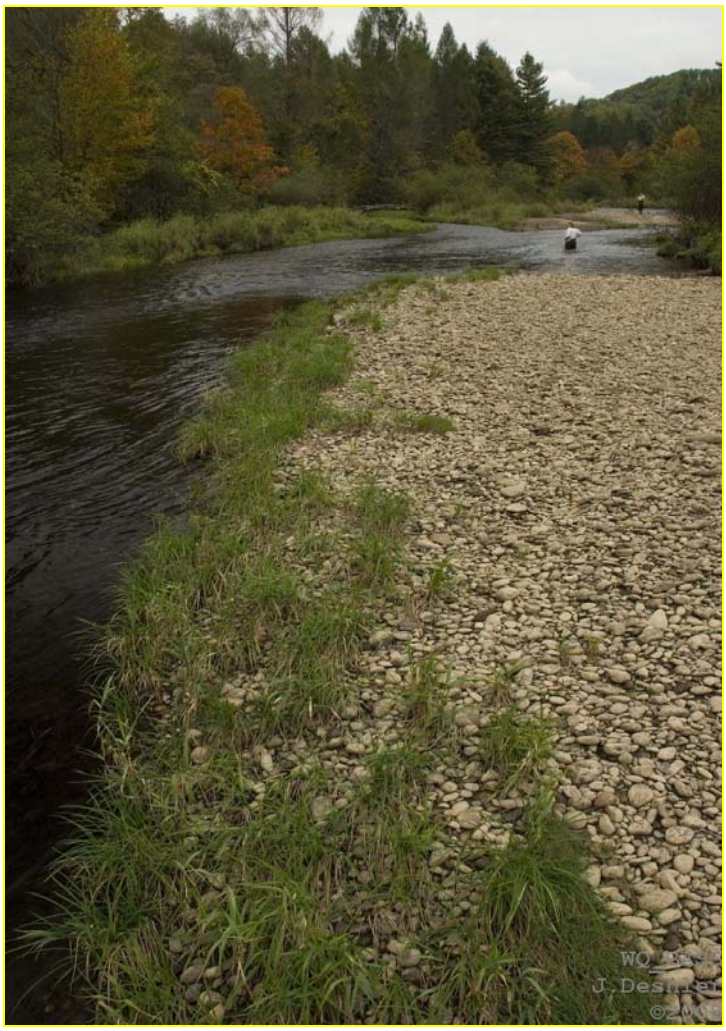
Aquatic Life Use Support Attainment of the Little River below Waterbury Reservoir January 2010



Location: Little River - river mile 2.2

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Background

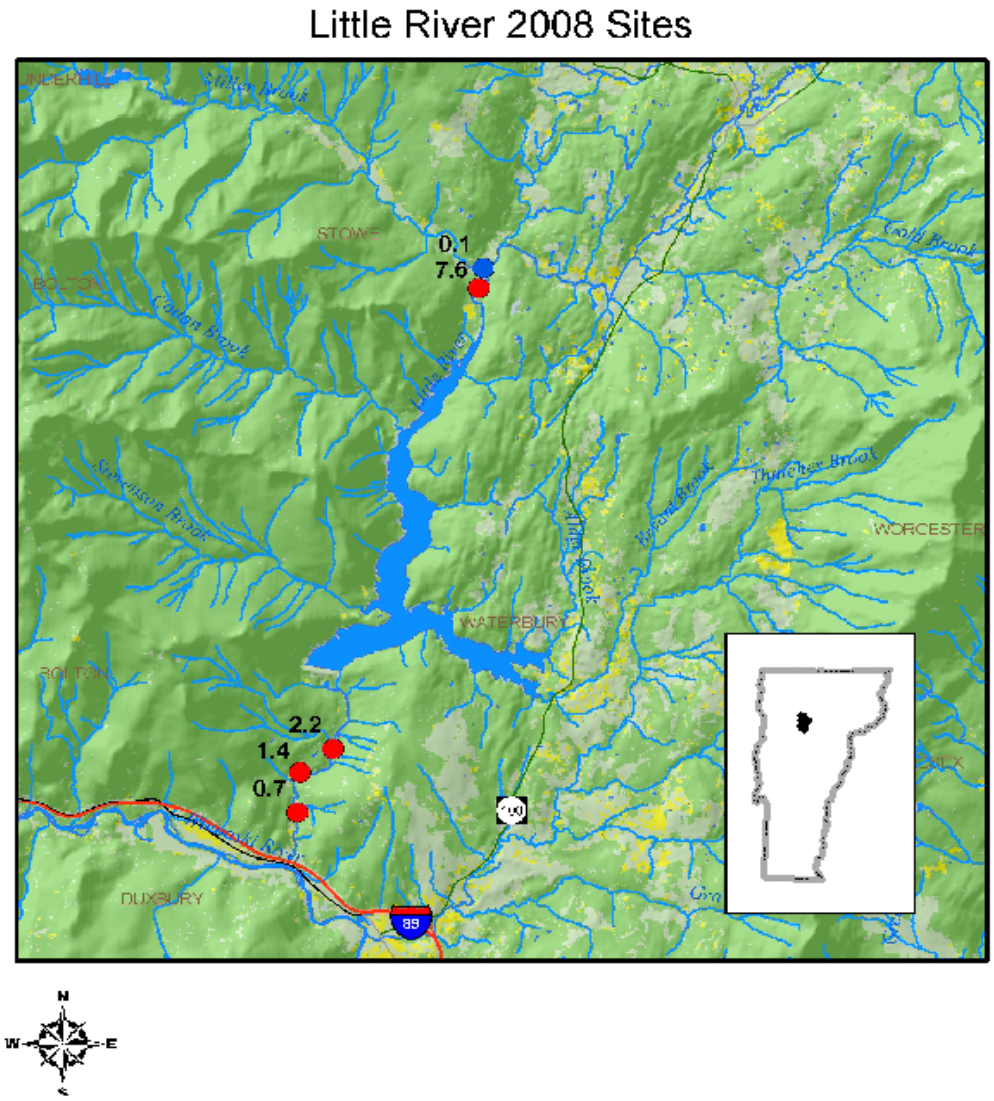
The Little River from its mouth to its headwaters is managed as Class B waters. The aquatic life use goal is high quality aquatic biota, with a narrative criteria of no more then a moderate change from "reference" condition. Peaking flow releases from the Waterbury Dam, located about 3.1 miles from mouth, have created rapid fluctuations in Little River discharge and water temperature, causing concern about the effects on downstream biota. This study evaluates the biological integrity of the aquatic biota within the permanently wetted stream perimeter (that portion of the river that is wetted during the lowest flows on a daily basis). The amount of habitat lost due to fluctuating stream flows is not assessed by this study. Habitat loss due to minimum flows will be assessed using the Instream Flow Incremental Methodology modeling (IFIM) and is not addressed in this report.

