EFFECT OF FLOW ON BATTENKILL WATER QUALITY

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SUMMARY

Physical, chemical and biological parameters were assessed during normal stream flow at sites previously studied by the NYS-DEC during low flow years in order to determine the effect of flow on water quality of the Battenkill. Metrics obtained from data at seven sites (above and below a sewage treatment plant) demonstrated that during a normal flow year the Battenkill's macroinvertebrate community structure was significantly affected from nutrients originating from point sources.

BACKGROUND

The Battenkill is a fifty-mile long river rising from the Green and Taconic Mountains of Southern Vermont and flowing westward into New York State through rural Washington County. The watershed covers approximately 1036 square kilometers in New York and Vermont, about 622 of which are in New York State. Agricultural land abuts much of its scenic banks, and the stream is prized for its cold-water fishing, as well as for canoeing, kayaking, swimming and nature study.

Water quality of the Battenkill has been documented in numerous studies over the past two decades. In 1999, the NYS DEC conducted a general water quality survey of the kill in response to reports of declining fish populations. A follow up survey was performed in 2001, which included study sites in Vermont located above and below the Manchester Sewage Treatment Plant (MSTP) discharge pipe (Sites VT1 and VT2A, respectively). Nolan (2004) conducted a survey in 2003 that included five sites on the Battenkill in New York State.

A map with site locations can be found on pages 6 & 7.

Both the 1999 and 2001 NYS DEC surveys provided benthic macroinvertebrate evidence that significant water quality changes occurred at several sites compared to earlier data (Bode et al., 2004; Nolan, 2004 unpublished). In the 1999 report Bode found no new source or change in a known point source to explain the decline in water quality, and therefore assigned the change to low flow conditions on the river. In a 2004 30-year trend report however, he indicated that the changes were probably secondary to non-point source nutrient additions. The survey conducted by Nolan (2004) in 2003 indicated non impacted water quality, based on the macroinvertebrate data, at all sites surveyed.

The NYS DEC surveys were conducted during what was reported as drought years; river flow was lower than normal during these years, though neither a sustained drought nor a completely dry streambed occurred in either year (Nolan, 2004 unpublished). The surveys suggest that low flow conditions may have concentrated nutrients, and that the changes in water quality based on benthic macroinvertebrate data were a response to this short-term drought situation (Novak et al., 2001).

The intent of this study was to determine the Battenkill's water quality by examination of the benthic macroinvertebrate community during normal flow conditions. The NYS DEC Stream Biomonitoring Unit Quality Assurance Work Plan procedures for biological stream monitoring were used for data collection and analysis (Bode et al., 2002). The present study evaluated water quality trends on the Battenkill and considered the effect that low flow may have on the Battenkill's water quality.

METHODS

Sites chosen for this study have previously been assessed by the NYS DEC or the VT DEC. Each site was evaluated for percent canopy cover, current speed, percent of rock, rubble, gravel, sand, and silt, and the embeddedness of the substrate. The depth and width of the stream were also measured. Physical attributes were required to meet the habitat comparability criteria as outlined in Bode et al. (1990).

Water temperature was obtained by grab sampling using a glass thermometer (accuracy ± 0.2° C). Specific conductance was obtained using an Oakton specific conductance meter with a range of 0 – 1990 µS (accuracy of ± 1%). An Oakton pH meter was used for pH with a range of -1 to 15 (accuracy ± 0.1 pH). Dissolved oxygen was determined by the azide modification of the Winkler method using a Lamotte microburet kit. Each manufacturer's method and calibration procedure for each kit or meter was followed prior to sampling. For physical and chemical data see appendix IV.

Flow was determined using data from the United States Geological Survey (USGS) Battenkill at Battenville flow gauging station.

Three replicate macroinvertebrate samples were collected at each site within the same riffle section using an 800-900 micron mesh kick net (9 by 18 inch). Samples were collected by disturbing the substrate by foot upstream of the net, and continuing over a five-meter transect for five minutes as described in the Quality Assurance Work Plan for Biological Stream Monitoring in New York State (Bode et al. 2002). Each replicate sample was separately preserved in 95% ethyl alcohol. Replicate samples were then sub-sampled in the lab by randomly selecting a tablespoon of detritus from the sample and examining it under a dissecting microscope. Invertebrates larger than 1.5 mm were removed, until 100 organisms were obtained for each replicate sample. Macroinvertebrates were identified to family level to determine the water quality category for each site. Identification to the required taxonomic level was conducted using the median replicate sample at each site to determine the Impact Source Determination (ISD) described by Riva-Murry et al. (2002).

Each site's replicates were compared to each other, at the ordinal level, to assess sampling technique and variability. Similarity between replicates at each site was 75 percent or higher.

The metrics used to determine water quality were those recommended by the NYS DEC Stream Biomonitoring Unit for family level taxonomic identification and have 92 percent accuracy in properly categorizing water quality (Smith and Bode, 2004).

The four community metrics utilized for both family and species level were: Richness (Plafkin et al. 1989), EPT richness (Lenat, 1987), Hilsenhoff's Biotic Index (Hilsenhoff, 1988), and Percent Model Affinity (PMA) (Novak and Bode, 1992). Tolerance values and scores for family metrics used to calculate the water quality were from Smith and Bode (2004).

Using each site's replicates, a mean score was derived for each metric. The mean score for each particular metric was then used to calculate each site's Biological Assessment Profile (BAP) by converting each metric mean score to a common scale of 0 – 10. The BAP score categorizes the overall water quality assessment into one of four categories: non-, slightly, moderately, or severely impacted (Bode et al. 2002).

In addition to categorizing water quality for each site, a statistical comparison of the replicate samples between sites was performed to determine if any significant biological difference was evident.

Impact Source Determination (ISD) was calculated for each site using the median replicate sub-sample from each site. ISD compares test site communities to model communities empirically derived from macroinvertebrate data; the greater the similarity of a test site community to a model community, the more likely a particular impact source is affecting the test community. Data is most conclusive if a test community exhibits at least 50% similarity to a model community (Bode et al. 2002). Riva-Murray et al. (2002) found that ISD correlated well with impairment sources inferred from chemical, physical, and watershed characteristics, and biomonitoring results.

Appendix III contains the macroinvertebrate taxa list for each sites replicates.

RESULTS

The Biological Assessment Profile (BAP) for all sites, except site VT2A, indicated non-impacted water quality. The BAP score at VT2A indicated slightly impacted water quality, although the data almost reached the non-impacted threshold (appendix I). A significant difference in Family EPT richness, percent abundance of Ephemeroptera, and BAP scores for each replicate was evident between sites VT1 and VT2A ($P<0.016$, $P<0.045$, and $P<0.024$ respectively). All sites are “natural” by Impact Source Determination criteria (appendix I).

Flow, as recorded at the USGS Battenville flow gauging station, dropped and remained below the 52-year daily mean flow for 14 days prior to sampling. The mean daily flow during 47 days prior to sampling, however, was 35% higher than the 52-year mean daily flow and the mean 7-day low flow in the two month period prior to sampling was 300 cu feet per second. Sampling occurred on June 25, 2004 (appendix V).

