New York State Energy Research and Development Authority

A Long-Term Monitoring Program for Evaluating Changes in Water Quality in Selected Adirondack Waters

Program Summary Report 2011

June 2012

No. 12-16

nyserda
Energy. Innovation. Solutions.

NYSERDA's Promise to New Yorkers:

New Yorkers can count on NYSERDA for objective, reliable, energy-related solutions delivered by accessible, dedicated professionals.

Our Mission: Advance innovative energy solutions in ways that improve New York's economy and environment.

Our Vision: Serve as a catalyst—advancing energy innovation and technology, transforming New York's economy, and empowering people to choose clean and efficient energy as part of their everyday lives.

Our Core Values: Objectivity, integrity, public service, and innovation.

Our Portfolios

NYSERDA programs are organized into five portfolios, each representing a complementary group of offerings with common areas of energy-related focus and objectives.

Energy Efficiency & Renewable Programs

Helping New York to achieve its aggressive clean energy goals – including programs for consumers (commercial, municipal, institutional, industrial, residential, and transportation), renewable power suppliers, and programs designed to support market transformation.

Energy Technology Innovation & Business Development

Helping to stimulate a vibrant innovation ecosystem and a clean energy economy in New York – including programs to support product research, development, and demonstrations, clean-energy business development, and the knowledge-based community at the Saratoga Technology + Energy Park®.

Energy Education and Workforce Development

Helping to build a generation of New Yorkers ready to lead and work in a clean energy economy – including consumer behavior, youth education, and workforce development and training programs for existing and emerging technologies.

Energy and the Environment

Helping to assess and mitigate the environmental impacts of energy production and use – including environmental research and development, regional initiatives to improve environmental sustainability, and West Valley Site Management.

Energy Data, Planning and Policy

Helping to ensure that policy-makers and consumers have objective and reliable information to make informed energy decisions – including State Energy Planning, policy analysis to support the Regional Greenhouse Gas Initiative, and other energy initiatives; and a range of energy data reporting including *Patterns and Trends*.

A LONG-TERM MONITORING PROGRAM FOR EVALUATING CHANGES IN WATER QUALITY IN SELECTED ADIRONDACK WATERS

Program Summary Report 2011

Prepared for the

**NEW YORK STATE
ENERGY RESEARCH AND
DEVELOPMENT AUTHORITY**

Albany, NY
nyserda.ny.gov

Gregory Lampman
Project Manager

Prepared by:

ADIRONDACK LAKES SURVEY CORPORATION

Karen M. Roy
New York State Department of
Environmental Conservation

James Dukett and Nathan Houck
Adirondack Lakes Survey Corporation

Gregory B. Lawrence
U.S. Geological Survey

NYSERDA
Report 12-16

NYSERDA 4915

June 2012

About the Adirondack Lakes Survey Corporation

The Adirondack Lakes Survey Corporation (ALSC) was established in 1983. The ALSC was established to undertake comprehensive biological and chemical surveys of waters in the Adirondacks; to study the water quality and the effect of acid rain; and to disseminate this information and contribute to scientific understanding through studies and reports. For over 25 years the ALSC has carried out this scientific and technical mission by conducting monitoring of surface water chemistry and fish; making these data available to the public and scientific community; and contributing to studies regarding acidification in the Adirondacks. The ALSC operates out of the New York State Department of Environmental Conservation (NYSDEC) Region 5 headquarters in Ray Brook, New York. To conduct its mission, the ALSC receives support from three sources: the New York Energy Research and Development Authority (NYSERDA), NYSDEC, and the United States Environmental Protection Agency (USEPA).

The ALSC remains current and responds to the needs of the scientific community through improvements in its field, laboratory and data processing capabilities. Field sampling is conducted year round throughout the Adirondack Park under a variety of field conditions. Staff is experienced in the collection of fish, sediment cores, and water samples for routine chemistry and ultra-clean sampling for mercury analysis. The laboratory is equipped to analyze over 20 chemical parameters. The data processing department is skilled in the analysis and delivery of a wide range of digital products.

Acknowledgments

This report is possible through the efforts of the ALSC field, laboratory, data management and administrative staff. We thank: Jeff Brown, Sara Burke, Mike Cantwell, Sue Capone, Paul Casson, Scott Fitzgerald, Elizabeth Faucher, Pam Corey, Matthew Kelting, Monica Schmidt, Phil Snyder and Chris Swamp for their dedication. This work is jointly supported by the NYSDEC, NYSERDA, USEPA, and USGS. This report has not been reviewed by the sponsoring agencies, and should not be construed to represent their practices and policies.

Table of Contents

List of Tables

List of Figures

Program Overview

The goal of the Adirondack Long Term Monitoring Program (ALTM) is to provide surface water chemistry data in the Adirondack region in response to changes in atmospheric deposition of acid rain precursors. The ALTM provides for increased understanding of the processes involved in lake and stream acidification recovery in several ways, including: the interpretation of the chemistry trends across lake classes; additional snowmelt sampling; periodic fisheries surveys; and other biological measurements. It also provides for participation in more intensive investigations at some sites by acquisition of supplemental data and/or by conducting additional field sampling. The monitoring objectives of the current five year (2007–2011) component of the ALTM are: continued sampling and analysis of 52 lakes on a monthly basis; periodic lake fisheries resurveys; annual summer sampling 43 lakes as part of a cooperative project with USEPA under the Temporally Integrated Monitoring of Ecosystems (TIME); stream monitoring at four locations on a bi-weekly basis; summer cloud water sampling and analysis from measurements made at the summit of Whiteface Mountain; weekly wet deposition sampling at Wanakena, NY; and analysis of selected lake samples for regional fisheries management.

Data are posted on the ALSC website (www.adirondacklakessurvey.org), following appropriate quality assurance checks and clearance by the ALSC Program Manager and the NYSDEC Research Manager. This report describes the major core areas of work contained in the 2007–2011 program plan and the data available through December 2010. This report is intended as an update on the ongoing ALTM work that will include updated datasets. Still, there is an inherent time lag in the analysis of the data and the reporting of the data. For each program element, site selection and sampling design as well as highlights of recent results are provided along with key references. Questions on this report can be directed to the address below.

Karen Roy
NYSDEC Adirondack Research Manager
Research Scientist 3
New York State Department of Environmental Conservation
Ray Brook, New York 12977.0296
kmroy@gw.dec.state.ny.us
518.897.1354

The report is available online at: http://nyserda.ny.gov/publications and http://www.adirondacklakessurvey.org.

Adirondack Long Term Monitoring (ALTM) Lakes

The Adirondack Long Term Monitoring (ALTM) program was initiated in 1982 to evaluate monthly chemistry of 17 Adirondack lakes. The lakes were selected from the Regionalization of the Integrated Lake Watershed Acidification Study (RILWAS) (Driscoll and van Dreason 1993). From 1984 to 1987 an intensive chemical and biological survey of 1469 lakes within the Adirondack Park was undertaken by the Adirondack Lakes Survey Corporation (ALSC). Following the completion of the interpretive analysis the ALTM was expanded to 52 lakes to provide a better representation of lakes across the region (Figure 1) (Baker et al. 1990). The expanded lake set was, in part, based on the lake classification system developed by Newton and Driscoll (1990). Monthly sampling of the 52 lakes began in June 1992 (Table 1).

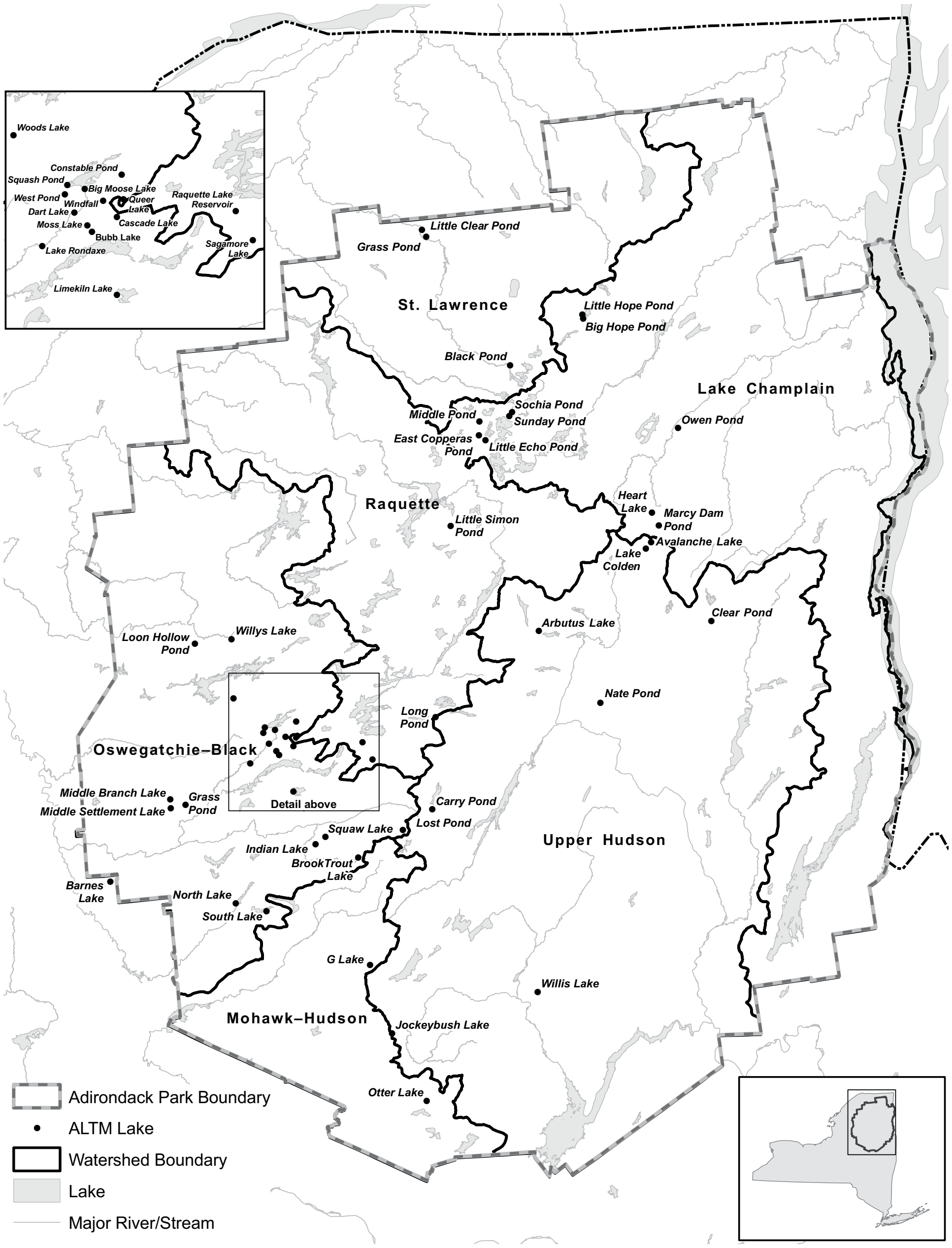


Figure 1. Location of 52 ALTM lakes sampled monthly by the ALSC.

Table 1. ALTM lake characteristics and identification of lakes included in: the original 17 ALTM lakes (Record Start 1982); lakes sampled during the Adirondack Lakes Survey (1984–1987)(ALS survey); and the EPA TIME/LTM project cross over lakes (TIME). Four lakes were limed within five years of the first survey or after monitoring began (Limed). ALTM lakes denoted as outlet pairs indicate the eight original lakes. The 12 lakes sampled weekly during March and April are indicated (Snowmelt).

Ref #	ALTM Pond Name	Record Start 1982	Classification	DOC[1]	Lake Elev (m)	Surface Area (ha)	ALS Survey	Limed	TIME	Outlet Pair	Snowmelt
050684	Arbutus Lake	X	Medium Till Drainage	low	516	48.9					
050707	Avalanche Lake		Thin Till Drainage	low	873	4.4	A				
040905	Barnes Lake	X	Mounded Seepage	high	395	2.9	A	L			
020059	Big Hope Pond		Medium Till Drainage	high	517	8.9	A		T		S
040752	Big Moose Lake	X	Thin Till Drainage	low	558	512.5					
030255	Black Pond Stream	X	Thick Till Drainage	low	495	29.0	A			O	
040874	Brook Trout Lake		Thin Till Drainage	low	724	28.7	A				
040748	Bubb Lake Stream	X	Thin Till Drainage	low	554	18.2	A			O	S
050669	Carry Pond		Mounded Seepage	low	652	2.8	A				
040747	Cascade Lake Stream	X	Medium Till Drainage	low	557	40.4	A			O	
050458	Clear Pond	X	Thick Till Drainage	low	584	70.4	A				
040777	Constable Pond Stream	X	Thin Till Drainage	low	580	20.6	A			O	
040750	Dart Lake	X	Thin Till Drainage	low	537	51.8	A				
020138	East Copperas Pond		Thin Till Drainage	high	480	3.6	A				S
070859	G Lake		Thin Till Drainage	low	620	32.2					
030171	Grass Pond		Mounded Seepage	high	381	1.6	A				
040706	Grass Pond		Medium Till Drainage	low	549	5.3	A				
020264	Heart Lake	X	Medium Till Drainage	low	661	10.7	A				S
040852	Indian Lake		Thin Till Drainage	low	654	33.2	A		T		
050259	Jockeybush Lake		Thin Till Drainage	low	599	17.3	A				
050706	Lake Colden		Thin Till Drainage	low	843	15.4	A				
040739	Lake Rondaxe	X	Thin Till Drainage	low	524	90.5	A				
040826	Limekiln Lake		Medium Till Drainage	low	575	186.9	A				
030172	Little Clear Pond		Mounded Seepage	low	381	1.9	A	L			
020126	Little Echo Pond	X	Mounded Seepage	high	482	0.8					S
020058	Little Hope Pond		Medium Till Drainage	high	517	2.8	A				
060182	Little Simon Pond		Medium Till Drainage	low	546	58.1	A	L			
050649	Long Pond		Thin Till Drainage	high	574	1.7	A				
040186	Loon Hollow Pond		Thin Till Drainage	low	605	5.7	A				
040887	Lost Pond		Thin Till Drainage	high	717	4.4	A				
020265	Marcy Dam Pond		Thin Till Drainage	low	720	1.2	A				
040707	Middle Branch Lake		Thin Till Drainage	low	496	17.0	A				
020143	Middle Pond		Carbonate Influenced	high	483	24.3	A				S
040704	Middle Settlement Lake		Thin Till Drainage	low	526	15.8	A				
040746	Moss Lake	X	Medium Till Drainage	low	536	45.7	A				S
050577	Nate Pond		Medium Till Drainage	high	613	8.3	A				
041007	North Lake		Thin Till Drainage	low	555	176.8	A		T		
070728	Otter Lake Stream	X	Thin Till Drainage	low	505	14.8				O	
020233	Owen Pond		Thick Till Drainage	low	514	7.6	A				S
060329	Queer Lake		Thin Till Drainage	low	597	54.5	A				
060315A	Raquette Lake Reservoir		Medium Till Drainage	high	564	1.5	A				S
060313	Sagamore Lake		Medium Till Drainage	high	580	68.0	A				S
020197	Sochia Pond		Mounded Seepage	low	495	1.6	A				
041004	South Lake		Thin Till Drainage	low	617	197.4			T		
040754	Squash Pond Stream	X	Thin Till Drainage	high	653	3.3	A			O	
040850	Squaw Lake		Thin Till Drainage	low	646	36.4	A		T		
020188	Sunday Pond		Mounded Seepage	low	495	4.0	A				S
040753	West Pond Stream	X	Thin Till Drainage	low	581	10.4	A			O	S
050215	Willis Lake		Medium Till Drainage	low	400	14.6	A				
040210	Willys Lake (Horseshoe)		Thin Till Drainage	low	632	24.3	A		T		
040750A	Windfall Pond Stream	X	Carbonate Influenced	low	591	2.4	A			O	
040576	Woods Lake		Thin Till Drainage	low	605	24.7		L			

[1] Dissolved Organic Carbon

Site Description

Descriptions of the Adirondack region, the ALTM study sites, sample collection and analytical procedures are available in Driscoll and van Dreason (1993), Driscoll et al. (2003), and Chen and Driscoll (2005). Eight of the original 17 lakes (1982) were sampled, not directly on the lake outlet, but at varying distances downstream in proximity to an access road. In June 1993, sampling was initiated at the upstream lake outlet sites at these eight locations. Seven of the 52 ALTM lakes (Little Echo Pond, Woods Lake, Big Moose Lake, South Lake, Arbutus Lake, Otter Lake and G Lake) were not part of the intensive survey performed in 1984–1987 but were added or remained either because they were part of the original 17 ALTM lakes or due to other intensive studies. Within this 52 lake set, the NYSDEC regional fisheries staff actively manage fish stocks in about half of these waters (ALSC 2003). Four lakes (Barnes Lake, Woods Lake, Little Simon Pond and Little Clear Pond) have a recent history of lake liming and are not included in time series analysis of chemistry data. Table 1 provides a summary of selected lake characteristics, management and sampling information.

The Adirondack region is also one of the USEPA lake water chemistry study areas in the TIME program (Stoddard et al. 2003) described in a separate section of this report. Under this program the ALSC conducts summer sampling of 43 lakes of which six lakes are common between TIME and ALTM. These are Big Hope Pond, Indian Lake, North Lake, South Lake, Squaw Lake, and Willys Lake (see Table 1). Some of these 43 lakes are also part of the NYSDEC fisheries management lakes.

Sampling Design

The ALTM lakes are sampled monthly. Lakes with no outlets and those accessed by helicopter are sampled at the deepest part of the lake at a depth of 0.5 m with a Kemmerer sampler. All other sites are sampled at the outlet by surface grab method. All samples are collected in high density polyethylene bottles. Samples are transported from the field in chilled coolers to the ALSC laboratory in Ray Brook, New York (ALSC 2002).

Samples are analyzed for the following parameters: pH, ANC, specific conductance, color, nitrate, sulfate, chloride, fluoride, calcium, magnesium, potassium, sodium, silica, ammonium, dissolved organic carbon, dissolved inorganic carbon, total dissolved aluminum, total monomeric aluminum, total organic monomeric aluminum, total inorganic monomeric aluminum (calculated), and starting in October 2008 for total phosphorus and chlorophyll a. Analytical procedures follow USEPA standards developed and described elsewhere (Morrison et al. 1991; ALSC 2002a; Driscoll and van Dreason 1993; Burns et al. 2006).

