Acid Rain Monitoring Project

FY11 End of Fiscal Year Report

June 30 2011

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Introduction

This report covers the period July 1, 2010 to June 30, 2011, the tenth year of Phase IV of the Acid Rain Monitoring Project. Phase I began in 1983 when about one thousand citizen volunteers were recruited to collect and help analyze samples from nearly half the state's surface waters. In 1985, Phase II aimed to do the same for the rest of the streams and ponds[1] in Massachusetts. The third phase spanned the years 1986-1993 and concentrated on a subsample of streams and ponds to document the effects of acid deposition to surface waters in the state. Over 800 sites were followed in Phase III, with 300 citizen volunteers collecting samples and doing pH and ANC analyses. In 2001, the project was resumed on a smaller scale: about 50 volunteers are now involved to collect samples from approximately 150 sites, 26 of which are long-term sites with ion and color data dating back to Phase I. In the first years of Phase IV (2001-2003), 161 ponds were monitored for 3 years. Between Fall 2003 and Spring 2010, the project monitored 151 sites, mostly streams, except for the 26 long-terms sites that are predominantly ponds. This year, reduced funding eliminated our October sampling and monitoring occurred on April 10, 2011 only. Some of the sites monitored changed, in order to revisit ponds that were monitored in 2001-2003.

Goals

The goals of this project are to determine the overall trend of sensitivity to acidification in Massachusetts surface waters and whether the 1990 Clean Air Act Amendment has resulted in improved water quality.

Methods

The sampling design was changed this year to monitor both streams and ponds. In 2001-2003 mostly ponds were monitored. In Fall 2003 the sampling scheme switched to streams to evaluate their response to air pollution reductions. This year the site list was modified to include both ponds and streams. Half of the streams monitored since 2003 were kept, and half of the ponds monitored in 2001-2003 were added back. The streams that were removed were chosen randomly by county. Ponds that were reinstated on the sampling list were chosen at random by county and by ease of accessibility to replace the removed streams. Because those sites were not chosen with a preconceived plan, they can be considered picked at random.

Also different from previous years, only one collection took place this year, due to budget reductions. The April sampling date (April 10, 2011) was chosen rather than the October collection, because surface waters show lowest pH and ANC in the spring, and the project aims to document the worst case conditions.

This year the sampling location for Quabbin Reservoir, one of our long-term sites, was changed from within the Reservoir to the outlet, because availability of a boat to collect mid-reservoir ceased, and in April the reservoir is often still frozen, preventing the collection of a mid-pond sample. A previous ARM study established that sampling at the outlet does not yield significant changes from sampling mid-lake (Godfrey et al, 1996).

Methods were otherwise unchanged from previous years: Volunteer collectors were contacted a month before the collection to confirm participation. Clean sample bottles were sent to them in the mail, along with sampling directions, a field sheet/chain of custody form, and directions including GPS coordinates and maps to the sampling sites. Volunteers collected a surface water sample at their sampling sites either from the bank or wading a short distance into the water body. They collected one foot below the surface, upstream of their body, after rinsing their sample bottle three times with pond or stream water. If collecting by a bridge, they collected upstream of the bridge unless safety and access do not allow it. They filled in their field data sheet with date, time, and site code information, placed their samples on ice in a cooler and delivered the samples to their local laboratory right away. They were instructed to collect their samples as close to the lab analysis time as possible. In a few cases, samples were collected the day prior to analysis because the lab is not open on traditional "ARM Sunday." Previous studies by our research team have established that pH does not change significantly when the samples are refrigerated and stored in the dark.