DISCUSSION

Discharge from the Manchester Sewage Treatment Plant has negatively impacted the stream, and although water quality returned to non-impacted levels by site VT3, the river remained strained for several kilometers before approaching the water quality level found above the treatment plant (appendix I). Hynes (1974) showed how mild organic pollution resulted in changes to the biota detectable at 25 kilometers.

Water quality deterioration between sites VT1 and VT2A was also documented by the NYS DEC in 2001, when the EPT species richness fell from 19 to 11, the BI increased from 3.85 to 4.25, and the BAP dropped from 8.96 to 7.9. However, in the 2001 survey water quality returned to levels found above the treatment plant at site VT2, located approximately 1200 meters downstream from the treatment plant and 160 meters below VT2A. This was the original site selected for sampling below the treatment plant; field sample fauna at the site was diverse and included baetiscid mayflies and the stonefly, *Pteronarcys*, both found in water of excellent quality (Novak, et al. 2001). EPT taxa richness increased from 11 to 15 between VT2A and VT2 (not including the baetiscid mayflies and the stonefly *Pteronarcys,* identified in the field sample and not included in the sub sample) and the BI dropped from 4.25 to 3.91. The BAP score at site VT2 (9.05) was higher than the BAP score assessed above the MSTP at VT1 (8.96). Impact Source Determination (ISD) for site VT2 was categorized solely as “natural” whereas the ISD for all the other sites surveyed in 2001 indicated either natural and nutrient additions or just nutrient additions.

Flow in 2001, as recorded at the USGS Battenville flow gauging station, dropped and remained below the 52-year daily mean flow for 42 days prior to sampling. The mean percent daily flow compared to the 52-year daily mean flow for 47 days prior to sampling was 64%. The mean 7-day low flow in the two month period prior to sampling was 105 cu feet per second. Sampling occurred on September 6, 2001 (appendix V).

The water temperature and specific conductance dropped between sites VT2A and VT2 in 2001 from 16.6 to 15.4 degrees Celsius and 501 to 488 umhos, respectively. A discharge from the MSTP caused a slightly grayish cast to the water at site VT2 (Novak et al. 2001), and, therefore, site VT2A was selected and sampled. The striking difference between sites VT2A and VT2 shows a sharp increase in the Battenkill’s water quality occurred over a short distance and suggests that the increase in water quality at VT2 was not simply a recovery due to distance from the MSTP outflow (appendix II).

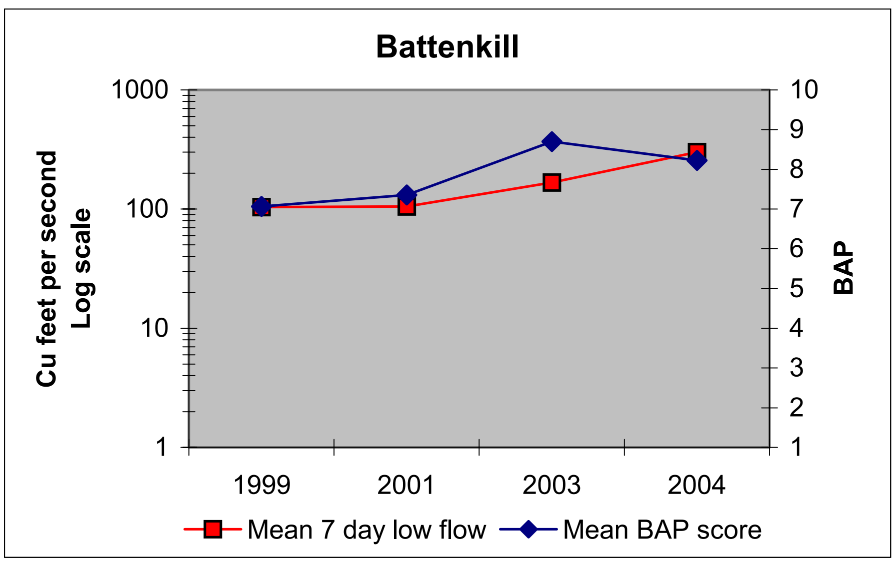
The changes in the benthic macroinvertebrate indices, physical properties of the water, and water chemistry, in conjunction with the geological location of site VT2 (located on the Battenkill where it courses along the edge of a 140 acre freshwater forested/shrub wetland) and low flow conditions, indicates that well-oxygenated groundwater upwelling likely attenuated the effects of the MSTP discharge. Upwelling of groundwater tends to occur during low flow and drought years, as it maintains base flows in streams and rivers. Temperature of upwelling groundwater during summer months is usually colder than surface waters. Upwelling groundwater not only maintains base flow, but also creates species-rich habitats, adding species to the community of the main channel and supporting the theory that cold, well-oxygenated groundwater mitigates the potential effects of organic waste (Malard et al. 2003; Riva Murry et al. 2002).

Groundwater upwelling areas are a distinct habitat that may harbor a different fauna, and should therefore be avoided in sampling regimes unless specifically included as part of the physical habitat sampling requirements (Davis and Simon 1995; Rosenberg and Resh, 1993).

The 1999 NYS survey documented the lowest water quality recorded for the Battenkill during a year when the mean percent flow was 50% of the 52-year daily mean flow for 47 days prior to sampling with a mean 7-day low flow in the two month period prior to sampling of 104 cu feet per second. Sampling occurred on August 25, 1999 (appendix II & V).

The lowest water quality (a BAP of 6) occurred at the farthest upstream survey site sampled in 1999, site AA, located at the NY and Vermont border (appendix II). Water quality changes were partly attributed to low flow conditions, which would concentrate point source pollutants, but rain events and increased flows did occur throughout the sampling season (Bode et al., 1999; Nolan 2004 unpublished). Nolan also documented increases in bacteria levels occurring in the Battenkill after rain events at all sites sampled, indicating that non point source organic pollutants are entering the kill.

It appears that during normal flow years the Battenkill's macroinvertebrate community structure is adversely affected from nutrients originating from a point source. These changes are significant, and once they occur the river struggles for many kilometers, and does not fully recover (appendix I). More so, the water quality in the Battenkill appears to be especially vulnerable during low flow years, when presumably minor point and non point source discharges result in substantial changes in the stream ecosystem (graph I).



Graph I. The graph depicts the relationship (correlation coefficient r = 0.62) of low flow and water quality, based on macroinvertebrate data, of the Battenkill using the mean 7-day low flow in the two month period prior to sampling for years 1999, 2001, 03 and 04 and the mean BAP score of sites AA, A, B, and 03 for the same years.

