Acid Rain Monitoring Project

FY22 Annual Report

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Funded by the Massachusetts Department of Environmental Protection
Bureau of Waste Prevention

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Front cover photo: Belmont Reservoir, Hinsdale, Massachusetts
April 10, 2022
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Executive Summary

- 2022 was the 21st year of Phase IV of the Acid Monitoring Project, which started in 1983 to document the effects of acid deposition on surface waters in Massachusetts.
- The project, funded by the Massachusetts Department of Environmental Protection's Bureau of Waste Prevention, is run by the Water Resources Research Center at the University of Massachusetts Amherst, and relied on 53 volunteers to sample 135 water bodies across the state.
- Samples are analyzed for pH and alkalinity at the UMass Environmental Analysis Lab and at 11 labs staffed by volunteers, from Westfield to the Cape Cod National Seashore. Samples from 26 Long-Term Sites (having data dating back to at least 1985) are also analyzed for color and 11 ions (Cl, NO_3, SO_4, Mg, Mn, Fe, Cu, Al, Ca, Na, K).
- Trend analyses show that 38% of the water bodies surveyed show a significant increase in pH and 50% show a significant increase in alkalinity over the duration of the project. Only 4% and 1% show a decrease in pH and alkalinity, respectively.
- Of the 26 Long Term sites, 20 show a significant increase in color, which is consistent with a recovery of natural alkalinity.
- Ions for the most part show no significant increase or decrease over the past 37 years. However, sulfate decreased significantly for 25 sites, an indication that the Clean Act Amendment of 1990 is having a positive effect on Massachusetts surface waters' water quality. Conversely, sodium and chloride increased for 17 sites, a likely result of road salting in the winter. This year potassium also increased significantly at 23 sites. The reason for this increase is unknown, though potassium chloride is sometimes used as a road salt as well.

Introduction
This report covers the period January 1, 2022 to June 30, 2022, the twenty-first year of Phase IV of the Acid Rain Monitoring Project. Phase I began in 1983 when around 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 monitored 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 60 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 twice a year (April and October), mostly streams, except for the 26 long-terms sites that are predominantly ponds. Since 2011, reduced funding eliminated the October sampling and monitoring now occurs in April only. In 2011, we also stopped monitoring some of the streams in order to add and revisit ponds that were monitored in 2001-2003. This year is the tenth year of monitoring for those added ponds. No collection took place in 2020 as the covid-19 pandemic prevented entry to many laboratories used in this project.

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 in 2011 to monitor both streams and ponds, and that design continues to date. In 2001-2003 mostly ponds were monitored. In Fall 2003 the sampling scheme switched to streams to evaluate their response to air pollution reductions. In 2011 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 within each county. Ponds that were reinstated on the sampling list were chosen at random within those counties and by ease of accessibility to replace the removed streams. Because those sites were chosen without a preconceived plan, they can be considered picked at random.

One collection took place this year, on **April 10, 2022**.

Methods were unchanged from previous years: Volunteer collectors were contacted six weeks 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 latitude and longitude coordinates along with 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 water 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 did 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

[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)

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 in 24 hours when the samples are refrigerated and stored in the dark.

This year, laboratories that have participated in the project for many years were able to resume analyzing samples after the covid-19 pandemic restrictions were lifted. The Ipswich Water Treatment Department and UMass Boston did not return, but Bristol Community College did, and two laboratories that joined the project last year remained involved in the project: Fitchburg State University and MIT Sea Grant.

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 ten days before the collection. They analyzed the first QC sample (an unknown) 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 26 long-term sites to fill three 50mL tubes per site for later analysis of ions and color. These aliquots were kept refrigerated until retrieved by UMass staff.

This year all 26 long-term sites were sampled again. Aliquots, empty bottles, and results were collected by the ARM Statewide Coordinator and the Principal Investigator between one and three days after the collection.