Volunteer labs were sent any needed supplies (sulfuric acid titrating cartridge, electrode, buffers), two quality control (QC) samples, aliquot containers for long-term site samples, and a lab sheet one week to

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[1] Note: The term stream in this report refers to lotic waters (from creeks to rivers) and the term ponds refers to lentic waters (lakes and ponds, but not marshes)

ten days before the collection. They analyzed the first QC sample in the week prior to the collection and called in their results to the Statewide Coordinator. If QC results were not acceptable, the volunteer analyst discussed possible reasons with the Statewide Coordinator and made modifications until the QC sample analysis gave acceptable results. On collection day or the day after, volunteer labs analyzed the second QC sample before and after the regular samples, and reported the results on their lab sheet along with the regular samples. Analyses were done on their pH-meters with KCl-filled combination pH electrodes. Acid neutralizing capacity (ANC) was measured with a double end-point titration to pH 4.5 and 4.2. Most labs used a Hach digital titrator for the ANC determination, but some used traditional pipette titration equipment. Aliquots were taken from the 26 long-term sites to fill two 60mL bottles and one 50mL tube per site for later analysis of ions and color. These aliquots were kept refrigerated until retrieval by UMass staff.

Aliquots, empty bottles, and results were collected by the ARM Statewide Coordinator a day or two after the collection. The Cape Cod National Seashore lab mailed those in, with aliquot samples refrigerated in a cooler with dry ice.

The Statewide Coordinator reviewed the QC results for all labs and flagged data for any lab results that did not pass Data Quality Objectives (within 0.3 units for pH and within 3mg/L for ANC). pH and ANC data were entered by one ARM staff and proofed by another. Data were entered in a MS excel spreadsheet and uploaded into the web-based database at http://umatei.tei.umass.edu/ColdFusionProjects/AcidRainMonitoring. Data were also posted on the ARM web page at http://www.umass.edu/tei/wrrc/arm/.

UMass Chemistry Department’s Dr. Julian Tyson and his laboratory team of graduate students ran the Environmental Analysis Lab (EAL) and provided the QC samples for pH and ANC to all of the volunteer labs. EAL also provided analysis for pH and ANC for some samples from Hampshire and Franklin Counties.

Aliquots for 26 long-term sites were analyzed for color on a spectrophotometer within one day; anions within one month on an Ion Chromatograph; and cations within one month on an ICP at the Environmental Analysis Lab (EAL) on the UMass Amherst campus. The data was sent via MS Excel spreadsheet to the Statewide Coordinator who uploaded it into the web-based database.

The Statewide Coordinator and the Project Principal Investigator plotted the data to check for data inconsistencies and gaps. They then analyzed the April data from 1983 through 2011, using the statistical software JMP (http://www.jmp.com/software/) to run bivariate analyses of pH, ANC, ions, and color against date. This yielded trends analyses with a fitted X Y line, using a 95% confidence interval.

Results

1. There were 150 sites to be monitored, 77 ponds and 73 streams. Of those, 19 ponds and 7 streams are “long-term” sites that are sampled every year and analyzed for color and a suite of ions in addition to pH and ANC.

2. Sampling was completed for 144 sites (74 ponds and 70 streams), including all of our long-term sites.

3. Some quality control problems arose, mostly due to new volunteer staff performing lab analyses. This resulted in three labs failing quality control for pH and two labs failing quality control for ANC. Consequently, pH data was discarded for 29 sites, and ANC data was discarded for 10 sites.

4. The network of volunteers was maintained and kept well informed on the condition of Massachusetts surface waters so that they would be able to participate effectively in the public debate. This was accomplished by e-mail and telephone communications, as well as through updates via an internet list-serv. 79 volunteers participated in this year’s collection. Several new volunteer collectors were recruited to replace ill or retiring volunteers via several internet listservs and by word of mouth. There were 11 volunteer labs across the state, in addition to the EAL at UMass Amherst, in charge of pH and ANC analyses (Table 1).

Table 1: Volunteer Laboratories

Analyst Name	Affiliation	Town
Joseph Ciccotelli	Ipswich Water Treatment Dept	Ipswich
Nicole Henderson	UMass Boston Environmental Studies Program	Boston
Cathy Wilkins	Greenfield High School	Greenfield
Sherrie Sunter	MDC Quabbin Lab	Belchertown
Dave Bennett	Cushing Academy	Ashburnham
Holly Bayley	Cape Cod National Seashore	South Wellfleet
Robert Caron	Bristol Community College	Fall River
Bob Bentley	Analytical Balance Labs	Carver
David Christensen	Biology Dept. Wilson Hall WSC	Westfield
Jim Bonofiglio	City of Worcester Water Lab	Holden
Carmen DeFillippo	Pepperell Waste Water Treatment Plant	Pepperell
Chengbei Li	University of Massachusetts Environmental Analysis Lab	Amherst

5. The ARM web site and searchable database were maintained and updated. 2011 pH, ANC, ions and color data that met data quality objectives were added to the web database via the uploading tool created in previous years. The database was evaluated for quality control and uploading errors were corrected.