Results

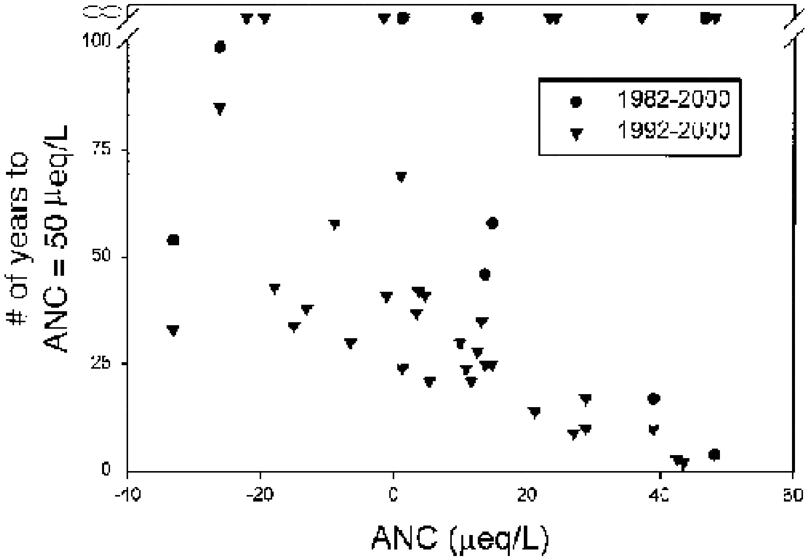
Since baseline monitoring was initiated in 1982 several lake chemistry time series analyses were conducted with the idea of evaluation of changes in atmospheric deposition. These evaluations are a snapshot of changes in chemistry that are attributed, for the most part, to changes in the acidic precursor emissions based upon the potential need for additional action for improvement from a policy frame work. The following represents a synopsis of published ALTM chemistry results. These analyses and others were the foundation for assessing acid deposition effects to lake chemistry in the Adirondack region in recent decades. Responses are evaluated relative to lake classes and relationships among parameters. Depending on the length of the time period evaluated, trends in lake chemistry were found to vary as deposition patterns changed.

Chemistry Trends Reported Based Upon 1982 to 1997 Sampling (17 lakes)

There were a total of three time periods analyzed for the original 17 lakes and the results are summarized here. The first time series conducted for the period 1982 to 1991 found most lakes exhibiting declines in sulfate concentrations consistent with decreases in SO_2 emissions and SO_4 in precipitation. ANC levels were continuing to decline in several lakes thought to be due to increasing concentrations of NO_3 (Driscoll and van Dreason 1993). The next time series conducted for 1982–1994 found continued decline in lake sulfate concentrations, but at rates considerably less than the rate of decline anticipated from atmospheric deposition. The delays in sulfate response were thought to be due to the release of stored sulfate in watershed soils. Lake nitrate concentrations did not show significant trends. No systematic increases in pH or ANC were detected (Driscoll et al. 1995). Similar patterns were observed in time series analysis on the same lakes during 1982–1997. The limited response of lake water ANC and pH were thought to be attributable to several factors, including: the depletion of base cations in soils; additional inputs of sulfate; elevated leaching of nitrates; and/or pH buffering associated with elevated levels of aluminum (Driscoll et al. 1998).

Chemistry Trends 1992–2000 (48 lakes)

The first time series analysis on the expanded 48 ALTM lakes for the 1992–2000 time period found all lakes exhibiting significant decreases in sulfate concentrations that coincided with decreases in atmospheric sulfur deposition. While atmospheric nitrogen deposition did not change over this period, some lakes exhibited decreases in nitrate concentrations. These declines contributed to increases in ANC and pH in over half of the lakes. Increasing DOC concentrations were observed in 20% of the lakes. In some lakes, monomeric aluminum shifted from toxic inorganic species to less toxic organic forms. Nevertheless, in 2000, 16 out of 48 lakes showed inorganic monomeric aluminum concentrations above 2 µmol L^{-1}, a value known to be toxic to many organisms including juvenile forms of Adirondack fish. Extrapolation of rates of lake ANC increase (Figure 2) suggested that the time frame of chemical recovery is on the order of decades at current rates of decrease in acidic deposition (Driscoll et al. 2003).

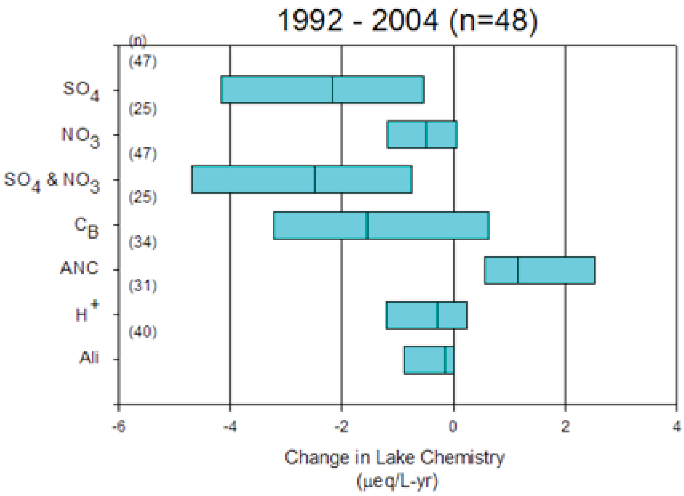


Time for lakes to reach ANC values of 50 µeq L^{-1} as a function of ANC value in the year 2000. These values are extrapolated based on the slope of ANC change from time series analysis assuming a linear rate of change. The extrapolation was done for two intervals, 1982–2000 (six lakes) and 1992–2000 (28 lakes) for those waters where ANC trends were significant. Lakes with 50 µeq L^{-1} or greater in 2000 are not shown here. The rates of ANC increase were generally greater when calculated over the later interval (example Big Moose Lake long interval rate is ~45 years, but over the shorter record is only 25 years to achieve 50 µeq L^{-1}).

Figure 2. Time for ANC to reach critical value of 50 µeq L^{-1}.

Chemistry Trends 1992–2004

Four years later, time series showed continued decreases in precipitation sulfate and hydrogen ions and decreases in lake water sulfate continuing at an average 2.2 µeq L^{-1} yr^{-1}. This rate is similar to values reported in eastern North America and Europe. The lake sulfate decreases were not uniform over the monitoring period coinciding with reduced rates of SO_2 emissions and wet sulfate deposition. Lake nitrate concentrations are declining in 27 lakes and increasing in three. The mechanism contributing to the apparent increase in lake watershed N retention is not evident. ANC and pH are increasing in 34 and 31 lakes, respectively. Base cations are decreasing in half of the lakes, largely due to decreases in calcium concentrations (Figure 3). Decreases in monomeric aluminum concentrations are largely occurring in thin till lakes. DOC changes are less distinct decreasing in 15 lakes while increasing in four lakes (Driscoll et al. 2007).



Mean rates of change in solute concentrations in 48 ALTM lakes during 1992–2004. Minimum, mean and maximum changes in concentration and the number of lakes with significant trends are shown. All values in µeq L^{-1} $year^{-1}$ except for concentrations of inorganic monomeric aluminum (Ali) which is µmol L^{-1} $year^{-1}$.

Figure 3. Mean rates of change in solute concentrations 1992–2004.

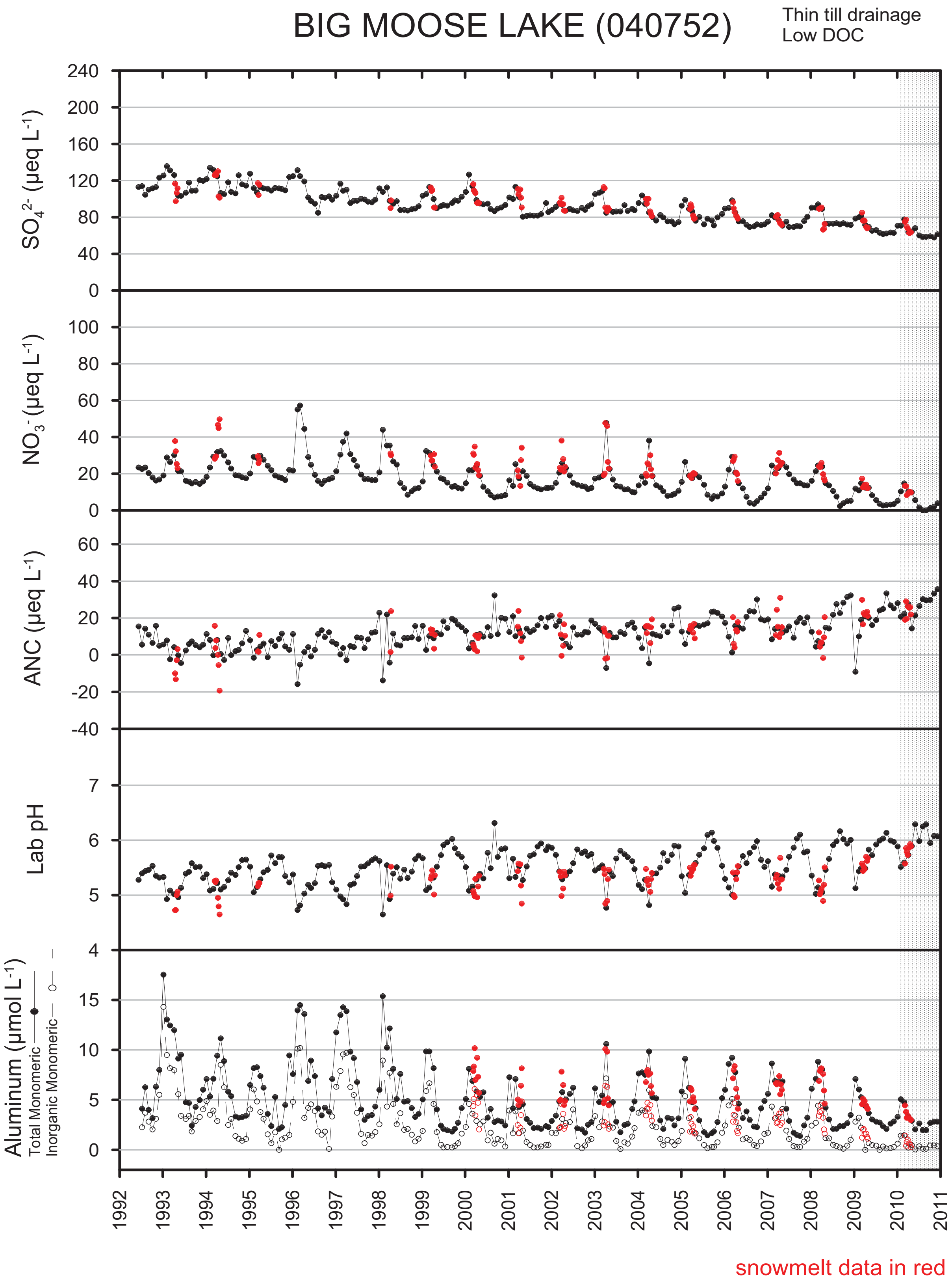


Figure 4. Monthly time series plots for Big Moose Lake. Values in µeq L^{-1} except total and inorganic monomeric aluminums, which are in µmol L^{-1}. Shaded area represents most recent (2010) data.

Chemistry Trends 1992–2008 and Ongoing

In 2011, the ALTM program conducted Seasonal Kendall tests (SKT) on all lake water solute concentrations according to methods described in Driscoll et al. 2004. This was done in collaboration with C.T. Driscoll and K.M. Driscoll. Appendix A provides results of SKT time-series analysis for the 48 ALTM lakes through 2000 and 2004 and annually to 2010. The values are expressed as a rate of change (median slope as µeq L^{-1} yr^{-1}; for Al, DIC, DOC, SiO_2 as µmol L^{-1} yr^{-1}). Only statistically significant trends ($p < 0.05$) are reported. The 2000 and 2004 results cover the time period from June 1992 to December, tracking the published papers. The annual updates beginning in 2005 cover the time period from June 1992 to May of the following year. Generally, the time series patterns have been consistent over recent years, however the rates of change have been declining (e.g. sulfate, nitrate and ANC). The number of lakes with significant levels of increasing DOC increased from 18 in 2009 to 23 lakes in 2010 (Appendix A).

The following is a summary of trends (1992 - 2010) for selected parameters:

Sulfate: all decreasing (n=48 lakes); range -0.59 to -4.14 mean -2.40 µeq L^{-1} yr^{-1}
Nitrate: all decreasing (n=27); range -0.03 to -1.24 mean -0.47 µeq L^{-1} yr^{-1}
CB: decreasing (n=40); range -0.51 to -3.15 mean -1.55 µeq L^{-1} yr^{-1}
CB: increasing (n=1); 0.34 µeq L^{-1} yr^{-1}
ANC: all increasing (n=38); range 0.43 to 2.09 mean 0.96 µeq L^{-1} yr^{-1}
Lab pH: increasing: (n=29); range 0.01 to 0.04 units yr^{-1} mean 0.02
Lab pH: decreasing (n=1); -0.01 units yr^{-1}
Al IM: decreasing (n=41); range -0.00 to -0.67 mean -0.12 µmol L^{-1} yr^{-1}
Al TM: decreasing (n=35); range -0.02 to -0.66 mean -0.17 µmol L^{-1} yr^{-1}
DOC: increasing (n=23); range 1.55 to 22.13 mean 5.59 µmol L^{-1} yr^{-1}
DOC: decreasing (n=4); range -1.94 to -10.29 mean -5.98 µmol L^{-1} yr^{-1}

Plots of selected chemical parameters for Big Moose Lake are provided (Figure 4). The plots are updated through December 2010 and include weekly data (red) collected during snowmelt (March and April). In 2009, despite the lowest concentrations of sulfate and nitrate observed since the onset of sampling in 1982, the ANC values remain below 20 and pH below six for the first half of the year, which coincides with the detection of toxic inorganic monomeric aluminum. However, an additonal year of data (half tone area on plot) shows that in the last two years (2009 and 2010) the monthly and the weekly snowmelt values (red) have been chemically more benign to biota with pH staying generally above 5.5 and Al IM levels around or below 2 µmol L^{-1}, a critical threshold for aquatic biota. For nitrate, snowmelt nitrate peaks are below 20 µeq L^{-1} and late summer base flow concentrations are nearing detection limits.

Lake Outlet Paired Sampling

Eight of the original 17 lakes used as part of the ALTM have water quality sampling locations at substantial distances downstream from the physical lake outlet (Table 2). These original eight sites were historically sampled by Syracuse University from 1982 to 1992. All sampling locations were chosen at the most accessible sites to allow completion of sampling within a 1–2 day interval. The plots are updated through December 2009, and include weekly data (red) collected during snowmelt (March and April). In 2009, despite the lowest concentrations of sulfate and nitrate observed since the onset of sampling in 1982, the ANC values remain below 20 and pH below six for the first half of the year, which coincides with the detection of toxic inorganic monomeric aluminum.

Table 2. ALTM lakes with paired outlet/pond sampling sites.

Pond Number	Pond Name	Lake Type	Sampling Pairs (km)
030256	Black Pond	Thick till drainage low DOC	0.3
040748	Bubb Lake	Thin till drainage low DOC	1.1
040747	Cascade Lake	Medium till drainage low DOC	2.0
040777	Constable Pond	Thin till drainage low DOC	2.7
070729	Otter Lake	Thin till drainage low DOC	0.5
040754	Squash Pond	Thin till drainage high DOC	0.6
040753	West Pond	Thin till drainage low DOC	0.3
040750A	Windfall Pond	Carbonate influenced	2.0

In July 1993, with respect to the eight original Syracuse sites, the ALSC established additional sampling locations at each lake. The intention was to standardize the sampling locations of all 52 lakes, with the goal of conducting sampling at the paired locations for a period of time sufficient to evaluate if there are site differences or locational dependence in chemistry of these waters.

In 2006, a comparison of monthly data at these eight paired sampling sites during 1993-2004 found that the Black Pond and Black Pond Outlet sites were statistically similar and therefore one of the sites could be discontinued. As a result, the upstream site was discontinued in December 2006 (Cirmo et al. 2007). Since the seven additional, unique sites are being continued, the names of the original downstream sites have been augmented with the addition of STREAM in the name label (Appendix A).

Snowmelt Sampling

In 1993, weekly sampling was initiated in a few ALTM lakes to capture more chemistry during snowmelt. The purpose of collecting more frequent data during the snowmelt period is to assess worse-case conditions to biota during this typically most acidic time of year. The intent was to sample more frequently each spring a total of 10 to 12 waters on a rotating basis from year to year. Sampling commenced at the onset of snowmelt, ended with the disappearance of the snowpack, lasted anywhere from three to eight weeks, and was adjusted with staff availability. Beginning in 2002, the lakes and sampling periods were standardized. The same 12 lakes were sampled each year: Little Echo; East Copperas; Middle; Sunday; Owen; Heart, Moss; Bubb, Big Moose, West, Sagamore; and Raquette Lake Reservoir (Table 1). Sampling begins in the first week of March and ends in the first week of May. All 12 lakes are sampled on the same day each week. The selected lakes generally represent all lake classes throughout the region at elevations ranging between 482 m (Little Echo) and 661 m (Heart). These are typically lakes within easy access of year-round roads so that they can be sampled with available field staff all in one day. Plots of weekly snowmelt and monthly data for the twelve lakes are updated through 2010 and provided in Appendix C. The weekly snowmelt chemistry data for all lakes (March 1993 - April 2010) were posted to www.adirondacklakessurvey.org in September 2011.

In 2011, C. Driscoll continued an analysis of the influence of snowmelt on ALTM lake chemistry including examinations of the processes that contribute to snowmelt acidification and of trends over all and during the snowmelt period.

We also began a preliminary examination of the 12 individual snowmelt lakes with respect to what additional information was provided by more frequent sampling. About half of the lakes seem to show little additional information with increased sampling (Middle Pond, Owen Pond, Heart Lake, East Copperas Pond, Little Echo Pond and Sunday Lake). Big Moose Lake also does not show significant additional information with the weekly sampling. The remaining lakes (Moss Lake, Bubb Lake, West Lake, Sagamore Lake and Raquette Lake Reservoir) show additional acidic depressions during the weekly sampling and provide valuable documentation of biologically stressful conditions during this critical time of year. Plots of weekly snowmelt and monthly data for the twelve lakes are provided in Appendix C.

