New York State
DEPARTMENT OF ENVIRONMENTAL CONSERVATION

Division of Water

Spring Run

Biological Assessment

2008 Survey

New York State
Department of Environmental Conservation

BIOLOGICAL STREAM ASSESSMENT

Spring Run
Saratoga County, New York
Upper Hudson River Basin

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Alexander J. Smith
Lawrence E. Abele
Diana L. Heitzman
Brian Duffy

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: Spring Run

River Basin: Upper Hudson

Reach: Saratoga Springs, NY

Background

The Stream Biomonitoring Unit (SBU) sampled Spring Run, Saratoga County, New York, on August 12, 2008. Sampling was conducted to assess recovery in benthic macroinvertebrate communities and improvements in water quality following fulfillment in 2007 of a consent order filed against the City of Saratoga Springs in 2002.

To characterize water quality based on benthic macroinvertebrate communities, a traveling kick sample was collected at each of five sites previously sampled in 2001. Methods used are described in the Standard Operating Procedure: Biological Monitoring of Surface Waters in New York State (Bode et al. 2002b) and summarized in Appendix I. The contents of each sample were field-inspected to determine major groups of organisms present, and then preserved in alcohol for laboratory inspection of 100-specimen subsamples from each site.

Macroinvertebrate community parameters used in the determination of water quality included: species richness, biotic index, EPT richness, and non-Chironomidae and Oligochaeta richness (see Appendices II and III). Amount of expected variability of results is stated in (Smith and Bode 2004). Table 1 provides a listing of sampling sites, and Tables 4a – 4e provide a listing of all species collected at each sampling location in the present survey. This is followed by field and laboratory summary data reports, including raw data from each site.

Results and Conclusions

1. Water quality improved at the two most upstream sampling locations. Biological assessment results changed from severely impacted at both stations 00 and 01 in 2002 to moderately impacted and slightly impacted respectively in 2008.

2. Results at downstream stations (02 – 04) did not show measurable improvement in water quality conditions.

3. Water quality at all sampling locations remains influenced by urban and storm-sewer runoff, although these effects appear to be lessening in the upper reaches. Continued efforts are needed to improve conditions in all reaches of the stream.

Discussion

Spring Run is a small (32 km^2 drainage area), low-gradient stream in the Kayaderosseras Creek watershed. It originates and flows southwest out of Saratoga Springs, Saratoga County, NY, before entering Lake Lonely. The entire stream is currently listed as impaired on the New York State Waterbody Inventory and Priority Waterbodies List (WI/PWL). Municipal sewage and storm-sewer runoff are known sources of pollutants, which have impaired aquatic life and recreational uses. Spring Run is also currently listed on the New York State Draft 2010 Section 303(d) List of Impaired Waters (NYSDEC 2010).

A biological assessment of water quality was conducted at four sites (stations 01, 02, 03, and 04) on Spring Run in August 2001 to document the impact of suspected sewage and storm-sewer runoff in the area of Saratoga Springs (Table 1, Figures 1 and 1b – 1e) (Bode et al. 2002a). Results indicated slight to moderate impact (Figure 2). Subsequent monitoring was conducted in March, 2002 at one additional upstream location and again at station 01 (Bode et al. 2002a) (Table 1, Figures 1, 1a). Water quality worsened and was assessed as severely impacted at both stations (Figure 2).

The City of Saratoga Springs has been under consent order since 2002 to survey and repair their entire sewage collection and storm sewer system which eventually discharges to Spring Run. Presently the items of the consent order have been satisfied and routine monitoring is being conducted (V. Spadaro, NYSDEC Region 5, personal communication, December 11, 2007).

The SBU conducted follow-up monitoring at all five historical sampling locations on August 12, 2008 to evaluate recovery of the stream since remediation began in 2002 after issuance of the consent order. Results of the survey suggest slight to moderate water quality impact (Figure 2). Historical sampling at the most upstream stations (00 and 01) indicates these were the most impacted of all sites previously surveyed (Figure 2). Water quality has improved considerably since 2002 at both locations. Station 00 improved from severely impacted to moderately impacted while Station 01 improved even more, going from severely impacted to slightly impacted (Figure 2). Species richness more than doubled at Station 00 since 2002 and many new species were also found at Station 01 (Tables 4a – 4b). However, invertebrate communities at both sites are still dominated by tolerant or facultative species. Mayflies and stoneflies remain absent. The presence of mayfly taxa will be a good barometer for successful remediation at these sites. The low-gradient, sandy habitat that dominates Spring Run makes stonefly colonization unlikely.

In addition to changes in community composition, changes in water chemistry, including reductions in specific conductance levels at stations 00 and 01, have been observed. Current levels are near, but still higher than the threshold for biological community impact of 800 μmhos (Appendix XII). Continued remediation of storm water and sewage inputs to the stream will affect reductions in specific conductance even further. Once levels are maintained below this threshold, significant improvements in the macroinvertebrate community are likely.

Measurable improvement in the 2008 biological-assessment score at Station 01 compared to 2002 is due in part to the loss of the tolerant Oligochaete *Limnodrilus hoffmeisteri.* Its presence in previous sampling was an indicator of high levels of organic wastes. Cleanup of these wastes is likely the reason for the loss of *L. hoffmeisteri* in the community. This station also benefits from dilution of pollutants from the outlet of Loughberry Lake which enters Spring Run just upstream (Figures 1 and 1b). The drainage area at Station 01 more than doubles compared to the upstream station (Table 2).

Water quality at the remaining sites was assessed as moderately impacted, which is a worsening of conditions at Station 02 but similar to previous surveys at stations 03 and 04

(Figure 2). The cause of a decline in water quality conditions at Station 02 is not fully understood at this time. Further sampling should be conducted to document the source of impact.

Specific conductance at most sites remains above 800 µmhos, the threshold above which conductivity is likely to impact a biological community (see Table 2 and Appendix XII). Biological assessment scores tend to mirror shifts in specific conductance values at all sites, with higher values typically resulting in poorer scores (Figure 3). Impact Source Determination (ISD) indicated complex municipal, industrial pollutant sources at all sites downstream of Station 01 (Table 3). Invertebrate communities remained similar to samples collected in 2001 and 2002, with most sites still dominated by the same tolerant organisms (Tables 4c-4e). These results suggest continued impact from urban runoff similar to previous surveys.

References

BODE, R. W., M. A. NOVAK, L. E. ABELE, D. L. HEITZMAN and A. J. SMITH. 2002a. Biological Stream Assessment: Spring Run, Saratoga County, New York. 41 pp. New York State Department of Environmental Conservation, Stream Biomonitoring Unit, Division of Water, Albany, New York. Technical Report.

BODE, R. W., M. A. NOVAK, L. E. ABELE, D. L. HEITZMAN and A. J. SMITH. 2002b. Quality Assurance Work Plan for Biological Stream Monitoring in New York State. 115 pp. New York State Department of Environmental Conservation, Stream Biomonitoring Unit, Division of Water, Albany, New York. Technical Report.

NYSDEC. 2010. New York State Draft Section 303(d) List of Impaired Waters. 44 pp. New York State Department of Environmental Conservation, Bureau of Water Assessment and Management, Division of Water, Albany, New York. Technical Report.

SMITH, A. J. and R. W. BODE. 2004. Analysis of variability in New York State Benthic Macroinvertebrate Samples. 43 pp. New York State Department of Environmental Conservation, Stream Biomonitoring Unit, Division of Water, Albany, New York. Technical Report.