6. The data collected was analyzed for trends in pH and ANC in April months only for 144 sites and for color and ions for 26 sites, using the JMP® Statistical Discovery Software (http://www.jmp.com/software/). Trend analyses (scatter plots, regression, and correlation) were run on pH, ANC, each ion, and color separately, predicting concentration vs. time.

Data Analysis Results

pH and ANC

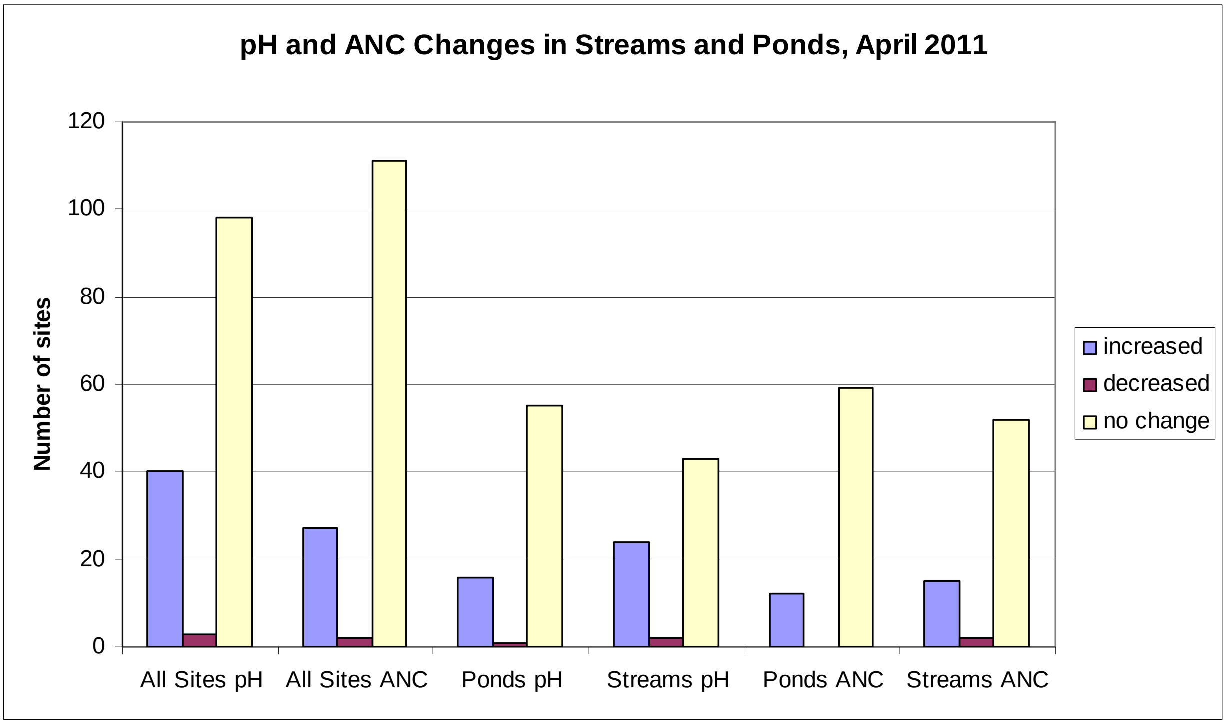
Trend analysis for pH and ANC
Table 2 displays the number of sites out of a maximum of 144 that show a significant change over time for pH or ANC. If the difference was not statistically significant ($p>0.05$), the sites are tabulated in the ‘No Change’ category.

