increase the chances of recovering at least one sample in case of vandalism, washout, or mishandling during retrieval. The method of sampler placement is dependent on stream depth and buoy availability. If navigation buoys are used, samplers are suspended with plastic-coated cable attached to a suitable above-water portion of the buoy. A plastic identification tag listing the agency is also attached with cable at this point. Samplers are attached with brass swivel snaps to facilitate sampler retrieval and replacement. In waterways with stronger current, each sampler is stabilized with a brick weight attached to the bottom of the turnbuckle with a swivel snap. Samplers are installed 1.0 meter below the water surface. If navigation buoys are not available and stream depth is greater than 0.5 meter deep, the sampler is suspended from a float constructed of a two-liter plastic bottle filled with styrofoam chips. The float is anchored with a three-holed concrete block, 4 x 8 x 16 inches. Connections are made with 1/8-inch plastic-coated cable. Brass swivel snaps are used to connect the sampler to the cable. Samplers are installed 1 meter below the water surface; in streams 0.5-2.0 meters deep, the samplers are placed midway between the water surface and the stream bottom. In streams less than 0.5 meter deep, the sampler is attached directly to a concrete block. The type of block used is a patio block, 2 x 8 x 16 inches, with a center hole drilled for attaching the sampler turnbuckle.

Sampler retrieval:
Samplers are retrieved 5 weeks after placement. The sampler is carefully brought to the water surface and the swivel snaps are unhooked. The sampler is removed from the water and placed in a bucket of stream water. The sampler is disassembled using pliers and screwdrivers. All accumulated organisms and other material are scraped from the plates with a 3-inch wide paint scraper into the water in the bucket. The resultant slurry is poured into a U.S. no. 30 standard sieve. The residue is rinsed with river water and placed in a 4-ounce glass jar. Ninety-five percent ethyl alcohol is added to fill the jar and preserve the sample.

Sample sorting and subsampling:
For routine monitoring, only one of the two samples collected from each site on a given date is processed in the laboratory; the other sample is retained for possible later use. The sample with the most accumulated material is selected for processing. The selected sample is then rinsed with tap water in a U.S. no. 40 standard sieve. It is then subsampled by placing the it in a tray, evenly distributing it over the bottom, and placing a divider in the tray to divide it into quarters. One by one the quarters are examined under a dissecting stereo-microscope and organisms larger than 1.5 mm are removed from the debris. As they are removed, they are sorted into major groups, placed in vials containing 70% ethyl alcohol, and counted. Once 250 individuals have been sorted, sorting stops. Samples with a large number of a particular group of organisms, may be subsampled for that group one quarter sample at a time, while the remaining organisms are sorted from the entire sample. Minimum subsample sizes are 50 for Oligochaeta, and 100 for all other groups. All identified specimens are archived.

Organism identification:
Procedures follow those for kick sampling (Smith et al. 2009), with the exception of Chironomidae and Oligochaeta. Chironomidae are subsampled for 100 individuals, and Oligochaeta are subsampled for 50 individuals. The numbers of individuals in the subsample are multiplied by the inverse of the proportion of the sample to determine the total number of individuals in the sample.

Appendix II. Macroinvertebrate Community Parameters for Multiplates from Non-Navigable Waters

1. Species Richness: The total number of species or taxa found in the sample. Higher species richness values are mostly associated with clean-water conditions.

2. EPT Richness: The total number of species of mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) found in a subsample. These are considered to be mostly clean-water organisms, and their presence generally is correlated with good water quality

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' tolerances, intolerant = 0-4, facultative = 5-7, and tolerant = 8-10. Tolerance values are listed in Hilsenhoff (1987).

4. Species Diversity: A value that combines species richness and community balance (evenness). Shannon-Wiener diversity values are calculated using the formula in Weber (1973). High species diversity values usually indicate diverse, well-balanced communities, while low values indicate stress or impact.

5. Dominance: A measure of community balance, or evenness of the distribution of individuals among the species. Simple dominance is the percent contribution of the most numerous species. Dominance-3 is the combined percent contribution of the three most numerous species. High dominance values indicate unbalanced communities strongly dominated by one or more very numerous species.

Appendix III. Levels of Water Quality Impact in Streams

The description of overall 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 or species diversity (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 organisms taken from macroinvertebrate 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 biota.