Table 1. Station Locations for Spring Run, Saratoga County, NY, 2008. Site photographs are in order of their listing in the table.

Station	Location		
SRUN-00	Saratoga Springs		
Spring Run	Excelsior Ave. at East Ave.		
	Latitude:	43.08916	
	Longitude:	-73.77138	
SRUN-01	Saratoga Springs		
Spring Run	5 m upstream of Excelsior Springs Dr.		
	Latitude:	43.08889	
	Longitude:	- 73.76361	
SRUN-02	Saratoga Springs		
Spring Run	10 m upstream of Weibel Ave.		
	Latitude:	43.08555	
	Longitude:	- 73.74444	
SRUN-03	Saratoga Springs		
Spring Run	5 m downstream of Gilbert Rd.		
	Latitude:	43.08083	
	Longitude:	- 73.74138	
SRUN-04	Saratoga Springs		
Spring Run	5 m downstream of Union Ave.		
	Latitude:	43.06972	
	Longitude:	- 73.74472	

Figure 1. Overview Map, Sampling Locations on Spring Run, Saratoga County.

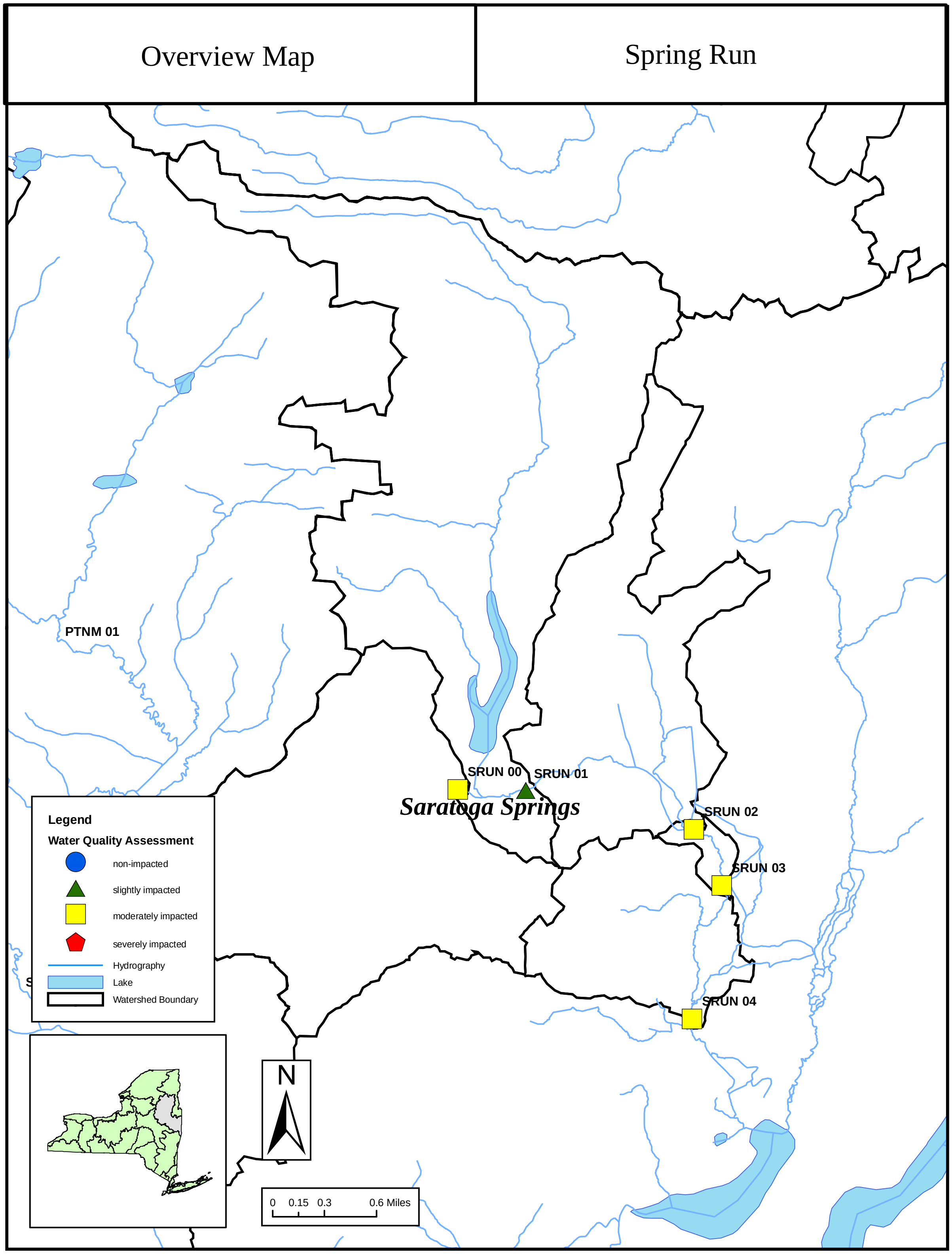


Figure 1a. Station Map, Spring Run Stations 00 and 01, Saratoga County.