Table 2: Trend analysis results for pH and ANC, April 1983 – April 2011

	All Sites		Ponds		Streams	
	pH	**ANC**	**pH**	**ANC**	**pH**	**ANC**
Increased	40	27	16	12	24	15
Decreased	3	2	1	0	2	2
No Change	98	111	55	59	43	52

Those results are also graphed in Figure 1.

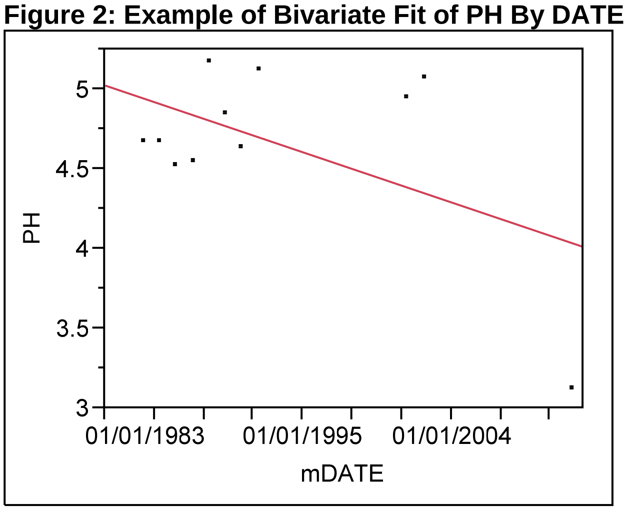
Figure 1. Changes in pH and ANC, from trend analysis



This trend analysis indicates that for most sites, neither pH nor ANC changed significantly over time. However, for those sites that show a significant change, more show an increase than a decrease in value: about a quarter of the sites saw an increase in pH and ANC, more so for pH than ANC. This is consistent with previous years' results. It is interesting to compare ponds and streams this year and to note that statistical results are very similar for both types of water bodies, though pH and ANC increased for more streams than ponds.

A visual check of the scatter plots for all data shows that for a number of ponds, the pH was clearly lower this year than in the past, see Figure 2 below with accompanying statistics. However, just one data point in 2011 compared to many data points before 2003 is not enough to create a statistically significant trend. Monitoring will need to continue for several years to establish whether such a trend is real or an anomaly due to late snowmelt or even an undetected laboratory error.

Figure 2: Example of Bivariate Fit of PH By DATE (Notch Pond, 72088.0001)



Linear Fit

PH = 7.7815024 - 1.1062e-9*mDATE

Summary of Fit

RSquare	0.25805
RSquare Adj	0.175611
Root Mean Square Error	0.512234
Mean of Response	4.668182
Observations (or Sum Wgts)	11

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	0.8213112	0.821311	3.1302
Error	9	2.3614524	0.262384	**Prob > F**
C. Total	10	3.1827636		0.1106

Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	7.7815024	1.766463	4.41	0.0017*
mDATE	-1.106e-9	6.25e-10	-1.77	0.1106

