2008 Water Quality Monitoring
Winooski Headwaters

Background

In 2008, for the second year, the Cabot Conservation Committee and the Marshfield and Plainfield Conservation Commissions joined together to support a volunteer water quality monitoring program in their towns. The study area is the Winooski River mainstem and the tributaries in the three towns. Although there is some water quality data available for selected locations within the study area, more information is needed:

- to document water quality conditions for aquatic life support including an important locality for the State threatened eastern pearlshell mussel (*Margaritifera margaritifera* Linn.);
- to support the State of Vermont's Winooski River Basin Planning Initiative;
- to provide baseline data to assess long-term changes to water quality in the river system; and
- to address public concerns about the risk of contact recreation associated with potential contaminants in the waters.

Site Selection

In both 2007 and 2008, ten basic water quality parameters were monitored at twelve sites once a month from June through October in the study area. In 2008 five of these sites were on the main stem at sites also sampled in 2007. Seven sites were located on Tributary streams. With the exception of Great Brook and Naismith Brook, a different set of tributaries were sampled in the two study years- with intensions of determining the significant contaminant contributing tributaries. The monitoring of the Jug Brook, Marshfield Brook and Molly's Brook in 2007 did not reveal any potential issues. Therefore, a number of different tributaries (Wells Brook, King/Guernsey Brook, Beaver Meadow Brook, Creamery Stream and Cabot Plains Brook) were monitored in 2008.

In comparison to the tributaries, the mainstem exhibited elevated levels of *E. coli in* 2007. Therefore in 2008 *E. coli* was sampled only on the main stem at ten sites, on a bi-weekly basis from June through early September. These sites were selected based on the likelihood of public contact (swimming holes, fishing spots, etc.) and to bracket potential pollution sources. These bacteria sites overlap with some of the water quality sampling sites, while some were sampled solely for the bacteria parameter.

Summary of Results

Appendix A has a summary of all sampling sites for both years. *E.Coli* bacteria continues to be chronically high ~~i~~ within the Winooski River mainstem and Great Brook subwatershed. Overall the water quality was found to be very good; however under high flows particular tributaries- Wells Brook, Great Brook, King Brook, and Beaver Meadow- were ~~also~~ identified as contributing Total Suspended Solids and consequently elevated levels of Turbidity and Total Phosphorus. Additional sampling, and or stream corridor surveys to identify the contaminant sources is recommended.

Water Quality Parameters

As noted above, the twelve water quality sites were tested for ten basic water quality parameters. Following is a brief excerpt of each parameter and its significance from the Vermont Volunteer Surface Water Monitoring Guide. For more information, you can view the full manual at: www.vtwaterquality.org/lakes/htm/lp_monitoringguide.htm

Temperature (ºC): Aquatic organisms, from microbes to fish, are dependent on certain temperature ranges for their optimum health. If temperatures are outside this optimal range for a prolonged period of time, organisms are stressed and can die. Both brook trout and the eastern pearlshell mussel prefer cold waters, and do best if temperatures do not exceed 16^0 C.

pH: pH is a measure of the hydrogen ion concentration, or acidity of water. The pH is not an indicator of a particular pollutant; however, it affects many chemical and biological processes in water. For example, low pH can allow toxic elements and compounds to become mobile and "available" for uptake by aquatic plants and animals causing the death of many organisms. This can disrupt the food chain and affect higher level organisms.

Conductivity: Conductivity estimates the amount of dissolved ions in the water. Conductivity is influenced by the size of the watershed and the geology. There are a number of pollution sources that may be signaled by increased conductivity. Wastewater from sewage treatment plants and septic systems, urban runoff from roads and agricultural runoff can all contribute to increased conductivity within a water body.

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Dissolved oxygen (%sat, and mg/l): Water contains oxygen in the form of a dissolved gas, which most aquatic organisms use to breathe. Dissolved oxygen (DO) is the measure of the concentration of the gas dissolved in water. All aquatic organisms have an optimal range of DO for functioning. Some require very high levels in order to flourish, and at low DO concentrations, sensitive animals may move away, weaken, or die.

Alkalinity (mg/l): Alkalinity is a measure of the calcium carbonate, buffering (or acid neutralizing) capacity of the water. Alkalinity is generally not a harmfull pollutant itself. It is often used as a measure of the sensitivity of a waterbody to acid rain. Streams with moderate levels of alkalinity are often more biologically productive and can support higher numbers of trout.

Total Suspended Sediment: (only if waters appear turbid), TSS is an important parameter to consider if you suspect sediment and water clarity issues. The total suspended solids (TSS) parameter is measured in milligrams per liter (mg/L), the mass of solids per unit volume of water.

Turbidity: Turbidity is a measure of light scattering properties of suspended materials. In theory, the more suspended material that exists, the more light scattering (turbid), and hence the less transparent. Turbidity data can reveal problems with water clarity and/ or suspended sediment in streams and rivers. Turbidity is reported in Nephelometric Turbidity Units (NTU).

Total phosphorus (TP) (ug/l): Phosphorus is also an essential plant and animal nutrient and is the nutrient of greatest concern in eutrophication (nutrient enrichment). It is in most cases the "limiting nutrient," meaning it is the one most likely to restrict plant growth because of its naturally low levels in the environment. Thus, even small increases in phosphorus loads to a waterbody can cause large algal blooms and excessive plant growth. This rapid increase in biological activity may disrupt the ecological balance of surface waters.

Total nitrogen (TN) (mg/l): Nitrogen is an essential plant and animal nutrient that naturally occurs in numerous forms in surface water. High concentrations of any form of nitrogen in a waterbody may indicate that pollutants from animal manure, sewage, or fertilizers applied to land are making their way into the water via runoff. The VTDEC has found that adverse impacts to aquatic life maybe seen for TN at concentrations above 0.75 mg-N/l.

Chloride (mg/l): Chloride is an ion that is released into surface waters through the breakdown of salt compounds. It is a naturally occurring mineral at very low levels in Vt. Levels above 5 mg/l in surface waters may be attributed to winter road maintenance practices and or to animal or human waste water. Levels consistently above 230 mg/l may cause harm to aquatic life. In addition to negatively impacting water quality, chloride in large concentrations can be corrosive; cause damage to vegetation; and enter the drinking water supply, causing discoloration, foul taste and odor.