Snowpack Sampling

During 1999 and 2000, mass-balance studies at three ALTM lakes (Grass, Constable and G) by M. Mitchell (SUNY College of Environmental Science and Forestry) included snow core sampling at these watersheds. When measureable snow was present, monthly samples of snowpack were collected and melt water was analyzed by the ALSC laboratory at each of these watersheds. These collections have been ongoing since 1999. These monthly data are being compiled and will be made available in the next report.

The sampling methods and monthly data were evaluated in 2011. One of the preliminary recommendations was to shift the sampling interval at the existing locations to bi-monthly in March and April to better capture changes at the end of the season. Other recommendations were to examine how much the snowpack varies among these watersheds in the southwestern Adirondacks and to consider what additional sites throughout the Adirondacks might be feasible.

ALTM Chemistry Data Reported to Date

Data currently available from this ALTM lake study (this section) include the 52 lakes and additional sampling collected at seven outlet pair locations. In 2011, annual mean concentrations of the parameters measured for the 52 lakes from January 1993 through December 2010 and the monthly chemistry data from June 1992 through May 2010 were posted to the ALSC website at http://www.adirondacklakessurvey.org. Data from the additional seven outlet pair locations are also included within these files.

Fisheries Surveys in ALTM Lakes

In 1994, the ALSC began fisheries surveys in ALTM waters. Lake chemistry improvements were anticipated from the 1990 Clean Air Act Amendments increasing interest in aquatic biota sampling. The ALSC had extensive experience with fisheries surveys. A majority of the ALTM lakes had been surveyed as part of the 1984–1987 ALSC survey. The resurveys were conducted following ALSC methods at a rate of 4–8 surveys per year (ALSC 2002a). In 2007, a preliminary analysis of those comparisons indicated that modest changes were detectible in some lakes. As a result, another round of survey was planned for 2008–2012. This new survey also presented an opportunity to evaluate fish tissue mercury concentrations in selected fish populations.

The rationale for fish mercury analysis was based, in part, on the findings of the NYSERDA study conducted during 2003–2005 by NYSDEC in collaboration with ALSC. In their statewide survey of mercury in fish in 131 lakes and reservoirs, Simonin et al. 2008 found the Adirondack and Catskill Park regions containing higher levels of mercury in fish than in other parts of the state. Of the chemical and physical characteristics of lakes examined, lake acidity (pH) was the most important variable associated with high mercury levels in fish. Species sampled included: yellow perch; small and largemouth bass; and walleye. While brook trout are an important sport fish for the Adirondacks, relatively few mercury data are available in part because this species is considered less prone to accumulating mercury.

Sampling Design

The current ALTM fisheries resurvey includes total and methyl mercury analysis in yellow perch and brook trout. All lake water samples are analyzed for total mercury with a subset for methyl analysis. The resurvey schedule is based on the interval between the two previous surveys and existing staff levels. Table 3 shows the 5-year schedule of lakes resurvey, the years between surveys, along with an actual or estimated presence of target species (yellow perch and brook trout) for mercury analysis.

Table 3. Five-year schedule of ALTM lakes resurvey 2008–2012.

							Analyzed			
			ALS Dates	TM Dates	Y		Y		T	T
Y	**Pond No.**	**Pond Name**	**dd/mm/yyyy**	**dd/mm/yyyy**	**yyyy**	**dd/mm/yyyy**	**Perch**	**T**	**YP**	**ST**
2008	020059	Big Hope Pond	22/05/1984	17/05/1994	2008	12/11/2008	0	24	0	25
	020233	Owen Pond	13/09/1984	24/05/1994	2008	25/09/2008	0	1	0	1
	030172	Little Clear Pond	09/10/1984	23/05/1994	2008	09/10/2008	0	7	0	7
	030171	Grass Pond	09/10/1984	15/06/1998	2008	09/10/2008	0	0	0	0
	040887	Lost Pond	12/09/1984	23/06/1994	2008	23/10/2008	0	6	0	6
	070859	G Lake		14/06/1994	2008	01/10/2008	0	31	0	32
	050669	Carry Pond	24/09/1987	23/06/1994	2008	16/10/2008	0	24	0	39
	040850	Squaw Lake	18/09/1984	17/10/1994	2008	21/08/2008	0	12	0	12
	040852	Indian Lake	17/09/1984	17/10/1994	2008	15/10/2011	0	1	0	1
2009	020058	Little Hope Pond	22/05/1984	15/05/1995	2009	15/10/2009	0	7	0	7
	020197	Sochia Pond	10/05/1984	22/05/1995	2009	24/06/2009	0	0	0	0
	040748	Bubb Lake	21/05/1986	19/09/1995	2009	24/09/2009	0	8	0	8
	040750A	Windfall Pond	07/06/1985	24/05/1995	2009	12/05/2009	0	0	0	0
	050458	Clear Pond	20/10/1987	24/04/1995	2009	28/10/2009	0	2	0	2
	050259	Jockeybush Lake	02/09/1987	17/07/1996	2009	08/10/2009	0	27	0	36
	040576	Woods Lake		27/05/1997	2009	19/05/2009	0	0	0	23
	020126	Little Echo Pond		28/05/1998	2009	29/06/2009	0	0	0	0
	020138	East Copperas Pond	19/07/1984	27/05/1998	2009	17/06/2009	0	0	0	0
	020143	Middle Pond	16/05/1984	27/05/1998	2009	10/09/2009	22	0	37	0
	040754	Squash Pond	29/05/1986	17/06/1998	2009	15/06/2009	0	0	0	0
	040752	Big Moose Lake	25/09/2000	25/09/2000	2009	22/10/2009	25	4	28	4
	040739	Lake Rondaxe	07/10/1986	18/10/2000	2009	18/09/2009	13	4	23	4
2010	050649	Long Pond	09/09/1987	15/06/1998	2010	21/06/2010	0	0	0	0
	030256	Black Pond	10/10/1985	15/07/1998	2010	25/10/2010	0	21	0	25
	040706	Grass Pond	18/09/1984	18/05/1999	2010	07/10/2010	0	0	0	0
	040747	Cascade Lake	12/06/1984	16/06/1999	2010	27/09/2010	25	1	82	1
	040753	West Pond	06/06/1985	26/05/1999	2010	23/06/2010	0	0	0	0
	040777	Constable Pond	11/06/1984	24/05/1999	2010	14/10/2010	25	6	109	6
	060329	Queer Lake	22/05/1986	14/06/1999	2010	20/10/2010	0	13	0	13
	070729	Otter Lake		22/07/1999	2010	28/06/2010	0	0	0	0
	040746	Moss Lake	23/09/1986	21/08/2000	2010	26/10/2010	25	0	48	1
	040750	Dart Lake	23/09/1986	27/09/2000	2010	19/10/2010	25	2	40	2
	020188	Sunday Pond	11/10/1984	07/06/2000	2010	09/09/2010	0	14	0	14

							Analyzed			
			ALS Dates	TM Dates	Y		Y		T	T
Y	Pond No.	Pond Name	dd/mm/yyyy	dd/mm/yyyy	yyyy	dd/mm/yyyy	Perch	T	YP	ST
2011	050215	Willis Lake	09/09/1987	21/05/2001	2011	08/09/2011	5	0	14	0
	041004	South Lake	16/09/1986	25/06/2001	2011	27/09/2011	0	20	0	28
	041007	North Lake	16/09/1986	25/06/2001	2011	26/08/2011	20	0	119	0
	050684	Arbutus Lake	na	27/06/2001	2011	06/10/2011	0	20	0	20
	060313	Sagamore Lake	09/10/1986	18/06/2001	2011	15/09/2011	19	10	19	11
	060315A	Raquette Lake Reservoir	10/10/1985	19/06/2001	2011	21/09/2011	0	16	0	18
	040186	Loon Hollow Pond	18/06/1985	28/05/2002	2011	23/05/2011	0	0	0	0
	040905	Barnes Lake	06/09/1985	29/10/2002	2011	19/05/2011	0	0	0	0
	020265	Marcy Dam Pond	14/05/1985	26/05/2004	2012	see text	na	na	na	na
	020264	Heart Lake	07/05/1985	26/05/2004	2012	13/10/2011	0	15	0	16
	050706	Lake Colden	20/10/1987	29/09/2004	2012	13/06/2011	0	0	0	0
	050707	Avalanche Lake	22/10/1987	29/09/2004	2012	13/06/2011	0	0	0	0
	060182	Little Simon Pond	14/05/1985	19/06/2002	2011	17/10/2011	0	14	0	14
2012	040704	Middle Settlement Lake	18/09/1984	18/06/2003	2012			Y		
	040707	Middle Branch Lake	19/09/1984	16/06/2004	2012			Y		
	040826	Limekiln Lake	15/10/1985	06/10/1997	2012		Y			
	040210	Willys Lake (Horseshoe)	06/06/1984	28/05/2005	2012					
	050577	Nate Pond	28/10/1987	18/10/2005	2012			Y		
	040874	Brook Trout Lake	29/06/1984	26/06/2002	2012			Y		

Y indicates likely to be present based on earlier surveys.

As part of this effort, a lake water chemistry sample and other field parameters are also collected at the time of the fish survey (fall or spring). In July a more extensive lake water sample is collected from all waters scheduled for fish survey for that calendar year. All water sample collections are according to “Clean Hands/Dirty Hands” protocol. Samples are kept cool and shipped overnight to Frontier Global Sciences in Seattle, WA for analysis of mercury in lake water.

ALSC follows ALS fisheries survey protocols conducting fish surveys in the spring and fall, with no surveys during July and August. Experimental gill nets are the primary equipment used along with minnow gill nets and minnow traps. The number of gill nets set in each survey is based on the surface area of the lake. Nets are set according to previous surveys for comparability. All sport fish and yellow perch are weighed, have lengths measured, and have scale samples and opercular bones taken for aging individuals. Fish are processed at the NYSDEC laboratory at Hale Creek by ALSC staff in accordance to the NYSDEC Bureau of Habitat Fish Preparation Procedures for Contaminant Analysis (Simonin et al. 2008). The samples are processed, frozen and shipped to Cebam Analytical, Inc. in Seattle, WA, for analysis of mercury in fish tissue.

Field collections have been completed for 2008, 2009 and 2010. Fish and water samples were analyzed for 2008 and 2009. During 2010, eleven lakes were surveyed. No fish were caught in four lakes. Brook trout and yellow perch populations were captured and analyzed for mercury in six and four lakes, respectively (Table 3). The 2010 water samples were analyzed. The 2010 fish specimens will be processed during spring 2011.

Twelve lakes were surveyed for fish in 2011. Marcy Dam Pond, which had been on the schedule for fall was abandoned due to the damage to the impoundment by Tropical Storm Irene in August. The small lake is no longer there and the standard fisheries methods could no longer apply. Thirteen lake water samples were collected in July and analyzed by Frontier Global Sciences, Inc. Six brook trout and three yellow perch populations were captured and analyzed for mercury from a total of eight lakes (Table 3). The 2011 fish specimens were processed in November at the NYSDEC Hale Creek Laboratory and analyzed by Cebam Analytical in December 2011.

Results

Preliminary results indicate that changes in fish populations between 1984–1987 and 1994–2005 are highly variable. There are signs of response/recovery in the number of fish species in some lakes over the average 14-year interval, but they are modest and mixed. Overall, the recent survey netted 169 fish populations compared to 141 populations from the same lakes in the earlier survey (Table 4). Sensitive minnows (fallfish, fathead minnow and bluntnose minnow) were evaluated as possible indicator species. The greatest species gains occurred in moderately sized lakes with pH 5.5 – 6.0. Fish response patterns were generally consistent with ANC, NO_3^- and Al_{im} trends. Preliminary results were presented at the 2009 NYSERDA EMEP Conference: http://www.nyserda.ny.gov/Page-Sections/Environmental-Research/EMEP/Conferences/2009-EMEP-Conference.aspx. Further analyses are being conducted and a manuscript is in preparation. The median, mean and maximum number of fish species (populations) per lake and are shown in Table 4. Lakes arranged by fish response classes show the greatest changes in medium sized lakes with 5.5–5.7 pH (Table 4.5).

Tables 4. Fish population changes in 42 ALTM lakes between 1984–1987 and 1994–2005 survey.

Period of Study	Fish Populations T			Maximum
1984-1987	141	3	3.36	10
1994-2005	169	4	4.02	12
Change	+28	+1	<1	+2

Tables 4.5. Changes in fish communities in Adirondack lakes between 1984–1987 and 1994–2005.

Category			V (10^4)	1984 - 1987	1994 - 2005	
No fish	10	4.7 - 4.7	46	0	0	0
No Change	8	5.3 - 5.5	100	2.0	2.0	0
Only gained	15	5.5 - 5.7	198	4.1	6.0	+1.9
Only lost	4	6.3 - 6.3	56	3.0	1.75	-1.25
Gained and lost	8	6.2 - 6.5	350	7.1	7.0	+0.9

Table 5. Cascade Lake was one of fifteen lakes that 'gained only' species between the 1984 and 1999 surveys.

Cascade Lake - ALS Survey 1984

pH=6.48

Species n=4	Val =1	Val=1-2	Min pH	Serial Number
Brown Bullhead	1	1	4.49	2.5
Yellow Perch	1	1	4.53	4.0
Brook Trout	1	1	4.64	8.0
White Sucker	1	1	4.64	8.0
Total	4	4	18.30	22.5
Median	—	—	4.59	6.0

Cascade Lake - Resurvey 1999

pH=6.73

Species n=8	Val =1	Val=1-2	Min pH	Serial Number
Brown Bullhead	1	1	4.49	2.5
Golden Shiner	1	1	4.49	2.5
Yellow Perch	1	1	4.53	4.0
Pumpkinseed	1	1	4.59	5.0
Brook Trout	1	1	4.64	8.0
Creek Chub	1	1	4.64	8.0
White Sucker	1	1	4.64	8.0
Common Shiner	1	1	4.86	14.5
Total	8	8	36.88	52.5
Median	—	—	4.62	6.5

During 2011, fisheries analysis continued on a closer examination of fish management records (e.g., stocking), fish community indices (Table 5).

Preliminary fish tissue mercury results from 2008-2010 surveys found total mercury concentrations in yellow perch and brook trout ranging from 45 to 1238 ng g^{-1} and 5 to 595 ng g^{-1} on a wet weight basis, respectively. Overall, the percent of total mercury as methyl-mercury ranged from 22 to 100 (Table 6).

Table 6. Fish tissue mercury concentrations in yellow perch (YP) and brook trout (BT) captured in 22 ALTM lakes during 2008-2010.

	Population	(N)	(mm)	W (g)	Analyzed THg (N)	THg, ng g^{21}	Analyzed MeHg (N)	MeHg, ng g ^{21}	%T as Methyl
YP	7	202	52 - 317	1 - 441	154	45 - 1238	28	64 - 1172	65 - 100
BT	21	253	95 - 408	8 - 800	195	5 - 595	41	4 - 511	22 -98

Data Reported to Date

The fisheries survey data are currently being analyzed. It is anticipated that the data along with the fish tissue mercury results will be available at the end of the project period (December 2012).

Temporally Integrated Monitoring of Ecosystems (TIME) Lakes

The Temporally Integrated Monitoring of Ecosystems (TIME) program began as part of a northeastern lakes survey in the early 1990s. Under the auspices of the USEPA Environmental Monitoring and Assessment Program (EMAP), TIME was a statistically-based rotating sampling program (Whittier et al. 2002) that collected lake chemistry and biological data on nearly 250 lakes in New England, New York, and New Jersey during 1991–1996 (USEPA 1993a; USEPA 1993b).

The purpose of EMAP was to monitor ecological indicators of U.S. natural resources across a spectrum of issues including eutrophication and acid deposition over several types of landscape features such as forests, wetlands, arid areas, including surface waters (lakes and streams). The approach was statistically based to assess current status, geographic extent, proportion of the resource population affected, the trends and probable causes (Whittier and Paulsen 1992). For lakes, EMAP Surface Waters (EMAP-SW) evaluated biotic integrity, trophic condition, and fishability of lakes and streams. The sampling time frame was every four years. The framework is described (Whittier and Paulsen 1992) as consisting of 40 km^2 hexagons in a triangular spaced grid representing approximately 12,500 points for the conterminous US. The grid density was increased three-fold in two high elevation acid sensitive areas of the Northeast, the Adirondack Mountain region and the southern Green Mountains/north central Massachusetts/southwestern New Hampshire Uplands subregion (Whittier and Paulsen 1992).

TIME is a statistically based sampling program that enables population estimates of low ANC lakes to be developed from 43 sites in the Adirondacks. There are approximately 1,000 low ANC (less than 100 µeq L^{-1}) lakes in the region out of a total population of 1,830 lakes with a surface area greater than one ha (Stoddard et al. 2003). This monitoring program enables researchers to monitor sensitive lakes over time. The goal of the program is to track the effectiveness of the 1990 Clean Air Act Amendments in the reduction of acidified surface waters. In addition to the 43 Adirondack lakes sampled once each year in the late summer/early fall, 30 New England lakes and 31 Appalachian streams are sampled by other investigators. An overview of these varied regional monitoring efforts and their relevance to developing scientifically-supported national policies to abate atmospheric emissions are provided by EPA (USEPA 1995). The TIME sampling design and tests of its ability to detect trends in ANC and sulfate are provided by Stoddard et al. (1996).

In the eastern US, the core of the EPA acid rain effects monitoring effort are the TIME and Long Term Monitoring (EPA LTM) programs. Both programs are operated in collaboration with academic institutions, state agencies, or other federal agencies (Stoddard et al. 2003). Two aspects of the TIME program include the design based probability sample called the TIME survey sites and the model-based aspect using a non-random group of lakes. The second group of lakes is sampled more frequently (8 – 16 times per year) to build links between chronic and episodic acidification (Stoddard et al. 1996). These long term monitoring (EPA LTM) efforts began in the early 1980s including lakes from Vermont, Maine, and 17 Adirondack lakes that became known as the Adirondack Long Term Monitoring (ALTM) lakes (Figure 5). These provide a characterization of seasonal or episodic acidification. In many of the regions, the sites include some higher ANC sites (i.e. greater than 100 µµeq L^{-1} ANC) to help separate effects of disturbances (e.g. climate) other than acidic deposition (Stoddard et al. 2003).