The Principal Investigator 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 proofread by another. Data were entered in a MS excel spreadsheet and uploaded into the web-based database at http://63.135.115.71/acidrainmonitoring/. pH and alkalinity data were also posted on the ARM web page at https://wrrc.umass.edu/research/projects/acid-rain-monitoring-project/arm-2022-results.

Water Resources Research Center's Cameron Richards, with the help of senior student Sara Molla, managed 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 color analysis for the long-term site samples. The UMass Extension Soils Laboratory analyzed the samples from the long-term sites for cations, and University of New Hampshire's Water Quality Analysis Laboratory, under the direction of Jody Potter, analyzed the samples from the long-term sites for anions.

Aliquots for the 26 long-term sites were analyzed for color on a spectrophotometer at UMass EAL within three days; anions within three months on an Ion Chromatograph at the University of New Hampshire; and cations within one month on an ICP at the UMass Extension Soils Laboratory on the UMass Amherst campus. The available data was sent via MS Excel spreadsheet to the Statewide Coordinator and uploaded into the web-based database.

The Project Principal Investigator plotted the data to check for data inconsistencies and gaps. She then analyzed the available April data from 1983 through 2022, using the statistical software JMP (http://www.jmp.com/software/) to run bivariate analyses of pH, ANC, color and ions against date. This yielded trends analyses with a fitted X Y line, using a 95% confidence interval.

Results

1. There are 149 on our list of sites, but only 135 sites --63 ponds and 72 streams-- were actually sampled by the volunteer collectors in 2022.

2. 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.

3. There were no major quality control problem this year. A couple of labs were a little bit outside the acceptable range of quality control for alkalinity, but the margin was small enough that the Principal Investigator approved using all of the data in the statistical analyses.

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 listserv. 53 volunteers participated in this year's collection. Several new volunteer collectors were recruited to replace retiring volunteers via personal connections, participating professors recruiting students, 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), though one lab, the Westfield State University, ended up not doing analyses due to logistical issues and sent their samples to the Springfield Water and Sewer Commission .

Table 1: Volunteer Laboratories

Analyst Name	Affiliation	Town
Amanda Moulton	MDC Quabbin Lab	Belchertown
Dave Bennett	Cushing Academy	Ashburnham
Bob Bentley	Analytical Balance Laboratory	Middleborough
Dave Christensen	Westfield State University	Westfield
Devon Avery	Upper Blackstone Clean Water	Millbury
Sue Tower	Springfield Water and Sewer Commission	Westfield
Mary Rapien	Bristol Community College	Fall River
MF Hatte	Deerfield River Watershed Association	Greenfield
Cameron Richards	UMass Amherst Environmental Analysis Lab	Amherst
Aisling O'Connor	Fitchburg State University	Fitchburg
Carolina Bastidas	MIT	Cambridge
Sophia Fox	Cape Cod National Seashore	Wellfleet

5. The ARM web site and searchable database were maintained and updated. 2022 pH, ANC, color, and ion data were added to the web database via the uploading tool created in previous years.

6. The data collected was analyzed for trends in pH and ANC in April months (135 sites) and for color and ions (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, color, and each ion separately for each site, predicting concentration vs. time.

Data Analysis Results

pH and ANC

Table 2 displays the number of sites 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 2022 (Number of sites)

	All sites		Ponds		Streams	
	pH	ANC	pH	ANC	pH	ANC
Increased	51	68	25	36	26	32
Decreased	5	1	0	0	5	1
No Change	79	66	38	27	41	39
Total	135	135	63	63	72	72

Those results are graphed as percentages of all sites in Figure 1.