The macroinvertebrate reference stream type and associated biocriteria for the Little River below the Waterbury dam is a Medium High Gradient stream type (MHG). The fish community health was evaluated using the Mixed Water Index of Biological Integrity (MW IBI), both of these multi metric community assessments are outlined in the Wadable Stream Biocriteria Development and Implementation for Fish and Macroinvertebrate Assemblages in Streams and Rivers, 2004. Macroinvertebrate and fish assemblages were sampled at four locations in the Little River over two years 2008, and 2009 in accordance with VTDEC sampling protocols. In 2008 sampling, two locations - RM 0.7 and 2.2 were evaluated below the Waterbury Dam, with flows at 59 cfs and one, RM 7.6, upstream from the dam (see table and map). In 2009 the river was again sampled at RM 2.2 and RM 1.4, with flows at 16cfs. The sampling sites downstream of the Waterbury Dam were 0.9, 1.7, and 2.4 miles below the Dam. Miller Brook was also sampled for macroinvertebrates an additional local control reach. This location is the first Tributary above the Reservoir.

Table 1. Sample sites location information for the 2008-9 sampled reaches.

Location	River mile from Mouth (RM)	Miles below Dam	Latitude / Longitude (D.D°)	Drainage Area (km^2)	Elevation (ft)	Macroinvertebrate Stream Type
Little River	0.7	2.4	44.360000/ 72.77611	289	405	MHG
	1.4	1.7	44.36611 / 72.77556	288	425	MHG
	2.2	0.9	44.36972 / 72.76889	284	430	MHG
	7.6	Above reservoir	44.44028 / 72.73972	215	605	MHG
Miller Brook	0.1	1st tributary above reservoir	44.44333 / 72.73889	35	610	MHG

Figure 1. Sampling Sites



Results

Fish

RMs 0.7, and 2.2- Downstream of the Dam - 2008.

The station closest to the mouth, RM 0.7 (2.4 miles below dam), averaged 25 meters in width and was 94 m in length. This section contained one habitat cycle of riffle-run-pool. The middle third of the stream was not sampled because of gear limitations and the fact that mid-channel areas generally support fewer fish due to reduced cover and resting habitat. As often the case in larger, faster moving streams and rivers, the bulk of the habitat structure is located along the banks. Much of the pool in RM 0.7 was not sampled due to depth restrictions. The section contained large woody debris keyed into the banks which provided fish cover in a few locations. Riffle velocity was moderate and riffle depth was <0.5m. Substrate was dominated by gravel.

The RM 2.2 section length was 131 meters and the mean width was only 13m. The RM 2.2 site was predominately fast riffle with a single pool at the upstream end. The entire cross-section was fished from bank to bank.

Rivers of this size often exhibit riffle-run-pool habitat cycles that are very long. The RM 0.7 section was selected to contain as much variation in physical habitat as possible, but the relatively short 94 m section length may not have captured a fully representative picture of reach habitat conditions and therefore the assessment should be regarded as tentative. Few trouts were collected in this reach (two Brown, one Rainbow and no Brook trout). Despite the lack of significant representation by top carnivores (trouts), the MWIBI was 35out of a possible 45 (g*ood*) (see Table 3).