E.coli*:* Fecal bacteria are a particular group of bacteria primarily found in human and animal intestines and wastes. *Escherichia coli* (*E. coli*) is one of the fecal coliform bacteria widely used as indicator organisms to show the presence of such wastes in water and the possible presence of pathogenic (disease-producing) organisms. When *E. coli* is found in waters, its presence is not the problem of concern itself but is used rather as an indicator of fecal contamination (most strains of *E. coli* are not pathogenic) from humans or animals is present. *E. coli* monitoring is commonly conducted to ensure that the water is safe for swimmers; to establish a relationship between rainfall, bird migration migration or other wildlife activity and *E. coli* levels; and to identify pollution sources (e.g., septic system failure, failing manure pit) in a watershed. The bacteria is measured in organisms or colony-forming units per 100 milliliters of water (cfu/100 mL). Vermont's Class B water quality standard sets the maximum tolerable *E. coli* level at 77 colonies per 100 ml of sampled water. This is a very conservative standard and that translates into a potential risk of contracting a gastero illness of 4 people in a 1,000 after ingestion of water.

Water Quality Parameters Results and Discussion

On the following pages are a few highlights of the testing. More detailed results are available in Appendix A.

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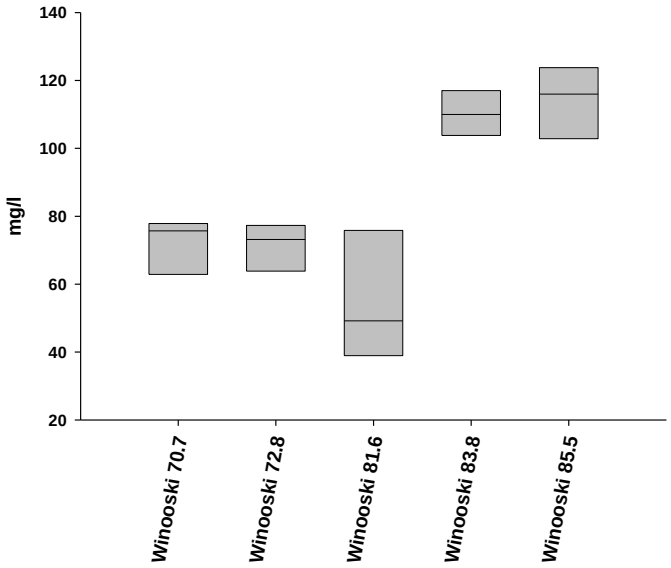
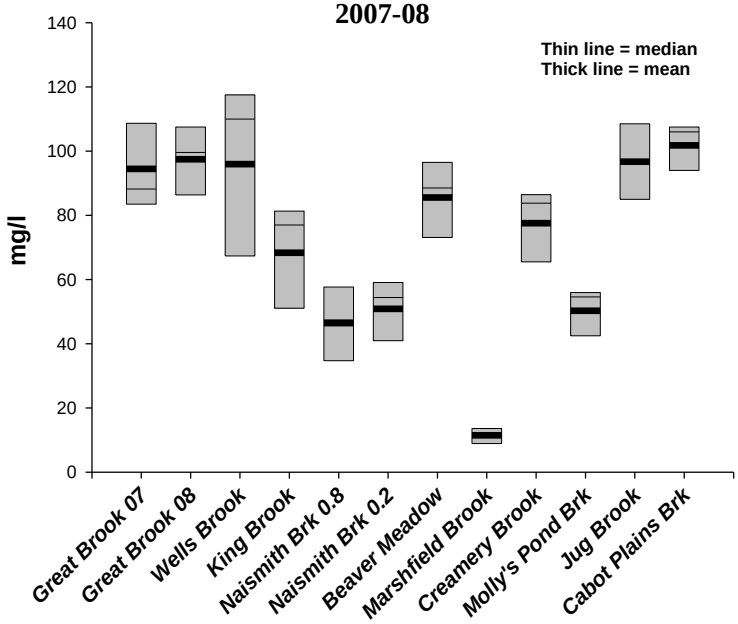
Alkalinity is a measure of the calcium carbonate buffering in water. Streams with alkalinity <10 mg/l are sensitive to acid precipitation. Streams with alkalinity 20-50 are moderately buffered. Streams with alkalinity >50 are highly buffered. The higher alkalinity readings of the further upstream reaches are likely due to the calcium-rich bedrock material of the majority of the Headwaters region. The tributaries originating in the eastern portion -closer to Groton area- are more granitic in character and consequently lower calcium carbonate readings. Often times, high alkalinity stream are also high in nutrients. Conversely low alkalinity streams have low buffering capacity and could be low productivity streams and more sensitive to low pH rainfall. Marshfield Brook maintained the lowest alkalinity reading and could be continually monitored.