Ions and Color

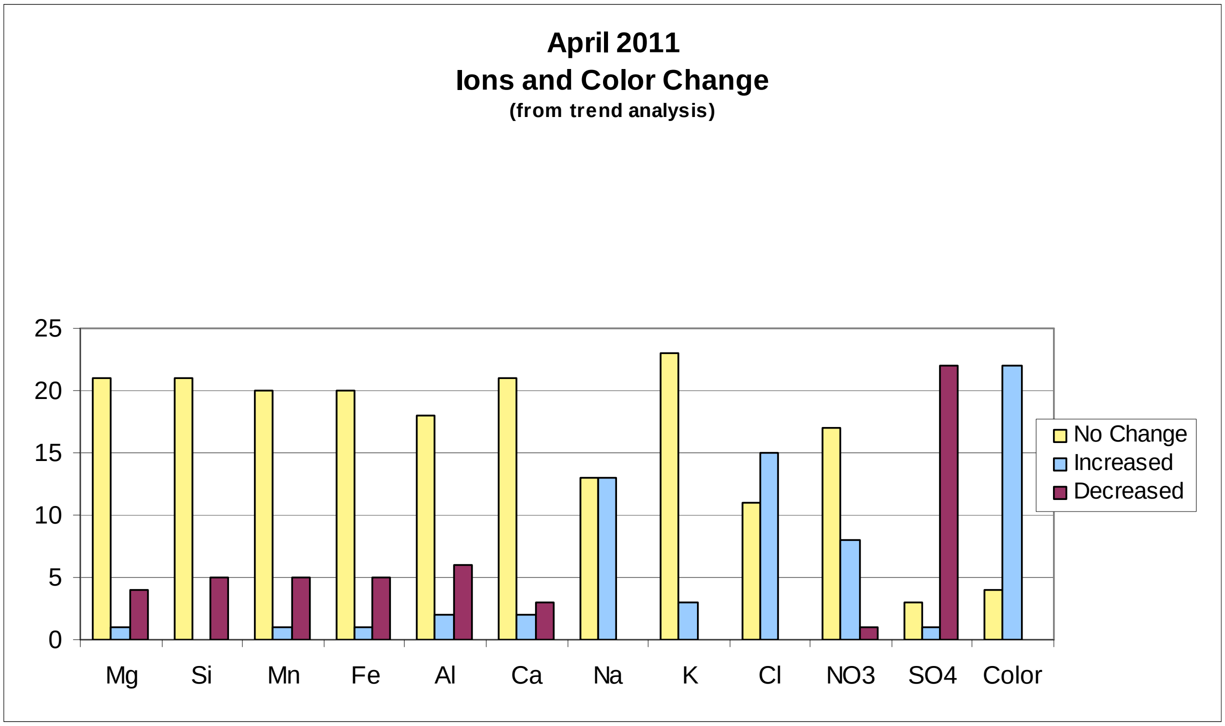
Trend analyses were run for the 26 long-term sites that are analyzed for eleven ions and color.

Table 3 and Figure 3 show the results of the trend analysis for all parameters.

Table 3: Trend analysis results for ions and color

	April 1983 - April 2011		
	No Change	Increased	Decreased
Mg	21	1	4
Si	21	0	5
Mn	20	1	5
Fe	20	1	5
Al	18	2	6
Ca	13	13	0
Na	23	3	0
K	11	15	0
Cl	17	8	1
NO3	3	1	22
SO4	4	22	0
Color	21	1	4

Figure 3: Results of trend analysis for ions and color for 26 long-term sites, April 2011



Most cations show no significant change over time for the 26 sites we are following. The exception, as in the past, is for sodium, which increased in half of the sites.

All anions show significant changes as well. Chloride never decreases with time, and increases for 58% of the sites. Nitrate's change is less definite, but it clearly increases for about a third of the sites and decreases for only one site. Sulfate shows the most dramatic change, a strong decrease for 85% of the sites.

Color also continues to show a consistent increase over time, for 85% of the sites as well.

Discussion

Despite a heavier snowpack that melted later in the season, results for 2011 are very similar to those of previous years – pH and ANC still show more increases than decreases with time. As noted above, however, unless the change were drastic, it would not affect the statistical analysis with only one new data point.

Looking at ponds vs. streams, no noticeable difference can be detected between the two. Ponds continue to show an increase in both pH and ANC in some sites though more sites still show no statistically significant change with time.

The base cations calcium and magnesium do not show any sign of recovery, though sulfate continues to show a strong and significant decline. The increase in nitrate is still present, as is the increase in sodium and chloride, and color.

These results are consistent with the analysis performed last year (Hatte and Finn, 2010). Conclusions mirror those of 2010, namely that the increase in nitrate is thought to be caused by emissions from increased vehicular circulation, the increase in sodium and calcium is attributed to road salting, and the increase in color is due to decreased acidic inputs (see Hatte et al, 2010).

This year's data confirm that the 1990 Clean Air Act Amendment has resulted in modest improvements in water quality in Massachusetts surface waters.

It is our recommendation that monitoring these ponds and streams continue in order to document water quality trends and detect any changes that might occur due to climate change effects on surface waters.