This probability-based survey allowed inferences to be made on the entire population of lakes in the Northeast, which numbered 10,381 in New York and New England combined. The survey was conducted in late summer during low flow conditions, so ANC values are expected to be the highest. Lakes were divided into biologically relevant ANC classes where: ANC levels of < 0 µeq L^{-1} are 'acute concern' or chronically acidic; ANC > 0 and < 50 µeq L^{-1} are 'elevated concern' or susceptible to episodic acidification; and ANC values > 50 and < 100 µeq L^{-1} are 'moderate concern'. Results from the Adirondack region representing a population of 1812 lakes (surface area greater than one ha) found 10% had ANC values of < 0 µeq L^{-1} (chronically acidified) and an additional 31% of all lakes where critically acidified with values of ANC > 0 and < 50 µeq L^{-1} bringing the total population of lakes with elevated or acute concern to 41%

(Driscoll et al. 2001). A charge-balance technique for evaluating the nature of the acid inputs to these lakes found 83% of the acid sensitive lakes (ANC <50 µeq L^{-1}) were dominated by inorganic anions with sulfate constituting 82% of the total anionic charge (Driscoll et al. 2001).

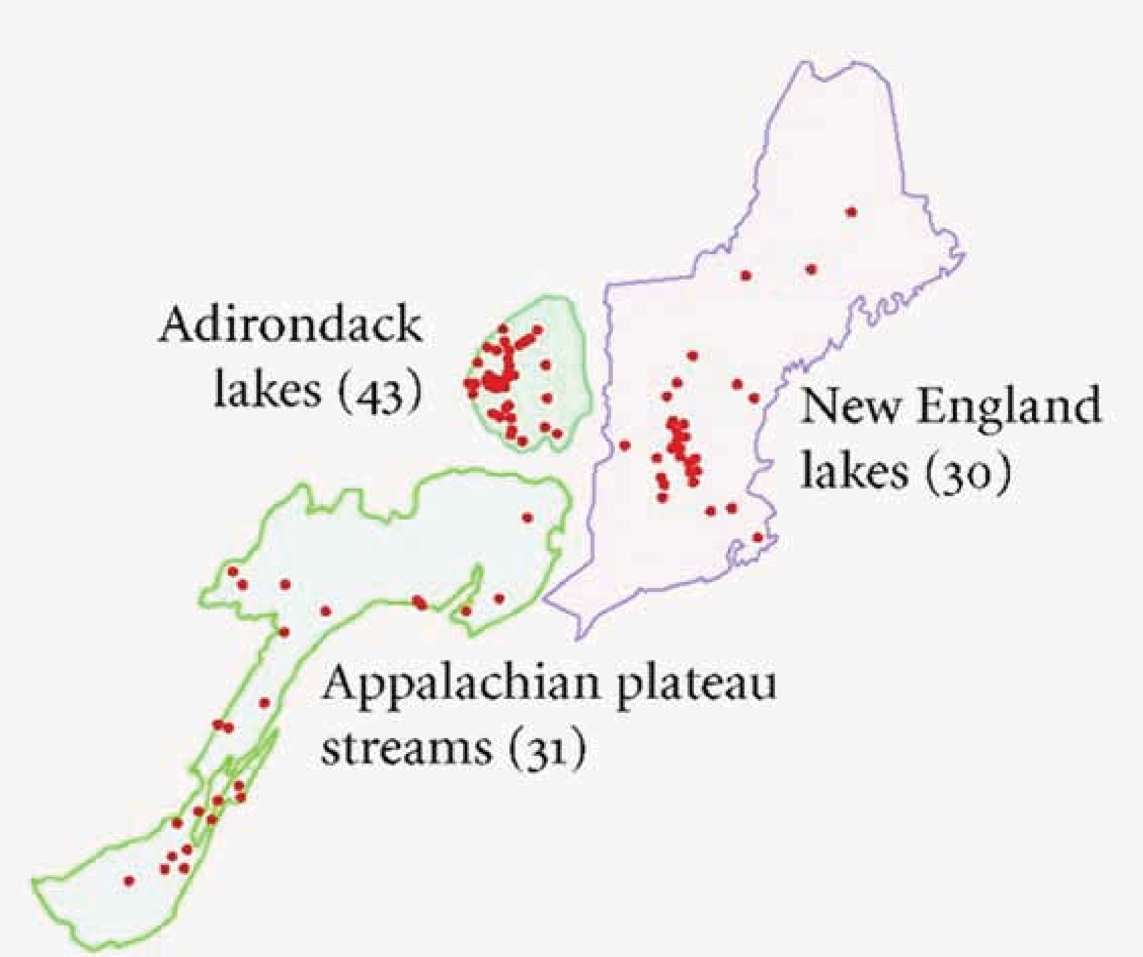


Figure 5. TIME Regional Surveys 1991–2000.

Site Description

EMAP lake sampling in the Adirondack region began in 1991 with a selection of different lakes each year: 1991 (26 lakes); 1992 (41 lakes); 1993 (23 lakes) and 1994 (27 lakes) for a total 117 lakes. In 1999, one set of 43 lakes was selected for annual sampling, which has been ongoing.

Table 5 identifies TIME/EMAP lake name and identification number, the NYSDEC/ALSC lake name and identification number. The surface area data were derived from the ALSC survey 1984–1987 and from NYSDEC sources for the 13 lakes that were not part of the survey. The lake classification is based on Newton and Driscoll (1990) developed from the ALSC survey. For non-ALSC surveyed lakes, chemistry data from the 1991–1994 EMAP were used. Of these 43 lakes, six are cross-over lakes with the ALTM program (Table 1).

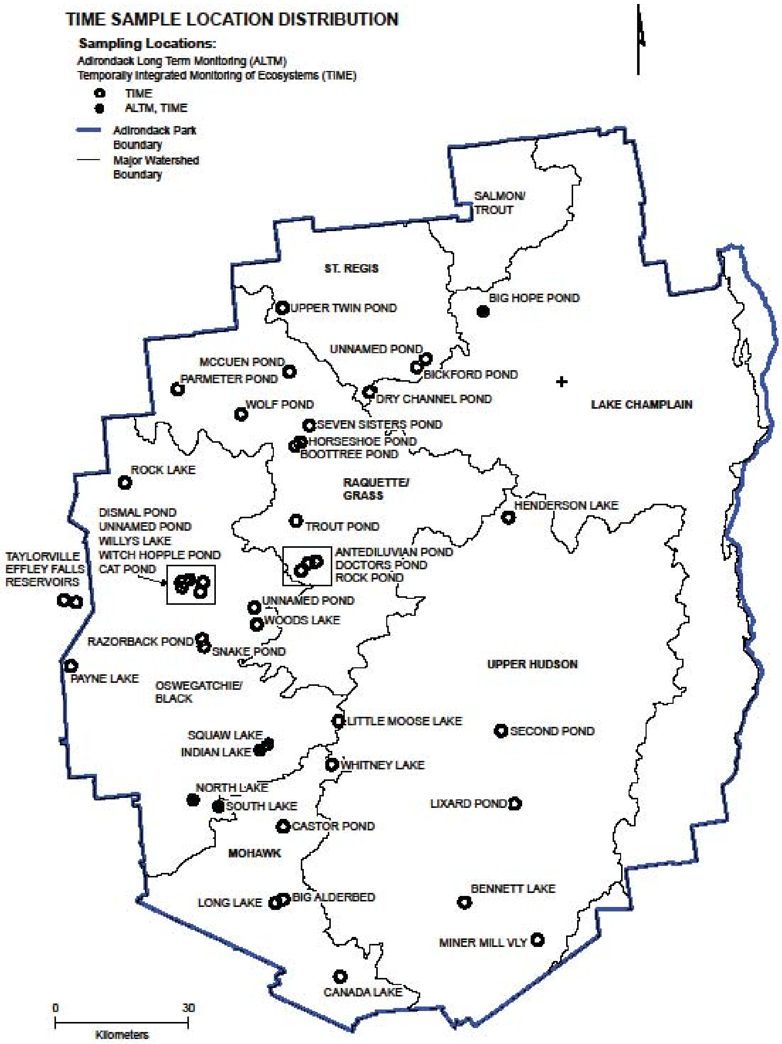
Table 7. Adirondack TIME lake characteristics.

EMAP Ref #	ALSC Ref #	TIME/EMAP Pond Name	ALS/DEC Pond Name	Elev (m)	Classification	Area (ha)
NY012L	020059	Hope Pond	Big Hope Pond	517	Medium till drainage High DOC	8.9
NY250L	030101	Twin Pond (E)	Upper Twin Pond	403	Thin till drainage, Low DOC	6.0
NY033L	030128	Dry Channel Pond	Dry Channel Pond	497	Thin till drainage, Low DOC	27.4
NY297L	030273	Bickford Pond	Bickford Pond	532	Thin till drainage, Low DOC	4.4
NY299L	030276	Pd. Near Spitfire Lake	Unnamed Pond	495	Flow through seepage, High DOC	2.1
NY278L	030331	Parmeter Pond	Parmeter Pond	351	Flow through seepage, High DOC	7.1
NY515L	030360	Wolf Pond	Wolf Pond	451	Thin till drainage, Low DOC	8.9
NY285L	030373	Horseshoe Pond	Horseshoe Pond	466	Thin till drainage, Low DOC	10.4
NY284L	030374	Boottree Pond	Boottree Pond	464	Flow through seepage, Low DOC	6.2
NY527L	040137	Rocky Lake	Rock Lake	424	Thin till drainage, Low DOC	8.2
NY790L	040203	Lower Beech Ridge Pond	Unnamed Pond	630	Thin till drainage, Low DOC	9.3
NY789L	040210	Willys Lake	Willys Lake	632	Thin till drainage, Low DOC	24.3
NY275L	040424	Taylorville Pond	Taylorville Res.	326	Medium till drainage Low DOC	37.5
NY277L	040426	Effley Falls Pond	Effley Falls Res.	354	Thin till drainage, Low DOC	121.5
NY791L	040515	Dismal Pond	Dismal Pond	624	Mounded seepage, Low DOC	21.5
NY792L	040518	No Name	Cat Pond	532	Thin till drainage, High DOC	6.7
NY788L	040528	Witchhopple Lake	Witchhopple Pond	536	Thin till drainage, Low DOC	37.6
NY029L	040566	Little Lilly Pond	Unnamed Pond	596	Thin till drainage, High DOC	6.5
NY280L	040573	Razorback Pond	Razorback Pond	675	Thin till drainage, Low DOC	5.3
NY281L	040579	Snake Pond	Snake Pond	589	Thin till drainage, Low DOC	7.3
NY794L	040620	Payne Lake	Payne Lake	383	Flow through seepage, High DOC	7.0
NY030L	040769	Upper Sister Lake	Upper Sister Lake	590	Thin till drainage, High DOC	32.0
NY014L	040850	Squaw Lake	Squaw Lake	646	Thin till drainage, Low DOC	36.4
NY015L	040852	Indian Lake	Indian Lake	654	Thin till drainage, Low DOC	33.2
NY798L	050607	Little Moose Pond	Little Moose Lake	695	Thin till drainage, Low DOC	11.3
NY282L	041004	South Lake	South Lake	615	Thin till drainage, Low DOC	197.4
NY279L	041007	North Lake	North Lake	555	Thin till drainage, Low DOC	176.8
NY536L	050131A	Miner Mill Vly	Miner Mill Vly	479	Medium till drainage, High DOC	3.3
NY256L	050182	Bennett Lake	Bennett Lake	356	Thin till drainage, Low DOC	14.8
NY505L	050197	Lixard Pond	Lixard Pond	528	Thick till, Low DOC	11.7
NY013L	050298	Second Pond	Second Pond	681	Thin till drainage, Low DOC	18.0
NY526L	050715	Henderson Lake	Henderson Lake	553	Thin till drainage, Low DOC	102.1
NY782L	060039	McCuen Pond	McCuen Pond	456	Thin till drainage, High DOC	2.6
NY288L	060074	Seven Sisters Pond	Seven Sisters Pond	469	Mounded seepage, Low DOC	3.0
NY287L	060126	Antediluvian Pond	Antediluvian Pond	532	Thin till drainage, High DOC	5.3
NY291L	060127	Doctors Pond	Doctors Pond	556	Thin till drainage, Low DOC	10.2
NY286L	060129	Rock Pond	Rock Pond	525	Thin till drainage, High DOC	112.2
NY767L	060146	Trout Pond	Trout Pond	545	Thin till drainage, Low DOC	63.4
NY292L	070717	Canada Lake	Canada Lake	472	Salt impacted	217.7
NY017L	070790	Big Alderbed	Big Alderbed	549	Thin till drainage, Low DOC	17.7
NY018L	070823	Long Lake	Long Lake	667	Thin till drainage, Low DOC	21.7
NY507L	070885	No Name	Castor Pond	700	Thin till drainage, High DOC	5.3
NY797L	070936	Whitney Lake	Whitney Lake	752	Thin till drainage, Low DOC	42.6

Sampling Design

TIME sites were selected using methods developed for the EMAP investigation (Hughes et al. 2000). The 43 Adirondack TIME lakes are sampled once in late summer/early fall each year. Samples are collected at a depth of 1.5 m (0.5 m if lake depth is less than 2.0 m), using a Van Dorn sampler. The samples, collected in two 60-ml syringes and two 1-liter Nalgene high density polyethylene bottles, are transported from the field on ice and shipped overnight to the EPA designated laboratory for analysis (ALSC 2002b). Water samples are also collected in separate bottles for speciated aluminum analysis by the ALSC laboratory since 2006. Samples are delivered directly to the laboratory in Ray Brook, New York.

Samples are analyzed by the EPA-designated laboratory for the following parameters: pH, ANC. specific conductance, color, nitrate, sulfate, chloride, fluoride, calcium, magnesium, potassium, sodium, silica, ammonium, dissolved organic carbon, dissolved inorganic carbon, and total aluminum. The ALSC laboratory provides total dissolved aluminum, total monomeric aluminum, total organic monomeric aluminum, and total inorganic monomeric aluminum (calculated). Analytical procedures follow EPA standards developed and described elsewhere (Morrison et al. 1991; ALSC 2002a; Driscoll and van Dreason 1993; Burns et al. 2006).



Regional trends in surface water chemistry response from five sensitive areas of the US during 1990–2000. Source: Stoddard et al. 2003. Response of Surface Water Chemistry to the Clean Air Act Amendments of 1990.

Figure 6. TIME and LTM sample locations.

Results

Chemistry Trends 1990–2000

Using EMAP, TIME and EPA LTM surface water chemistry, Stoddard analyzed regional trends in five sensitive areas of the eastern US over the time period 1990–2000 (Stoddard et al. 2003). The EPA LTM lakes in the Adirondack region are referred to as the ALTM lakes. Trend analysis was conducted on 48 ALTM lakes (non-limed) sampled on monthly basis. Includes both drainage and seepage lakes in the ANC range -50 to 100 µeq L^{-1} with three lakes in the >100 but < 200 µeq L^{-1} range (Stoddard et al. 2003). In three regions (Adirondacks, Northern Appalachian Plateau and Upper Midwest) ANC increased at a rate of 1–2 µeq L^{-1} yr^{1} despite a decrease in base cations. In the Adirondacks, declines in sulfate occurring in nearly all lakes (2.5 µeq L^{-1} yr^{-1}) and in some lakes declines in nitrates (0.5 µeq L^{-1} yr^{-1}). This combination resulted in pH increases in many lakes (Figure 7). In evaluating lake chemistry responses to atmospheric deposition trends, only sulfate was closely examined because changes in nitrate emissions and deposition were insignificant. During this period 1990–2000, the rate of decline in precipitation sulfate concentrations compared with surface water concentrations varies among the regions. In the Adirondacks, New England, and the Northern Appalachians, declines in precipitation were greater than declines in surface water concentrations, suggesting a lagged response. The five factors identified as important in determining response/recovery in surface water chemistry are: base cations, nitrogen deposition, natural organic acidity, climate fluctuations, and lag in response (Stoddard et al. 2003).

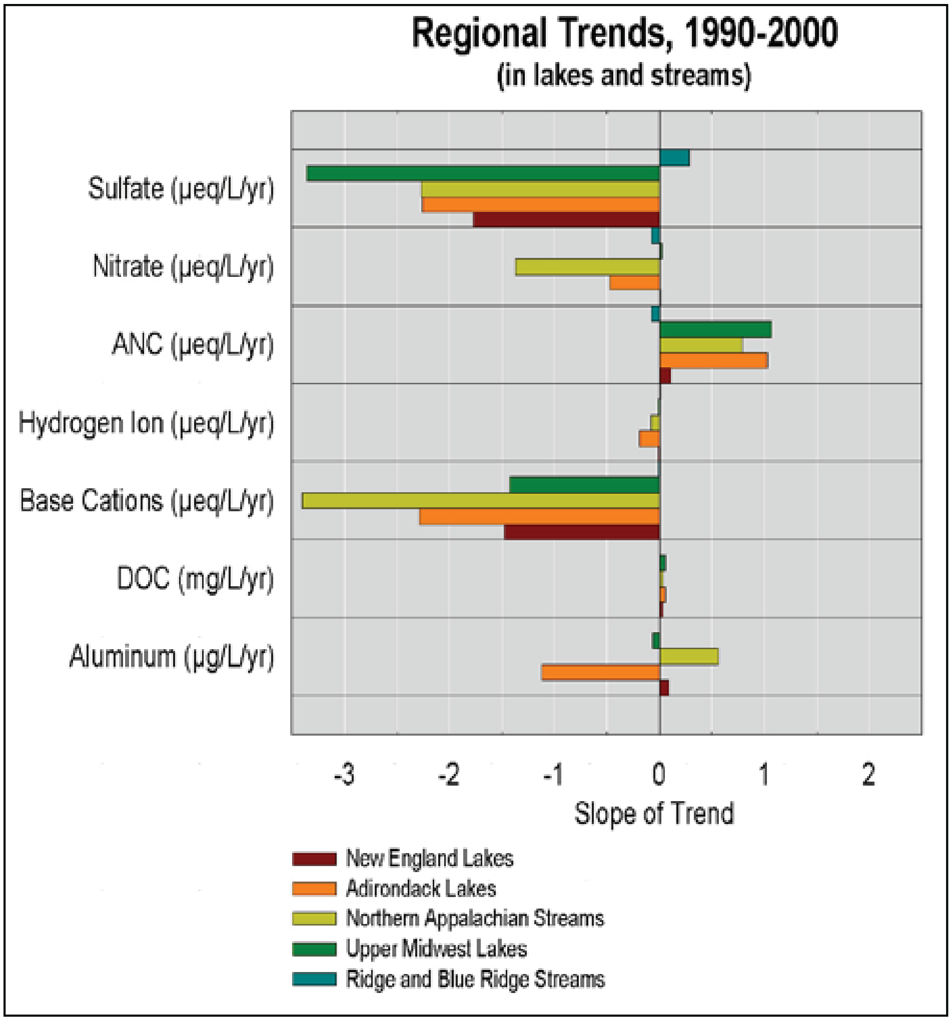


Figure 7. Regional trends in surface water chemistry.