Alakalinity from the Upper Winooski River
2008



Alkalinity of Tributaries
from the Upper Winooski Watershed
2007-08



2008 Water Quality Monitoring
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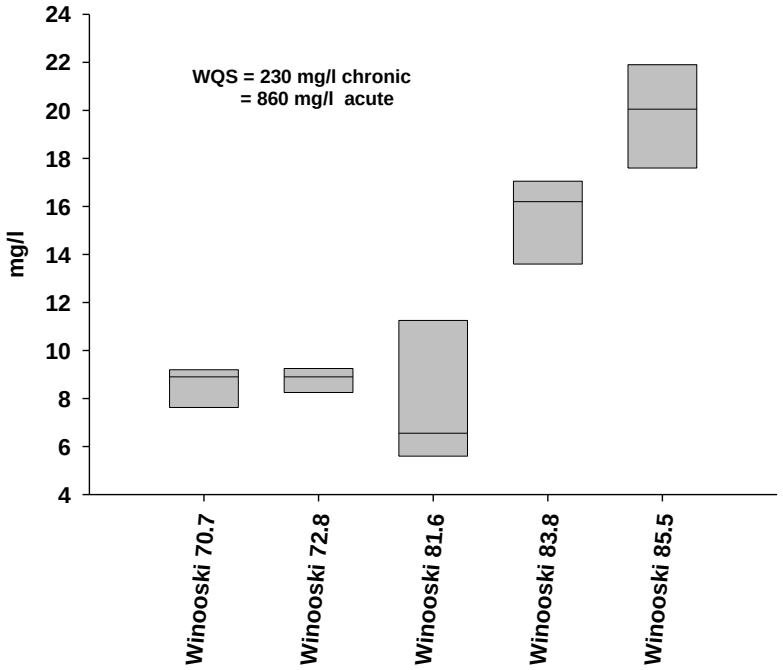
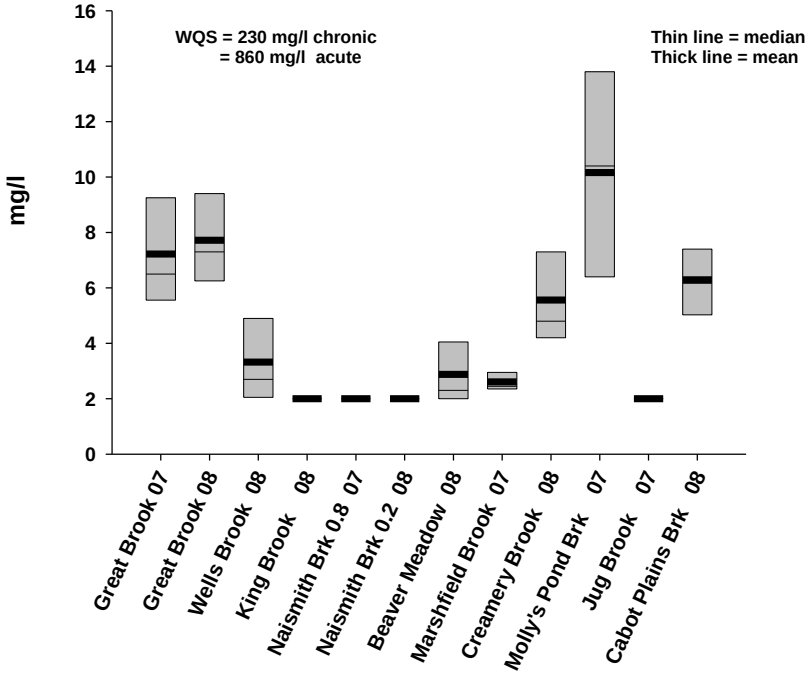
Figure showing **Chloride concentrations** at site in upper Winooski River and Tributaries.
EPA guidance Aquatic Life Criteria - Acute 860mg/l, Chronic 230 mg/l. Based on the two sampling years, no significant chloride problems were identified in the Headwaters region- within the mainstem or tributaries.

Chloride from the Upper Winooski River
2008



Chloride of Tributaries
from the Upper Winooski Watershed
2007-08



2008 Water Quality Monitoring
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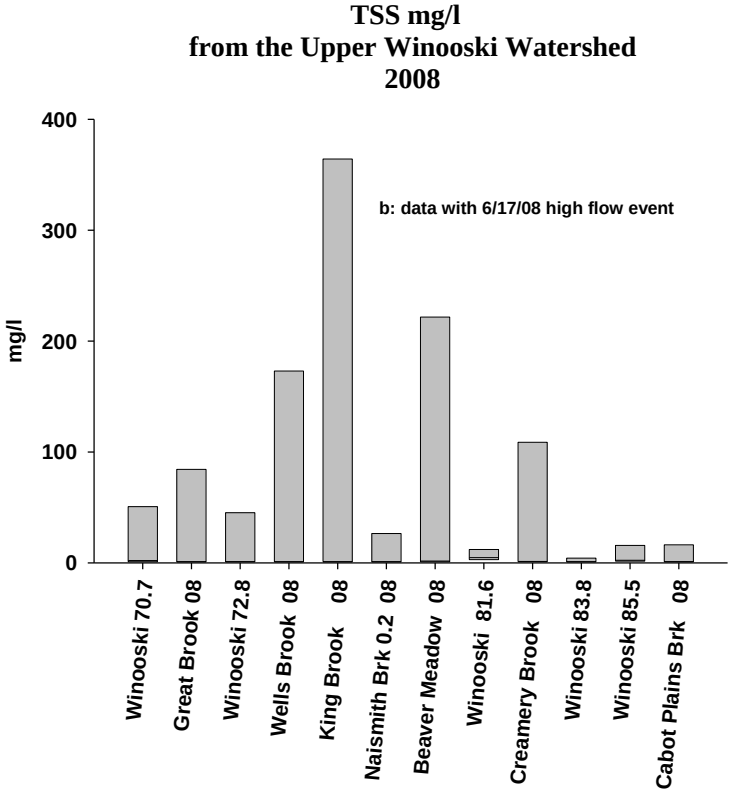
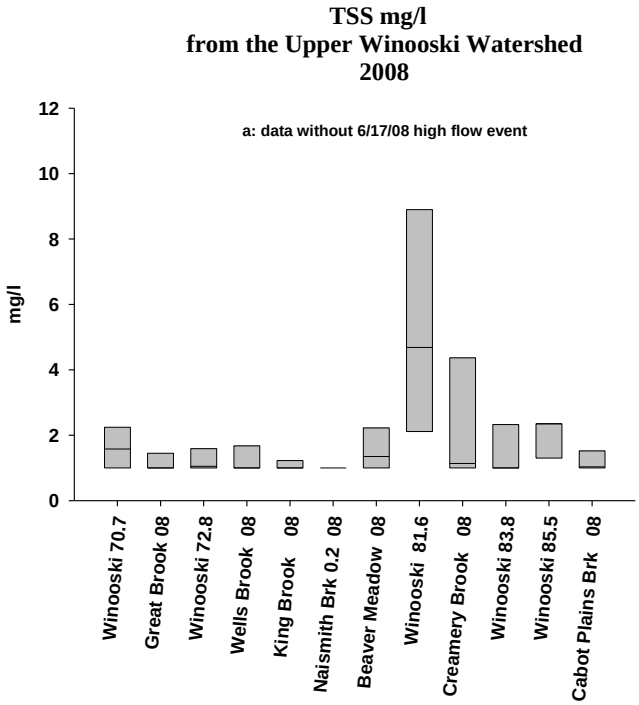
Total Suspended Sediment: (only if waters appear turbid), TSS is an important parameter to consider if you suspect sediment and water clarity issues. The total suspended solids (TSS) parameter is measured in milligrams per liter (mg/L), the mass of solids per unit volume of water. This parameter focuses on the particles that are available due to larger storm events and therefore can indicate streams experiencing streambank erosion and system instability. The Wells Brook, King Brook, and Beaver Meadow tributaries each maintained high TSS levels- likely as a result of the 6/17/08 storm event- and should be explored for streambank erosion issues.