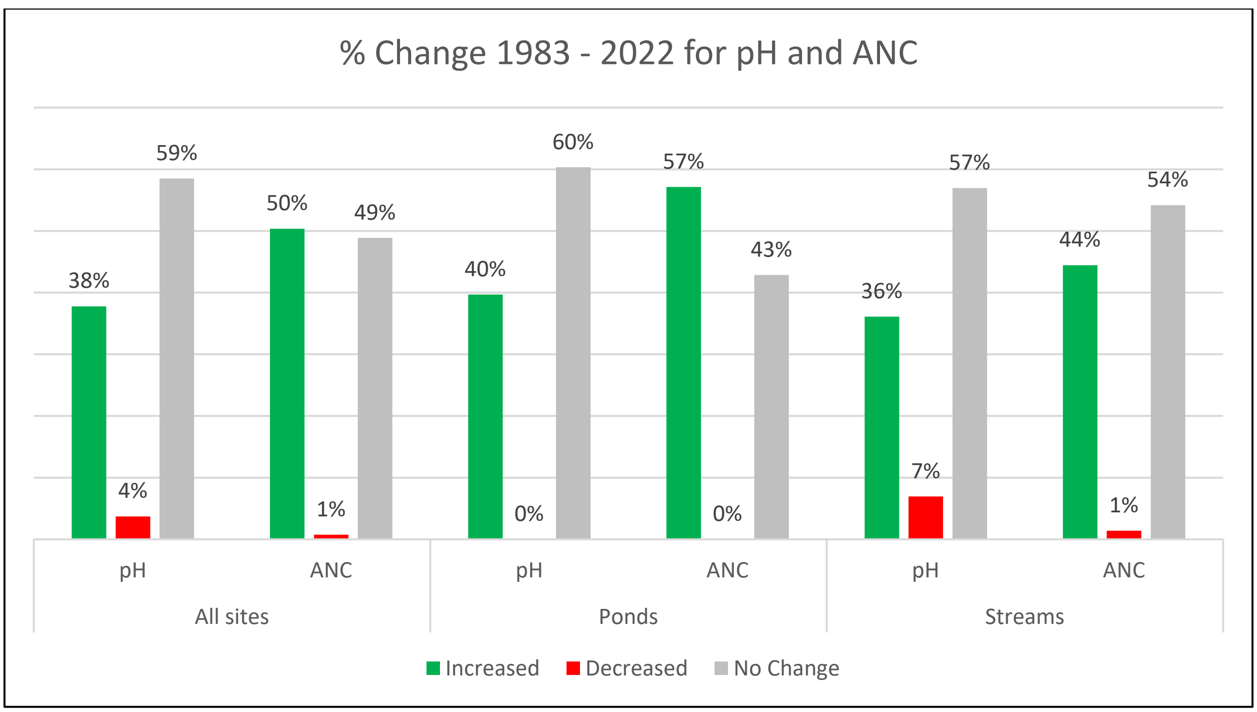

Figure 1. Percent change in number of sites for pH and ANC, from trend analysis, April 1983-2022

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, many more show an increase than a decrease in value: 38% of the sites saw an increase in pH and 50% had an increase in ANC. It can be noted that more sites are exhibiting an increase in pH and ANC each year of the past 3 years.

We continue to see a much higher percentage of ponds exhibiting an increase in ANC compared to streams (57% vs. 44%), but the percentage difference is smaller than in previous years. Streams continue to show more numbers increasing in pH. As far as decreases in pH are concerned, the situation is similar to the past two years: 7% of streams had a statistically significant decrease in pH this year (7% in 2021, 8% in 2019). Again, no ponds had a statistically significant decrease in pH or ANC this year, and only 1% of streams had a decrease in ANC.

The 2021-2022 winter preceding the sample collection did not have large amounts of snowfall, but it must be noted that, as in 2021, we sampled later than usual this year (second instead of first weekend of April) and by then all snowpack had melted, and our results again do not indicate an acid pulse due to snowmelt.

Ions and color

Trend analyses were run for 26 long-term sites that were analyzed for eleven ions and for color. Results are shown in Table 3 and Figure 2. Note that the trend period is 1985-2022.