Only four species were collected at the RM 2.2 site. A total of 233 fish were collected, although relatively high discharge limited the ability to net all of the stunned fish with many being swept downstream before being captured. Again few trouts were collected. The MWIBI scored for this site was 37 (*Good*). This site is located above a physical barrier to upstream movement, possibly explaining the lack of species recorded at that site. A single dramatic discharge event could decimate the population between the gorge and the dam without the possibility of recolonization from downstream areas.

The intolerant coldwater-dependent, slimy sculpin, was the most abundant species at both sites. Native specialist-feeding species, numbers of expected number of species, and proportions as benthic insectivores, were recorded at levels indicative of least impaired sites in this size range.

RM 1.4 and 2.2 - 2009.

In 2009 a 204m section at RM 1.4 was sampled. This section was longer and deemed more habitat representative than the RM 0.7 reach sampled in 2008. The mean width was 10.7m. For most of the section the entire cross sectional area was fished. The site assemblage scored a MWIBI of 41 (v*ery* g*ood*). Again, as in 2008, trouts were poorly represented (9 brown trout, 2 brook trout and 2 rainbow trout). Total fish density based on the single electrofishing pass was low, but still above the density threshold that would have resulted in a non compliance with the Class B WQS.

The RM 2.2 fish collection from 2009 was similar to the 2008 sample. The MWIBI was scored at 37(*good*) with only four native species being recorded. Numbers collected in 2009 were higher than in 2008 when high flows limited collection efficiency. Again, only three trout were recorded from this site but in 2009, instead of brook trout, only rainbow and brown trout were collected.

Upstream of the dam - 2008. A single site was qualitatively sampled at RM 7.6. Only a species list was generated at this site. The river was very wide and shallow at this site with the exception of a very deep pool which could not be sampled with electrofishing gear. Specific habitat patches were sampled within a 600-meter section immediately downstream of the confluence with Miller Brook. The gradient was slight, with correspondingly fine substrate composed of fine gravel and sand; the two downstream sites were of higher gradient and larger substrate. Riffles and wadeable pools were sampled in proportion with the visible river reach. A total of 10 species (8 native) were collected. Only a single rainbow trout represented the top carnivore trophic level. Two benthic insectivore species and no native intolerant species were recorded. No firm comparison can be made of the fish data from this site and the two downstream sites since this was a qualitative sampling and the habitats differed in velocity and substrate particle size.

Table 2. Mixed Water Index of Biotic Integrity (MWIBI) metric raw values for fish assemblages. Values in bold are metric scores (1-poor, 3-fair to good, and 5-excellent). Total score is the sum of metric scores for all metrics. The range of this IBI is 9 (poor)-45 (excellent). [1] first value - total species richness, second value - native richness

Site (river mile) and date	**MWIBI**	Native Richness[1]	# Intolerant Species[1]	Native Benthic Insectivores	Creek Chub + White Sucker %	Generalist Feeder %	Insectivore %	Top Carnivore %	% Anomaly	Density # 100m2 1-run
0.7 (2008)	**35** (Good)	11 **(5)**	2 **(5)**	3 **(5)**	23 **(3)**	48 **(3)**	51 **(3)**	1 **(1)**	0 **(5)**	20.3 **(5)**
1.4 (2009)	**41** (Very Good)	10 **(5)**	4 (2) **(5)**	2 **(5)**	<1 **(5)**	3 **(5)**	94 **(5)**	3 **(1)**	<1 **(5)**	16.9 **(3)**
2.2 (2008)	**37** (Good)	4 **(1)**	3 (1) **(5)**	2 **(5)**	<1 **(5)**	<1 **(5)**	99 **(5)**	<1 **(5)**	<1 **(5)**	34.0 **(5)**
2.2 (2009)	**37** (Good)									
7.6 (2008)	**-**	9	1 (0)	2	-	-	-	-	-	-

Table 3. Fish species list for four sites on the Little River, 2008 and 2009 in order of proportion of total.

RM 0.7 (2008)	RM 1.4 (2009)	RM 2.2 (2008, 2009)		RM 7.6[1] (2008)
Slimy sculpin	Longnose dace	Slimy sculpin		Blacknose dace
White sucker	Slimy sculpin	Longnose dace		Longnose dace
Longnose dace	Blacknose dace	Blacknose dace		Bluntnose minnow
Common shiner	Brown trout	Brook trout		Tessellated darter
Lake chub	Creek chub	Rainbow trout	**D**	Creek chub
Blacknose dace	Lake chub	Brown trout	**A**	Fallfish
Tessellated darter	Brook trout	Creek chub	**M**	Rainbow trout
Creek chub	Fathead minnow			Brown bullhead
Brown trout	Fallfish			Smallmouth bass
Fallfish	White sucker			Pumpkinseed
Bluntnose minnow				
Brassy minnow				
Rainbow trout				

1. Sampled for presence-absence only, order not relevant.

Macroinvertebrates

The macroinvertebrate community was sampled in four stream reaches in 2008, and two in 2009 (see table 1, fig 1) to assess the effects of the Waterbury Hydro Dam Facility on the macroinvertebrate community of permanently wetted riffle habitats of the river. Three reaches at RM 0.7, 1.4 and 2.2 were located below the Waterbury Hydro Dam, 2.4, 1.7 and 0.9 miles below the dam respectively. Two local "reference" upstream (of Waterbury Dam) sites were also sampled RM 7.6 on the Little River and at RM 0.1 on the Millers Brook. All the stream locations are considered Medium High Gradient Streams, and as such all were assessed using the MHG stream type biocriteria.