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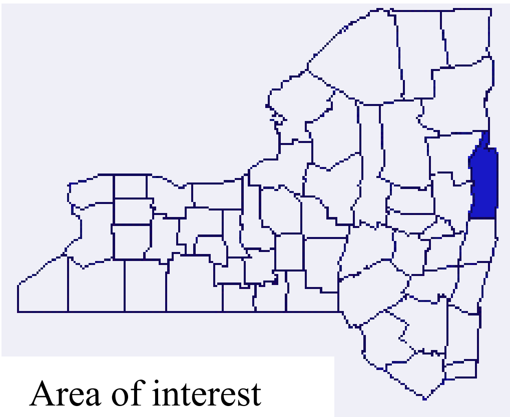
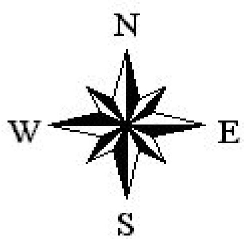
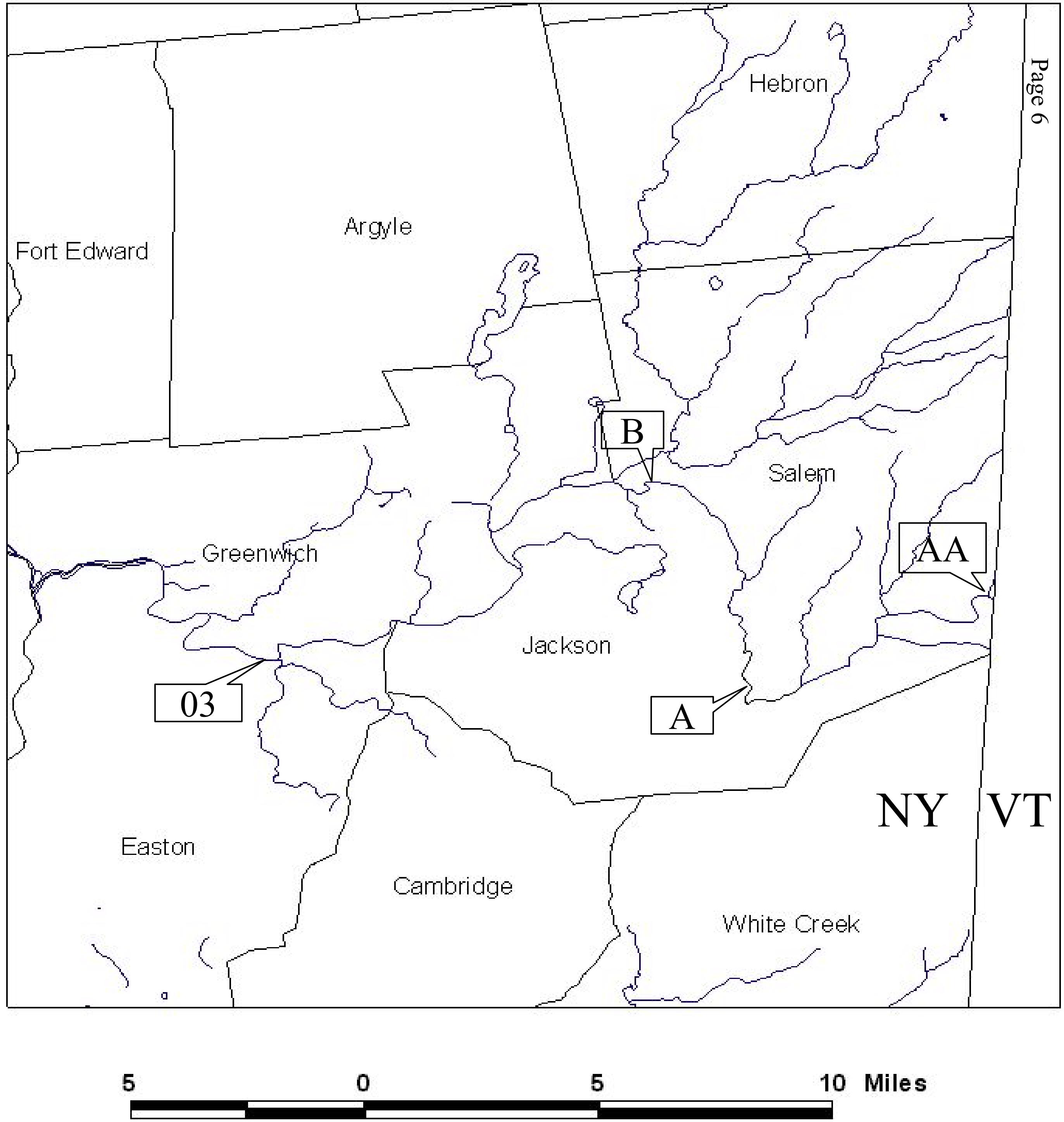
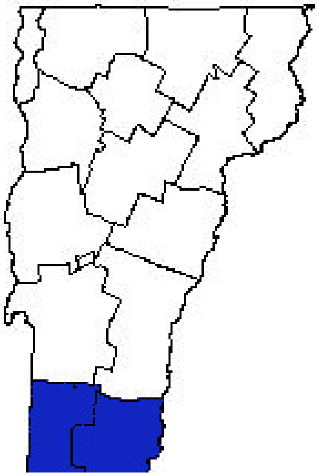