Chemistry Trends 1990–2007 and Ongoing

EPA's 1990–2007 update of regional trends in four sensitive areas of the eastern US found continued sulfate declines in surface water chemistry in three of the regions including the Adirondacks where declines averaged 2.2 µeq L^{-1} yr^{-1}. Nitrate declines in some Adirondack lakes occurred at a rate of 0.2 µeq L^{-1} yr^{-1}. ANC increases occurred in the same three regions with Adirondack trends averaging 0.77 µeq L^{-1} yr^{-1} (EPA Acid Rain Program 2008 Progress Report found at http://www.epa.gov/airmarkets/progress/arp08.html). In the Adirondack region, all significant trend slopes (rates of change) have diminished from the previous 1990–2000 assessment.

EPA conducted another assessment during this time period examining 156 northeastern US lakes monitored in the TIME and LTM programs. ANC changes were evaluated between 1992–1994 and 2004–2007. Adirondack lakes were included in this dataset. Lakes with ANC levels below 0 µeq L^{-1} are considered of 'acute concern' because aquatic biota in these ecosystems are severely compromised. The evaluation found lakes with 3-year average ANC values below 0 µeq L^{-1} occurred in 30% of the total population in 1992–1994. The percentage of lakes in the same category had diminished to 18% by 2004–2007(http://www.epa.gov/airmarkets/progress/arp08.html).

The EPA Clean Air Markets Division published a series of reports in 2010 under Acid Rain Program 2009 Progress Reports (http://www.epa.gov/airmarkets/progress/). The Adirondack LTM lakes data were featured prominently in Environmental Results (October 2010) and Highlights: 15 Years of Results (December 2010). Critical loads for sulfur and nitrogen deposition were established for Northeast and Adirondack lakes. Calculations of critical loads exceedences for two time periods 1989-1991 and 2007-2009 were compared for each region. In the Adirondacks, 37% of lakes with exceedences in the earlier time period no longer were receiving critical loads considered threatening to those lakes. The region, however, remained among the areas with the highest concentration of lakes where acid deposition exceeded the critical loads.

During 2010, two analyses were conducted on Adirondack TIME chemistry, with manuscripts under preparation for both. One was a comparison of the TIME and ALTM results using the six cross-over lakes in common with both projects. Chemistry trends (1992-2008) for sulfate, nitrate, base cations, dissolved organic carbon, hydrogen ion, ANC, and aluminum found sulfate and base cations better represented in the annual TIME data than the other parameters associated with seasonal variability. Seasonal concentrations of total and inorganic aluminum were also examined relative to annual only data. The second analysis involved a broader time series (1991-2007) examination of all the TIME waters with a focus on two measures of ANC and the change in ANC sensitivity classes over the record.

The two manuscripts were accepted in 2011. Civerolo et al. (2011) found at the six crossover lakes (Figure 8) (Big Hope, Squaw, Indian, Willys, South and North) key chemical parameters paired in time and analyzed by different laboratories generally agreed well Figure 9 (sulfate and ANC plots).

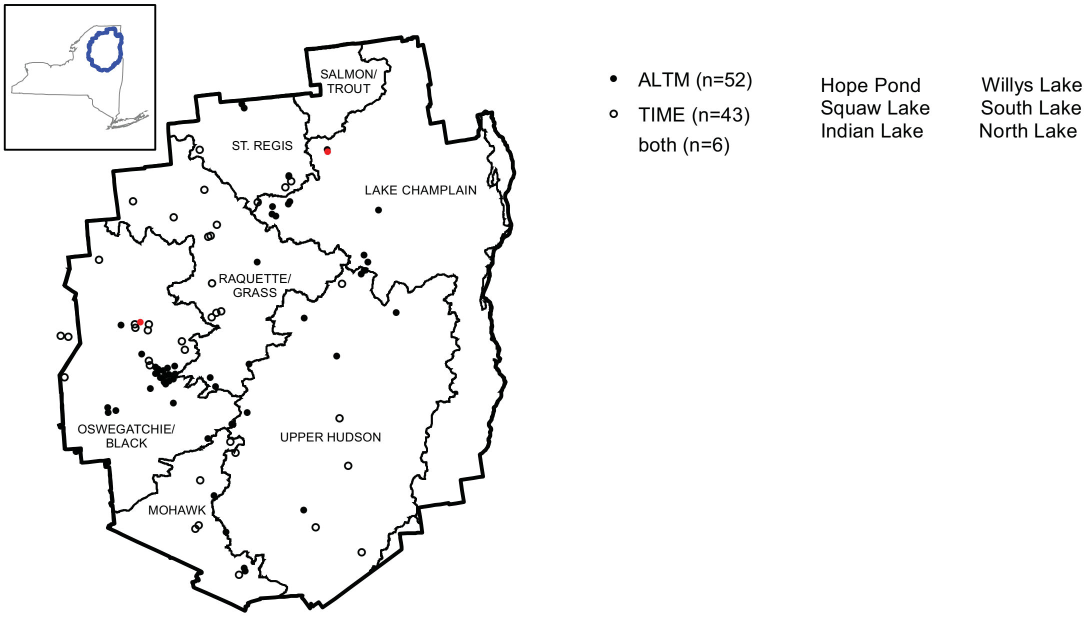


Figure 8. Location of 52 ALTM (black) and 43 TIME (open circles) and the six crossover lakes (red) common to both projects.

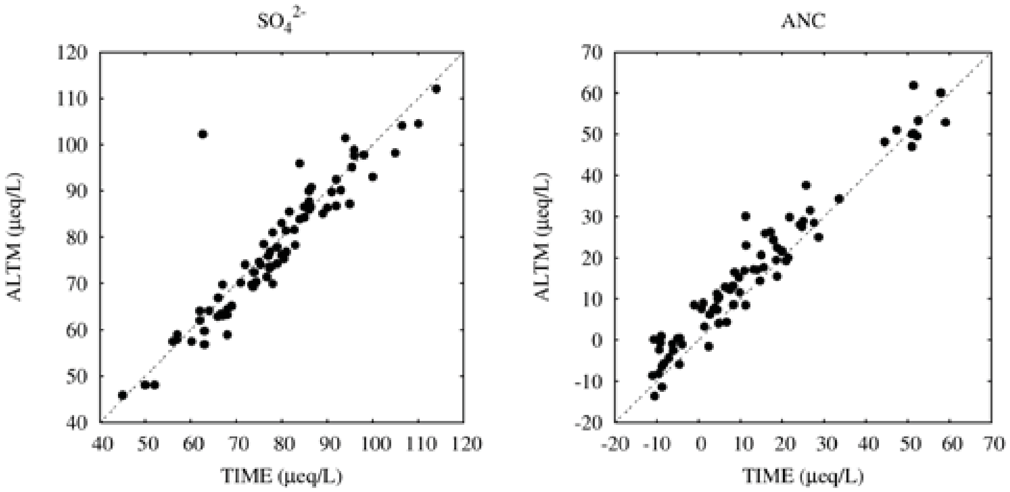


Figure 9. Comparison of sulfate and ANC from TIME and ALTM at six crossover lakes during 1992-2008.

Comparison of monthly ALTM sampling trends with annual TIME trends were consistent for sulfate and the sum of the base cations but not very consistent for ANC and total aluminum (Table 8).

Table 8. Comparison of long term trends from TIME and ALTM at six crossover lakes using Mann-Kendall for TIME and Seasonal Kendall for ALTM during 1992 - 2008. The number of lakes with significant trends ($p<0.05$) are shown with the range of slopes.

	TIME	ALTM
SO_4^{2-}, µeq L^{-1} yr^{-1}	-3.44 to -2.03 (n=6)	-3.36 to -2.11 (n=6)
ΣCB,µeq L^{-1} yr^{-1}	-2.41 to -1.05 (n=5)	-2.48 to -0.98 (n=5)
NO_3^-, µeq L^{-1} yr^{-1}	-1.16 to -0.81 (n=3)	-1.10 to -0.22 (n=5)
DOC, µmol L^{-1} yr^{-1}	+6.25 to +9.44 (n=2)	+3.60 to +6.74 (n=3)
H^+, µeq L^{-1} yr^{-1}	-0.17 (n=2)	-0.31 to -0.04 (n=5)
ANC, µeq L^{-1} yr^{-1}	+0.65 to +1.49 (n=2)	+0.70 to +2.08 (n=6)
Total Al, µmol L^{-1} yr^{-1}	Non-significant	-0.56 to -0.17 (n=4)
Al_{IM}, µmol L^{-1} yr^{-1}	N/A	-0.65 to -0.01 (n=5)

ANC, nitrate, DOC and pH exhibited varying degrees of consistency in magnitude and statistical significance of trends (Table 8). Because these parameters along with aluminum have substantial seasonal variability Figure 10 and are biologically relevant to aquatic biota, the authors concluded that both projects/approaches are needed to assess the full impacts of acidification.

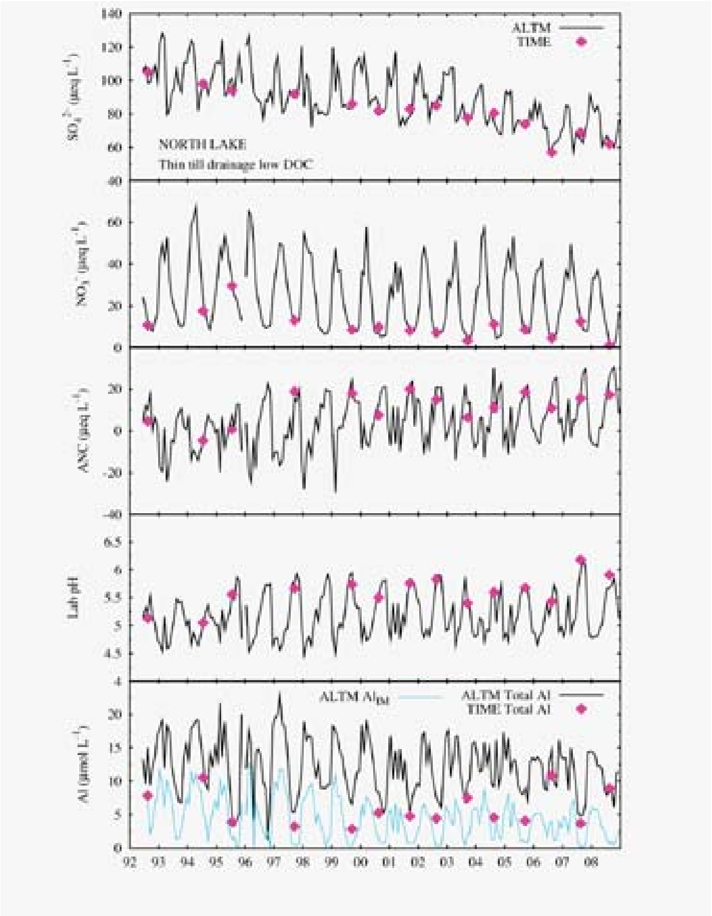


Figure 10. Time series of selected parameters at North lake (1992 - 2008) from ALTM and annual (diamonds) from TIME.

Waller et al. (2012) used the NADP NTN and TIME to evaluate response of lake watersheds to changes in sulfur and nitrogen oxides from 1991 to 2007. Decreases in wet sulfate deposition corresponded to decreases in lake sulfate. Lake ANC changes resulted in shifts among lake ANC classes. The percentage of acidic lakes (ANC < 0 ueq L-1) decreased from 15.5% (284 lakes) to 8.3% (152 lakes) over the period. ANC determined by Gran plot analysis and by calculation of major ion chemistry showed dissimilar values likely due to increases in naturally occurring organic acids. These differences are important to understanding surface water recovery (Waller et al. 2012). The once-per-year population-based TIME study and the monthly ALTM study with seasonal data and aluminum speciation together provide complementary measurements to assess the full impacts of acidification in the Adirondack region.

Data Reported to Date

Data currently available from this TIME lake study (this section) include the original EPA EMAP data for the lakes available at http://www.epa.gov/emap/html/data/surfwatr/data/nelakes.html. The EPA LTM/TIME program is responsible for making available the TIME lake chemistry data. Additional chemistry data (i.e., speciated aluminum) analyzed by the ALSC laboratory for the 43 lakes were provided to EPA for the 2006-2009 sampling seasons. In 2011, the ALSC collected water samples from the 43 lakes, and provided speciated aluminim chemistry for the same lakes sampled in 2010. Additional data may be available by contacting the NYSDEC Research Manager.

Stream Chemistry

The streams component of the ALTM program began in June 1992 at the completion of the USEPA Episodic Response Project (ERP). The ERP examined the chemistry and biological effects of episodes, defined as a period of time when Acid Neutralizing Capacity (ANC) values decreased to less than or equal to 0 μeq L^{-1}, in 13 streams from the fall of 1988 through the spring of 1990 in three study regions: the Catskill and Adirondack Mountains of New York, and the Northern Appalachian region of Pennsylvania. The Adirondacks were represented by four streams: Buck Creek, Bald Mountain Brook, Seventh Lake Inlet, and Fly Pond Outlet. The streams are located in the southwestern highlands area within the Oswegatchie-Black watershed (Figure 11). The bedrock, surficial geology and soils in these watersheds are considered typical of the region. Fly Pond Outlet is the only stream with a small pond as headwater and is the reference stream for biological studies (Wigington et al. 1996a).

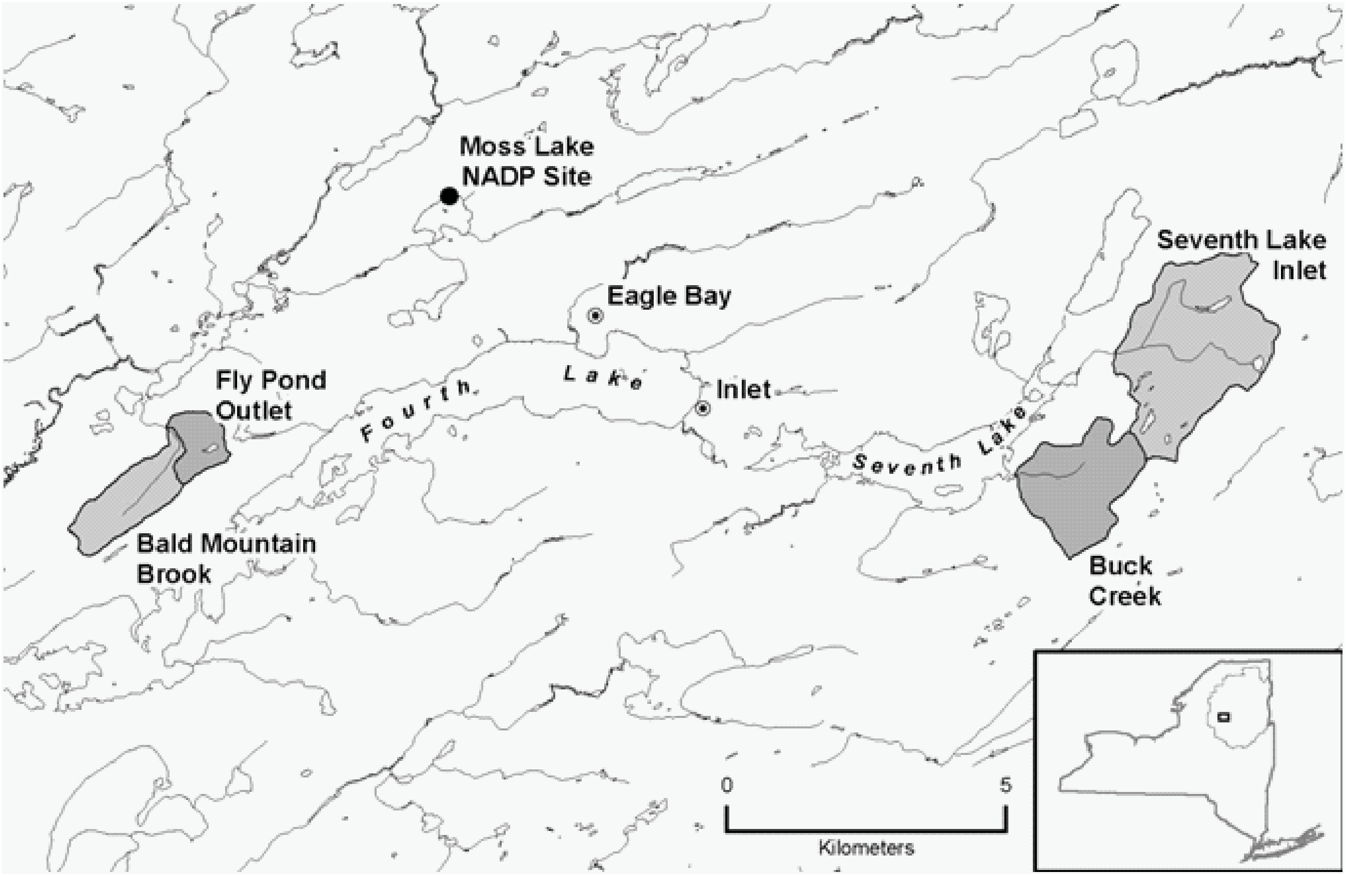


Figure 11. Stream watersheds of original four ERP streams; Buck Creek, Bald Mountain Brook, Fly Pond Outlet and Seventh Lake Inlet.