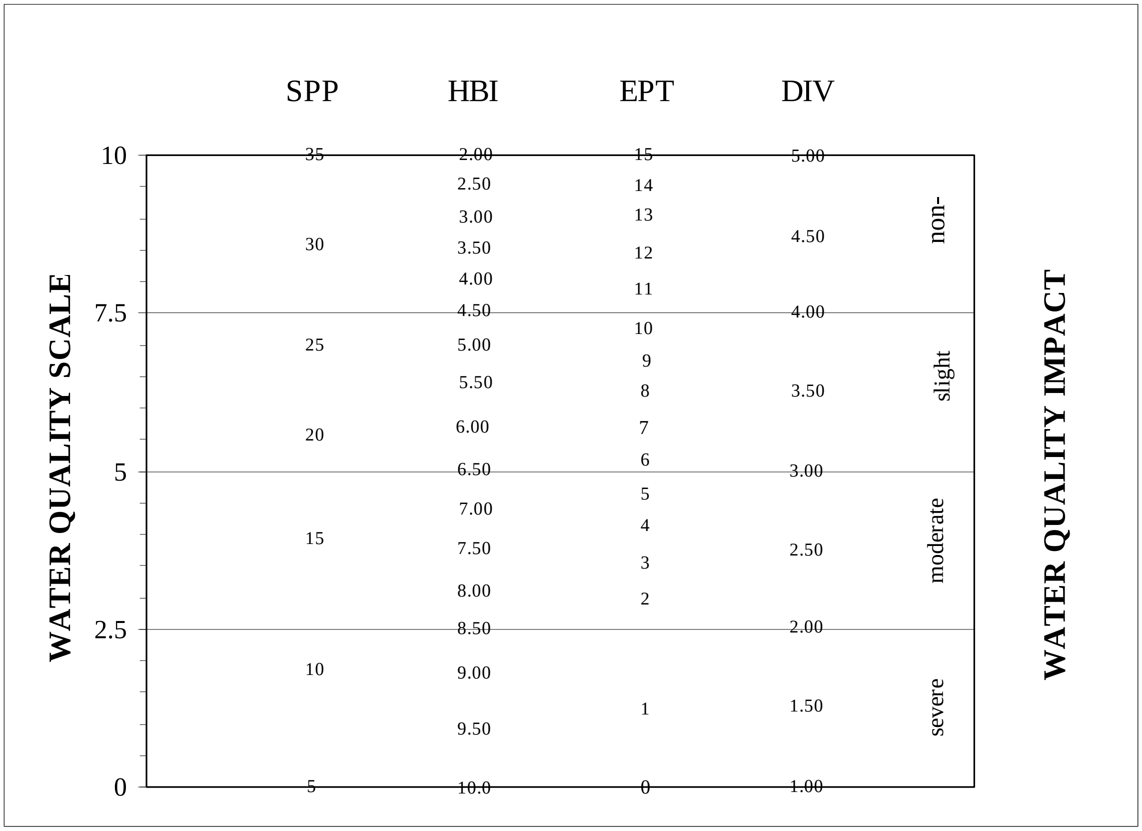
2. *Slightly impacted*: Indices reflect good water quality. The macroinvertebrate community is slightly but significantly altered from the pristine state. Species richness is usually 19-26. Mayflies and stoneflies may be restricted, with EPT richness values of 6-10. The biotic index value is 4.51-6.50. 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; 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 for Multiplate Samples from Non-Navigable Waters: Conversion of Index Values to a 0-10-Scale

For multiplate samples from non-navigable waters, the indices used in calculating the BAP are: SPP (species richness), HBI (Hilsenhoff Biotic Index), EPT (EPT richness), and DIV (species diversity). Values from the four indices are converted to a common 0-10 scale as shown below. The mean scale value of the four indices represents the assessed impact for each site. Ten scale conversion formulae for these individual metrics follow.



Biological Assessment Profile (BAP) of index values for multiple-plate samples from non-navigable waters. Values from four indices; species richness (SPP), Hilsenhoff's Biotic Index (HBI), EPT richness (EPT), and species diversity (DIV) are converted to a common 0-10 scale as shown in this figure. The mean value of the four indices represents the assessed impact for each site.