Acknowledgements

Thank you to all of the project's volunteers who make this project possible by collecting samples all over the state under any weather conditions, and who spend many hours in the lab analyzing samples.

Literature Cited

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Hatte, Marie-Françoise, Elizabeth Finn, 2010. Acid Rain Monitoring Project FY10 End of Fiscal Year Report, Water Resources Research Center, University of Massachusetts Amherst. (http://www.umass.edu/tei/wrrc/arm/ARM%20FY10%20Annual%20Report.pdf)

Appendix

Table 4: April 2011 ARM Color and Ion Data

Name	Palsite	MG	SI	MN	FE	CU	AL	Ca	NA	K	CL	NO3_N	SO4	Color
Shingle Island Brook	188	1.200	0.330	0.100	0.370	0.010	0.260	2.800	10.000	0.910	15.930	0.110	6.880	217
Belmont Reservoir	21010	0.190	0.160	0.033	0.022	0.005	0.240	0.580	0.650	0.360	1.090	0.030	3.420	24
Cobble Mt. Reservoir	32018	0.960	0.240	0.026	0.100	0.003	0.065	2.400	9.300	0.560	14.640	0.050	3.750	41
Hawley Reservoir	34031	0.520	0.390	0.027	0.032	0.007	0.130	2.100	7.900	0.440	12.860	0.060	5.120	26
Wyola Dam	34103	0.470	0.300	0.043	0.090	0.002	0.100	2.100	6.300	0.550	9.000	0.090	4.610	40
Upper Naukeag Lake	35090	0.140	0.060	0.013	0.040	0.005	0.034	0.400	5.000	0.220	7.860	0.030	1.530	22
Crystal Lake	36043	0.180	0.005	0.024	0.012	0.021	0.033	0.550	0.640	0.280	1.330	0.000	2.560	21
Lake Lorraine	36084	0.720	0.019	0.010	0.061	0.014	0.014	3.800	23.000	1.100	35.570	0.050	4.310	24
Quabbin Station	36129	0.610	0.130	0.006	0.018	0.005	0.014	2.600	6.200	0.640	8.640	0.010	4.140	14
Nipmuck Pond	42039	0.410	0.280	0.015	0.040	0.005	0.190	1.800	12.000	0.290	19.920	0.000	5.610	16
N. Watuppa Lake	61004	0.870	0.061	0.100	0.120	0.007	0.120	2.300	14.000	0.530	21.730	0.000	6.170	88
Ashby Reservoir	81001	0.520	0.190	0.022	0.210	0.016	0.100	1.900	11.000	0.630	16.610	0.010	4.220	57
Wright Pond	81160	0.370	0.120	0.054	0.300	0.005	0.100	1.200	7.500	0.670	11.180	0.000	2.910	94
Whitehall Reservoir	82120	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Hedges Pond	94065	1.100	0.035	0.007	0.034	0.002	0.048	0.870	7.700	0.640	13.430	0.000	3.900	50
College Pond	95030	0.640	0.033	0.003	0.043	0.006	0.014	0.790	4.300	0.430	6.400	0.000	3.310	27
Ezekiel Pond	95051	1.200	0.009	0.003	0.052	0.003	0.017	2.000	18.000	0.910	30.460	0.060	4.910	27
Little Sandy Pond	95092	0.880	0.008	0.003	0.052	0.006	0.021	1.100	14.000	1.300	22.540	0.030	3.000	24
Great Pond	96117	7.000	0.010	0.010	0.019	0.005	0.017	2.400	60.000	2.300	14.530	0.000	3.280	21
Kinnacum Pond	96163	32.000	0.030	0.014	0.043	0.021	0.047	11.000	261.000	11.000	15.230	0.020	1.940	68
Caldwell Creek	3626575	0.750	0.370	0.019	0.021	0.006	0.120	1.900	9.100	0.290	10.900	0.000	5.220	20
W. Branch Swift River	3626800	0.310	0.320	0.027	0.040	0.010	0.130	1.300	2.700	0.310	3.680	0.010	4.650	30
E. Branch Swift River	3627200	0.560	0.240	0.027	0.110	0.009	0.110	2.300	7.400	0.700	10.560	0.020	4.230	72
Rattlesnake Brook	6235125	0.640	0.320	0.035	0.190	0.007	0.260	1.400	7.200	0.350	9.670	0.000	7.110	133
Angeline Brook	9560000	1.200	0.200	0.012	0.160	0.003	0.390	1.900	8.700	0.570	14.240	0.040	6.390	193
Bread & Cheese Brook	9560150	1.900	0.240	0.040	0.240	0.005	0.210	5.500	37.000	1.400	63.450	0.490	7.300	190