Washington Co. NY

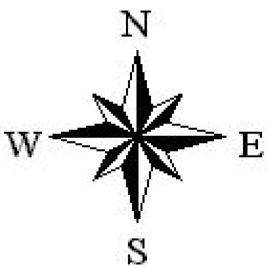


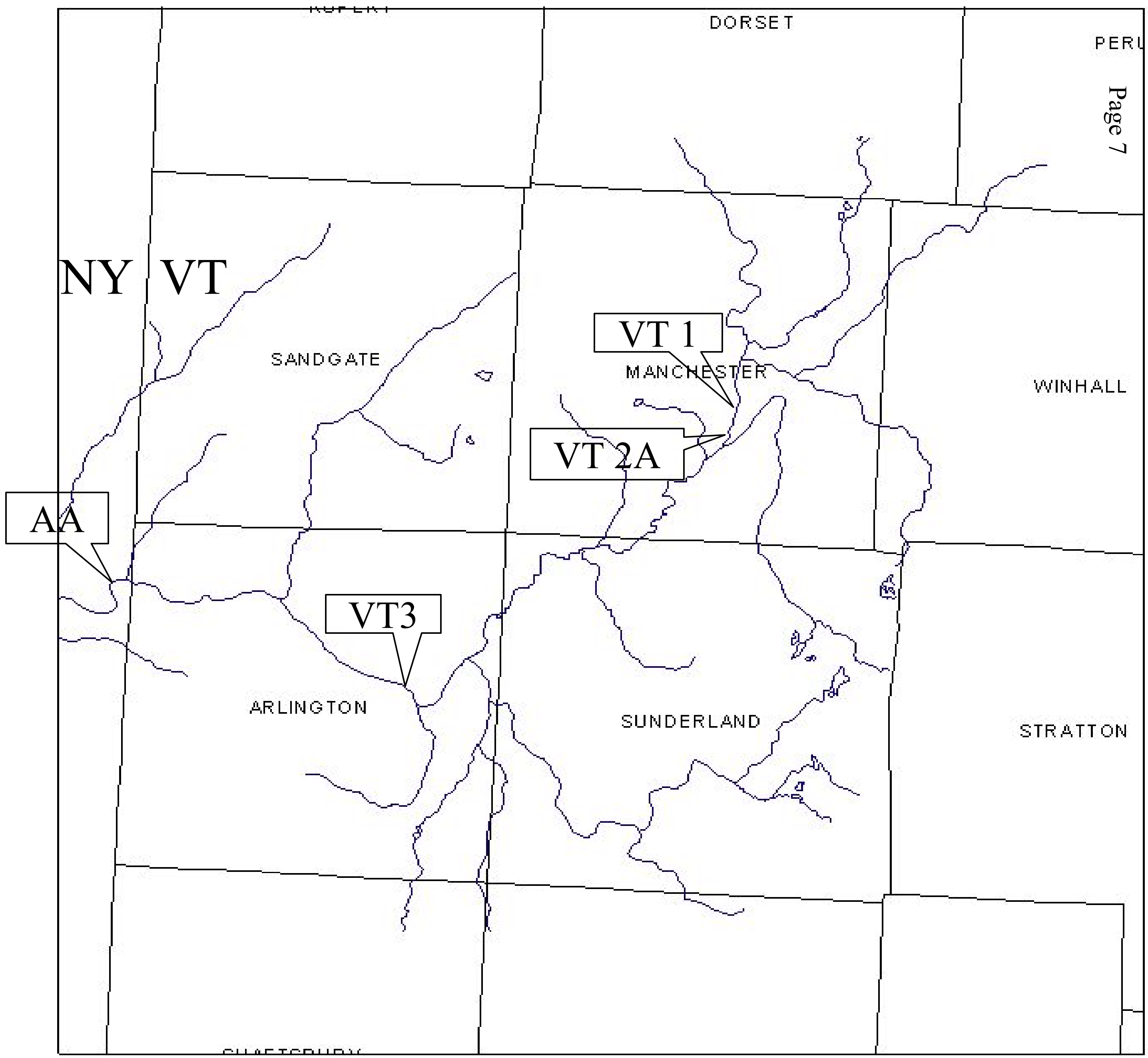




Area of interest

Bennington Co. VT





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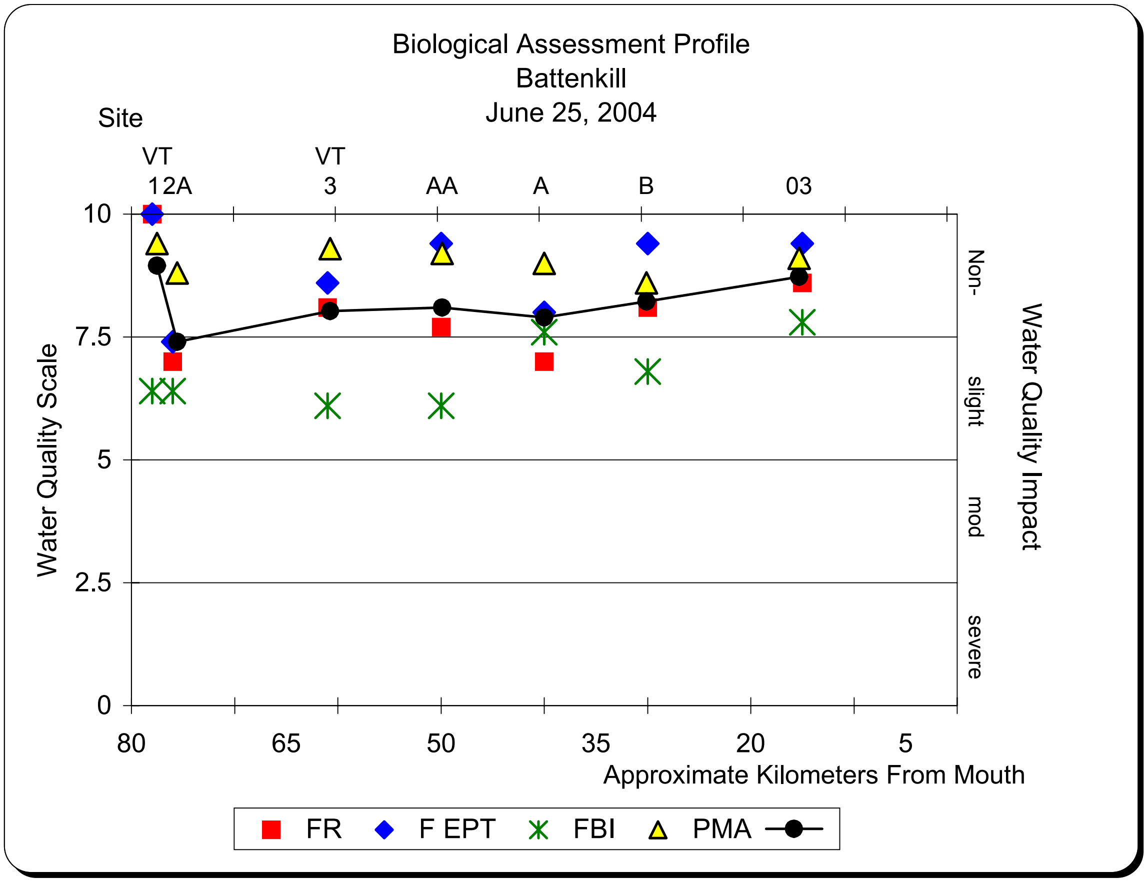
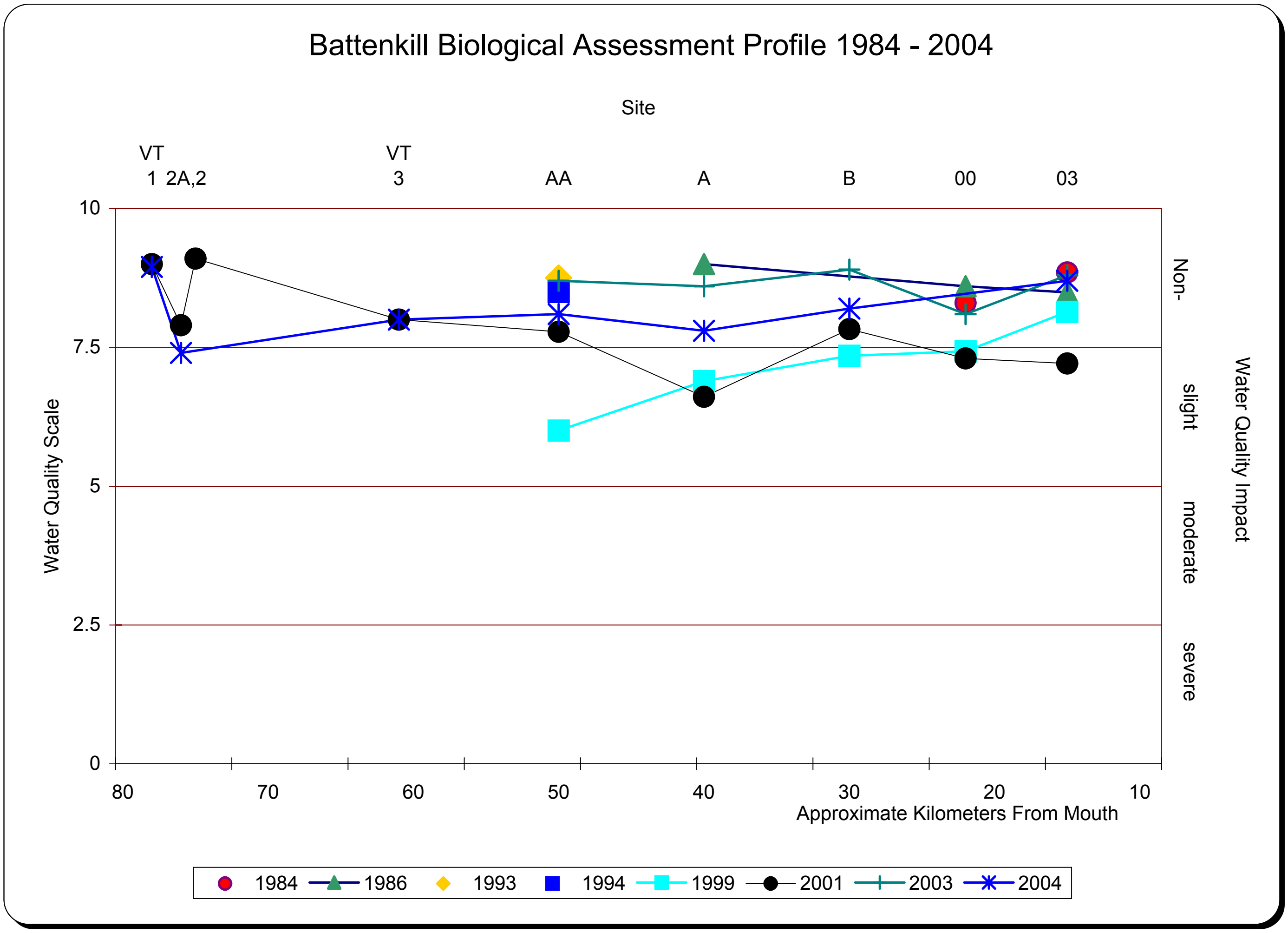