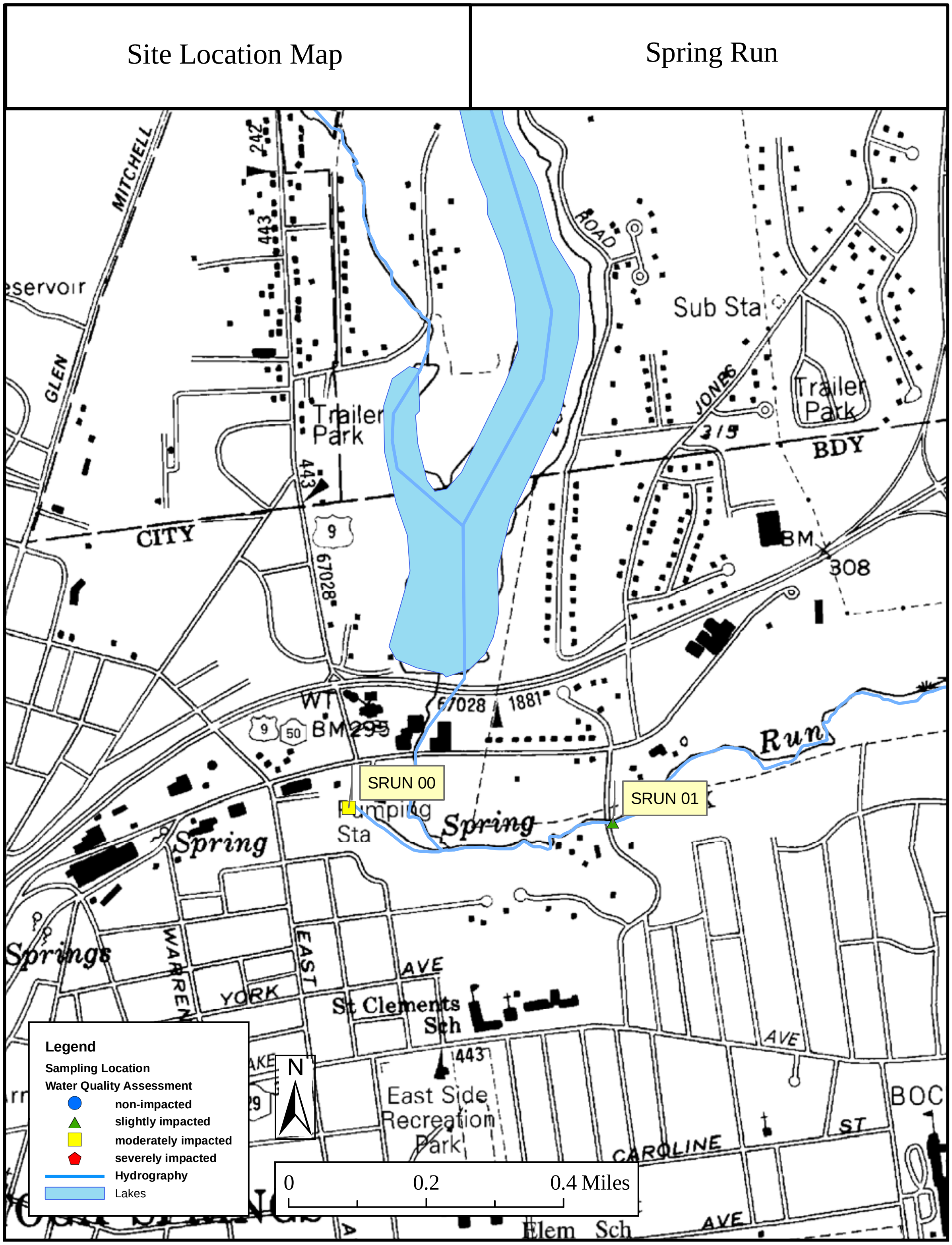


Figure 1b. Station Map, Spring Run Stations 02, 03, and 04, Saratoga County.

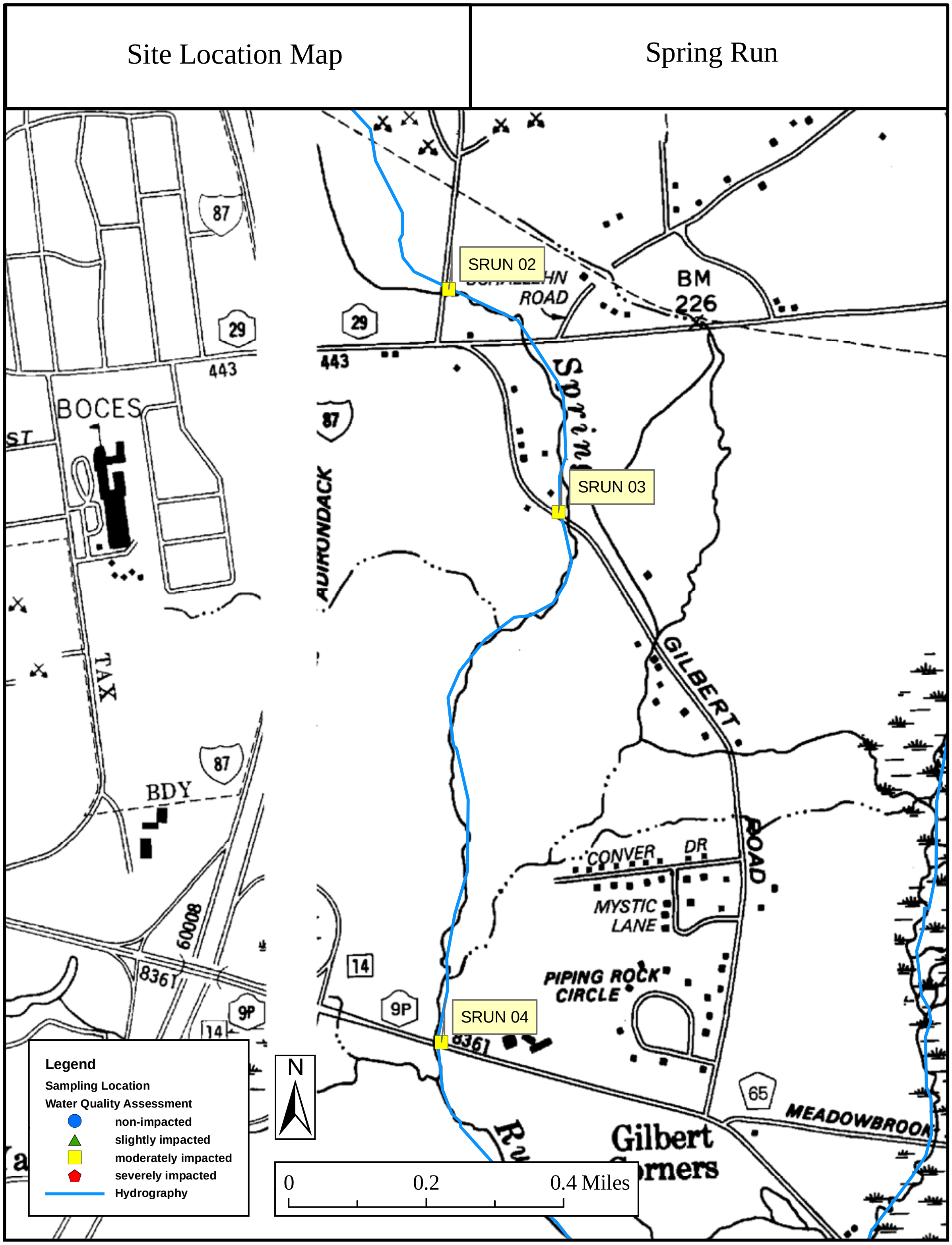


Figure 2. Biological Assessment Profile (BAP) of Index Values, Spring Run, 2008, and the most recent historical data from each location. Values are plotted on a normalized scale of water quality. The water quality scores for each sample year are the mean of four values at each site, representing species richness, EPT richness, Hilsenhoff Biotic Index and Non- Chironomidae and Oligochaeta richness. See Appendix IV for a more complete explanation.

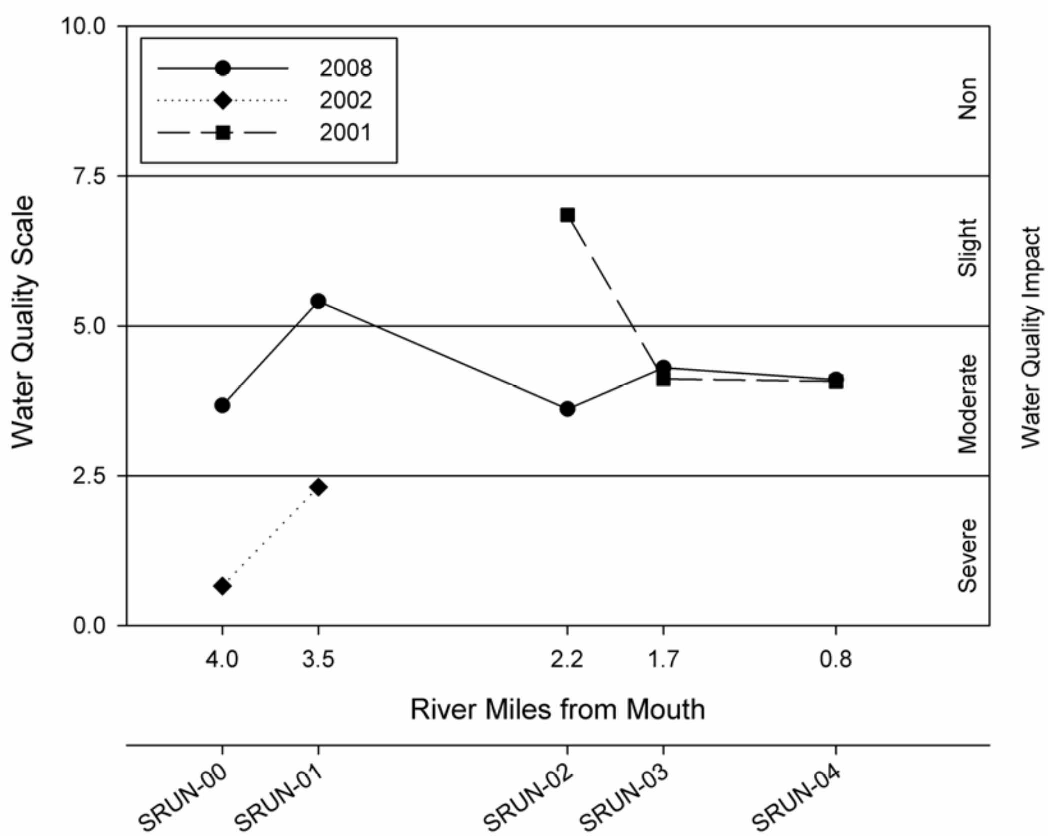


Table 2. Overview of Field Data. Cells marked by (-) signify a parameter that was not recorded in the field.