The station closest to the mouth river mile 0.7 site was sampled once 2008; and data is also presented from the year 2000. Both events were scored "f*air to good*" (Table 4) indicating a moderate to greater then moderate change in community integrity. Community metrics were similar between the two dates except for density, which was lower in 2008. The EPT richness was very low during both samples, and is the primary cause for this site to have scored at the threshold of *good-fair* both years. Compared to the reference expectation the

decrease **in EPT species represents about a 25% loss**. Compared to both the upstream site on the Little River 7.6, and the off stream control on Miller Brook it represents a **36% loss in EPT taxa**. All other community metrics including both taxonomic order level composition and functional group composition were relatively similar to both the statewide reference expectation, as well as the upstream local control reaches.

Site RM 1.4 was assessed once in 2009, and rated as *very good-good*. The number of EPT taxa present at both sites sampled in 2009 was greater then that found in 2008. The number of EPT taxa present at this site was excellent in 2009. The reason for the *very good-good* rating was a shift in taxonomic composition toward more nutrient tolerant taxa as measured by the Bio Index value of 4.16. The abundance and species richness at the site were also moderate to high, which often can occur when minor shifts in functional feeding group composition occur, resulting in the occurrence of more functional taxonomic groups.

Table 4. The Macroinvertebrate community assessment and metric scores for the Little River and Miller Brook**.** Class B 2-3 (**Good**) ALS criteria for a MHG stream is the management goal for the Aquatic Biota. **Bolded** metrics are those most responsible for assessment determination.

Location	River Mile	Date	Assessment	Density	Richness	EPT	PMA-O	BI	% Olig	EPT/ EPT&C	PPCS-F
Little River	0.7	18-Oct-00	Good-**Fair**	2720	45.0	**17.0**	86	3.99	2.94	0.88	0.53
		30-Sep-08	**Good**-Fair	**632**	40.5	**18.0**	87	**4.24**	1.67	0.87	0.55
	1.4	01-Sep-09	VGood-**Good**	2364	44.0	26.0	77	**4.16**	0.2	0.81	0.63
	2.2	30-Sep-08	**Fair**	1588	33.0	**14.0**	76	3.87	1.90	0.94	0.50
		01-Sep-09	**Good**	3830	49.5	**19.5**	81	**4.51**	0.2	0.77	**0.43**
	7.6	30-Sep-08	Excellent-**Vg**	1932	54.0	27.0	83	**3.61**	2.28	0.73	**0.48**
Miller Brook	0.1	30-Sep-08	**Excellent**	2072	56.0	28.0	75	3.16	2.51	0.78	0.55
Medium High Gradient (MHG)			**Excellent** (A1)	> 500	> 43	> 24	> 65	< 3.50	< 2	> 0.65	> 0.50
			Very Good (B1)	> 400	> 39	> 22	> 55	< 4.00	< 5	> 0.55	> 0.45
			Good (B2-3)	> 300	> 30	> 18	> 45	<5.00	< 12	> 0.45	> 0.40

Site RM 2.2, was sampled in 2008 and again in 2009, it assessed as f*air* , below ALS Class B expectation, in 2008, and *good* in 2009. The EPT richness clearly failed to met Class B ALS criteria in 2008 but improved to a good number of EPT in 2009, indicating a moderate level of change or degradation. Only 14 EPT species were found in 2008 representing a **42% loss compared to the state wide reference expectation and a 49% loss compared to the immediate upstream local control sites**. The overall species richness at the site was also only in the *good* range. Compared to the upstream controls the **overall loss in species is about 40%.** In 2009 the loss of EPT species was 30% compared to the local reference stream sites RM 7.6, AND Millers Run RM 0.1. None of the other community metrics were found to be significantly degraded compared to the statewide expectation for MHG streams or compared to the local control locations In 2008. In 2009 the Bio Index value at the site was also moderately elevated. Similar to the lower sites when a moderate shift toward enrichment tolerant taxa occurred, the reach showed very high density and richness. This was again the case at RM 2.2 in 2009. The Tables 5 and 6 show the order level and functional group composition for the site and the MHG reference expectation. The order level composition show the Ephemeroptera are hyper dominant compared to reference expectation. This hyper dominance is primarily due to immature *Ephemerellidae* and *Ephemerella subvaria* both in 2008 and 2009 see Appendix 1. As a result the functional group composition is high in percent collector gatherers, and low in the percent scrappers, compared to both the reference expectation and the local control sites; which are actually high in scrappers compared to the reference model for MHG streams.

The local control reaches Site RM 7.6, located above the dam on the Little River was assessed as e*xcellent* to v*ery good,* easily meeting Class B criteria for all eight macroinvertebrate metrics. Miller Brook also was assessed as excellent with all eight community metrics with the reference range for the MHG stream type.