Using each site's replicates a mean score was derived for each metric. The mean score for each particular metric was then used to calculate each site's BAP by converting each metric mean score to a common scale of 0-10.

IMPACT SOURCE DETERMINATION (ISD)							
Battenkill June 25, 2004	**VT 1**	**VT 2A**	**VT 3**	**AA**	**A**	**B**	**03**
NATURAL	63	56	55	63	66	64	63
NON POINT NUTRIENTS	32	43	43	44	49	42	45
TOXIC	29	46	41	40	30	37	28
SEWAGE EFFLUENT	29	45	35	39	39	41	35
MUNICIPAL/INDUSTRIAL	19	29	25	30	30	33	33
SILTATION	30	41	46	43	50	41	47
IMPOUNDMENT	22	34	28	35	34	34	40

The highest community type similarity score, as well as those within 5% of it, are identified. Analysis is most conclusive when similarity scores are greater than 50% (Bode, *et al*. 2002).



<u>The graph depicts the BAP scores for multiple sampling years. Sampling years 1984—2001 were conducted by NYS DEC. The 2003 and 2004 survey's were conducted by Battenkill Conservancy-NY and SUNY Albany</u>.

Battenkill, VT1

Rep 2 Taxa (ISD)	Number	Rep 3 Taxa	Number	Rep 4 Taxa	Number
Baetidae	43	Baetidae	31	Baetidae	22
Brachycentridae	4	Brachycentridae	2	Brachycentridae	2
Chloroperlidae	1	Chironomidae	22	Chironomidae	14
Cricotopus vierriensis	3	Elmidae	1	Elmidae	17
Ephemerellidae	7	Ephemerellidae	9	Empididae	1
Glossosomatidae	3	Heptageniidae	3	Ephemerellidae	11
Heptageniidae	13	Hydropsychidae	9	Glossosomatidae	2
Hydropsychidae	3	Leptophlebliidae	2	Helicopsychidae	1
Micropsectra sp.	1	Leuctridae	1	Heptageniidae	8
Oligochaeta	3	Oligochaeta	5	Hydropsychidae	4
Optioservus sp.	5	Perlidae	2	Oligochaeta	6
Perlidae	2	Philopotamidae	1	Perlidae	1
Philopotamidae	1	Polycentropodidae	1	Philopotamidae	2
Polypedilum aviceps	2	Simuliidae	2	Rhyacophilidae	1
Simulium tuberosum	2	Tipulidae	8	Simuliidae	1
Sympotthastia sp.	2	Uenoidae	1	Tipulidae	5
Tipulidae	5			Uenoidae	2

Battenkill, VT2A

Rep 1 Taxa (ISD)	Number	Rep 3 Taxa	Number	Rep 4 Taxa	Number
Baetidae	13	Baetidae	11	Baetidae	20
Blephariceridae	2	Blephariceridae	1	Blephariceridae	1
Brachycentridae	4	Brachycentridae	3	Brachycentridae	2
Cricotopus bicinctus	2	Chironomidae	35	Chironomidae	24
Cricotopus trifascia gr.	1	Elmidae	12	Corydalidae	1
Cricotopus vierriensis	9	Ephemerellidae	4	Elmidae	15
Ephemerellidae	13	Glossosomatidae	9	Ephemerellidae	12
Eukiefferiella devonica gr.	1	Heptageniidae	1	Glossosomatidae	3
Glossosomatidae	2	Hydropsychidae	7	Hydropsychidae	8
Heptageniidae	2	Oligochaeta	7	Oligochaeta	3
Hydropsychidae	8	Psephenidae	1	Perlidae	1
Leptophlebliidae	1	Tipulidae	9	Psephenidae	2
Lopescladius sp.	1			Rhyacophilidae	2
Oligochaeta	9			Tipulidae	6
Optioservus sp.	17				
Orthocladius dubitatus	3				
Parametriocnemus lundbecki	1				
Polypedilum aviceps	6				
Psephenus herricki	2				
Tipulidae	3				

Battenkill, VT 3					
Rep 1		**Rep 2**		**Rep 3**	
Taxa	**Number**	**Taxa**	**Number**	**Taxa (ISD)**	**Number**
Baetidae	33	Baetidae	27	Baetidae	27
Brachycentridae	1	Chironomidae	31	Brachycentridae	1
Chironomidae	20	Elmidae	4	Cricotopus tremulus gr.	1
Corydalidae	1	Ephemerellidae	15	Ephemerellidae	12
Elmidae	3	Glossosomatidae	1	Eukiefferiella devonica gr.	1
Ephemerellidae	13	Heptageniidae	3	Hydropsychidae	5
Ephemeridae	0	Hydropsychidae	9	Leptophlebliidae	3
Glossosomatidae	1	Leptophlebliidae	2	Oligochaeta	10
Heptageniidae	3	Oligochaeta	3	Optioservus sp.	5
Hydropsychidae	8	Simuliidae	1	Orthocladius dubitatus	2
Leptophlebliidae	4	Tipulidae	2	Parametriocnemus lundbecki	4
Oligochaeta	1	Uenoidae	2	Perlodidae	1
Perlidae	1			Philopotamidae	2
Psephenidae	1			Polypedilum aviceps	14
Simuliidae	3			Polypedilum flavum	2
Tipulidae	4			Promosesia sp.	2
Uenoidae	3			Rhyacophilidae	1
				Simulium tuberosum	1
				Tipulidae	1
				Tvetenia vitracies	2
				Uenoidae	3