Location	Depth (meters)	Width (meters)	Current (cm/sec)	Canopy (%)	Embedd (%)	Temp (˚C)	Cond. (µmhos)	pH (units)	DO (mg/l)	Drainage Area (km^2)
SRUN-00	0.2	3.5	45	75	Sand*	16	1114	7.5	14	7.4
SRUN-01	0.3	3.5	70	50	Sand*	18	893	7.9	13	19.8
SRUN-02	0.9	4.0	25	75	Sand*	18	903	8.3	13	24.6
SRUN-03	0.4	2.5	83	50	Sand*	18	852	8.4	12	24.8
SRUN-04	0.8	6.0	-	25	Sand*	18	751	8.5	12	26.8

*Indicates embeddedness was not measured due to sand substrate and absence of rocks.

Figure 3. Biological Assessment Profile (BAP) Score and Specific Conductance, Spring Run, 2008. BAP scores tend to reflect spatial trends in specific conductance; that is, as conductance increases BAP scores tend to worsen.

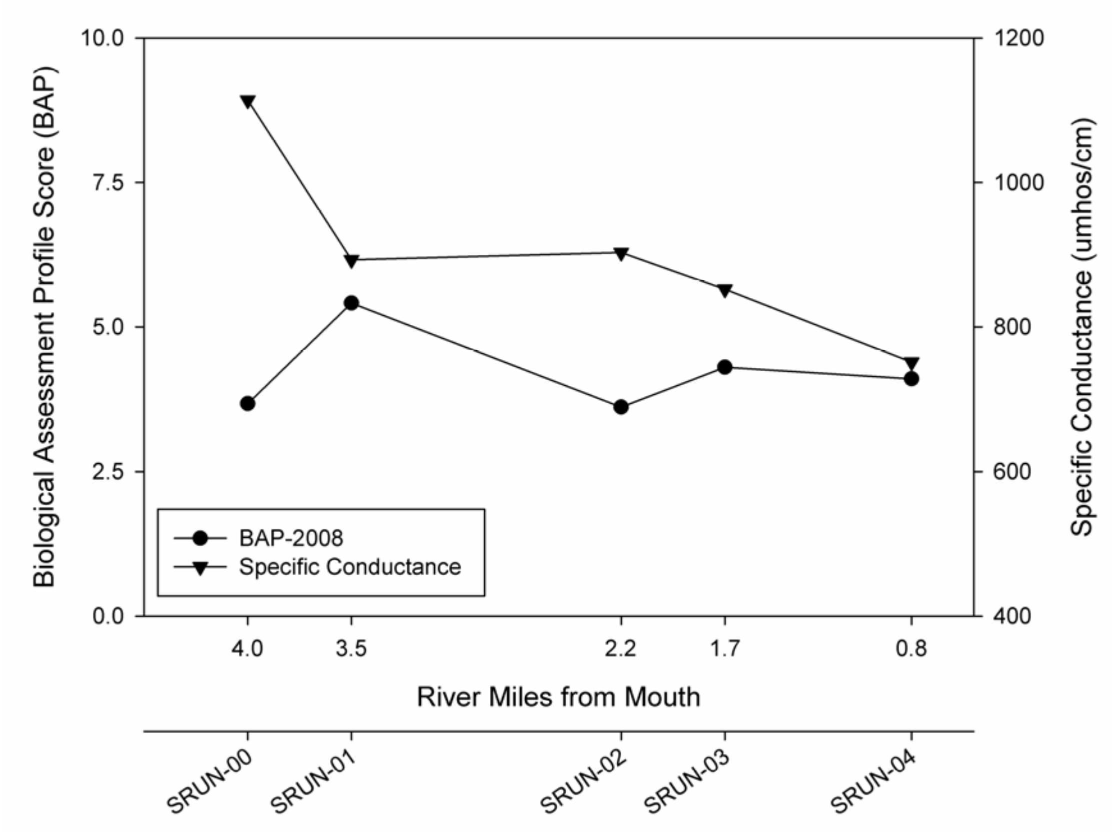


Table 3. Impact Source Determination (ISD), Spring Run, 2008. Numbers represent percent similarity to community type models for each impact category. Highest similarities at each station are shaded. Similarities less than 50% are inconclusive. Highest numbers represent probable stressor(s) to the community. See Appendix XI for further explanation.

Station		*Community Type*						
		Natural	Nutrients	Toxic	Organic	Complex	Siltation	Impoundment
SRUN	00	9	16	24	43	67	23	54*
	01	25	35	52	63	47	45	42*
	02	8	18	27	47	63	24	57*
	03	16	46	40	46	50	30	50*
	04	17	17	32	31	52	23	52*

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

*Impoundment results are considered spurious. Sand substrate and low gradient at all sites produced communities similar to those found downstream of impoundments.

Table 4a. Macroinvertebrate Data Report (MDR), Spring Run Station 00

STREAM SITE: Spring Run, Station 00
LOCATION: Saratoga, NY
DATE: 8/12/2008, 3/22/2002
SAMPLE TYPE: Kick, Sandy Streams
SUBSAMPLE: 100 organisms

			2008	2002
ANNELIDA				
OLIGOCHAETA				
LUMBRICIDA				
		Undetermined Lumbricina	12	-
TUBIFICIDA	Enchytraeidae	Undetermined Enchytraeidae	40	53
	Tubificidae	*Aulodrilus limnobius*	1	-
		Limnodrilus hoffmeisteri	9	4
		Limnodrilus udekemianus	1	-
		Undet. Tubificidae w/ cap. setae	1	-
	Naididae	*Nais elinguis*	-	3
MOLLUSCA				
GASTROPODA	Physidae	*Physella* sp.	7	-
BASOMMATOPHORA	Lymnaeidae	*Fossaria* sp.	5	-
	Planorbidae	Undetermined Planorbidae	16	-
PELECYPODA	Sphaeriidae	*Sphaerium* sp.	2	-
VENEROIDEA				
ARTHROPODA				
INSECTA	Hydropsychidae	*Hydropsyche morosa*	1	-
TRICHOPTERA				
	Tipulidae	*Tipula* sp.	-	1
DIPTERA		Undetermined Diptera	1	-
	Chironomidae	*Prodiamesa olivacea*	1	37
		Cricotopus bicinctus	1	-
		Cricotopus tremulus gr.	-	2
		Cricotopus sp.	1	-
		Orthocladius sp.	1	-
		SPECIES RICHNESS:	16	6
		BIOTIC INDEX:	8.23	9.16
		EPT RICHNESS:	1	0
		NCO RICHNESS:	6	1
		ASSESSMENT:	Moderate	Severe

Description:
The sample was collected just downstream from where Spring Run “daylights” near the intersection of Excelsior and East Avenues in Saratoga Springs. Many Oligochaetes were noted in the net along with aquatic sowbugs and aquatic dipterans. A storm water discharge was observed discharging very turbid water into the stream at this station. Water quality was assessed as moderately impacted which is an improvement from the 2002 assessment of severely impacted.