NS = No Sample

Table 5: pH and ANC, all sampling sites.

PALSITE	NAME	April 2011	
		PH	ALK
188	Shingle Island Brook	5.40	0.70
371	Beagle Club Pond	6.94	8.00
11002	Cheshire Res. North	NS	64.90
21010	Belmont Res;Steam Sawmi	NS	-0.30
21040	Lake Garfield	NS	22.20
21062	Long Pond	NS	40.70
31042	Trout Pd 2; Demming Pd	NS	4.30
31044	Upper Spectacle Pond	NS	3.10
32012	Buck Pond	NS	18.40
32018	Cobble Mtn. Reservoir	NS	3.60
33001	Ashfield Pd;Ashfield L;	7.19	33.10
33003	Bog Pond; Anthony Pond	NS	0.60
33017	Plainfield Pond	6.45	2.90
34011	Brass Mill Pond	6.83	7.60
34023	Fiske Pond	5.13	-0.20
34031	Hawley Reservoir	5.76	0.66
34080	Scarboro Pond	6.20	2.50
34103	Lake Wyola; Locks Pond	6.06	2.50
35002	Bassett Pond	5.81	1.30
35013	Cowee Pd;Marm Johns Pd	5.05	0.00
35017	Lake Denison	5.42	1.80
35026	Greenwood Pond	5.14	-0.30
35048	Moores Pond; Lake Moore	5.83	1.40
35085	Stump Pond	5.18	0.10
35089	Tully Pond	6.36	2.10
35090	Upper Naukeag Lake	5.66	0.60
35095	Lake Watatic	5.78	2.00
35107	L Rohunta; South Basin	6.14	1.80
36015	Bickford Pd;Ropers Res	5.85	1.00
36036	Cloverdale Street Pond	6.39	7.90
36043	Crystal Lake	5.60	0.01
36084	Lake Lorraine		8.40
36129	Quabbin Res.Station 202	6.63	3.77
41014	East Brimfield Res	NS	4.30
42039	Nipmuck Pond	NS	
51024	Coes Reservoir	7.08	12.60
51063	Holden Res 1;Upper Hold	6.27	3.80
51090	Lynde Brook Reservoir	6.66	12.10
51179	Whitin Res;Wallis Res	5.62	1.50
52032	Plain Street Pond	6.68	9.00
61004	N Watuppa L;N Watuppa R	5.61	0.40
62048	County Road Pond	6.46	7.40
62058	Deep Pond	6.62	6.00
62097	Johnson Pd; Factory Pd	6.14	2.40
62213	Winnecunnet Pd;Winnecon	6.75	7.50