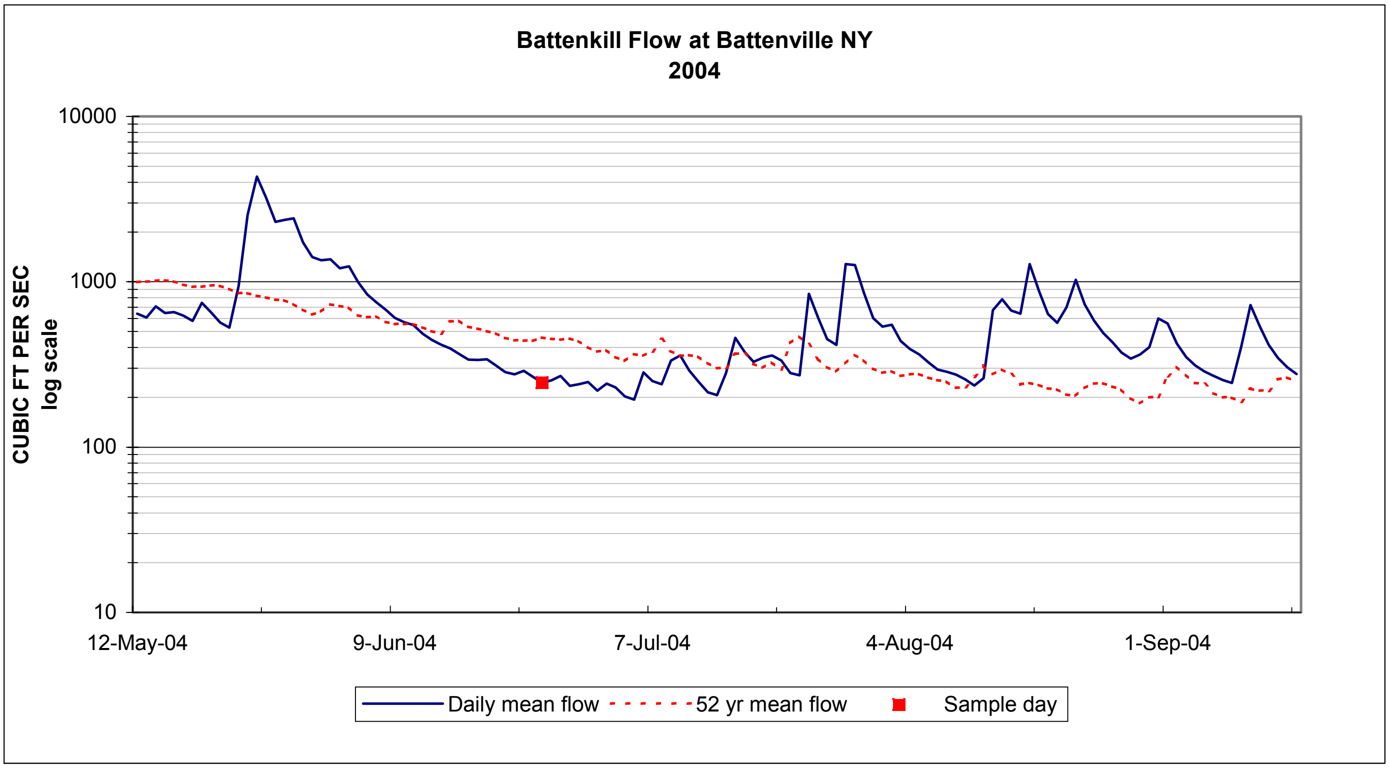
Battenkill, AA					
Rep 1		**Rep 2**		**Rep 3**	
Taxa	**Number**	**Taxa (ISD)**	**Number**	**Taxa**	**Number**
Baetidae	28	Baetidae	35	Baetidae	31
Brachycentridae	1	Cricotopus vierriensis	1	Capniidae	1
Chironomidae	16	Ephemerellidae	4	Chironomidae	16
Elmidae	6	Helicopsychidae	1	Elmidae	11
Ephemerellidae	15	Heptageniidae	5	Ephemerellidae	9
Glossosomatidae	0	Hydropsychidae	8	Heptageniidae	11
Helicopsychidae	0	Leptophlebliidae	2	Hirudinea	1
Heptageniidae	5	Limnephilidae	1	Hydropsychidae	5
Hydropsychidae	11	Oligochaeta	9	Leptophlebiidae	1
Leptophlebliidae	3	Opitoservus sp.	15	Neophylax sp.	2
Limnephilidae	1	Orthocladius dubitatus	2	Oligochaeta	6
Oligochaeta	2	Philopotamidae	1	Perlidae	1
Perlidae	1	Polypedilum aviceps	9	Philopotamidae	2
Philopotamidae	4	Polypedilum flavum	3	Tipulidae	3
Rhyacophilidae	1	Polypedilum illinoense	1		
Uenoidae	6	Rheotanytarsus pellucidus	1		
		Thienemannimyia grp. sp.	1		
		Tipulidae	1		

Battenkill, A					
Rep 1		**Rep 2**		**Rep 3**	
Taxa	**Number**	**Taxa**	**Number**	**Taxa (ISD)**	**Number**
Baetidae	16	Baetidae	6	Baetidae	11
Chironomidae	11	Ceratopogonidae	1	Ceratopogonidae	1
Elmidae	16	Chironomidae	6	Cricotopus bicinctus	2
Ephemerellidae	13	Corydalidae	1	Ephemerellidae	11
Glossosomatidae	1	Elmidae	27	Heptageniidae	19
Heptageniidae	25	Ephemerellidae	10	Hydropsychidae	8
Hydropsychidae	5	Glossosomatidae	1	Lopescladius sp.	4
Leptophlebliidae	3	Heptageniidae	24	Oligochaeta	7
Oligochaeta	4	Hydropsychidae	11	Optioservus sp.	15
Perlidae	5	Isonychia	2	Perlidae	4
Tipulidae	1	Leptoceridae	2	Philopotamidae	3
		Oligochaeta	3	Polypedilum aviceps	11
		Perlidae	1	Psephenus herricki	1
		Philopotamidae	2	Stenelmis sp.	2
		Tipulidae	2	Tipulidae	1
		Uenoidae	1		