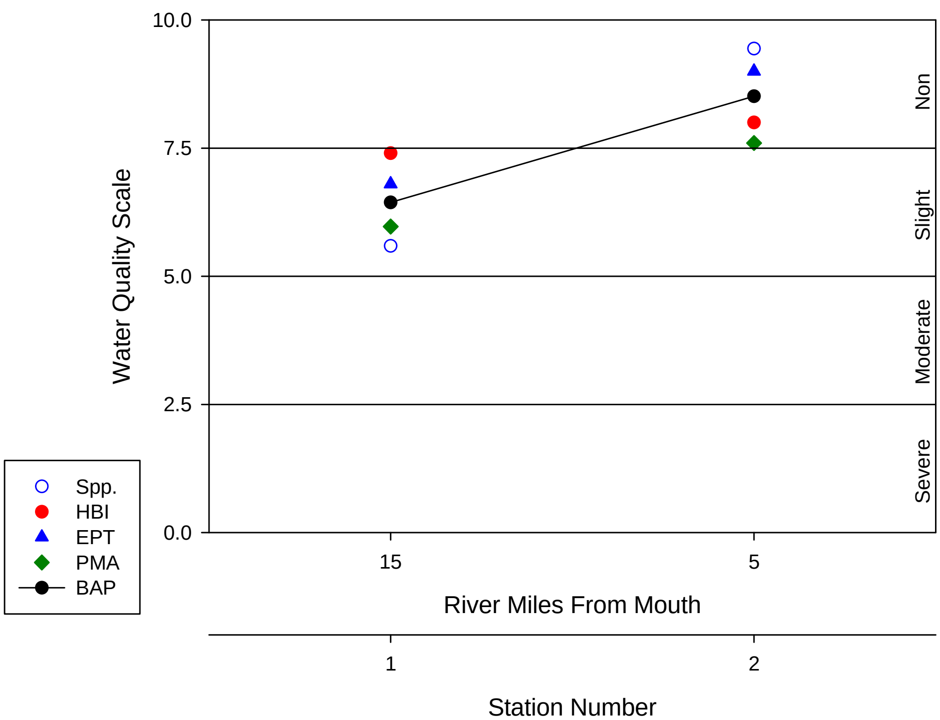
Appendix IV-B. Biological Assessment Profile: Plotting Values

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
Diversity	3.5	5.97	4.5	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-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 VI-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.

SOWBUGS

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

Appendix VII. 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 the actual 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 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 VIII. 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 IX. Biological Impairment Criteria Sampling

Background/Rationale:
Biological impairment criteria allow determination of significant water quality impairment based on upstream/downstream changes in one of five biological indices. The criteria are used for enforcement or compliance monitoring, as distinguished from trend monitoring. *Biological Impairment Criteria* Bode et al., 1990, should be consulted for a detailed description.

Sampling:
The most appropriate sampling method is determined by measuring habitat parameters at available upstream and downstream sites. Kick sampling is used for wadeable riffles with rock/gravel/sand substrates; multiplate sampling is used for all other habitats. Upstream and downstream sites are selected that meet the habitat criteria for site comparability. Sampling is conducted at the upstream and downstream site. For kick sampling, four replicates are collected at each site. For multiplate sampling, three five-week exposure replicates are collected at each site.

Sample Sorting and Identification:
Kick samples are sorted for 100 individuals as described in Smith et al., 2009. Multiplate samples are sorted as described in Appendix I. Identification procedures for both follow those described in Appendix I. For kick samples, percentage similarity is used (as in Bode et al., 1990) to calculate similarity between three of the replicates at each site. If similarity is less than 50 for any replicate pairing, 100 organisms are re-subsampled from the replicate with the lowest average similarity. If similarity is still less than 50 for the replicate pairing, a fourth replicate is subsampled from the site. If 50% similarity cannot be achieved with these replicates or subsamples, re-sampling is necessary.

Data Reduction:
The parameters are calculated for each sample are listed in Determination of Impairment below. Parameters A-E are used for kick samples and parameters A-D are used for multiplate samples. The average index value for the three samples from each site is calculated for each index: Hilsenhoff Biotic Index, EPT Richness, Species Richness, Species Dominance, and Percent Model Affinity.

Determination of Impairment:
Values from the downstream site are compared to those from the upstream site. For kick samples, violation of one or more of the criteria for parameters A-E indicates provisional impairment. For multiplate samples, violation of one or more criteria for parameters A-D indicates provisional impairment A) Biotic Index: +1.5 (0-10 scale), B) EPT Value: -4, C) Species Richness: -8, D) Species Dominance: +15, E) Percent Model Affinity: -20. For sites with provisional impairment, perform the Student's T-test (as in Bode et al., 1990) to determine if results are statistically significant at the level P=.05. If results are significant, biological impairment is indicated.