71043	Upper Mystic Lake	7.44	
72039	Farm Pond	3.05	
72088	Notch Pond	3.12	
72092	Lake Pearl; Whitings Pd	6.81	
72095	Pleasant St. Pd;Frankli	6.17	
72113	Stony Brook Pond	6.82	
72115	Storrow Pond	6.35	
81001	Ashby Reservoir	6.68	1.50
81053	Grove Pond	6.80	15.90
81056	Heald Pond	6.88	11.05
81100	Phoenix Pond; Double Pd	6.92	16.70
81111	Robbins Pond	7.71	32.50
81117	Sandy Pond	6.73	8.35
81151	L Wampanoag; Nashua Res	4.95	-0.40
81160	Wright Pd; Upper Wright	5.46	0.80
82120	Whitehall Reservoir	6.32	
84072	Upper Attitash Pond	NS	15.80
94065	Hedges Pond	6.17	1.70
94072	Indian Pond	6.15	9.50
95030	College Pond	6.44	2.20
95051	Ezekiel Pond	6.68	
95092	Little Sandy Pond	6.80	1.20
95112	New Long Pond	6.46	1.60
95142	Spectacle Pond	6.72	3.60
95151	Turner Pd;Turners Mill	4.79	-1.00
95170	Noquockoke L;South Basi	5.95	1.60
96117	Great Pond	5.17	
96163	Kinnacum Pond	4.94	
2103725	Soda Creek	NS	34.10
2104100	Williams River	NS	99.30
2104200	Sleepy Hollow Brook	NS	127.40
2105350	Barton Brook	NS	11.40
2105425	Anthony Brook	NS	2.60
2105700	Kilburn Brook	NS	4.20
2105725	Cady Brook	NS	8.80
2105750	Bilodeau Brook	NS	14.10
3106825	Fox Brook	NS	2.60
3107375	Benton Brook	NS	3.60
3107625	Babcock Brook	NS	2.50
3107700	Valley Brook	NS	1.70
3208725	Little River	NS	5.70
3313175	Hinsdale Brook	7.83	43.60
3313850	Shingle Brook	7.65	50.30
3314100	North River	7.11	12.30
3314450	Kinsman Brook	7.02	7.70
3314550	Vincent Brook	7.30	10.50
3314650	Underwood Brook	6.79	3.80

3314925	East Oxbow Brook	6.88	4.50
3315075	Hartwell Brook	7.51	17.40
3315325	Bozrah Brook	7.27	11.00
3316050	Todd Brook	5.49	-0.10
3316550	Lord Brook	5.50	0.20
3419825	Mill River	7.20	32.60
3522675	Black Brook	6.20	1.20
3523750	Kenny Brook	5.84	0.30
3523825	Beaman Brook	6.08	2.40
3523950	Wilder Brook	5.12	-0.10
3524050	Baker Brook	5.69	1.50
3524200	Towne Brook	5.53	0.50
3524250	Robbins Brook	5.38	-0.10
3625975	Sucker Brook	6.34	5.70
3626475	Maynard Brook	5.56	1.80
3626575	Cadwell Creek	5.84	0.49
3626800	West Br Swift River	5.58	-0.20
3627000	Hop Brook	6.61	4.10
3627200	East Br Swift River	6.34	1.89
3627500	Flat Brook	6.57	5.27
3628175	West Br Ware River	6.05	1.40
4230075	French River	6.63	12.70
4230325	Wellington Brook	6.35	22.90
5131275	Round Meadow Brook	5.89	2.00
5131425	Aldrich Brook	6.36	5.20
5132600	Sewall Brook	7.19	17.30
5132625	Cronin Brook	6.56	8.60
5132700	Dorothy Brook	6.73	17.90
5233750	Bungay River	6.76	15.90
5334075	Torrey Creek	6.51	11.80
5334100	Rocky Run	6.89	19.40
5334150	Clear Run Brook	7.37	32.70
6134500	Kickamuit River	6.25	4.20
6134700	Blossom Brook	4.40	-2.40
6134725	King Phillip Brook	4.52	-1.70
6235125	Rattlesnake Brook	4.59	-1.50
6235775	Mulberry Meadow	6.67	7.30
6236100	Bassett Brook	6.39	4.00
7240375	Godfrey Brook	7.08	25.60
8143675	Gulf Brook	7.05	11.45
8143825	Robinson Brook	7.18	18.90
8144725	Mcgovern Brook	7.06	9.70
8146000	Bartlett Pond Brook	5.36	0.20
8247475	Millham Brook	6.99	23.10
9253500	Ipswich River	NS	18.20
9253700	Black Brook	NS	16.20
9253925	Boston Brook	NS	15.60

9560000	Angeline Brook	4.68	-1.30
9560150	Bread And Cheese Brook	5.94	1.10

NS = No Sample