The ERP investigators produced a series of articles published in Ecological Applications 1996 Issue 6. Wigington found none of the Adirondack streams chronically acidic during the sutdy period 1988-1990, however, during high flow, Bald Mountain Brook and Buck Creek exhibited critical chemistry with median ANC values less than -10 μeq L^{-1} (Wigington et al. 1996a). More detailed episodic chemistry was examined by Wigington et al. (1996b). This additional analysis found acid episodes within the 90th percentile with ANC decreases of up to 200 μeq L^{-1}, decreases of pH of up to one unit, and increases in inorganic monomeric Al of up to 15 μmol L^{-1}. Others reported negative responses of wild brook trout and native forage fish to changes in chemistry (Van Sickle et al. 1996; Baker et al. 1996).

Site Description

The ALSC continued to sample Buck Creek, Bald Mountain Brook and Fly Pond Outlet on a weekly basis beginning in June 1992. Stream gaging that took place during the ERP was discontinued. Weekly surface grab samples are analyzed for Lab pH, Air Equilibrated pH, ANC, and specific conductivity. In May 1997, the ALSC started analyzing the first weekly samples each month for the full suite of chemical parameters analyzed as they are for the ALTM lakes, namely: Lab pH, Air Equilibrated pH, ANC, specific conductivity, color, nitrate, sulfate, chloride, fluoride, calcium, magnesium, potassium, sodium, silica, ammonium, dissolved organic carbon, dissolved inorganic carbon, total dissolved aluminum, total monomeric aluminum, total organic aluminum, and total inorganic aluminum (calculated).

Following an analysis by Lawrence et al 2004, in September of 2006 the stream sampling interval was changed to bi-weekly sampling of Buck Creek and Bald Mountain Brook. Sampling at Fly Pond outlet was continued on a monthly basis. All samples are analyzed for full complement chemistry.

Starting in 1998, the United States Geological Survey (USGS) with support from the Adirondack Effects Assessment Program (AEAP), conducted bi-weekly and event-driven chemistry and flow monitoring at two upstream tributaries of Buck Creek referred to as the North Tributary and the South Tributary. Additional sampling started at the main stem of Buck Creek in 2001. All samples were analyzed for the full suite of analytes. At all three locations, USGS collected bi-weekly samples and selected storm event samples collected by automated samplers. The USGS effort included soil temperature and moisture monitoring at a location adjacent to the stream sites. An assessment of episodic acidification in Buck Creek watershed in relation to atmospheric deposition and soil chemistry during 1998–2000 is discussed by Lawrence (2002). Diatom community dynamics and water chemistry were assessed from May 2000 through July 2003 (Passy et al. 2006; Passy 2006). Buck Creek is also one of eight research sites across the Northeast examined in 2000 by the USGS and others (Ross et al. 2004) for patterns of soil nitrogen accumulation. Sampling methods and site characteristics of the Buck Creek watershed are detailed by Lawrence et al. (2002); Ross et al. (2004); Passy (2006); Passy et al. (2006).

In response to funding reductions at the AEAP, in September 2006, the USGS consolidated efforts with the ALSC at Buck Creek and the ALSC assumed responsibility for sample collections at the tributaries and main channel. The ALSC continues bi-weekly sampling at the North Tributary (AB), South Tributary (BB) and the main channel of Buck Creek (BCK). Discharge monitoring also continues at both tributaries and the main channel of Buck Creek, with 5–7 event based samples analyzed each year. Laboratory analysis of the samples collected for these discharge events is based on the guidance of Greg Lawrence (USGS). Bald Mountain Brook and Fly Pond outlet sampling continues on a bi-weekly basis. Chemistry analyzes are performed by the ALSC laboratory in Ray Brook.

Buck Creek was a critical calibration site during the Western Adirondack Stream Survey (WASS) conducted during 2003–2005 (Lawrence et al. 2008a; Lawrence et al. 2008b). Buck Creek is the only stream within the Oswegatchie River and Black River drainages monitored for year-round flow and chemistry. During the WASS, Buck Creek served as an index stream to place results within the context of variations throughout the year.

Monitoring of stream discharge and chemistry in the Buck Creek watershed has supported research that has provided valuable information on (1) trends in stream chemistry over the last two decades, (2) methods to improve the ability to distinguish between acid rain effects and natural acidity, and (3) sensitivity of aquatic organisms to low levels of inorganic aluminum. The incorporation of historic vegetation and soil chemistry data and continuation of sampling/analysis at these sites provide critical information on the linkages between (soil acidification) terrestrial condition/status and the hydrologic and aquatic chemistry conditions.

Sampling Design

Descriptions of the stream study sites, and laboratory and field methods are provided by Kretser et al. (1992). The surface grab samples are collected in high density polyethylene bottles and analyzed weekly for Lab pH, Air Equilibrated pH, ANC, and specific conductivity. In addition, twice each month, the samples are analyzed for the following additional parameters: color, nitrate, sulfate, chloride, fluoride, calcium, magnesium, potassium, sodium, silica, ammonia, dissolved organic carbon, dissolved inorganic carbon, total dissolved aluminum, total monomeric aluminum, total organic aluminum, and total inorganic aluminum (calculated). Event based samples for discharge monitoring are collected in ISCO samplers, maximum of 24 bottles, and analyzed for all of the above parameters except dissolved inorganic carbon, color and specific conductivity.

Table 9. Physical characteristics of the four ERP study streams in the Adirondack Mountains of New York.

	Study		**Fly Pond**	
				Inlet
Stream gage				
Latitude	43° 44' 39" N	43° 45' 03" N	43° 45' 05" N	43° 45' 49" N
Longitude	074° 43' 20" W	074° 54' 39" W	074° 54' 34" W	074° 42' 11" W
Watershed				
Area (km2)	3.1	1.8	0.9	6.4
Maximum elevation (m)	775	715	710	725
Minimum elevation (m)	560	570	563	570
Lake or pond present	No	No	Yes	Yes
Wetland present	Minor	Yes	Yes	Yes
Soil series	Becket-Lyman Becket-Sherry	Lyman Becket	Lyman Becket	Lyman Becket-Sherry Becket-Lyman Adams-Croghan
Stream				
Order	2	1	1	2
Length (km)	2.1	2.2	0.8	3.7
Gradient (m km^{-1})	50	25	9	31

a. continued bi-weekly sampling

b. continued monthly sampling

c. discontinued after 1991

Results

Trend Analysis 1991–2001

In 2004, the ALTM Program performed a time series analysis of these three streams, Buck Creek, Bald Mountain Brook, and Fly Pond Outlet for the period October 1991-September 2001. Examining monthly pH values during these 10 years found that Buck Creek is acidic, Bald Mountain Brook is moderately-well buffered and Fly Pond Outlet is well buffered. Concentrations of dissolved organic carbon (DOC) were similar among the three streams. Total and inorganic monomeric aluminum (Al) concentrations were at or near detection limits in Bald Mountain Brook and Fly Pond Outlet, and higher in Buck Creek. While similar increasing trends in ANC and pH were found in all three streams, the trends changed uniquely for each stream when the effect of flow variation was removed (Figure 12). In Buck Creek, the increasing trend in ANC was no longer observed if flow effect was removed. In Bald Mountain Brook, a downward trend in ANC from 1991–1995, followed by an upward trend from 1996 to 2001 was evident. In Fly Pond Outlet, ANC increased abruptly in 1997, with no clear trend before or after. These comparisons indicate the importance of long-term flow data for interpreting long term stream chemistry trends (Lawrence et al. 2004).

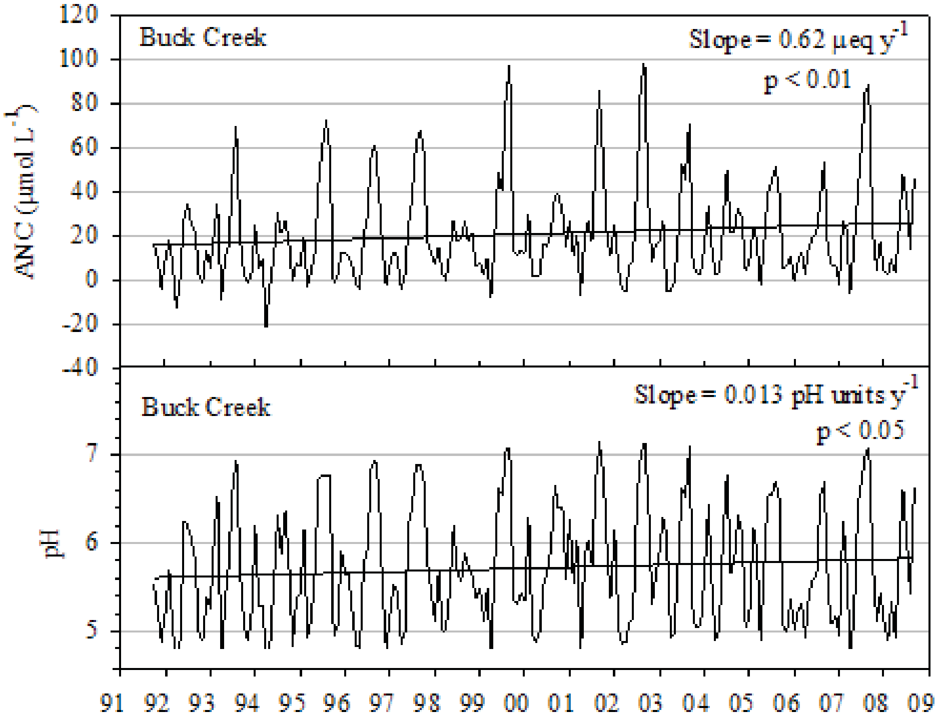


Figure 12. Trend 1991–2008 Buck Creek.

Examination of flow variation within the year identified five periods: the month of April with pronounced snowmelt peak; spring and early summer (May-July); a late summer minimum (Aug–Sept) that results from a soil moisture deficit over the course of the growing season; a rise in flow in the fall (Oct–Nov) after the growing season; and a relatively stable period (Dec–Mar) during the winter months (Lawrence et al. 2004)

Trend Analysis 1991–2008

An updated time series analysis is currently underway for the period October 1991–September 2008. In Buck Creek, measurements of ANC and pH show limited but statistically significant increases over the 17-year period (Figure 11). Extending the average annual rate of increase (slope shown in Figure 12) over the 17 years resulted in a total increase in ANC of 10 µeq L^{-1} and a total increase in pH of 0.22 pH units.

In Bald Mountain Brook, measurements of ANC and pH also showed overall increases that were statistically significant (Figure 13). Extending the average annual rate of increase (slope shown in Figure 12) over the 17 years resulted in a total increase in ANC of 31 µeq L^{-1} and a total increase in pH of 0.8 pH units. The average annual rate of increase of ANC and pH in Bald Mountain Brook (1.8 µeq L^{-1} y^{-1}, 0.047 pH units y^{-1}, respectively) was approximately 3–4 times the rate of increase of ANC and pH in Buck Creek (0.62 µeq L^{-1} y^{-1}, 0.013 pH units yr^{-1}, respectively). The temporal patterns of both measurements in Bald Mountain Brook show a decrease over the first three years, followed by a pronounced increase over the next 5–6 years, then small to moderate decreases over the final 7–8 years (Figure 12).

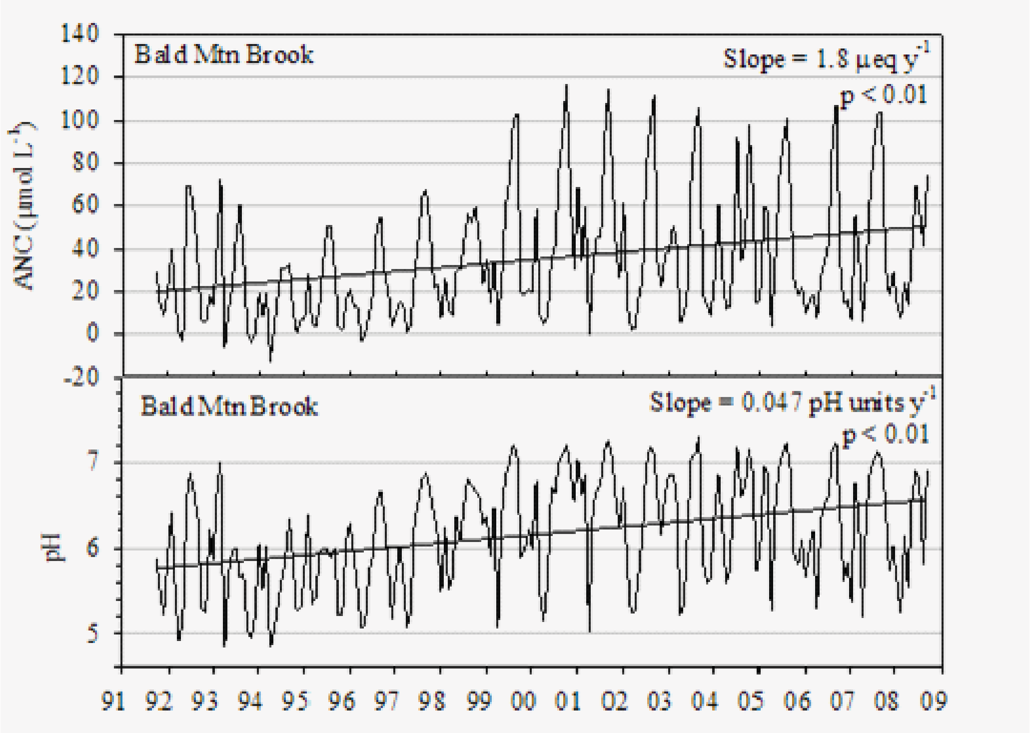


Figure 13. Trend 1992–2008 Bald Mountain Brook.

With respect to conditions for aquatic biota, in general, values of ANC less than 50 µeq L^{-1}, pH less than 6.0, and inorganic Al concentration greater than 2.0 µmol L^{-1} indicate that species are at risk from acidification (Driscoll 2001). The average annual rate of increase of ANC and pH in Bald Mountain Brook suggests a moderate degree of recovery over this period, whereas the rate in Buck Creek suggests relatively minimal recovery. The average annual rate of increase for pH and ANC in both streams is less than the rate reported by Lawrence et al. (2004) for the water year 1992–2001, which indicates that the rate of recovery has slowed over the past seven years. The overall trends for Bald Mountain Brook were considerably stronger than those observed for Buck Creek, but also more erratic. Buck Creek continues to exhibit episodic depressions in ANC (< 0 µeq L^{-1}) and pH (< 5.0) at values inhospitable to acid-sensitive aquatic species (Driscoll et al. 2001) (Figure 13).

In summary the updated analysis includes an extension of the 10-year stream monitoring results presented in Lawrence et al. (2004) and includes results from the two tributary streams (North Tributary and South Tributary) within the Buck Creek (Tables 10a-d) watershed that was initiated in 1998. The paper evaluated: the record of Bald Mountain Brook and Buck Creek extended from 10 to 17 years; the 10-year record of the North and South tributaries including a more in-depth evaluation of biogeochemical processes related to recovery; and compared the chemistry of 12 streams sampled in the early 1980s with samples collected in 2003 - 2005 from the same streams. A significant (50%) reduction in atmospheric deposition of sulfur occurred over this period (1998 to 2008). Results for Buck Creek and Bald Mountain Brook are discussed above (Figures 11 and 12). The North Tributary with high DOC, showed sulfate concentrations decreased at a rate of 2.0 µmol L^{-1} y^{-1} and the neighboring South Tributary with low DOC, showed a decrease of only 0.73 µmol L^{-1} y^{-1}. In the 12 streams over 23 years, overall increases in pH of only 0.28 and ANC of 13 µeq L-1 were observed. While consistent with the range of chemistry changes reported for Adirondack lakes, results from the group of streams presented are highly variable with a more muted recovery response (Lawrence et al. 2011) .

Current Seasonal Chemistry (October 2009 – September 2010)

The chemistry of the four monitored streams varies widely from the severely acidic North Tributary of Buck Creek (fall median pH 4.30) to the relatively well buffered Bald Mountain Brook (fall median pH 6.25). Still, consistent seasonal patterns in chemical concentrations of stream water were apparent among the four streams despite these large concentration differences.Concentrations of DOC were highest in the late summer in Buck Creek and its tributaries, and highest in the fall in Bald Mountain Brook. These results were likely tied to autumn leaf fall, which provided large quantities of soluble carbon that could be leached into soil and stream waters. Median concentrations of NO_3^- were lowest in the fall and highest in the winter in all streams. Low concentrations of NO_3^- in the fall may have been related to microbial activity triggered by leaf drop, whereas high winter concentrations may have reflected the lack of vegetation demand to this key nutrient.

Normally the most acidic conditions are expected during the snowmelt period, but in this year, the most acidic conditions in terms of pH and inorganic Al concentrations were in the fall, in all streams. Consistent seasonal patterns among the streams were not apparent for ANC or base cation surplus (BCS). Variations between seasons were small for all streams except Bald Mountain Brook, which exhibited values that varied by a factor of three. Snowmelt acidification was less extreme than typically observed, but acidification was spread more uniformly throughout the year. The relative effects of these differing temporal patterns of acidification on stream biota are not known.

Table 10a-d. Median stream concentrations for October 2009 through September 2010 in the North Tributary of Buck Creek (a), the South Tributary of Buck Creek (b), Buck Creek (c) and Bald Mountain Brook (d), for fall (October-November), winter (December-March), snowmelt (April), spring/summer (May-July) and late summer (August-September). All concentrations are expressed as µmol L^{-1} except ANC (µeq L^{-1})and BCS (µeq L^{-1}), and pH (pH units).

10a.

	Fall	**Winter**		**Spring/Summer**	
Number of samples	4	10	2	9	8
SO_4^{2-}	32.6	38.0	33.2	22.8	21.5
NO_3^-	0.4	14.5	6.9	5.5	3.2
Cl^-	14.2	11.3	6.8	8.0	11.3
ANC	-47.3	-36.6	-41.1	-41.1	-36.4
DOC	1397.2	1223.7	1284.0	1669.2	1739.4
Si	107.8	138.1	71.7	76.4	106.1
Ca^{2+}	20.5	23.3	21.0	19.8	19.5
Mg^{2+}	9.1	9.8	8.6	7.6	7.7
Na^+	24.3	27.0	27.5	22.3	20.8
K^+	2.6	4.5	5.0	4.0	5.6
NH_4^+	0.0	0.5	0.1	2.1	2.1
Total Al	28.2	26.4	28.6	34.5	30.7
Total Monomeric **Al**	19.0	17.5	16.2	18.6	17.1
Organic Monomeric **Al**	11.6	10.7	11.3	12.1	12.5
Inorganic Monomeric **Al**	6.7	5.8	4.9	6.2	4.7
pH	4.30	4.36	4.38	4.34	4.35
BCS	-86	-85	-75	-100	-92

10b.