Table 4b. Macroinvertebrate Data Report (MDR), Spring Run Station 01

STREAM SITE: Spring Run, Station 01
LOCATION: Saratoga, NY
DATE: 8/12/2008, 8/15/2001, 3/22/2002
SAMPLE TYPE: Kick, Sandy Streams
SUBSAMPLE: 100 organisms

			2008	2002	2001
PLATYHELMINTHES					
TURBELLARIA					
TRICLADIDA					
		Undetermined Turbellaria	-	1	-
ANNELIDA					
OLIGOCHAETA					
TUBIFICIDA	Enchytraeidae	Undetermined Enchytraeidae	-	1	2
	Tubificidae	*Limnodrilus hoffmeisteri*	-	21	19
		Undet. Tubificidae w/ cap. setae	1	2	4
		Undet. Tubificidae w/o cap. setae	12	-	-
	Naididae	*Nais elinguis*	-	35	-
		Ophidonais serpentina	2	5	-
HIRUDINEA					
RHYNCHOBDELLIDA		Undetermined Hirudinea	-	1	4
MOLLUSCA					
GASTROPODA					
BASOMMATOPHORA	Physidae	*Physella* sp.	2	-	5
PELECYPODA					
VENEROIDEA	Sphaeriidae	*Pisidium* sp.	3	1	-
ARTHROPODA					
CRUSTACEA					
ISOPODA	Asellidae	*Caecidotea* sp.	-	-	3
AMPHIPODA	Gammaridae	*Gammarus* sp.	14	-	-
INSECTA					
EPHEMEROPTERA	Baetidae	*Callibaetis* sp.	-	-	1
COLEOPTERA	Dytiscidae	*Agabus* sp.	-	-	2
		Undetermined Dytiscidae	-	-	1
	Elmidae	*Optioservus fastiditus*	-	-	1
TRICHOPTERA	Hydropsychidae	*Diplectrona* sp.	1	-	-
		Hydropsyche betteni	12	-	-
		Hydropsyche sp.	3	-	1
DIPTERA	Simuliidae	*Simulium vittatum*	28	-	2
	Muscidae	*Undetermined Muscidae*	-	-	2

			2008	2002	2001
DIPTERA					
	Chironomidae	*Thienemannimyia* gr. spp.	-	4	37
		Diamesa sp.	2	-	-
		Odontomesa sp.	-	-	1
		Prodiamesa olivacea	7	1	6
		Brillia sp.	-	-	1
		Cricotopus bicinctus	5	21	2
		Cricotopus tremulus gr.	-	7	-
		Cricotopus vierriensis	-	-	1
		Cricotopus sp.	1	-	-
		Orthocladius annectens	1	-	-
		Orthocladius sp.	3	-	-
		Tvetenia bavarica gr.	1	-	-
		Chironomus sp.	-	-	1
		Cryptochironomus sp.	1	-	-
		Polypedilum scalaenum gr.	1	-	-
		Micropsectra polita	-	-	4
		SPECIES RICHNESS:	19	12	21
		BIOTIC INDEX:	7.07	8.68	7.41
		EPT RICHNESS:	3	0	2
		NCO RICHNESS:	7	3	10
		ASSESSMENT:	Slight	Severe	Slight

Description:
The sample was collected 5 meters upstream of Excelsior Springs Drive in Saratoga Springs. An oily sheen was observed when sediments were disturbed during collection of the sample. Flow was greater at this site compared to the upstream sampling location. This is likely because the outlet of Loughberry Lake enters Spring Run just upstream of this location. The improvement in the results at this site compared to 2002 is due in part to the loss of the tolerant Oligochaete *Limnodrilus hoffmeisteri*. Its presence in previous sampling was an indicator of organic wastes. Its absence suggests wastes have diminished at this site. The sample was assessed as slightly impacted.

Table 4c. Macroinvertebrate Data Report (MDR), Spring Run Station 02

STREAM SITE: Spring Run, Station 02
LOCATION: Saratoga, NY
DATE: 8/12/2008, 8/15/2001
SAMPLE TYPE: Kick, Sandy Streams
SUBSAMPLE: 100 organisms

			2008	2001
ANNELIDA				
OLIGOCHAETA				
TUBIFICIDA				
	Enchytraeidae	Undetermined Enchytraeidae	-	5
	Tubificidae	*Limnodrilus hoffmeisteri*	40	11
		Limnodrilus udekemianus	1	-
		Undet. Tubificidae w/ cap. setae	-	1
HIRUDINEA				
RHYNCHOBDELLIDA		Undetermined Hirudinea	-	1
MOLLUSCA				
GASTROPODA				
BASOMMATOPHORA	Physidae	*Physella* sp.	3	1
	Lymnaeidae	Undetermined Lymnaeidae	1	-
PELECYPODA				
VENEROIDEA	Sphaeriidae	*Sphaerium* sp.	1	-
ARTHROPODA				
CRUSTACEA				
ISOPODA	Asellidae	*Caecidotea racovitzai*	-	6
AMPHIPODA	Gammaridae	*Gammarus* sp.	40	40
INSECTA				
EPHEMEROPTERA	Baetidae	*Callibaetis* sp.	-	1
ODONATA	Coenagrionidae	Undetermined Coenagrionidae	-	1
HEMIPTERA	Corixidae	Undetermined Corixidae	-	5
TRICHOPTERA	Hydropsychidae	*Cheumatopsyche* sp.	-	2
		Hydropsyche betteni	-	11
		Hydropsyche sp.	1	-
	Leptoceridae	Undetermined Leptoceridae	-	1
DIPTERA	Tipulidae	*Dicranota* sp.	1	2
		Tipula sp.	1	-
	Ceratopogonidae	Undetermined Ceratopogonidae	-	1
	Simuliidae	*Simulium vittatum*	-	1

			2008	2001
DIPTERA				
	Chironomidae	*Diamesa* sp.	2	-
		Pagastia orthogonia	-	1
		Prodiamesa olivacea	-	6
		Orthocladius sp.	2	-
		Thienemanniella xena	-	1
		Cladopelma sp.	-	1
		Cryptochironomus sp.	2	-
		Saetheria tylus	-	1
		Stictochironomus sp.	5	-
		SPECIES RICHNESS:	13	21
		BIOTIC INDEX:	7.82	6.92
		EPT RICHNESS:	1	4
		NCO RICHNESS:	7	13
		ASSESSMENT:	Moderate	Slight

Description:
Station 02 was sampled 10 meters upstream of Weibel Avenue. Water quality was assessed as moderately impacted. This is a worsening in condition compared to the results of sampling in 2001. Further sampling is needed at this site to fully understand the source(s) and extent of impact.