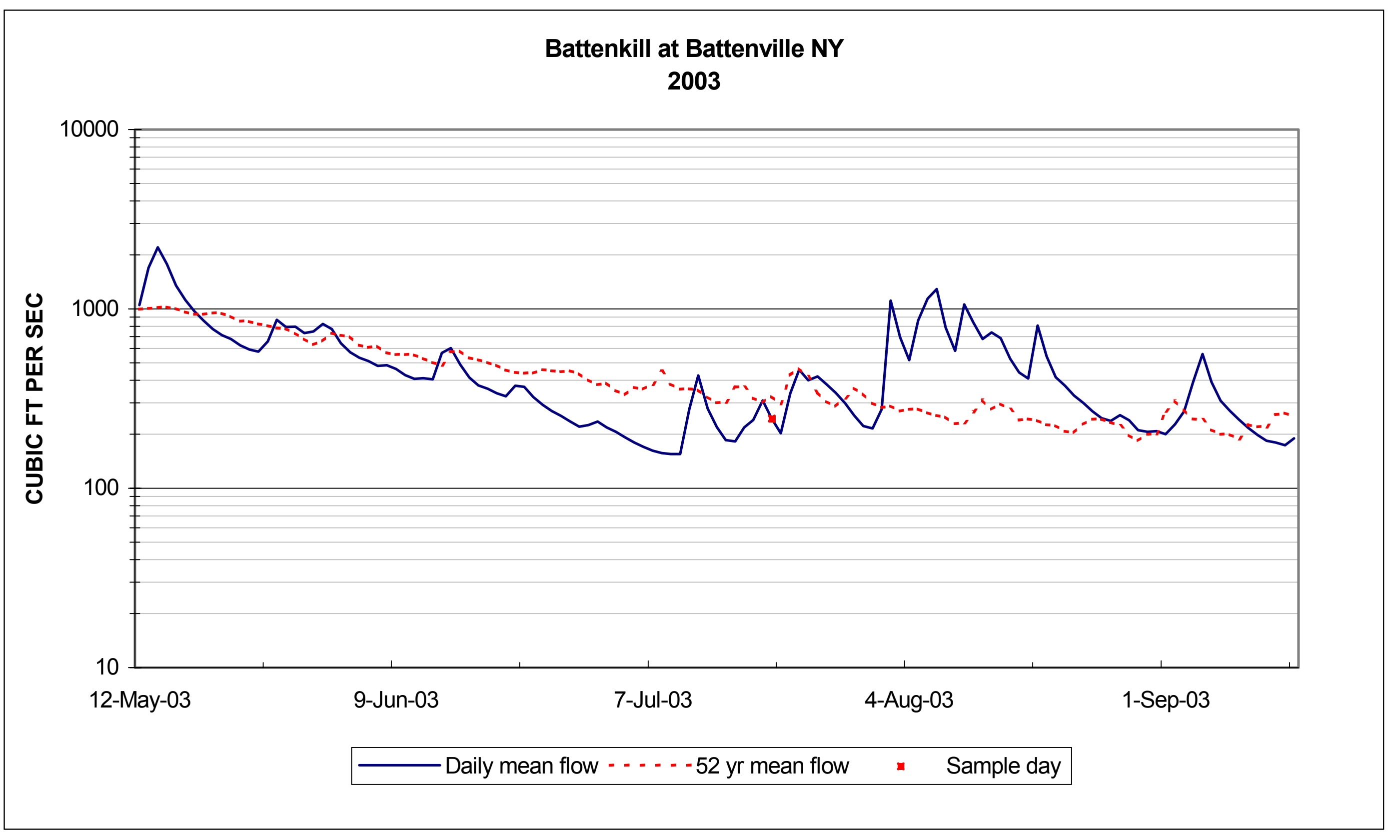
Battenkill, B					
Rep 1		**Rep 2**		**Rep 3**	
Taxa	**Number**	**Taxa (ISD)**	**Number**	**Taxa**	**Number**
Baetidae	11	Baetidae	16	Baetidae	8
Chironomidae	11	Cricotopus vierriensis	1	Cambaridae	1
Elmidae	23	Ephemerellidae	13	Chironomidae	10
Ephemerellidae	17	Heptageniidae	12	Ephemerellidae	17
Ephemeridae	0	Hydropsychidae	8	Heptageniidae	9
Heptageniidae	5	Isonychia	8	Hydropsychidae	3
Hydropsychidae	8	Oligochaeta	11	Isonychia	1
Hydroptilidae	0	Opitoservus sp.	4	Leptoceridae	5
Isonychia	1	Perlidae	5	Leptophlebliidae	2
Lepidostomatidae	0	Philopotamidae	9	Limnephilidae	1
Leptoceridae	3	Polypedilum aviceps	7	Oligochaeta	10
Oligochaeta	11	Tipulidae	2	Optioservus sp.	19
Perlidae	2	Tvetenia vitracies	1	Perlidae	2
Philopotamidae	7	Uenoidae	3	Philopotamidae	5
Polymitarcyidae	0			Polycentropodidae	1
Tipulidae	1			Psephenus herricki	1
				Stenelmis sp.	1
				Tipulidae	3
				Uenoidae	1

Battenkill, 03					
Rep 1		**Rep 2**		**Rep 3**	
Taxa	**Number**	**Taxa (ISD)**	**Number**	**Taxa**	**Number**
Baetidae	5	Baetidae	5	Baetidae	15
Brachycentridae	2	Ephemerellidae	25	Cambaridae	1
Caenidae	1	Eukiefferiella devonica	3	Chironomidae	13
Chironomidae	12	Helicopsychidae	1	Elmidae	8
Corydalidae	1	Heptageniidae	12	Ephemerellidae	19
Elmidae	6	Hydropsychidae	19	Heptageniidae	11
Ephemerellidae	27	Isonychia	3	Hydropsychidae	14
Helicopsychidae	1	Leptophlebliidae	1	Isonychia	3
Heptageniidae	3	Limnephilidae	1	Limnephilidae	1
Hydropsychidae	24	Oligochaeta	2	Oligochaeta	2
Leptoceridae	1	Opitoservus sp.	5	Perlidae	10
Leptophlebliidae	1	Orthocladius dubitatus	1	Philopotamidae	1
Leuctridae	1	Perlidae	6	Psephenidae	2
Oligochaeta	7	Polypedilum aviceps	10		
Pelecypoda	1	Psephenus sp.	2		
Philopotamidae	1	Stenelmis sp.	3		
Psephenidae	2	Tvetenia vitracies	1		
Tipulidae	4				

FIELD DATA SUMMARY							
STREAM NAME: Battenkill Washington Co. NY and Bennington Co. Vermont							
REACH:	Manchester VT to below Center Falls NY						
STATION	VT 1	VT 2A	VT 3	AA	A	B	03
ARRIVAL TIME AT STATION	4:30 PM	5:30 PM	2:30 PM	1:15 PM	11:45 AM	11:00 AM	9:00 AM
LOCATION	Union Ave.	below Manchester STP	Arlington	Vermont border	above Shushan	Rexleigh	Center Falls
PHYSICAL CHARACTERISTICS							
Width (meters)	14	15	35	25	30	25	60
Depth (meters)	0.4	0.3	0.4	0.5	0.4	0.5	0.4
Current speed (cm/sec)	80	70	100	90	80	90	80
Substrate (%)							
Rock (>25.4, or bedrock)	25%	—	10%	—	—	10%	—
Rubble (6.35-25.4 cm)	35%	20%	25%	30%	25%	30%	40%
Gravel (0.2-6.35 cm)	20%	50%	25%	30%	25%	30%	30%
Sand (0.06-2.0 mm)	15%	20%	30%	25%	30%	20%	20%
Silt (0.004-0.006 mm)	50%	10%	10%	15%	20%	10%	10%
Embeddedness (%)	40	50	25	40	40	40	50
CHEMICAL MEASUREMENTS							
Temperature (degree C)	18	18	17	18	18	19	18
Specific Conductance (umhos)	390	400	300	270	260	270	260
Dissolved Oxygen (mg/l)	7.4	8.6	8.4	9.8	9	10	8
% oxygen saturation	74	89	85	102	93	106	83
pH	7.7	7.9	7.9	7.8	7.4	7.3	7.8
BIOLOGICAL ATTRIBUTES							
Canopy (%)	50	10	20	20	10	10	5
Aquatic Vegetation							
algae-suspended							
algae- attached, filamentous	x	x					x
algae- diatoms	x	x	x	x	x	x	x
macrophytes or moss	x						