Table 5 . Percent composition of the major macroinvertebrate orders by site on all sampling dates for Little River and Miller Brook.

Location	River Mile	Date	Coleoptera	Diptera	Ephemeroptera	Plecoptera	Trichoptera	Oligochaeta	Other
Little River	0.7	18-Oct-00	3	14	45	3	31	3	1
		30-Sep-08	3	15	44	9	27	2	1
	1.4	01-Sep-09	3	20	19	54	4	<1	<1
	2.2	30-Sep-08	2	9	52	12	23	2	1
		01-Sep-09	2	24	25	45	1	<1	2
	7.6	30-Sep-08	5	26	40	5	20	2	1
Miller Brook	0.1	30-Sep-08	1	24	47	12	12	3	<1
MHG Model			6	18	34	8	33	0.5	0.5

Table 6. Percent composition of macroinvertebrate functional groups for sampling dates for Little River and Miller Brook.

Location	River Mile	Date	Collector/ Gatherer	Collector/ Filterer	Predator	Shredder/ Detritus	Shredder/ Herbivore	Scraper
Little River	0.7	18-Oct-00	41	29	5	1	1	3
		30-Sep-08	54	24	10	<1	2	7
	1.4	01-Sep-09	26	51	7	2	2	11
	2.2	30-Sep-08	58	22	15	1	2	2
		01-Sep-09	42	35	3	<1	4	5
	7.6	30-Sep-08	30	20	7	1	7	36
Miller Brook	0.1	30-Sep-08	26	13	15	1	2	43
MHG Model			32	30	13	4	1	13

Non - Temperature and Discharge Related Conditions

Table 7 presents habitat variables assessed at the time of macroinvertebrate sampling in 2008, and 2009. These include substrate composition, embeddedenss, silt rating, and periphyton cover indexes. These habitat observations show that the Little River below the Waterbury Dam is not stressed by high embeddedness (from sand packed into the substrate). The levels of embeddedness were comparable to the upstream control sites; while the amount of sand was lower. In 2009, despite an improvement in biological condition, the percent sand at both RM 1.4 and 2.2 was higher, which often indicates sediment stress. Embeddedness however remained very good, and no sediment biological response signatures were evident in the macroinvertebrate community structure. The two sites below the dam did have a significantly higher amount of silt entrained within the substrate as indicated by the higher silt rating at RM 0.7 and 1.4, compared to the upstream control sites. The canopy cover is relatively low at all sites (<35%), indicating that sunlight reaches the stream bed for extended periods of time and is not a limitation on periphyton growth. Despite this none

of the sites showed heavy periphyton growth. This maybe due to the frequent (almost daily) extreme high flow events in the river acting to scour off any accumulations of filamentous algae.

Table 7 . Physical habitat and periphyton assessments at Little River and Miller Brook sites.

Location	River Mile	Date	Embeddedness Rating (1 poor-5 exc)	Silt Rating (1 low-5 high)	Canopy %	Sand %	Gravel %	Coarse Gravel %	Cobble %	Boulder %	Moss Cover Index (0-10)	Macro Algae Cover Index (0-10)	Micro Algae Index (0-10)[1]
Little River	0.7	18-Oct-00	5	1	20	0	5	67	28				
		30-Sep-08	5	3	35	0	27	65	8	0	0.04	1.4	1.0
	1.4	01-Sep-09	4	2	20	16	21	59	3	1	1.1	0.9	0.9
	2.2	30-Sep-08	4	3	25	1	18	65	16	0	0.08	2.9	0.4
		01-Sep-09	4	2	25	16	21	59	3	1	0.0	0.7	0.9
	7.6	30-Sep-08	5	1	25	12	13	42	33	0	0.0	0.3	0.4
Miller Brook	0.1	30-Sep-08	4	1	10	12	16	30	41	1	0.2	2.6	0.5

1. Blue Green and Diatom Thickness

Table 8 presents water quality data collected at the time of biological sampling. These samples were collected during a non-hydro release base flow regime. These limited data show the river to be moderate in alkalinity, about 20mg/l, with a pH within an acceptable range, 6.5 -7.2 for all sites sampled. Dissolved Oxygen (D.O.) was also found to be within acceptable ranges to support aquatic life and Class B standards. The lowest reading was from RM 2.at 8.5mg/l, 91 percent saturation. All DO measurements were taken during mid day, during base flows. The macroinvertebrate and fish communities did not indicate D.O. as a likely stressor. Nutrients phosphorus and nitrogen were found to be low at all sites in 2008, and the macroinvertebrate community is also not indicative of a high nutrient stressed river. In 2009 total phosphorus was slightly elevated and the macroinvertebrate community showed a moderate level of compositional shifts. No metals or cations and anions, were found to be near Aquatic Life Criteria levels, indicating that the low EPT species found below the dam are not likely due to toxic levels of metals.

Table 8. Water quality measures from Little River and Miller Brook sites sampled collected at time of biological sampling. T=Total, D=dissolved (filtered).