	Fall	Winter	Spring/Summer		
Number of samples	4	9	2	8	12
SO_4^{2-}	39.2	40.8	39.0	41.2	36.2
NO_3^-	8.2	37.9	27.4	13.0	17.2
Cl^-	6.6	7.4	7.6	9.3	9.9
ANC	8.1	15.5	8.0	15.9	16.6
DOC	304.6	209.2	239.0	260.9	377.1
Si	87.8	115.4	102.0	101.6	101.0
Ca^{2+}	26.4	34.1	29.8	31.4	32.7
Mg^{2+}	8.1	10.9	9.0	9.1	9.9
Na^+	23.1	30.7	30.1	30.6	26.1
K^+	3.7	4.5	4.1	3.2	5.0
NH_4^+	0.0	0.2	0.1	0.5	0.7
Total Al	12.1	8.6	11.7	9.2	6.2
Total Monomeric Al	6.9	4.0	5.8	4.5	5.1
Organic Monomeric Al	3.6	2.9	3.1	3.1	3.6
Inorganic Monomeric Al	3.1	1.3	2.7	1.4	1.5
pH	5.22	5.64	5.357	5.64	5.70
BCS	-15	0	-14	-2	0

10c.

	Fall	Winter	Spring/Summer		
Number of samples	4	15	2	16	14
SO_4^{2-}	43.6	43.4	45.8	40.7	37.6
NO_3^-	6.6	35.5	18.7	11.5	10.6
Cl^-	8.8	8.9	9.3	10.0	10.7
ANC	15.2	18.9	12.4	21.5	31.7
DOC	504.8	438.1	383.1	526.6	682.8
Si	118.3	124.1	122.2	120.6	133.9
Ca^{2+}	34.7	42.8	37.7	38.3	42.6
Mg^{2+}	12.0	13.2	12.4	12.9	14.3
Na^+	30.3	28.6	33.8	34.7	34.4
K^+	4.9	5.8	5.5	5.0	7.5
NH_4^+	0.0	0.4	0.2	0.8	0.6
Total Al	13.7	12.8	11.2	14.6	8.4
Total Monomeric Al	7.8	7.0	6.0	6.1	6.3
Organic Monomeric Al	4.9	4.1	3.9	4.3	4.9
Inorganic Monomeric Al	2.8	2.8	2.0	2.0	1.4
pH	5.36	5.46	5.53	5.61	5.88
BCS	-4	-7	-2	7	24

10d.

	Fall	Winter	Spring/Summer		
Number of samples	4	9	2	6	5
SO_4^{2-}	39.8	45.0	43.1	39.9	41.9
NO_3^-	13.2	32.1	24.3	16.6	17.9
Cl-	8.8	7.8	7.7	8.5	9.2
ANC	33.4	52.4	33.0	54.0	109.0
DOC		201.0	224.4	260.2	215.0
Si		174.8	151.4	174.7	211.6
Ca^{2+}	35.5	44.6	38.3	40.9	51.0
Mg^{2+}	15.8	20.9	16.7	18.1	25.7
Na^+	35.8	45.4	46.3	50.3	57.4
K^+	5.9	6.1	6.7	6.4	7.9
NH_4^+	0.0	0.3	0.0	0.2	0.0
Total Al	7.0	4.6	5.5	4.8	3.4
Total Monomeric Al	3.5	2.3	2.5	2.2	1.7
Organic Monomeric Al	2.9	2.2	2.4	2.0	1.9
Inorganic Monomeric Al	0.5	0.1	0.2	0.1	0.0
pH	6.25	6.44	6.32	6.64	6.90
BCS	26	51	34	51	110

Data Reported to Date

Data currently available from this stream study (this section) include chemistry from Fly Pond Outlet, Bald Mountain Brook, and Buck Creek. Weekly concentrations of the parameters measured for Fly Pond Outlet, Bald Mountain Brook, and main stem of Buck Creek collected from June 1992 through December 2004, and reported seasonally since then through September 2008 are posted to the ALSC website at http://www.adirondacklakessurvey.org. Seasonal medians for Buck Creek and Bald Mountain Brook are provided in Appendix B. Additional data may be available by contacting the NYSDEC Research Manager.

Buck Creek – Vegetation and Soils Studies

North and South Tributary – Trees

Vegetation plots were established in the Buck Creek watershed by USGS in 2000. Fifteen vegetation plots (254 m2 area) were established in both the North Tributary and the South Tributary (Figure 14). Tree measurements are collected at five year intervals. Soil chemistry measurements were collected at 27 locations throughout the North Tributary watershed in 2009–2010. The results that follow are part of a manuscript in progress.

In the North Tributary watershed, the predominant tree species were red spruce, red maple and American beech. Most tree species showed an increase in total basal area over the 10-year measurement period (2000 – 2010), with the notable exception of red spruce, which showed a pronounced decrease as a result of unusually high mortality between 2005-2010 of trees in all size classes (Figure 15). This decrease in red spruce resulted in an overall decrease in basal area for the watershed. The cause of the elevated mortality in red spruce is not known.

In the South Tributary watershed, American beech, the dominant tree species, showed an increase in basal area over the 10-year period (Figure 15). This occurred despite beech bark disease in virtually all beech trees in the watershed and elevated mortality of large beech trees. Increases in basal area of yellow birch, sugar maple and red spruce also occurred during this period. Most striped maple over 5 cm diameter died over the 10 years without being replaced.

Figure 14. Watersheds of the North Tributary (navy) and the South Tributary (red) within the Buck Creek watershed.

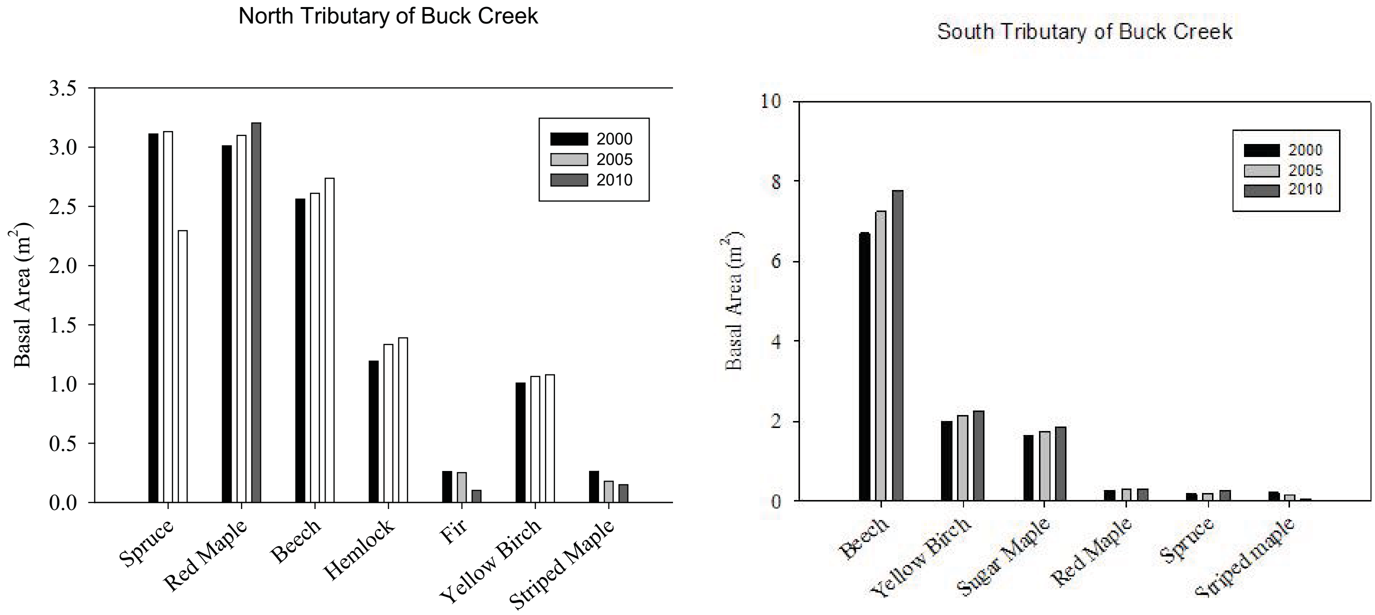


Figure 15. Basal area of major tree species (with dbh greater than 5 cm) in the North and South Tributary watershed of Buck Creek, in 2000, 2005 and 2010, based on measurements in 15 plots per watershed (each plot is 254 m^2 in area).

North Tributary – Soils

Soil samples were collected from the Oe horizon, Oa horizon, and upper 10 cm of the B horizon at 27 locations throughout the North Tributary watershed of Buck Creek. Soils had thick Oa horizons, which are common in forests with a large component of coniferous trees. Low pH in the Oe and Oa horizons reflect the strong influence of natural organic acidity that derives from the decomposition of organic matter. Relatively low concentrations of exchangeable bases (Ca, Mg, K and Na) and high concentrations of exchangeable Al in the upper B horizon are consistent with stream chemistry data for this watershed that indicates calcium depletion by acidic deposition. Low base saturation in the Oa and upper B horizon provides minimal buffering of soil water acidity.

Table 11. Mean values of soil chemistry measurements of samples collected in 2009-2010 from Oe horizon, Oa horizon and upper 10 cm of the B horizon in the North Tributary watershed of Buck Creek.

Horizon		Horizon	Horizon	Horizon
thickness	cm	5.5	14.7	-----
exchangeable Ca	cmolesc/kg	16.5	8.1	0.41
exchangeable Mg	cmolesc/kg	2.7	1.3	0.10
exchangeable K	cmolesc/kg	1.5	0.4	0.09
exchangeable Na	cmolesc/kg	0.06	0.04	0.023
exchangeable Al	cmolesc/kg	0.8	7.4	8.55
exchangeable H	cmolesc/kg	9.9	13.1	1.44
base saturation	fraction of CEC	0.65	0.32	0.06
carbon	percent	513	465	91.4
nitrogen	percent	24.6	20.1	3.61
C:N	g/g	21	23	26
Organic matter	percent	92.7	83.2	17.9
pH (0.01 $CaCl_2$)		3.16	2.74	3.53

Western Adirondack Stream Survey 2003–2005

Despite the stream sampling efforts of the ALTM, AEAP and other occasional Adirondack stream studies, prior to 2003 there was insufficient information to assess the current regional status of streams with regard to acidification. The Western Adirondack Stream Survey (WASS) was conducted to assess the chemical and biological conditions of streams in the region of the Adirondacks considered most impacted. Because regional stream assessments that included episodic acidification had not been previously conducted, this project was implemented as a pilot study to evaluate methods for possible future use. The effort was undertaken by program staff of the ALSC, NYSDEC (Air Resources and Fish and Wildlife) as well as USGS.

The WASS was conducted in the 4,585 km^2 Oswegatchie-Black River region of the Adirondack ecological zone with the following objectives: 1) develop an improved method for distinguishing between the chemical effects of acidic deposition and those of naturally-derived acidity, 2) determine the extent of acidic deposition effects on stream chemistry and biota in this region, 3) evaluate the role of soil chemistry as a control of stream chemistry, and 4) determine to the extent possible, changes in stream chemistry over the past two decades.

Five seasonal surveys were conducted between summer 2003 and spring 2005. There were several major findings. Of the 565 streams assessed, 66% (718 km of stream reaches) were identified as prone to acidification, i.e. likely to be acidified to levels harmful to biota. Of these, approximately half were likely to be episodically acidified and half were likely to be chronically acidified. The percentage of streams determined to be moderately to severely impacted by acidic deposition on the basis of the diatom data ranged from 66% to 89% over four surveys. Macroinvertebrate communities were moderately to severely impacted in 52% of assessed streams. The approach of seasonal sampling survey conducted within three-day periods throughout the study region was successful for capturing the episodic and seasonal variability of stream chemistry. When indexed to a site with both episodic and long-term monitoring data (i.e. Buck Creek), this approach was an effective method for the regional assessment of episodic acidification. The full report and executive summary (NYSERDA Report 08-22 Project 7613 November 2008) are available at http://www.nyserda.ny.gov/en/Page-Sections/Environmental-Research/EMEP as well as journal articles completed (Lawrence et al. 2008; Baldigo et al. 2009) and in progress.

East-Central Adirondack Stream Survey

Following the completion of the WASS, a second survey was conducted for the remaining portion of the Adirondack region. The new East-Central Adirondack Stream Survey (ECASS) was designed as a similar flow-synchronized sampling of 200 first-order streams over a 3-day period. Three sampling seasons were proposed to take place during 2010-2012. The first round of sampling was conducted on August 9-11 at 208 stream sites. Additionally, ten high-elevation streams were sampled during September.

The second and third (final) rounds of sampling were successfully completed in 2011. Spring sampling included: 269 sites during April 18 - 20; 10 high elevation sites during April 25 - May 5; and five historic sites sampled weekly during April 4 - May 2. The fall sampling included 230 sites during October 31-November 2. Additional collections included periphytic diatoms at each site to be analyzed by S.Passy (University of Texas Arlington) and macroinvertebrates at 40 stream sites. Preliminary chemistry assessments based on April 2011 results indicate that over one third of streams are prone to acidification. The ECASS study region encompasses nearly 20,000 km^2 (approximately 80%) of the Adirondack region.

Together the WASS and ECASS stream projects have covered essentially the entire Adirondack region. This total of eight seasonal surveys collected between summer 2003 and fall 2011 now stands as the largest survey in North America to evaluate stream chemistry over varying stream flows, which is essential for evaluating acidification. The work provides important data on the current conditions that will be available to more thoroughly assess ecosystem recovery.

Whiteface Mountain Cloud Monitoring

Title IV of the 1990 Clean Air Act Amendments (CAAA) required a two phase reduction in sulfur dioxide (SO2) emissions by approximately 10 million tons. The first phase was implemented in 1995 when large electric generating facilities reduced emissions. The second phase began in 2000 by targeting other power plants. Title IX of the CAAA mandated the deployment of a comprehensive research and monitoring program, which would evaluate emission reduction program effects on deposition, air quality, and changes in affected ecosystems. In response to this mandate, the USEPA implemented the Clean Air Status and Trends Network (CASTNet) in 1991.

The Mountain Cloud Acid Deposition Program (MADPro) was initiated in 1993 as part of the research necessary to support CASTNet objectives. The two main objectives of MADPro were to develop cloud water measurement systems useful in a network-monitoring environment and to update the Appalachian Mountain cloud water concentration and deposition data collected by the National Acid Precipitation Assessment Program (NAPAP) during the 1980s. MADPro measurements were conducted between May and October of 1994 – 1999 at three permanent mountaintop sampling stations. These sampling stations were located at Whiteface Mountain, New York; Clingmans Dome, Tennessee/North Carolina; and Whitetop Mountain, Virginia. A mobile manual sampling station was also operated at two locations in the Catskill Mountains of New York during 1995, 1997, and 1998.

Beginning in June 2001 the ALSC commenced field operations and provided laboratory analyses of cloud water from the Whiteface site. Operation included all quality assurance/quality control activities, data processing and review, analytical chemistry, and data delivery. The ALSC objective has been to continue the cloud-monitoring program as run under the CASTNet program. The mountaintop site at Whiteface has changed little since the cloud collection system was installed in 1994. The system has proven to be quite durable, having survived several lightning strikes and harsh weather conditions.

Site Description

Located in the northeastern part of the New York State Adirondack Park, Whiteface Mountain, at an elevation of 4867 feet, is the fifth highest peak in the Adirondacks. The site is the only high peak within the Adirondack Park with a summit that is road accessible and has AC power. The cloud collection system is installed on the roof of the summit observatory building operated and maintained by the SUNY Albany Atmospheric Sciences Research Center. In addition to the cloud monitor, the summit building also houses several gas monitors, meteorological sensors, and a high volume air sampler. The summit is reached in warm weather months, from late May to early October, via the Veterans Memorial Highway.

Sampling Design

The collector, an omni-directional passive collector is also known as an ASRC or Mohnen collector (Falconer and Falconer 1980; Mohnen 1989). The collector consists of two disks separated by vertical bars with Teflon filament strung between the disks. The principle of operation for collecting cloud water samples is relatively simple. As winds blow clouds through the collector, cloud water condenses on the filaments and gravity draws the cloud water down to a funnel. Tubing attached to the bottom of the funnel runs into the observatory and delivers cloud water to an accumulator. The accumulator collects cloud water until it is full, the site clears, or the top of the hour is reached. At the top of each hour, a distributor arm dispenses the accumulated sample into one of twenty-four refrigerated indexed carousel bottles (Baumgardner et al. 1997).

The cloud water collector is deployed from its protective housing only after the following conditions are met: the air liquid water content reaches 0.05 grams per cubic meter or greater indicating the presence of cloud; the temperature is two degrees Celsius or greater to prevent freezing; the wind speed is two meters per second or greater to assure the movement of clouds through the collector; and a heated grid rain sensor indicates no rain is present to limit sampling from precipitating clouds.

Samples are analyzed for the following parameters: pH, specific conductance, nitrate, sulfate, chloride, calcium, magnesium, potassium, sodium, and ammonium. The primary meteorological parameters collected are: liquid water content (LWC), wind direction, wind speed, and temperature.

Results

Fossil fuel combustion, the oxidation of sulfur and nitrogen oxides to sulfuric (H_2SO_4) and nitric acids (HNO_3) in the atmosphere, are the primary sources of anthropogenic acidity in cloudwater.

The major ions found in clouds at Whiteface Mountain are sulfate, hydrogen, nitrate, and ammonia. There is a strong coefficient of determination (R^2 0.87) between hydrogen and sulfate + nitrate (Figure 16).