Table 3: Trends for number of sites with increases or decreases in ion concentration and color April 1985 – April 2022

	Increased	Decreased	No Change
Color	20	0	6
Cl	17	0	9
NO3	1	0	23
SO4	0	25	1
Mg	5	0	21
Mn	0	11	15
Fe	0	9	17
Cu	8	0	18
Al	1	4	21
Ca	4	1	21
Na	17	0	9
K	23	0	3

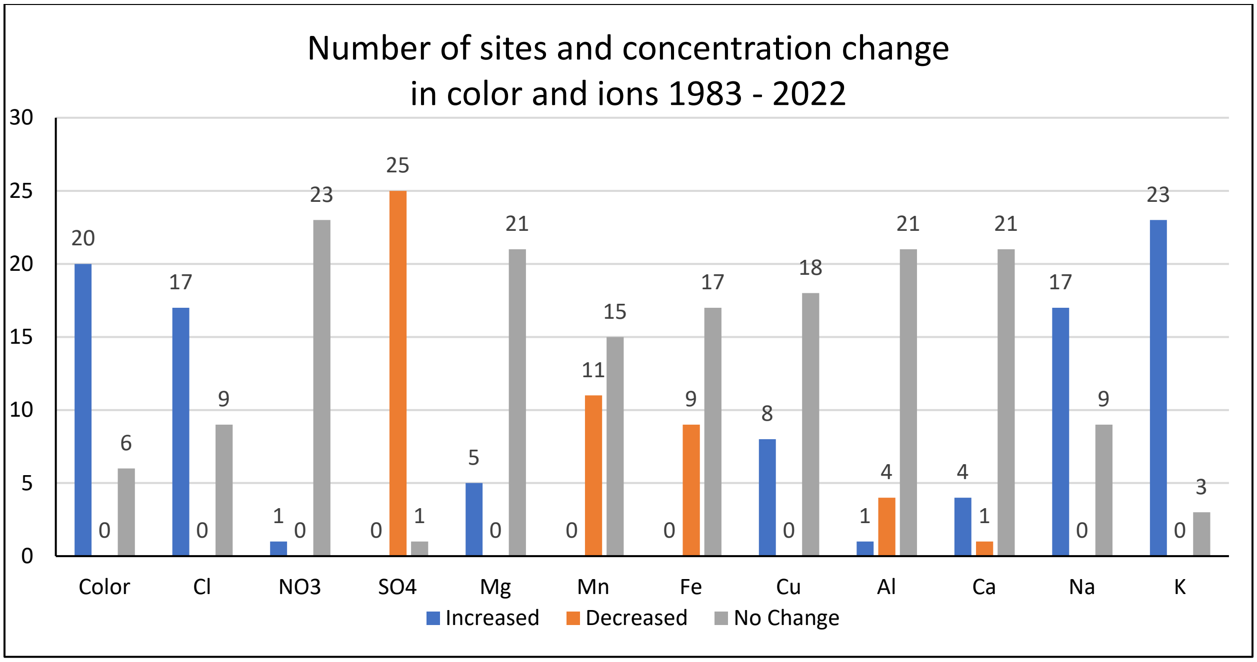

Figure 2: Results of trend analysis for ions and color at 26 long-term sites, April 1985-2022. The bars depict how many sites showed a statistically significant increase (blue), decrease (orange), or no significant change (grey) over the period 1985 – 2022.

Results are similar to previous years, except for nitrate (NO_3). In 2019, 10 sites showed a statistically significant increase in NO_3, while in 2021 only one site did. The source of nitrates being overwhelmingly vehicle emissions, last year's decrease might have been caused by the decrease in vehicular traffic in the early part of the pandemic. However, this year there is still only one site showing a decrease in nitrate, yet vehicular traffic has returned to pre-pandemic frequency.

While there are still more sites that show no significant change either up or down, some cations show significant increases or decreases over the years. Sodium (Na) and potassium (K) are the cations with the most increases (23 out of 26 for K this year, a sizeable increase from last year when it was 16), with manganese and iron showing the most decreases. Sodium and chloride increases are usually associated with road salting in the winter. Potassium chloride is sometimes used to salt roads as well.