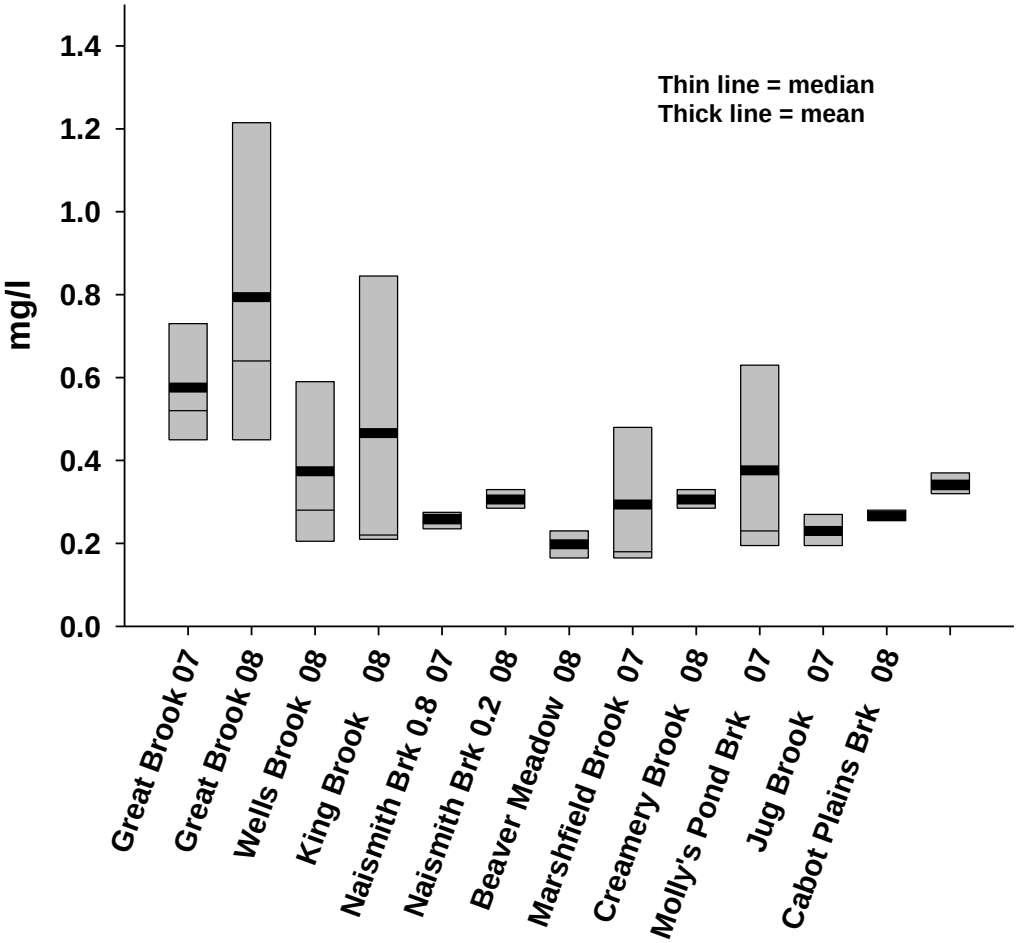


2008 Water Quality Monitoring
Winooski Headwaters

Total nitrogen (TN) Nitrogen is an essential plant and animal nutrient that naturally occurs in numerous forms in surface water. High concentrations of any form of nitrogen in a waterbody may indicate that pollutants from animal manure, sewage, or fertilizers applied to land are making their way into the water via runoff.

TN levels on the Winooski mainstem were all below the state standard of concern. The median TN level on Great Brook 2008 sampling site was above 0.7 mg-N/l, determining Nitrogen sources should be explored in this tributary. The 2008 sampling site on Great Brook is located directly below the Town of Plainfield and septic system problems have been discussed as a potential TN source.

TN mg n/l of Tributaries
from the Upper Winooski Watershed
2007-08



2008 Water Quality Monitoring
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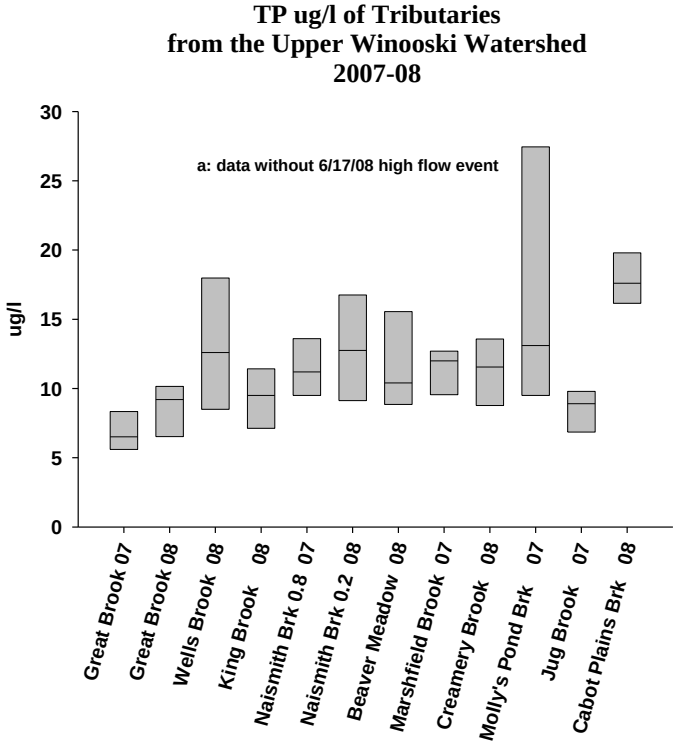
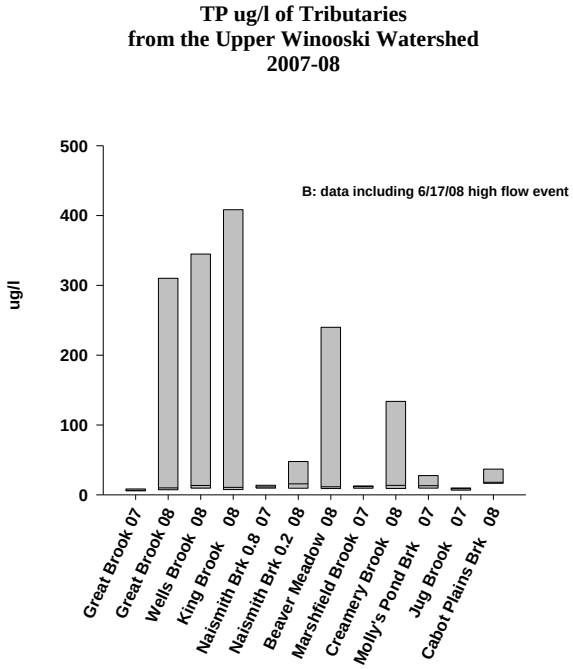
Total phosphorus (TP) Phosphorus is also an essential plant and animal nutrient and is the nutrient of greatest concern in eutrophication (nutrient enrichment). It is in most cases the "limiting nutrient," meaning it is the one most likely to restrict plant growth because of its naturally low levels in the environment. Thus, even small increases in phosphorus loads to a waterbody can cause large algal blooms and excessive plant growth. This rapid increase in biological activity may disrupt the ecological balance of surface waters.