Location	River Mile	Date	Time	Water Temp °C	pH stnd. units	Alk mg/L	Cond. umhos	Color Pt Co Units	DO mg/L	DO%	Turb. NTU	TSS. mg/L	Flow Type
Little River	0.7	10/18/2000		19									
		7/8/2004	1420	19.1	7.22	20.0		12.5	8.3	93.0	2.3	1.6	Base
		9/30/2008	0930	17.3	6.47	20.3	79.5	15	9.5	99.0	7.8	1.4	Base
	1.4	9/01/2009	1000	14.3	7.00	21.2	82.6	25	8.7	**85.2**	3.3	-	Base
	2.2	9/30/2008	1100	17.9	6.87	20.0	79.8	15	8.5	91.0	1.3	1.3	Base
		9/01/2009	1230	17.7	6.90	21.9	83.2	25	8.2	**86.3**	4.3	-	Base
	7.6	9/30/2008	1400	23.6	7.27	31.5	139.5	12.5	12.5	122.0	1.1	2.9	Base
Miller Bk	0.1	9/30/2008	1510	14.9	6.65	20.6	68.7	5	9.15	93.0	0.72	<1	Base

Table 8 Continued.

Location	River Mile	Date	Total P ug/L	Total Diss. P ug/g	Total Cl mg/L	Total SO4 mg/L	Total N mg/L	Total NOX mg/L
Little River	0.7	7/8/2004	10.0	4	6.8	8.07	0.16	0.15
		9/30/2008	9.6	< 5	7.6	5.69	0.24	0.07
	1.4	9/01/2009	9.7	5.8	7.2	6.15	0.36	0.24
	2.2	9/30/2008	8.5	6.1	7.7	5.82	0.28	0.07
		9/01/2009	23	6.7	7.4	6.00	0.35	0.25
	7.6	9/30/2008	9.6	6.9	16.1	9.03	0.22	0.13
Miller Bk	0.1	9/30/2008	<5	<5	3.9	6.25	0.1	0.08

Location	River Mile	Date	Diss Ca mg/L	Total Ca mg/L	Diss Mg mg/L	Total Mg mg/L	Diss. Na mg/L	Total Na mg/L	Diss K mg/L	Total K mg/L	Diss Al ug/L	Total Al ug/L	Total Hardness	Total Hardness from totals
Little River	0.7	7/8/2004	7.84		1.37		4.21		0.47		12		25.2	
		9/30/2008		8.14		1.39		5.16		0.58		19		26
	1.4	9/01/2009		8.45		1.55		4.95		0.56		26		27.5
	2.2	9/30/2008		8.14		1.39		5.25		0.58		25		26
		9/01/2009		8.74		1.57		5.05		0.59		29.9		28.3
	7.6	9/30/2008		13.5		2.42		10.4		0.86		20		43.6
Miller Bk	0.1	9/30/2008		7.82		1.3		3.12		0.48		16		24.9

Location	River Mile	Date	Diss. As ug/L	Total As ug/L	Diss. Cd ug/L	Total Cd ug/L	Diss. Cr ug/L	Total Cr ug/L	Diss. Cu ug/L	Total Cu ug/L	Diss. Fe ug/L	Total Fe ug/L	Diss. Pb ug/L
Little River	0.7	7/8/2004	< 1		< 1		< 5		< 10		73.5		< 5
		9/30/2008		< 1		< 1		< 5		< 10		113	
	1.4	9/01/2009		<1		<1		<5		<10		**374**	
	2.2	9/30/2008		< 1		< 1		< 5		< 10		98.1	
		9/01/2009		<1		<1		<5		<10		**474**	
	7.6	9/30/2008		< 1		< 1		< 5		< 10		237	
Miller Brk	0.1	9/30/2008		<1		<1		<5		<10		<50	

Location	River Mile	Date	Total Pb ug/L	Diss. Mn ug/L	Total Mn ug/L	Total Ni ug/L	Diss. Zn ug/L	Total Zn ug/L
Little River	0.7	7/8/2004		44.5			< 10	
		9/30/2008	< 1	47.8		< 5		< 50
	1.4	9/01/2009	<1		**452**	<5		<50
	2.2	9/30/2008	< 1	41.8		< 5		< 50
		9/01/2009			**741**	<5		<50
	7.6	9/30/2008	< 1	63.6		< 5		< 50
Miller Bk.	0.1	9/30/2008	<1		<5	<5		<50

Discussion - Potential Temperature and Discharge Stressors

The macroinvertebrate community at RM 2.2, about 0.9 miles below the Waterbury Dam, was found to be in *fair* condition in 2008, and *good* condition in 2009. In 2008 the impaired condition was due to very low numbers of water quality-sensitive EPT species; the overall number of species present was also low but within the *good* range. In 2009 the good condition was due to a shift in community composition toward nutrient-tolerant taxa. The difference in the macroinvertebrate community taxa richness between the two years could be due to the flow regimes between the two years (see **table 9**). In 2008 an extreme high flow event occurred in July with flows twice that of any in 2009. An extreme high flow event likely had a severe scour effect on the macroinvertebrate community in 2008, resulting in very low EPT richness values. At RM 0.7, about 2.3 miles below the dam, the community showed partial recovery in 2008 to a *good-fair* condition. The 2008 assessments indicate that for 1 - 2 miles below the dam, the Little River is below Class B WQS for aquatic biota - macroinvertebrates.