For anions, we continue to see a very significant downward trend in Sulfate (all sites except one). Nitrates, as noted above, is showing no increases this year, except at one site.

Color is still increasing in most of our sites, which is consistent with a recovery of natural alkalinity.

Discussion

The continued trend in decreasing sulfate confirms that the Clean Air Amendment of 1990 is having a positive effect in the quality of the Commonwealth's surface water quality. Road salting in the winter continues to affect the concentration of sodium and chloride in the water bodies. Continued monitoring will help tease out whether nitrate pollution is increasing or whether previous trends were affected by the analyses of 2014, which showed unusually high results.

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.

Appendix

Table A-1: April 10, 2022 pH and Alkalinity Data

Name	Town	Palsaris	pH	ANC
Aldrich Brook	Millville	5131425	6.25	5.1
Angeline Brook	Raynham	9560000	4.97	-0.2
Anthony Brook	Dalton	2105425	6.88	10
Ashby Reservoir	Ashby	81001	6.37	3.2
Ashfield Lake	Ashfield	33001	7.66	43.3
Babcock Brook	Tolland	3107625	5.79	1.5
Bagg Brook	West Springfield	3417750	7.54	61
Baker Brook	Gardner	3524050	5.78	1.6
Bartlett Pond Brook	Leominster	8146000	5.72	1.1
Barton Brook	Dalton	2105350	7.41	24
Bassett Brook	Swansea	6236100	6.3	3.5
Bassett Pond	New Salem	35002	6	1.1
Beagle Club Pond	Easton	371	6.83	10.8
Beaman Brook	Winchendon	3523825	6.12	2.1
Beaver Brook	Freetown	6235800	6.64	15.6
Belmont Reservoir	Hinsdale	21010	5.33	0.3
Benton Brook	Otis	3107375	6.48	9
Bickford Pond	Hubbardston	36015	6.75	2.9
Bilodeau Brook	Hinsdale	2105750	7.33	26
Black Brook	Hamilton	9253700	6.75	22.8
Black Brook	Warwick	3522675	6.31	2
Blossom Brook	Fall River	6134700	4.62	-1.2
Blue Hills Reservoir	Quincy	73004	7.43	15.2
Bog Pond	Savoy	33003	6.24	4
Boston Brook	Middleton	9253925	6.98	22.9
Bozrah Brook	Hawley	3315325	7.26	13.3
Brass Mill Pond	Williamsburg	34011	7.11	10.7
Bread And Cheese Brook	Easton	9560150	6.06	3.1
Buck Bond	Westfield	32012	6.82	22

Name	Town	Palsaris	pH	ANC
Bungay River	New Bedford	5233750	6.72	19.6
Cadwell Creek	Pelham	3626575	5.79	0.77
Cady Brook	Hinsdale	2105725	7.05	18
Cheshire Reservoir North	Cheshire	11002	8.2	80.2
Clear Run Brook	Westport	5334150	6.83	41.5
Cloverdale Street Pond	Rutland	36036	6.87	6.5
Cobble Mountain Reservoir	Blandford	32018	6.74	10
College Pond	Plymouth	95030	6.47	2
Cowee Pond	Gardner	35013	5.58	0.2
Cronin Brook	Grafton	5132625	6.46	9.1
Crystal Lake	Palmer	36043	5.62	0.24
Dorothy Brook	Worcester	5132700	7.12	26
East Branch Swift River	Petersham	3627200	6.25	3.08
East Brimfield Reservoir	Brimfield	41014	6.6	10
East Oxbow Brook	Charlemont	3314925	6.68	3.7
Ezekiel Pond	Plymouth	95051	6.75	3.3
Farm Pond	Sherborn	72039	6.8	3.5
Fiske Pond	Wendell	34023	5.47	0.4
Flat Brook	Ware	3627500	6.4	7.56
Fox Brook	Granville	3106825	6.44	2.8
French River	Oxford	4230075	6.65	10.1
Godfrey Brook	Milford	7240375	7.01	26.6
Great Pond	Wellfleet	96117	6.071	0.7
Greenwood Pond	Templeton	35026	5.69	0.6
Gulf Brook	Pepperell	8143675	7.4	15
Hartwell Brook	Charlemont	3315075	7.4	19.7
Hatches Creek	Eastham	9661525	7.547	8.9
Hawley Reservoir	Pelham	34031	6.02	1.79
Heald Pond	Pepperell	81056	7.34	17.5
Hedges Pond	Plymouth	94065	6.31	1.4
Hinsdale Brook	Shelburne	3313175	7.83	48.4
Holden Reservoir 1	Holden	51063	6.58	6.2