Table 4d. Macroinvertebrate Data Report (MDR), Spring Run Station 03

STREAM SITE: Spring Run, Station 03
LOCATION: Saratoga, NY
DATE: 8/12/2008, 8/15/2001
SAMPLE TYPE: Kick, Sandy Streams
SUBSAMPLE: 100 organisms

			2008	2001
ANNELIDA				
OLIGOCHAETA				
TUBIFICIDA				
	Tubificidae	*Limnodrilus hoffmeisteri*	-	5
ARTHROPODA				
CRUSTACEA				
ISOPODA	Asellidae	*Caecidotea racovitzai*	-	13
AMPHIPODA	Gammaridae	*Gammarus* sp.	40	40
INSECTA				
ODONATA	Aeshnidae	Undetermined Aeshnidae	-	1
COLEOPTERA	Elmidae	*Optioservus fastiditus*	1	-
MEGALOPTERA	Corydalidae	*Nigronia serricornis*	1	-
TRICHOPTERA	Hydropsychidae	*Cheumatopsyche* sp.	34	1
		Hydropsyche betteni	16	4
		Hydropsyche sp.	5	-
DIPTERA	Simuliidae	*Simulium vittatum*	-	4
	Chironomidae	*Thienemannimyia* gr. spp.	-	2
		Diamesa sp.	3	-
		Cryptochironomus fulvus gr.	-	1
		Polypedilum flavum	-	1
		Stictochironomus sp.	-	25
		Rheotanytarsus exiguus gr.	-	3
		SPECIES RICHNESS:	7	12
		BIOTIC INDEX:	5.65	7.29
		EPT RICHNESS:	3	2
		NCO RICHNESS:	6	6
		ASSESSMENT:	Moderate	Moderate

Description:
Station 03 was sampled 5 meters downstream of Gilbert Road. Water quality was assessed as moderately impacted which is the same as in 2001. The invertebrate community was similar to previous sampling. Although more caddisflies were noted in 2008 the tolerant freshwater scud *Gammarus* sp. remained dominant.

Table 4e. Macroinvertebrate Data Report (MDR), Spring Run Station 04

STREAM SITE:	Spring Run, Station 04
LOCATION:	Saratoga, NY
DATE:	8/12/2008, 8/15/2001
SAMPLE TYPE:	Kick, Sandy Streams
SUBSAMPLE:	100 organisms

			2008	2001
ANNELIDA				
OLIGOCHAETA				
TUBIFICIDA				
	Tubificidae	*Limnodrilus hoffmeisteri*	5	1
MOLLUSCA				
GASTROPODA				
BASOMMATOPHORA	Physidae	*Physella* sp.	21	-
ARTHROPODA				
CRUSTACEA				
ISOPODA	Asellidae	*Caecidotea racovitzai*	-	15
AMPHIPODA	Gammaridae	*Gammarus* sp.	40	40
INSECTA				
TRICHOPTERA	Hydropsychidae	*Cheumatopsyche* sp.	1	7
		Hydropsyche betteni	1	1
DIPTERA	Simuliidae	*Simulium vittatum*	7	-
	Chironomidae	*Diamesa* sp.	1	-
		Cricotopus bicinctus	9	-
		Limnophyes sp.	1	-
		Chironomus sp.	1	-
		Cryptochironomus fulvus gr.	-	3
		Microtendipes pedellus gr.	-	3
		Paratendipes albimanus	2	-
		Polypedilum flavum	-	20
		Polypedilum scalaenum gr.	-	3
		Stictochironomus sp.	10	-
		Paratanytarsus confusus	-	3
		Rheotanytarsus exiguus gr.	-	4
		Tanytarsus sp.	1	-
		SPECIES RICHNESS:	13	11
		BIOTIC INDEX:	7.13	6.34
		EPT RICHNESS:	2	2
		NCO RICHNESS:	5	4
		ASSESSMENT:	Moderate	Moderate

Description:
Station 04 was sampled 5 meters downstream of Union Avenue. Water quality was assessed as moderately impacted. Similar to Station 03 the community continued to be dominated by *Gammarus* sp..

Table 5. Laboratory Data Summary, Spring Run, Saratoga County, NY, 2008.

STATION	*SRUN-00*	*SRUN-01*	*SRUN-02*	*SRUN-03*	*SRUN-04*
Date	8/12/2008	8/12/2008	8/12/2008	8/12/2008	8/12/2008
Five Most Dominant Species and Percent Contribution to the Sample	Undet. Enchytraeidae (40%)	*Simulium vittatum* (28%)	*Gammarus* sp. (40%)	*Gammarus* sp. (40%)	*Gammarus* sp. (40%)
	Undet. Planorbidae (16%)	*Gammarus* sp. (14%)	*Limnodrilus hoffmeisteri* (40%)	*Cheumatopsyche* sp. (34%)	*Physella* sp. (21%)
	Undet. Lumbricina (12%)	*Hydropsyche betteni* (12%)	*Stictochironomus* sp. (5%)	*Hydropsyche betteni* (16%)	*Stictochironomus* sp. (10%)
	Limnodrilus hoffmeisteri (9%)	Undet. Tubificidae w/o cap. setae (12%)	*Physella* sp. (3%)	*Hydropsyche* sp. (5%)	*Cricotopus bicinctus* (9%)
	Physella sp. (7%)	*Prodiamesa olivacea* (7%)	*Diamesa* sp. (2%)	*Diamesa* sp. (3%)	*Simulium vittatum* (7%)
Percent Contribution of Major Taxonomic Groups					
Chironomidae	4	22	11	3	25
Trichoptera	1	16	1	55	2
Ephemeroptera	0	0	0	0	0
Plecoptera	0	0	0	0	0
Coleoptera	0	0	0	1	0
Oligochaeta	64	15	41	0	5
Mollusca	30	5	5	0	21
Crustacea	0	14	40	40	40
Other Insects	1	28	2	1	7
Other Inverts.	0	0	0	0	0
Water Quality Assessment Metric Scores					
Species Richness	16	19	13	7	13
Biotic Index	8.23	7.07	7.82	5.65	7.13
EPT Richness	1	3	1	3	2
NCO Richness	6	7	7	6	5
Biological Assessment Profile Score	3.67	5.41	3.61	4.3	4.1
Overall Assessment	Moderately impacted	Slightly impacted	Moderately impacted	Moderately impacted	Moderately impacted

Table 6. Field Data Summary, Spring Run, Saratoga County, NY, 2008.

Station	*SRUN-00*	*SRUN-01*	*SRUN-02*	*SRUN-03*	*SRUN-04*
Arrival Time	9:05	9:54	10:27	11:00	11:22
Physcial Characteristics					
Depth (meters)	0.2	0.3	0.9	0.4	0.75
Width (meters)	3.5	3.5	4.0	2.5	6.0
Current Speed (cm/sec)	45	70	25	83	-
Canopy (%)	75	50	75	50	25
Embeddedness (%)	-	-	-	-	-
Substrate (%)					
Rock (>25.4 cm, or bedrock)	0	2	0	0	-
Rubble (6.35 - 25.4 cm)	0	8	0	0	-
Gravel (0.2 - 6.35 cm)	45	45	50	75	-
Sand (0.06 - 2.0 mm)	50	40	50	25	-
Silt (0.004 - 0.06 mm)	5	5	0	0	-
Chemical Measurements					
Temperature (oC)	16	18	18	18	18
Specific Conductance (μmhos)	1114	893	903	852	751
Dissolved Oxygen (mg/l)	14	13	13	12	12
DO - Saturation (%)	143	135	136	130	129
pH (units)	7.5	7.9	8.3	8.4	8.5
Biological Attributes					
Aquatic vegetation					
Algae - suspended					
Algae - filamentous					
Algae - diatoms		X			
Macrophytes		X		X	X
Occurrence of Macroinvertebrates					
Ephemeroptera					
Plecoptera					
Trichoptera		X		X	
Coleoptera					
Megaloptera				X	
Odonata					
Chironomidae	X	X		X	X
Simuliidae		X			
Decapoda				X	X
Gammaridae		X	X	X	X
Mollusca			X		
Oligochaeta	X	X	X		
Others	X		X		X
Faunal Condition (field)	Very Poor	Very Poor	Very Poor	Very Poor	Very Poor