Table 9 Flows at time of sampling, and flow ranges one and three months previous to sampling.

Flows cfs	9/30 2008	9/1 2009	Sept 2008 1 month	July-Sept 2008 3 months	April-May 2008 yoy	Aug 2009 1 month	June-Aug2009 3 months	April-May 2009 yoy
Mean	59.4	15.6	39	418	519	134	251	566
Min	-	-	21	20	11	13	13	13
Max	-	-	576	3528	1770	672	1002	1733
Range	-	-	555.1	3508	1758	660	989	1720

The assessments using the MWIBI for the fish assemblage downstream from the Waterbury Dam were representative more of habitat -water quality than habitat -water quantity. The conventional IBI may not effectively capture the extent of impact due to peaking operations of hydroelectric generation facilities. While IBI scores did reflect lower than expected total density and a depauperate top carnivore trophic level, those departures did not cause the MWIBI to drop to a level of non compliance with the Class B Std. It appears that the effects of sudden artificially high flows exerted on a daily basis are manifested on the fish community such that fish species that are most tolerant of this condition also score *positively* in the MWIBI. This phenomenon was also observed downstream of the Taftsville facility in a 1985 study. The mechanical force of increased flow has the potential to displace smaller fishes including the young of larger species-especially when the increases happen quickly. Larger, stronger swimming fish and those species that are negatively buoyant (having reduced or no gas bladders) should be more able to hold position or seek suitable refuge and therefore be more resistant to increased flows.. The two most frequently collected species at sites below the dam – slimy sculpin and longnose dace - are benthic fish, the former with no gas bladder and the later, with a much reduced one. They are both specialist feeders and the sculpin is also classified intolerant – both characteristics that score *positively* in the index. In this case the traits of being benthic specialists actually *increase* their likelihood of survival. Consequently in this instance they could be considered as *tolerant* to flow related impact. Species that have more developed gas bladders and primarily inhabit pools, such as creek chub and blacknose dace are underrepresented in the samples below the dam. These species, considered as *tolerant* to most environmental stresses, appear to be *intolerant* to peaking flows. Since larger fishes are generally more able to hold ground in high flows, the lack of higher numbers of trout may be related to the effects on younger, smaller individuals which presumably are not able to successfully hold their ground in the face of rapidly increasing discharges on a daily basis. This would result in poor recruitment rates to larger sizes.

Temperatures taken during biological sampling show that the sites below the dam (RM 0.7, 1.4 and 2.2) had lower water temperatures (17-18^0 C). Site RM 7.6, upstream from the dam, showed a temperature of 23^0 C during sampling. Water temperature logger data from 2003 indicated somewhat higher than expected daily variation. .Data from two other non regulated coldwater Vermont rivers showed an average daily range of 2.8^0 C with a maximum daily change of 5.6^0 C during the month of August. The Little River showed a sustained period of over two weeks of daily variation ranging between 4.5 and 6.1^0 C. The remaining daily variations for August in the Little River were nearer that of the two other Vermont rivers. Water temperature exceeded 20 ^{0} over approximately 20 % of the hourly measurements between August 14 and October 1. The

mean temperature exceedance over 20^0 was 1.5^0, with a maximum of 5^0 C exceedance. The moderately greater daily variation in temperatures below the dam accompanied abrupt daily changes in discharge.

Temperature data from 2003, however may not have been representative of operating conditions under full reservoir pool. The reservoir had been drawn down for maintenance, affecting the depth of water from which the release was taken. Water temperature would have theoretically been lower than what was observed in 2003 because the depth from which the water was taken would have been deeper into the hypolimnion. It is recommended that temperature monitors be placed into the Little River below the dam during the spring and summer of 2010 to measure current thermal conditions in that reach.

Conclusions

Biological data collected from the Little River downstream from the Waterbury Dam in 2008-2009 indicated that macroinvertebrate and fish communities were undergoing stress. The macroinvertebrate community at RM 2.2 failed to meet Class B criteria in 2008 and narrowly met criteria in 2009. The degradation is due to a loss of taxa of 40 - 50%, most likely due to high flow scour. Fish community assessments showed consistent compliance with the Class B WQS. These results are more indicative of conditions in the wetted area water *quality*, and to some extent *velocities* of the river rather than effects of water *quantity*. The effects of water quantity could not be fully assessed using the conventional approaches that were applied. It is recommended that assessing aquatic habitat loss and evaluation of recreational fishery (trout populations) that is supported by "high quality habitat" consistent with the Class BWQS be evaluated using the Instream Flow Incremental Methodology.

Appendix 1: Dominate (>2%) Macroinvertebrate taxa from RM sites on the Little River, above and below Waterbury Dam. Data from 2008 and or 2009 KN samples VTDEC.