Typical Vermont base flow levels fall below the criteria of 35 ug/l. The following tributaries sampled in 2008 did demonstrate readings above the criteria: Great Brook; Wells Brook; King Brook; Beaver Meadow Brook; and Creamery Brook. Each of these could be considered for subsequent sampling- in an effort to identify the likely source.





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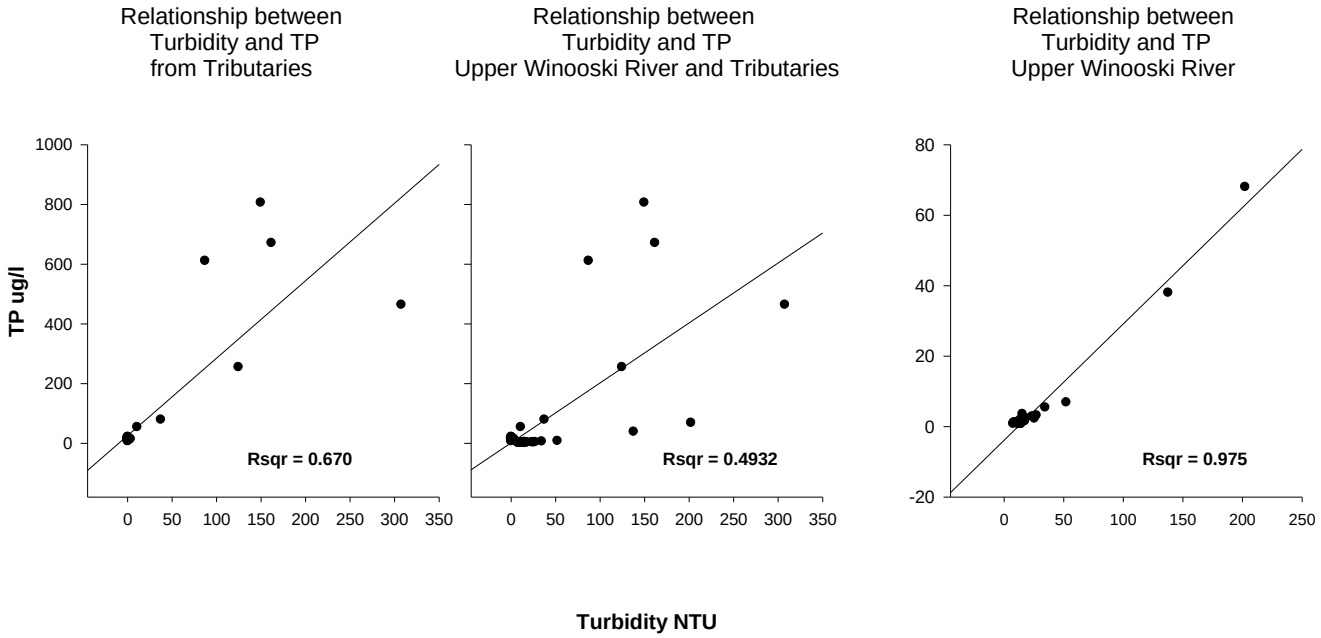
Turbidity is a measure of the clarity of water and is used to indirectly measure total suspended solids. The Aquatic Life Criteria for Class B Cold water habitat is 10 NTU.

In general, the 2008 sampling determined higher Turbidity levels lower in the watershed. Direct relationships can also be identified between Total Phosphorus and Turbidity due to the particulates (often sediment carrying Phosphorus) found within the stream system.



2008 Water Quality Monitoring
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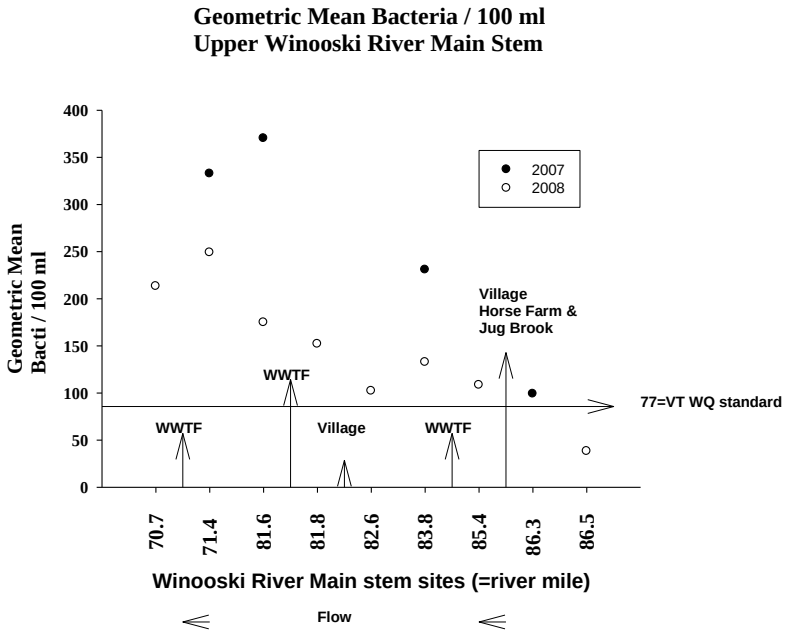
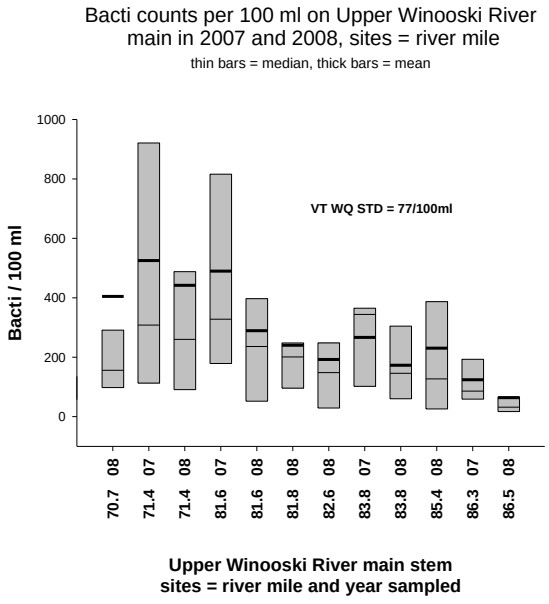
Bacteria *(E. coli)* Results and Discussion