Name	Town	Palsaris	pH	ANC
Hop Brook	**New Salem**	3627000	6.76	4.8
Indian Pond	**Kingston**	94072	6.33	10
Ipswich River	**Ipswich**	9253500	7.06	31.1
Johnson Pond	**Dartmouth**	62097	6.21	3.8
Kenny Brook	**Royalston**	3523750	6.39	2.2
Kickamuit River	**Mansfield**	6134500	6.59	11.4
Kilburn Brook	**Peru**	2105700	6.94	8
King Phillip Brook	**Freetown**	6134725	4.64	-1.3
Kinnacum Pond	**Wellfleet**	96163	6.92	0
Kinsman Brook	**Heath**	3314450	6.98	11.7
Lake Denison	**Winchendon**	35017	6.09	6.4
Lake Garfield	**Monterey**	21040	7.74	51
Lake Lorraine	**Springfield**	36084	6.28	11
Lake Wampanoag	**Ashburnham**	81151	5.84	1
Lake Watatic	**Ashburnham**	35095	6.57	3.8
Lake Wyola	**Shutesbury**	34103	6.62	1.1
Little River	**Westfield**	3208725	7.08	30
Little Sandy Pond	**Plymouth**	95092	6.58	3
Long Pond	**Great Barrington**	21062	7.62	88
Lord Brook	**Rowe**	3316550	6.69	2.4
Maynard Brook	**Oakham**	3626475	5.89	1.7
Mill River	**Conway**	3419825	7.36	65.6
Millham Brook	**Marlborough**	8247475	6.96	27.6
Moores Pond	**Warwick**	35048	6.49	2.5
Mulberry Meadow	**Seekonk**	6235775	6.72	10.8
Mystic Pond	**Methuen**	84043	6.85	23
New Long Pond	**Plymouth**	95112	6.34	1.2
Nipmuck Pond	**Webster**	42039	5.71	0.8
Noquockoke Lake South Basin	**Fall River**	95170	6.06	3.6
North River	**Colrain**	3314100	7.11	15.5
North Watuppa Lake	**Rehoboth**	61004	5.28	0.4