Appendix I. Biological Methods for Kick Sampling

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

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

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

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

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

Appendix II. Macroinvertebrate Community Parameters

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

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

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

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

5. Non-Chironomidae and Oligochaeta Richness: NCO denotes the total number of species of organisms other than those in the groups Chironomidae and Oligochaeta. Since Chironomidae and Oligochaeta are generally the most abundant groups in impacted communities, NCO taxa are considered to be less pollution tolerant, and their presence would be expected to be more indicative of good water quality. This measure is the Sandy Stream counterpart of EPT richness.

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.

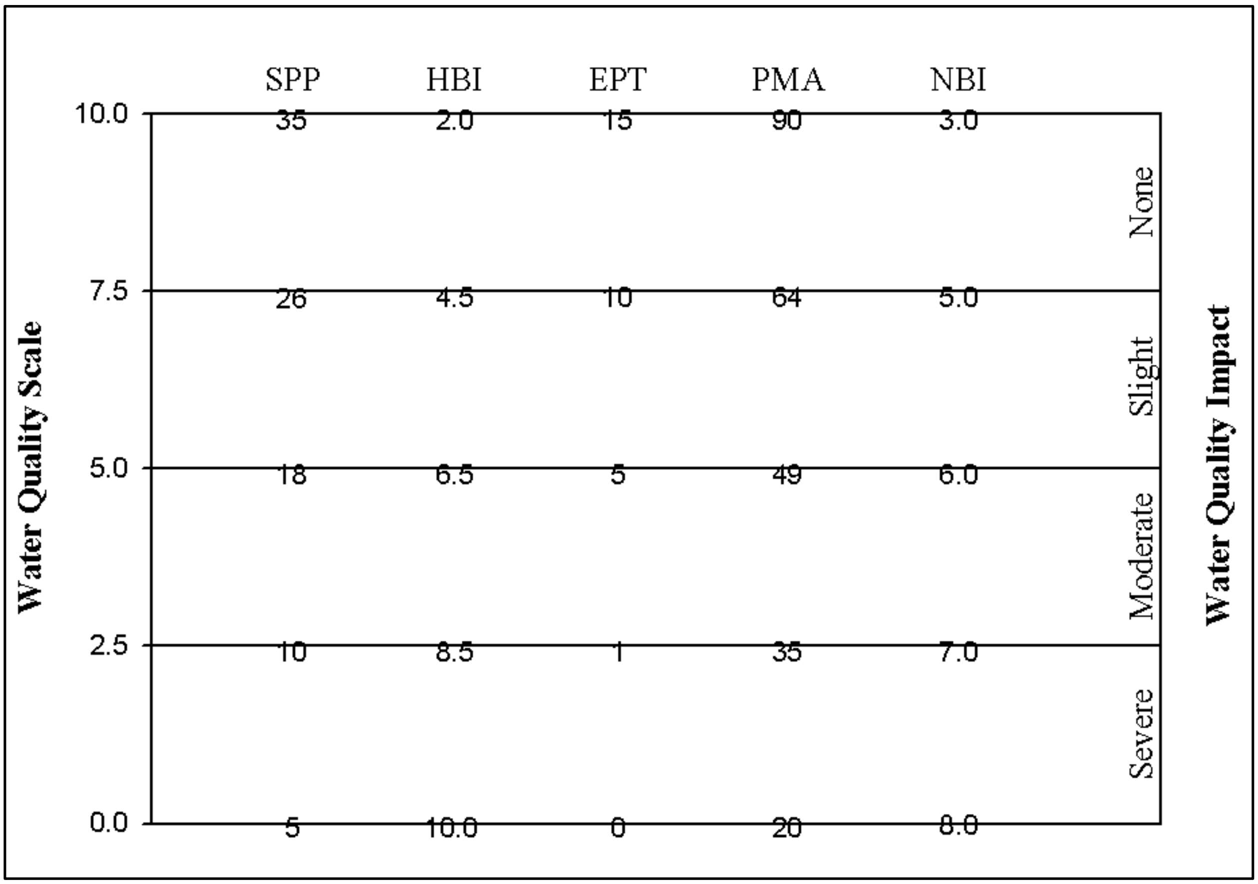
2. *Slightly impacted*: Indices reflect good water quality. The macroinvertebrate community is slightly but significantly altered from the pristine state. Species richness is usually 19-26. Mayflies and stoneflies may be restricted, with EPT richness values of 6-10. The biotic index value is 4.51-6.50.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



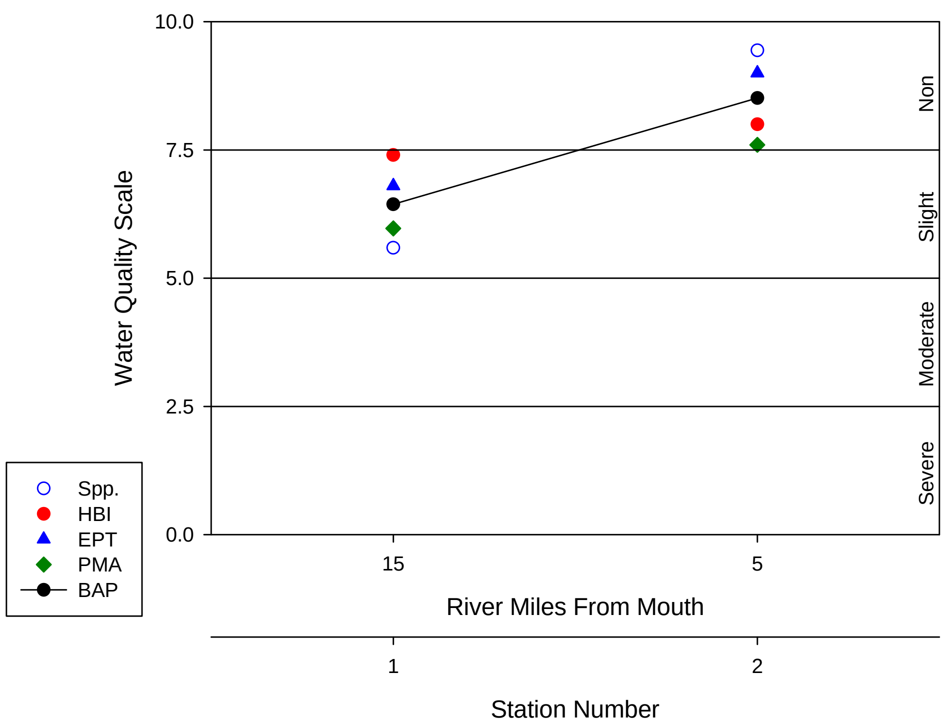
Appendix IV-B. Biological Assessment Profile: Plotting Values