E.coli concentrations at site in upper Winooski River and Tributaries.
VTDEC Class B criteria 77/100ml (<4 in 1000 risk), EPA 235/100ml (8 in 1000 acceptable risk)
The geometric mean reduces the influence of very high and very low numbers on the average. The EPA standard for geometric mean is 126/100ml (8 in 1000 risk).

Based on 2007 and 2008 sampling results of mainstem sites, bacteria levels exceed either the Vermont or the Federal EPA water quality standards on all sites except Upper Cabot- below the upper recreational fields in town. Based on the location of the mainstem sampling sites it appears *E.coli* bacteria loading may be coming from the following locations: 1) Jugg Brook; 2) Creamery Street in Marshfield; and 3) Plainfield village. The largest spikes were observed in 2007 downstream of the Marshfield wastewater treatment facility and following rain events in lower sections of the sampling area- Plainfield.





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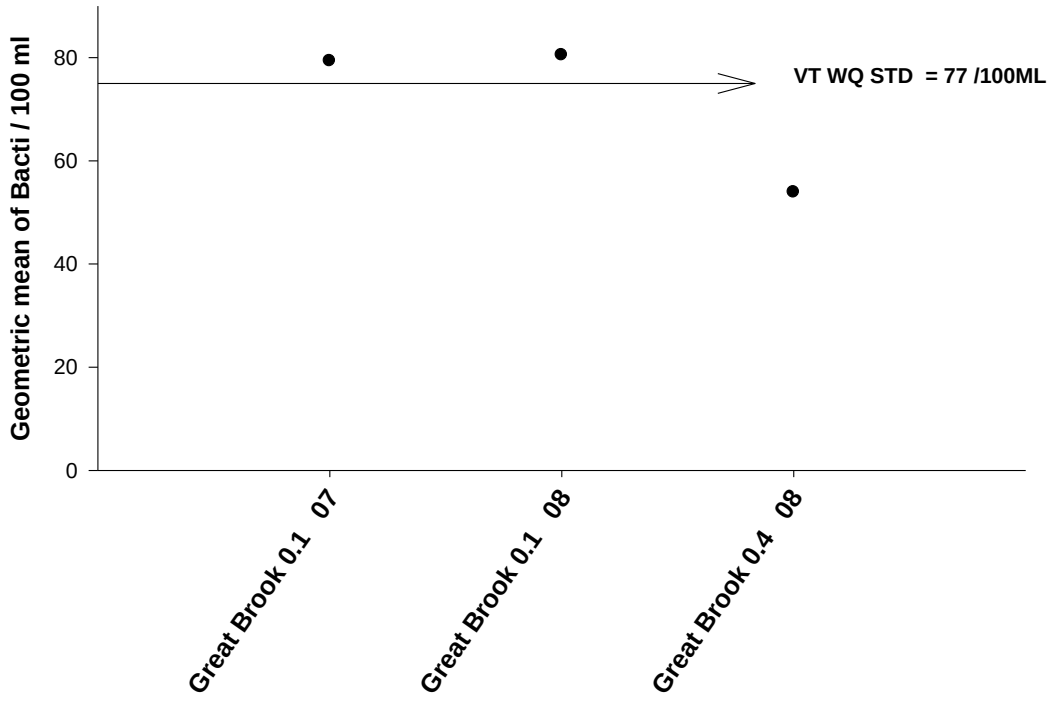
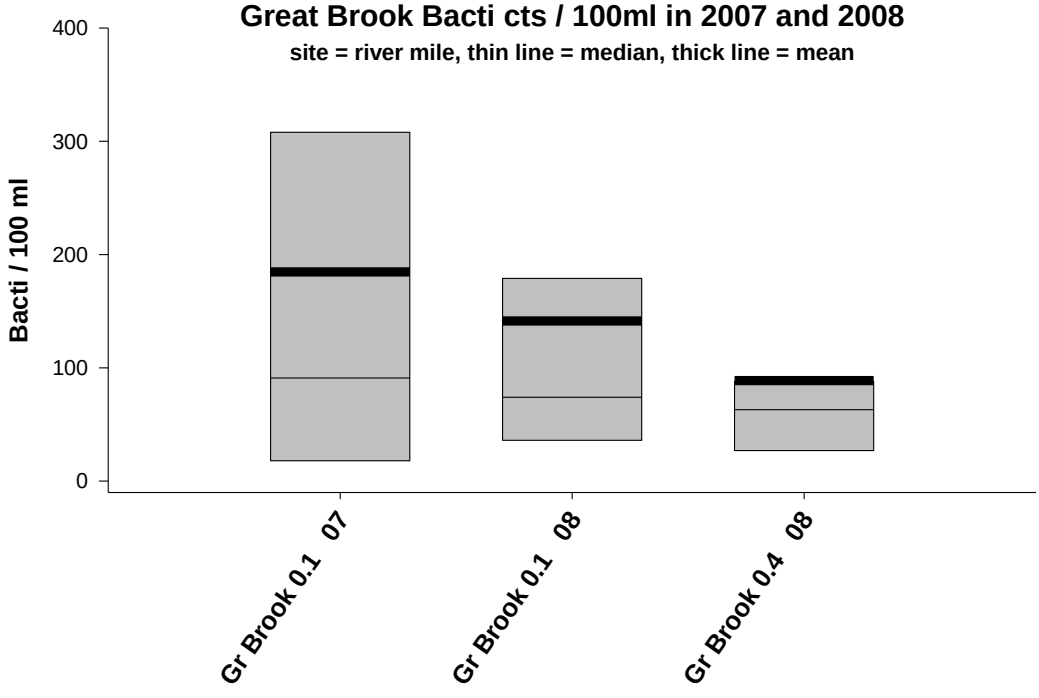
Great Brook Geometric mean of Bacti / 100 ml