Name	Town	Palsaris	pH	ANC
Notch Pond	**Medfield**	72088	5.16	0.4
Plain Street Pond	**Norton**	52032	6.77	14.3
Plainfield Pond	**Plainfield**	33017	6.83	7
Quabbin Reservoir Station 202	**Belchertown**	36129	**6.41**	3.65
Rattlesnake Brook	**Westport**	6235125	5.21	0.3
Robbins Brook	**Winchendon**	3524250	6.07	1.3
Robinson Brook	**Pepperell**	8143825	7.56	27.2
Rocky Run	**Raynham**	5334100	6.55	10.2
Round Meadow Brook	**Mendon**	5131275	6.33	5.6
Round Pond	**Brewster**	96264	5.273	0
Round Pond	**Brewster**	96264	5.273	0
Scarboro Pond	**Belchertown**	34080	6.35	2.5
Sewall Brook	**Boylston**	5132600	6.99	18.2
Shingle Brook	**Shelburne**	3313850	7.63	51
Shingle Island Brook	**North Attleborough**	188	5.34	1
Sleepy Hollow Brook	**Richmond**	2104200	7.88	131
Soda Creek	**Sheffield**	2103725	7.1	28
Spectacle Pond	**Wareham**	95142	6.89	5.4
Storrow Pond	**Westwood**	72115	6.3	5.6
Stump Pond	**Gardner**	35085	5.71	1.6
Sucker Brook	**New Braintree**	3625975	6.62	5.3
Todd Brook	**Charlemont**	3316050	6.68	2.8
Torrey Creek	**Dartmouth**	5334075	6.3	18.4
Towne Brook	**Royalston**	3524200	5.56	0.5
Trout Pond 2	**Tolland**	31042	5.6	0.7
Tully Pond	**Orange**	35089	6.49	2.5
Turner Pond	**Seekonk**	95151	4.64	-1.4
Underwood Brook	**Heath**	3314650	6.89	5.7
Upper Attitash Pond	**Amesbury**	84072	7.36	18.7
Upper Mystic Lake	**Winchester**	71043	7.92	44.4
Upper Naukeag Lake	**Ashburnham**	35090	6.28	1.6

Name	Town	Palsaris	pH	ANC
Upper Spectacle Pond	**Sandisfield**	31044	6.75	11
Valley Brook	**Granville**	3107700	6.64	6.4
Vincent Brook	**Colrain**	3314550	7.31	12.6
Walker Brook	**Becket**	3210300	7.13	16
Wellington Brook	**Oxford**	4230325	6.54	23.8
West Branch Swift River	**Shutesbury**	3626800	5.82	0.3
West Branch Ware River	**Hubbardston**	3628175	**6.2**	2.73
Whitehall Reservoir	**Hopkinton**	82120	6.25	5.6
Whitin Reservoir	**Douglas**	51179	5.66	0.7
Wilder Brook	**Gardner**	3523950	5.14	-0.9
Williams River	**West Stockbridge**	2104100	7.84	114
Winnecunnet Pond	**Taunton**	62213	6.86	9.6
Wright Pond	**Ashby**	81160	6.6	3.4

Data in red font did not pass initial QA/QC objectives, but were included in analyses as per the Principal Investigator's judgment.

Palsaris is a unique water body code based on the Massachusetts Department of Environmental Protection's inventory coding systems (SARIS for streams and PALIS for ponds).

Table A-2: April 10, 2022 color and ion concentration for 26 long term sites.
Ion concentrations are in mg/L, color in PCU