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

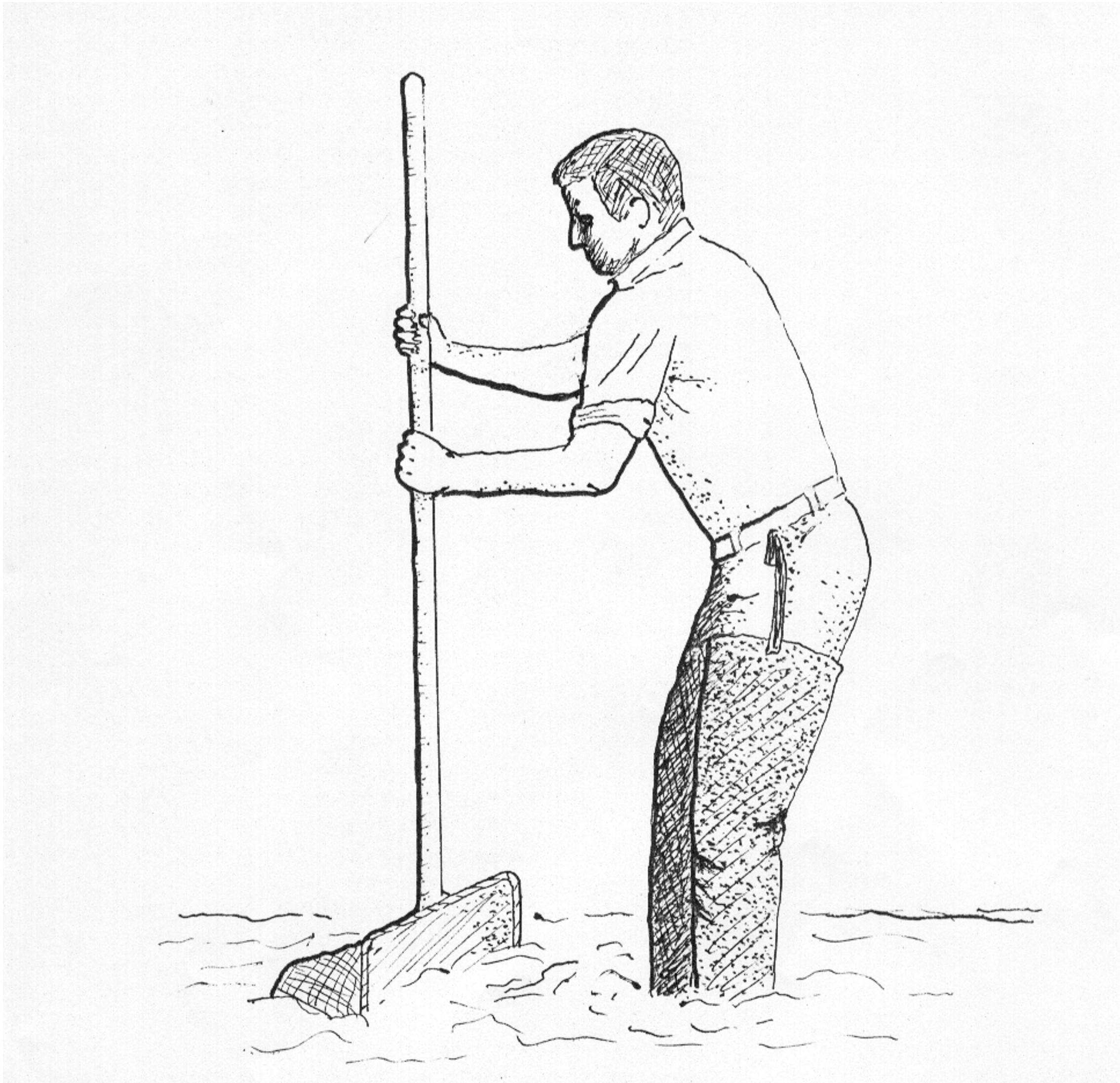
	Species Richness	Hilsenhoff Biotic Index	EPT Value	Percent Model Affinity*	Diversity**
Non-Impacted	>26	0.00-4.50	>10	>64	>4
Slightly Impacted	19-26	4.51-6.50	6-10	50-64	3.01-4.00
Moderately Impacted	11-18	6.51-8.50	2-5	35-49	2.01-3.00
Severely Impacted	0-10	8.51-10.00	0-1	<35	0.00-2.00

*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 the Nutrient Biotic Indices

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

TAXON	TP T-Value	NO3 T-Value
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 Impacts of Waters with High Conductivity

Definition: Conductivity is a measure of the ability of an aqueous solution to carry an electric current. It may be used to estimate salinity, total dissolved solids (TDS), and chlorides. Salinity is the amount of dissolved salts in a given amount of solution. TDS, although not precisely equivalent to salinity, is closely related, and for most purposes can be considered synonymous. EPA has not established ambient water-quality criteria for salinity; for drinking water, maximum contaminant levels are 250 mg/L for chlorides, and 500 mg/L for dissolved solids (EPA, 1995).

Measurement: Conductivity is measured as resistance and is reported in micromhos per centimeter (μmhos/cm), which is equivalent to microsiemens per centimeter (μS/cm). To estimate TDS and salinity, multiply conductivity by 0.64 and express the result in parts per million. For marine waters, salinity is usually expressed in parts per thousand. To estimate chlorides, multiply conductivity by 0.21 and express the result in parts per million. Departures from these estimates can occur when elevated conductivity is a result of natural conditions, such as in situations of high alkalinity (bicarbonates), or sulfates.

Effects on macroinvertebrates: Bioassays on test animals found the toxicity threshold for *Daphnia magna* to be 6-10 parts per thousand salinity (6000-10,000 mg/L) (Ingersoll et al., 1992). Levels of concern for this species were set at 0.3-6 parts per thousand salinity (300-6000 mg/L) (U.S. Dept. of Interior, 1998).

Stream Biomonitoring findings: Of 22 New York State streams sampled with specific conductance levels exceeding 800 μmhos/cm, 9% were assessed as severely impacted, 50% were assessed as moderately impacted, 32% were assessed as slightly impacted, and 9% were assessed as non-impacted. Many of the benthic communities in the impacted streams were dominated by oligochaetes, midges, and crustaceans (scuds and sowbugs). Thirty-five percent of the streams were considered to derive their high conductance primarily from natural sources, while the remainder were the result of contributions from point and nonpoint anthropogenic (human caused) sources. For nearly all streams with high conductivity, other contaminants are contained in the water column, making it difficult to isolate effects of high conductance.

Recommendations**:** Conductivity may be best used as an indicator of elevated amounts of anthropogenic-source contaminants. Based on findings that the median impact at sites with specific conductance levels exceeding 800 μmhos/cm is moderate impact, 800 μmhos/cm is designated as a level of concern with expected biological impairments. Eight-hundred umhos/cm corresponds to ~170 mg/L chlorides, ~510 parts per million Total Dissolved Solids, and ~0.51 parts per thousand salinity.

US Dept. of Interior. 1998. Guidelines for interpretation of the biological effects of selected constituents in biota, water, and sediment. National Irrigation Water Quality Program Information Report No. 3.

Ingersoll, C.G., F.J. Dwyer, S.A. Burch, M.K. Nelson, D.R. Buckler, and J.B. Hunn. 1992. The use of freshwater and saltwater animals to distinguish between the toxic effects of salinity and contaminants in irrigation drain water. Environmental Toxicology and Chemistry, 11:503-511.

U.S. EPA. 995. Drinking water regulations and health advisories. U.S. Environmental Protection Agency, Office of Water, Washington, D.C., 11 pages.