Great Brook Bacti cts / 100ml in 2007 and 2008

site = river mile, thin line = median, thick line = mean



2008 Water Quality Monitoring
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Appendix B
Water Quality Parameters

Station	Date	Alkalinity	Chloride (mg/L)	Nitrogen, Total - Persulfate (mg N/L)	Phosphorus, Total (ug P/L)	Solids, Total Suspended (mg/L)	Turbidity NTU)	Flow
BM 0.1	6/17/08	68.80	5.70	0.72	463.00	441.00	308.00	Medium
	7/15/08	96.80	2.00	0.24	16.90	2.40	1.41	Medium
	8/26/08	88.50	2.00	0.16	11.50	1.00	0.36	Medium
	9/16/08	96.20	2.30	0.18	8.70	1.70	2.09	Medium
	10/21/08	77.40	2.40	0.17	9.30	1.00	1.26	Medium
Median		85.54	2.88	0.29	101.88	89.42	62.62	
CP 0.1	6/17/08	91.00	6.50	0.38	53.30	30.80	11.30	Low
	7/15/08	106.00	7.70	0.33	20.40	1.67	0.67	Low
	8/26/08	97.00		0.32	17.20	1.00	0.20	Medium
	9/16/08	108.00	6.30	0.36	18.00	1.07	0.84	Low
	10/21/08	107.00	4.60	0.32	15.80	1.00	1.69	Low
Median		101.80	6.28	0.34	24.94	7.11	2.94	
CS 0.1	6/17/08	58.60	7.40	1.02	254.00	212.00	125.00	Medium
	7/15/08	83.80	7.20	0.24	13.60	1.00	0.75	Medium
	8/26/08	84.80	4.80	0.23	13.50	5.40	3.91	High
	9/16/08	88.00	4.60	0.20	8.50	1.00	0.70	Low
	10/21/08	72.40	3.80	0.19	9.60	1.27	1.18	Medium
Median		77.52	5.56	0.38	59.84	44.13	26.31	
GB 0.1	6/17/08	81.00	7.20	1.64	610.00	167.00	87.50	Medium
	7/15/08	109.00	10.70	0.79	10.20	1.00	0.56	Low
	8/26/08	99.60	7.30	0.48	10.00	1.00	0.34	Low
	9/16/08	106.00	8.10	0.64	5.90	1.00	0.67	
	10/21/08	91.70	5.30	0.42	8.40	1.60	1.29	Medium
Median		97.46	7.72	0.79	128.90	34.32	18.07	
KB 0.1	6/17/08	33.00	2.00	1.43	805.00	727.00	150.00	High
	7/15/08	77.80	2.00	0.26	10.60	1.30	0.86	Low
	8/26/08	77.00	2.00	0.20	11.70	1.00	0.46	Low
	9/16/08	84.80	2.00	0.22	6.70	1.00	0.63	
	10/21/08	69.10	2.00	0.22	8.40	1.00	0.63	Medium
Median		68.34	2.00	0.47	168.48	146.26	30.52	

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NB 0.2	6/17/08	37.60	2.00	0.25	78.30	52.00	37.80	Medium
	7/15/08	56.50	2.00	0.21	17.10	1.00	0.72	Low
	8/26/08	44.30	2.00	0.17	15.70	1.00	0.85	Low
	9/16/08	61.60	2.00	0.16	8.90	1.00	1.09	
	10/21/08	54.40	2.00	0.20	9.80	1.00	0.58	Medium
Median		50.88	2.00	0.20	25.96	11.20	8.21	
WB 0.1	6/17/08	41.10	3.90	0.90	670.00	344.00	162.00	High
	7/15/08	116.00	2.10	0.28	13.40	1.90	0.57	Low
	8/26/08	110.00	2.00	0.18	19.50	1.00	0.94	Low
	9/16/08	119.00	2.70	0.23	7.40	1.00	0.61	
	10/21/08	93.60	5.90	0.28	11.80	1.00	0.90	Medium
Median		95.94	3.32	0.37	144.42	69.78	33.00	

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Station	Date	Alkalinity	Chloride (mg/L)	Nitrogen, Total - Persulfate (mg N/L)	Phosphorus, Total (ug P/L)	Solids, Total Suspended (mg/L)	Turbidity NTU)	Flow
WIN 70.7	6/17/08	64.85	8.05	0.49	202.50	99.10	67.90	medium
	7/15/08	60.90	7.20	0.32	25.70	2.27	2.18	Low
	8/26/08	77.10	8.90	0.24	16.90	1.00	1.95	Low
	9/16/08	78.60	9.30	0.27	10.90	2.16	1.17	
	10/21/08	75.70	9.10	0.27	10.20	1.00	1.09	Medium
Median	**WIN70.7**	71.43	8.51	0.32	53.24	21.11	14.86	
WIN 72.8	6/17/08	58.40	8.00	0.77	138.00	88.60	37.90	Medium
	7/15/08	73.15	9.20	0.26	17.70	1.75	1.47	Low
	8/26/08	79.00	9.30	0.21	14.20	1.00	1.89	Low
	9/16/08	75.60	8.50	0.22	11.40	1.10	1.20	
	10/21/08	69.30	8.90	0.24	9.30	1.00	1.06	Medium
Median	**WIN72.8**	71.09	8.78	0.34	38.12	18.69	8.70	
	6/17/08	36.50	5.60	0.21	34.80	13.90	5.34	medium
	7/15/08	41.40	5.60	0.24	25.50	4.67	2.79	
	8/26/08	49.20	6.55	0.30	28.40	4.70	3.08	medium
	9/16/08	78.30	11.00	0.24	13.00	1.26	1.16	
	10/21/08	73.40	11.50	0.25	14.90	10.30	1.02	
Median	**WIN81.6**	55.76	8.05	0.25	23.32	6.97	2.68	
WIN 83.8	6/17/08	99.60	13.80	0.31	23.70	5.80	2.76	low
	7/15/08	115.00	17.40	0.38	18.20	2.77	2.27	medium
	8/26/08	110.00	13.40	0.26	11.70	1.00	0.62	medium
	9/16/08	119.00	16.20	0.41	7.85	1.00	0.71	medium
	10/21/08	108.00	16.70	0.36	11.00	1.00	1.15	medium
Median		110.32	15.50	0.34	14.49	2.31	1.50	