Site name	Palsaris	Color	Cl	NO3_N	SO4	Mg	Mn	Fe	Cu	Al	Ca	Na	K
Shingle Island Brook	188	213.00	15.15	0.06	1.32	1.07	0.05	0.47	0.04	0.22	2.19	11.06	4.12
Belmont Reservoir	21010	137.00	0.62	0.02	0.93	0.27	0.04	0.01	0.04	0.04	0.28	1.18	2.69
Cobble Mtn. Reservoir	32018	55.00	12.89	0.06	0.91	1.16	0.00	0.07	0.04	0.03	2.27	9.41	3.20
Hawley Reservoir	34031	24.00	13.53	0.05	1.57	0.74	0.01	0.01	0.05	0.03	2.43	9.77	3.02
Lake Wyola	34103	51.00	6.64	0.04	1.22	0.49	0.00	0.02	0.04	0.03	1.43	5.79	3.05
Upper Naukeag Lake	35090	25.00	19.26	0.02	0.72	0.43	0.00	0.02	0.05	0.03	0.94	14.89	3.27
Crystal Lake	36043	49.00	1.08	0.01	0.03	0.25	0.00	0.01	0.05	0.03	0.01	1.34	2.85
Lake Lorraine	36084	19.00	8.75	0.02	0.27	0.56	0.00	0.07	0.04	0.03	2.00	8.32	3.38
Quabbin Res.Station 202	36129	87.00	7.87	0.02	1.24	0.67	0.00	0.01	0.04	0.03	1.94	6.44	3.35
Nipmuck Pond	42039	31.00	10.18	0.01	1.27	0.47	0.00	0.01	0.04	0.03	1.32	7.93	2.85
N Watuppa Lake	61004	117.00	16.51	0.01	1.42	0.74	0.09	0.16	0.03	0.05	1.26	11.78	2.66
Ashby Reservoir	81001	316.00	22.45	0.03	1.05	0.74	0.00	0.12	0.04	0.03	2.14	16.75	3.13
Wright Pond	81160	57.00	31.90	0.01	1.26	0.63	0.00	0.24	0.04	0.03	1.46	13.18	4.03
Whitehall Reservoir	82120	31.00	18.27	0.00	0.59	1.33	0.00	0.01	0.05	0.03	4.37	23.88	4.06
Hedges Pond	94065	42.00	15.37	0.02	1.28	1.46	0.00	0.01	0.05	0.03	0.73	10.41	3.35
College Pond	95030	30.00	7.07	0.01	1.11	0.93	0.00	0.01	0.04	0.03	0.62	5.57	3.03
Ezekiel Pond	95051	77.00	27.90	0.06	1.43	1.46	0.00	0.01	0.05	0.03	1.95	22.73	3.52
Little Sandy Pond	95092	46.00	24.81	0.28	1.31	1.33	0.00	0.01	0.05	0.03	1.31	18.91	3.99
Great Pond	96117	71.00	26.40	0.02	1.55	2.26	0.00	0.01	0.05	0.03	0.71	18.35	3.43
Kinnacum Pond	96163	322.00	20.67	0.00	0.77	1.79	0.03	0.01	0.05	0.03	0.28	13.57	3.57
Cadwell Creek	3626575	315.00	10.31	0.00	1.37	0.57	0.01	0.01	0.04	0.03	1.27	7.96	2.83
West Br Swift River	3626800	29.00	4.05	0.02	1.19	0.41	0.00	0.02	0.04	0.03	0.95	3.91	3.14
East Br Swift River	3627200	35.00	10.43	0.03	1.19	0.67	0.00	0.10	0.05	0.03	1.99	8.08	3.55
Rattlesnake Brook	6235125	49.00	8.55	0.01	1.58	0.78	0.03	0.26	0.04	0.19	1.57	8.80	2.86
Angeline Brook	9560000	25.00	11.77	0.02	0.94	0.98	0.00	0.29	0.04	0.49	1.24	8.30	3.06
Bread And Cheese Brook	9560150	60.00	37.72	0.28	1.39	1.60	0.01	0.47	0.04	0.21	4.10	30.22	3.76

Table A-3: 2022 Sample Collectors

Adam McLaughlin	Joy Livergood
Albert Rosati	Ken Guertin
Andrea Donlon	Lara Mataac
Barbara Allen	Lauren Gaherty
Bill Eykamp	Marc Hoechstetter
Bill Frenette	Marie-Françoise Hatte
Bill Lafley	Mary Thomas
Bob Bentley	Michael Rosser
Caleb Walk	Michael Sperry
Cathy Pierce	Nicholas Guidi
Charlie Kennedy	Paul Kaplan
Cindy Carvill	Paul Lagreze
Dan Crocker	Richard Greene
David Nelson	Rob Whitaker
Debra LaVergne	Robert Natario
Denise Prouty	Rory Kallfelz
Ellen Weeks	Shauna Macuga
Emily Crawford	Sheila Russell
Eric Decker	Sonny Crawford
Gail Gray	Sophie Brown
Gene Chague	Steven Peterson
Glenn Krevosky	Sue Tower
Henry Barbaro	Timothy McCaul
Jan Chague	Tom Trainor
Jerry Schoen	Trouble Mandeson
Jim Hoberg	Victoria Dumont
John Kennedy	