RM 0.7 - 2008			RM 1.4 - 2009			RM 2.2 – 2008 & 2009				RM 7.6 - 2008		
Genus	Species	%	Genus	Species	%	year	Genus	Species	%	Genus	Species	%
EPHEMERELLA	*subvaria*	*23*	*SYMPHITOPSYCHE*	*slossonae*	*32*	*2008*	*EPHEMERELLIDAE*	*imm*	*39*	*ACENTRELLA*	*turbida*	*27*
EPHEMERELLIDAE	*imm*	*16*	*SYMPHITOPSYCHE*	*sp*	*8*	*2009*	*EPHEMERELLIDAE*	*imm*	*22*	*RHITHROGENA*	*sp*	*6*
SYMPHITOPSYCHE	*slossonae*	*7*	*SYMPHITOPSYCHE*	*sparna*	*8*	*2009*	*SYMPHITOPSYCHE*	*slossonae*	*17*	*SYMPHITOPSYCHE*	*sparna*	*6*
SYMPHITOPSYCHE	*morosa*	*7*	*EPHEMERELLA*	*sp*	*7*	*2008*	*EPHEMERELLA*	*subvaria*	*11*	*SYMPHITOPSYCHE*	*morosa*	*5*
SYMPHITOPSYCHE	*bronta*	*5*	*TVETENIA*	*bavarica*	*6*	*2008*	*SYMPHITOPSYCHE*	*slossonae*	*11*	*CRICOTOPUS/ORTHOCLAD*	*sp*	*5*
ISOPERLA	*sp*	*4*	*MICROPSECTRA*	*sp*	*5*	*2008*	*ISOPERLA*	*sp*	*10*	*TVETENIA*	*bavarica*	*5*
POLYPEDILUM	*aviceps*	*4*	*PLAUDITUS*	*sp*	*5*	*2009*	*HYDROPTILA*	*sp*	*9*	*SYMPHITOPSYCHE*	*slossonae*	*5*
SYMPHITOPSYCHE	*sparna*	*4*	*POLYPEDILUM*	*aviceps*	*3*	*2009*	*SYMPHITOPSYCHE*	*sparna*	*7*	*OPTIOSERVUS*	*sp*	*3*
AGNETINA	*capitata*	*2*	*HEXATOMA*	*sp*	*2*	*2009*	*TVETENIA*	*bavarica*	*7*	*TVETENIA*	*vitracies*	*3*
HYDROPTILA	*sp*	*2*	*OULIMNIUS*	*latiusculus*	*2*	*2009*	*SYMPHITOPSYCHE*	*sp*	*7*	*SYMPHITOPSYCHE*	*bronta*	*3*
ANTOCHA	*sp*	*2*	*ACENTRELLAPLAUDITUS*	*sp*	*2*	*2008*	*SYMPHITOPSYCHE*	*morosa*	*5*	*EUKIEFFERIELLA*	*devonica*	*2*
CHEUMATOPSYCHE	*sp*	*2*	*CRICOTOPUS*	*spa*	*2*	*2009*	*PAGASTIA*	*sp*	*3*	*EUKIEFFERIELLA*	*claripennis*	*2*
STENELMIS	*sp*	*2*	*SYMPHITOPSYCHE*	*morosa*	*2*	*2008*	*SYMPHITOPSYCHE*	*sparna*	*3*	*EUORTHOCLADIUS*	*sp*	*2*
LUMBRICULIDAE	*unid*	*2*	*EPHEMERELLIDAE*	*imm*	*1*	*2009*	*ANTOCHA*	*sp*	*3*	*NAIDIDAE*	*unid*	*2*
CRICOTOPUS	*spa*	*1*	*RHYACOPHILA*	*acutiloba*	*1*	*2009*	*MICROPSECTRA*	*sp*	*2*	*POLYPEDILUM*	*aviceps*	*2*
CHLOROPERLIDAE	*imm*	*1*	*LEUCTRA*	*sp*	*1*	*2009*	*CRICOTOPUS*	*spa*	*2*	*HEXATOMA*	*sp*	*1*
ACENTRELLA	*turbida*	*1*	*ISOGENOIDES*	*sp*	*1*	*2009*	*SYMPHITOPSYCHE*	*morosa*	*2*	*EPHEMERELLA*	*subvaria*	*1*
OULIMNIUS	*latiusculus*	*1*	*SYMPHITOPSYCHE*	*bronta*	*1*	*2008*	*CRICOTOPUS/ORTHOCLAD*	*sp*	*2*	*ACENTRELLAPLAUDITUS*	*sp*	*1*
ORTHOCLADIUS	*sp*	*1*	*BAETIS*	*flavistriga*	*1*	*2009*	*CRICOTOPUS*	*trifascia*	*2*	*STENONEMA*	*sp*	*1*
PLAUDITUS	*dubius*	*1*	*BAETIS*	*tricaudatus*	*1*	*2008*	*SYMPHITOPSYCHE*	*bronta*	*2*	*CHLOROPERLIDAE*	*imm*	*1*
HEXATOMA	*sp*	*1*	*BAETIS*	*intercalaris*	*1*	*2008*	*NAIDIDAE*	*unid*	*2*	*AGNETINA*	*capitata*	*1*