Station	Date	Alkalinity	Chloride (mg/L)	Nitrogen, Total - Persulfate (mg N/L)	Phosphorus, Total (ug P/L)	Solids, Total Suspended (mg/L)	Turbidity NTU)	Flow
WIN 85.5	6/17/08	98.80	18.50	0.43	52.50	20.10	6.79	Medium
	8/26/08	117.00	17.30	0.25	14.60	1.30	0.63	Medium
	9/16/08	126.00	22.00	0.23	8.40	2.35	1.02	Medium
	10/21/08	115.00	21.55	0.26	15.70	2.35	3.48	Low
Median		114.20	19.84	0.29	22.80	6.53	2.98	

2008 Water Quality Monitoring
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e. coli Results

Location	Date	Prelim E. Coli. (mpn/100ml)	Time	24 Hr rainfall	48 Hr rainfall	72 Hr rainfall	96 Hr rainfall	Flow	Tendency
GB 0.1	6/18/08	548.00	6:33					Medium	Receding
	7/2/08	85.00	6:40					Medium	Receding
	7/16/08	47.00	6:35					Low	Receding
	7/30/08	36.00	6:40						
	8/27/08	179.00	6:25					Low	Receding
	9/3/08	74.00	6:35					Low	Receding
	9/17/08	21.00	7:20					Low	Receding
Mean		141.43							
Geometric Mean		80.51							
GB 0.4	6/18/08	326.00	6:30					Medium	Receding
	7/2/08	75.00	6:35					Medium	Receding
	7/16/08	30.00	6:25					Low	Receding
	7/30/08	27.00	6:30					Medium	Receding
	8/27/08	63.00	6:45					Low	Receding
	9/3/08	88.00	6:30					Low	Receding
	9/17/08	12.00	7:10					Low	Receding
Mean		88.71							
Geometric Mean		53.88							
WIN 70.7	6/18/08	1860.00	6:40					Medium	Receding
	7/2/08	291.00	6:47					Medium	Receding
	7/16/08	214.00	6:40						Receding
	7/30/08	96.00	6:59					Medium	Receding
	8/27/08	98.00	6:40					Low	Receding
	9/3/08	118.00	6:45					Low	Receding
	9/17/08	156.00	7:30					Low	Receding
Mean		404.71							
Geometric Mean		213.26							
WIN 71.4	6/18/08	1730.00	6:35					Medium	Receding
	7/2/08	488.00	6:30					Medium	Receding
	7/16/08	288.00	6:20					Low	Receding
	7/30/08	91.00	6:15					Medium	Receding
	8/27/08	58.00	6:15					Low	Receding
	9/3/08	260.00	6:20					Low	Receding
	9/17/08	178.00	7:05					Low	Receding
Mean		441.86							
Geometric Mean		249.03							
WIN 81.6	6/18/08	866.00	6:23					Medium	Receding
	7/2/08	291.00	6:10					Medium	
	7/16/08	236.00	5:15					Medium	Receding

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Location	Date	Prelim E. Coli. (mpn/100ml)	Time	24 Hr rainfall	48 Hr rainfall	72 Hr rainfall	96 Hr rainfall	Flow	Tendency
	7/30/08	156.00	5:20					Medium	Receding
	8/27/08	52.00	11:20					Medium	
	9/3/08	26.00	6:55					Low	
	9/17/08	397.00	6:00					Medium	Receding
Mean		289.14							
Geometric Mean		174.77							
WIN 81.8	6/18/08	687.00	6:28					Medium	Receding
	7/2/08	201.00	6:15					Medium	
	7/16/08	248.00	5:25					Medium	Receding
	7/30/08	130.00	5:30					Medium	Receding
	8/27/08	96.00	11:25					Medium	
	9/3/08	84.00	7:00					Low	
	9/17/08	236.00	5:45					Medium	Receding
Mean		240.29							
Geometric Mean		188.55							
WIN 82.6	6/18/08	687.00	6:33					Medium	Receding
	7/2/08	172.00	6:20					Medium	
	7/16/08	148.00	5:05					Medium	Receding
	7/30/08	248.00	5:05					High	Receding
	8/27/08	29.00	11:30					Medium	
	9/3/08	17.00	7:05					Low	
	9/17/08	26.00	5:35					Medium	Receding
Mean		189.57							
Geometric Mean		91.95							
WIN 83.8	6/18/08	345.00	5:45					Low	Receding
	7/2/08	193.00	6:25					Medium	
	7/16/08	291.00	5:35					Low	Receding
	7/30/08	99.00	5:40					Medium	Receding
	8/27/08	66.00							
	9/3/08	43.00	5:25						Receding
	9/17/08	24.00	6:05					Medium	Receding
Mean		151.57							
Geometric Mean		103.89							

2008 Water Quality Monitoring
Winooski Headwaters

WIN 85.4	6/18/08	770.00	5:35					Low	Receding
	7/2/08	248.00	6:35						
	7/16/08	387.00	5:40					Medium	Receding
	7/30/08	127.00	5:50					High	Receding
	8/27/08	36.00							
	9/3/08	20.00	5:35						
	9/17/08	26.00	6:15					Medium	Receding
Mean		230.57							
Geometric Mean		108.38							
WIN 86.5	6/18/08	248.00	5:25					Low	Receding
	7/2/08	32.00	6:40						
	7/16/08	53.00	5:50					Low	Receding
	7/30/08	66.00	6:00					Medium	Receding
	8/27/08	17.00	5:45					Medium	Receding
	9/3/08	14.00	5:45						Receding
	9/17/08	18.00	6:25					Medium	Receding
Mean		64							
Geometric Mean		38.21							