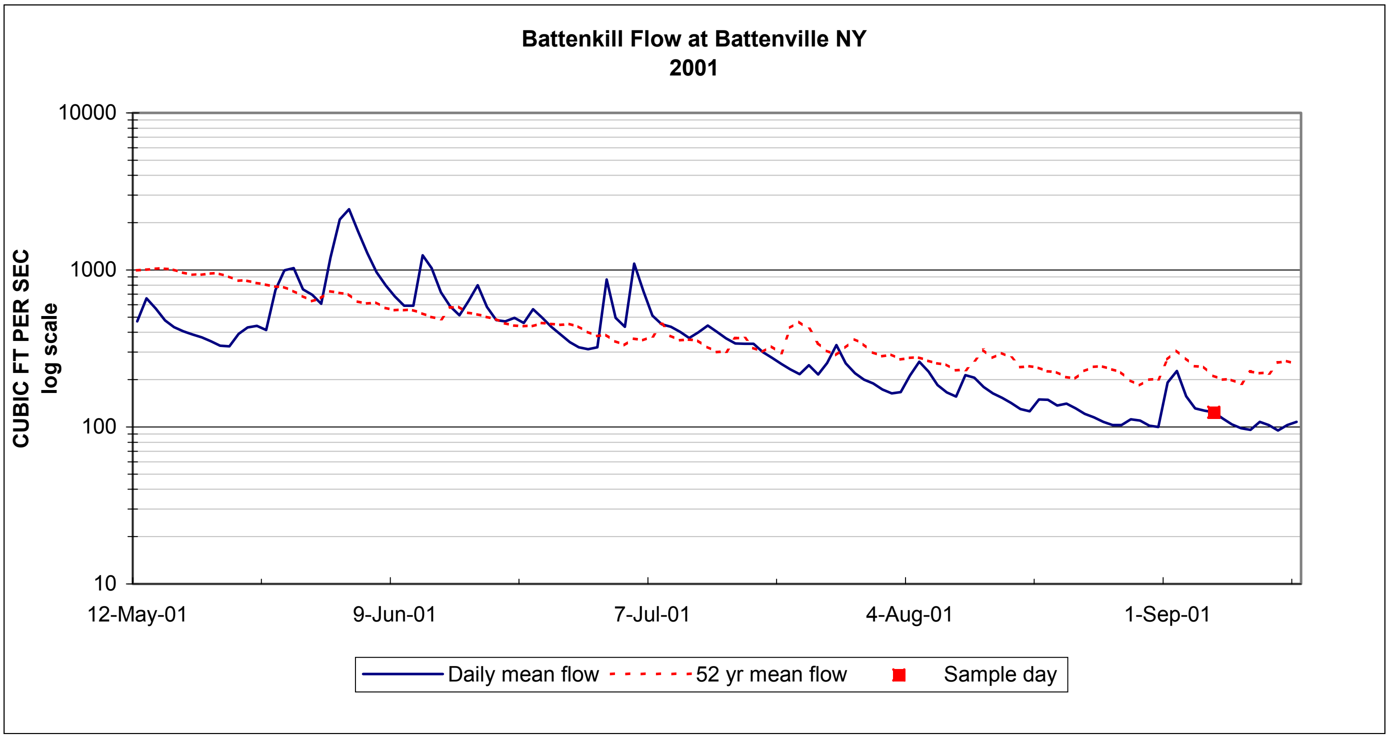


In 2004 the mean daily flow during 47 days prior to sampling was 35% higher than the 52-year mean daily flow.

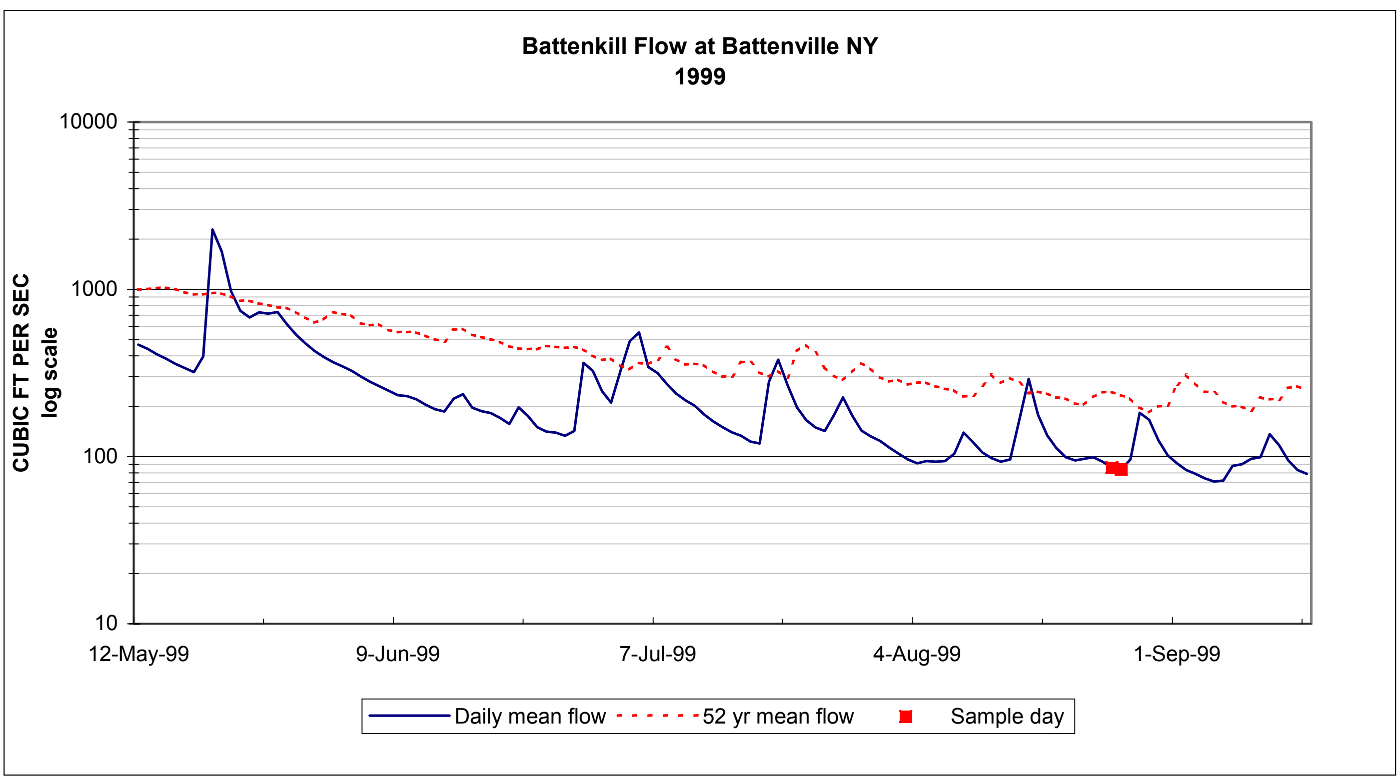


In 2003 the mean percent daily flow compared to the 52-year daily mean flow for 47 days prior to sampling was 70%.

Appendix V cont.



<u>In 2001 the mean percent daily flow compared to the 52-year daily mean flow for 47 days prior to sampling was 64%</u>.



<u>The 1999 mean percent flow was 50% of the 52-year daily mean flow for 47 days prior to sampling</u>.