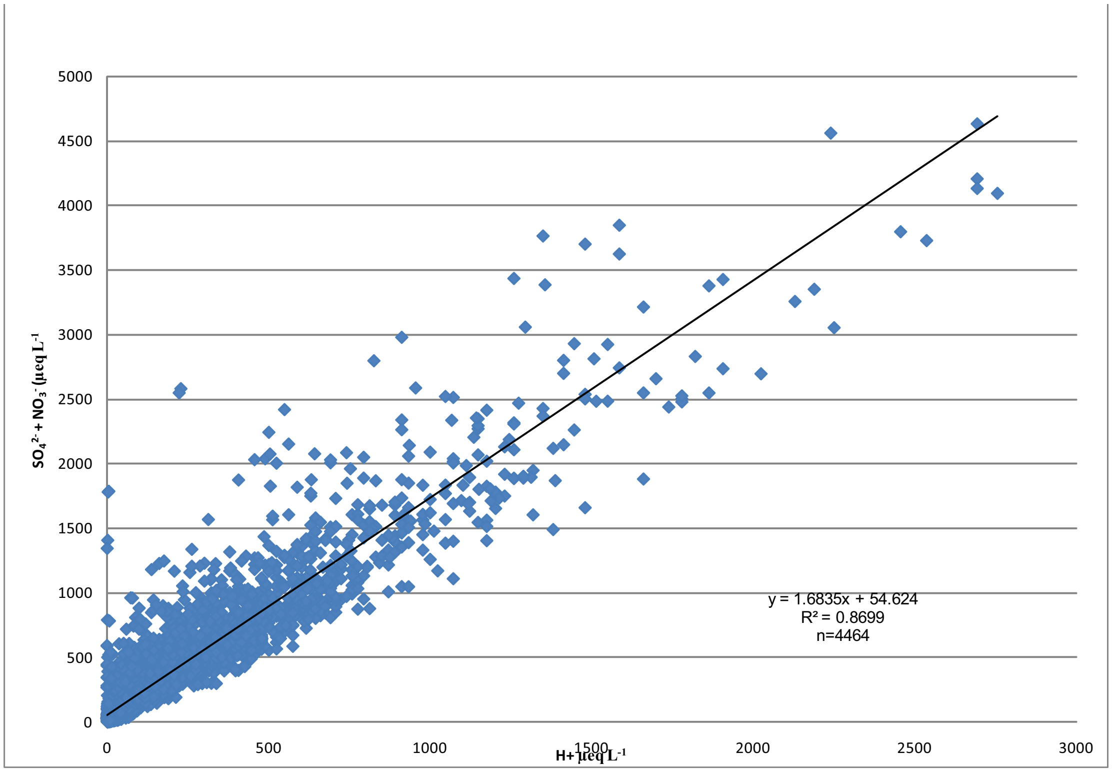


Figure 16. Hydrogen Ion versus sulfate + nitrate.

Compared with precipitation, cloud water exhibits significantly higher concentrations of major ions (Khwaja et al. 1995). Cloud water depositions have been reported at 14 to 28 times rainwater depositions during the summer season (Aleksic et al. 2009). The pH of cloud water below ~5.0 is assumed to be influenced by anthropogenic pollution (Li and Aneja 1992; Dukett et al 2011). For samples collected, 1994–2010, approximately 87% of the cloud water samples analyzed are below pH 5.0 or $H^+ > 10.00$ µeq L^{-1}. For samples collected, 2007–2010, approximately 77% are below pH 5.0 or $H^+ > 10.00$ µeq L^{-1}.

In 2011, clean air target values were established based on 4185 cloud water samples collected for the period 1994–2009, and 263 of those values were used to identify a clean air target pH range (Dukett et al. 2011). For this report, additional data collected through 2010 has been incorporated into the analysis, which is based on 4464 cloud water samples, with 285 of those values identifying the clean air target pH range. Additionally, for each major ion (SO_4^{2-}, NO_3^-, H^+, and NH_4^+), results were compared against the reference clean air value by calculating simple ratios of all annual data versus the reference clean air value. Figure 17 shows these ratios, as well as, a relative comparison since the first year (1994) of the record to the last year (2010). As illustrated in Figure 17, the horizontal line at ratio 1 indicates the clean air level. In 1994, ratios were 26.5, 12.8, 30.3, and 12.8 times above the clean air concentration threshold for SO_4^{2-}, NO_3^-, H^+, and NH_4^+ respectively. For 2010, SO_4^{2-}, NO_3^-, H^+, and NH_4^+ ratios were respectively 5.0, 3.6, 4.9, and 4.1 times the clean air concentration threshold (Figure 17). In other words, a comparison of 2010 results against 1994, and for all samples that met our criteria, suggests we have achieved an 81%, 72%, 84%, and 68% relative anthropogenic reduction respectively for these ions. The criteria for samples used to determine the ratios in Figure 17 are found in Dukett et al. 2011.

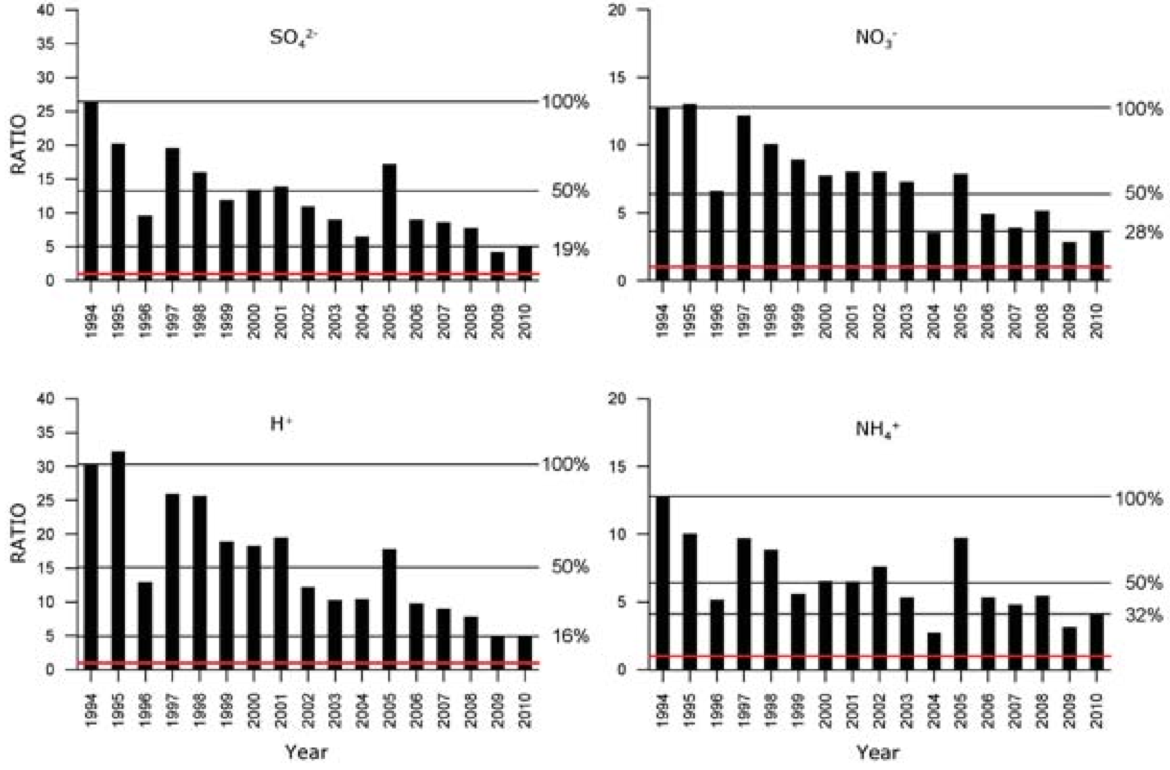
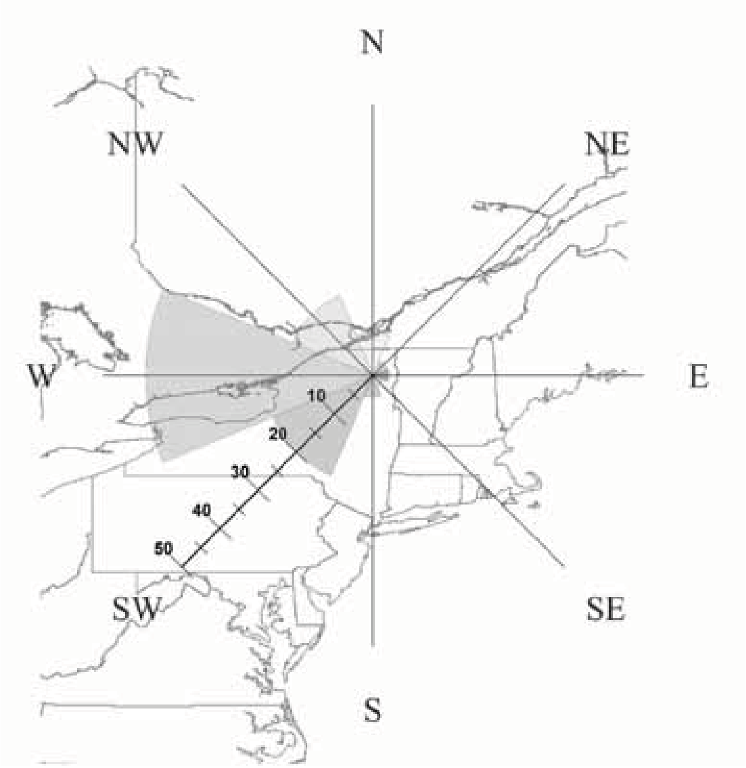


Figure 17. Ratios of all annual data versus clean air target values 1994–2010.



	Percent
N	8.2
NE	3.0
E	3.4
SE	2.5
S	3.6
SW	19.7
W	43.1
NW	16.5
n =	4464

Figure 18. 1994-2009 Wind distribution by octant.

Distribution

The origin of cloud water acidity is assumed to be based on both local and regional emission sources. Given the frequency distribution, it is suggested that clouds at Whiteface may pass over the Ohio Valley and Canadian Provinces. Factors such as wind speed and oragraphic effects help shape the movement and ion content of clouds (Baumgardner et al. 2003). ALTM lakes at higher elevations (>600 m) may have higher nitrate concentrations and acidity than lower elevation lakes (Aleksic et al. 2009). Cloud water samples have been collected at Whiteface Mountain primarily arrive from the southwest to northwest (Figure 18).

Data Reported to Date

Data currently available from this mountain cloud study (this section) include hourly and 3-hr composites of the chemical parameters in cloud water and the meteorological data associated with those samples. As of June 2011, chemistry and meteorological data collected during the 2001–2009 sampling seasons are posted to the ALSC website at http://www.adirondacklakessurvey.org. Additional data may be available by contacting the NYSDEC Research Manager.

Data Summary Statistics

Summary statistics for the 2010 cloud sampling season can be found in Appendix F. These statistics are based on 'Valid' sample data criteria. The criteria for valid samples are:

Passes MADPro Ion balance test
Must be analyzed for all four major ions (H^+, SO_4^{2-}, NO_3^-, NH_4^+)
Is a valid composite sample
Sample does not contain rain

Additional information can be found in the '2010 WFC MetaData' worksheet associated with the 2010 Whiteface Mountain Cloud data found on the ALSC website.

2009 Pilot Studies

In 2009, the ALSC participated in two pilot studies to look at mercury and carbon in clouds. A mercury pilot project began on 7/7/09 and ended on 9/23/09. A second cloud collector was installed to allow for the collection in mercury specific sample bottles. A total of 21 samples was collected and shipped to Syracuse University for total mercury analysis. A carbon species pilot project collected 11 samples on 9/23/09 and 9/24/09. Samples were shipped to Rutgers University for analysis of highly polar organic compounds (HPOC). The ALSC also analyzed total organic carbon (TOC) on these samples. Carbon analysis, both at the species (HPOC) and fraction (TOC) level, provides a deeper understanding of the organic acids in cloud water; and may help increase the level of scientific understanding that clouds serve as a climate driver (National Academics 2008).

2010 Pilot Study

The carbon species pilot project started in 2009 continued in 2010. A total of 50 samples were shipped to Rutgers University for highly polar organic complex analysis. The ALSC also analyzed total organic carbon (TOC) on these samples and 47 additional samples for a total of 97 samples analzed for TOC in 2010.

Wet Deposition Monitoring

Site Description

The ALSC collects weekly precipitation and meteorological data from the NYSDEC wet deposition monitoring station located in St. Lawrence County at the Wanakena Ranger School in Fine, New York. The station, Wanakena Ranger School (Air Monitoring Location 4458–05), is located at an elevation of 458 m.

Sampling Design

The station was established as part of the NYSDEC Acid Deposition Monitoring Network in January 1987. The network consists of 20 monitoring sites located throughout New York State. Wanakena is a rural site that supports Type 3 instrumentation, which included a tipping bucket rain/snow gage to measure the amount of precipitation, and a Viking Hyetometer, which is a bucket type collector designed to collect samples under wet or dry conditions http://www.dec.ny.gov/chemical /8409.html.

Data Reported to Date

The analyzed chemistry and meteorological data are posted on the NYSDEC Division of Air Resources Air Quality Surveillance website. The most recent data for 2007 are available at http://www.dec.ny.gov/chemical/29155.html.

Regional Fisheries Chemistry

Since 1992, the ALSC has provided laboratory services to fisheries staff in NYSDEC Regions 5 and 6 (Adirondack Region) for lake chemistry analyses. A large number of these waters are included in the DEC Lake Liming Program where annual data are needed to assess the acid-base condition of lakes. These samples are collected by regional fisheries staff. The results provide a snapshot of lake chemistry relative to the viability of fisheries in areas beyond the ALTM and TIME lakes. The average number of lake water samples analyzed each year is 130.

Data Reported to Date

The lake chemistry data from this section are provided annually to NYSDEC Region 5 and 6 fisheries staff. Additional information may be available by contacting the NYSDEC Research Manager.

References

Adirondack Lakes Survey Corporation. 1997. EMAP Sampling Protocol. Adirondack Lakes Survey Corporation, Ray Brook, NY.

Adirondack Lakes Survey Corporation. 2002a. Standard Operating Procedures: Laboratory Operations. 1–89. Adirondack Lakes Survey Corporation, Ray Brook, NY.

Adirondack Lakes Survey Corporation. 2002b. Standard Operating Procedures: Field Operations. 1–20 plus appendices. Adirondack Lakes Survey Corporation, Ray Brook, NY.

Adirondack Lakes Survey Corporation. 2003. Grant F-48-R Study 13: Chemical and Biological Assessment of Adirondack Waters. Adirondack Lakes Survey Corporation, Ray Brook, NY. 1–50 plus appendices.

Aleksic, N., Roy, K., Sistla, G., Dukett, J., Houck, N., and Casson, P. 2009. Analysis of cloud and precipitation chemistry at Whiteface Mountain, NY. Atmospheric Environment 43: 2709–2716.

Aleksic, N. and Dukett, J. 2010. Probabilistic relationship between liquid water content and ion concentrations in cloud water. Submitted to Atmospheric Research.

Baker, J.P., Gherini, S.A., Christensen, S.W., Munson, R.K., Driscoll, C.T., Newton, R.M., Gallagher, J., Reckhow, K.H., and Schofield, C.L. 1990. Adirondack Lakes Survey: An Interpretive Analysis of Fish Communities and Water Chemistry, 1984–1987. Adirondack Lakes Survey Corporation, Ray Brook, NY.

Baker, J.P., Van Sickle, J., Gagen, C.J., DeWalle, D.R., Sharpe, W.E., Carline, R.F., Baldigo, B.P., Murdoch, P.S., Bath, D.W., Kretser, W.A., Simonin, H.A., and Wigington, P.J.Jr. 1996. Episodic acidification of small streams in the northeastern United States: Effects on fish populations. Ecological Applications 6: 422–437.

Baldigo, B.P., Lawrence, G.B., Bode, R.W., Simonin, H.A., Roy, K.M., and Smith, A.J. 2009. Impacts of acidification on macroinvertebrate communities in streams of the western Adirondack Mountains, New York, USA. Ecological Indicators 9: 226-239.

Baumgarder, R.E., Kronmiller, K.G., Anderson, J.B., Bowser, J.J., and Edgerton, E.S. 1997. Development of an automated cloudwater collection system for use in atmospheric monitoring networks. Atmospheric Environment 31: 2003–2010.

Baumgardner, R.E., Jr., Isil, S.S., Lavery, T.F., Rogers, C.M., and Mohnen, V.A. 2003. Estimates of cloud water deposition at Mountain Acid Deposition Program sites in the Appalachian Mountains. Journal of the Air & Waste Management Association 53: 291–308.

Burns, D.A., McHale, M.R., Driscoll, C.T., and Roy, K.M. 2006. Response of surface water chemistry to reduced levels of acid precipitation: comparison of trends in two regions of New York, USA. Hydrological Processes 20: 1611–1627.

Chen, L. and Driscoll, C.T. 2005. Regional assessment of the response of the acid-base status of lake watersheds in the Adirondack region of New York to changes in atmospheric deposition using PnET-BGC. Environmental Science & Technology 39: 787–794.

Cirmo, C.P., Roy, K., Houck, N., and Civerolo, K. 2007. A comparison of water quality parameters at eight paired lake-outlet sampling sites of the Adirondack Long-Term Monitoring Project.

Civerolo, K.L., Roy, K.M., Stoddard, J.L., and Sistla, G. 2011. A Comparison of the Temporally Integrated Monitoring of Ecosystems and Adirondack Long-Term Monitoring Programs in the Adirondack Mountain Region of New York. Water, Air, & Soil Pollution 222: 286-296.

Dixit, S.S. and Smol, J.P. 1994. Diatoms as indicators in the environmental monitoring and assessment program-surface waters (EMAP-SW). Environmental Monitoring and Assessment 31: 275–306.

Driscoll, C.T. and Van Dreason, R. 1993. Seasonal and long-term temporal patterns in the chemistry of Adirondack lakes. Water, Air, and Soil Pollution 67: 319–344.

Driscoll, C.T., Postek, K.M., Kretser, W.A., and Raynal, D.J. 1995. Long-term trends in the chemistry of precipitation and lake water in the Adirondack region of New York, USA. Water, Air, and Soil Pollution 85: 583–588.

Driscoll, C.T., Postek, K.M., Mateti, D., Sequeira, K., Aber, J.D., Kretser, W.A., Mitchell, M.J., and Raynal, D.J. 1998. The response of lake water in the Adirondack region of New York to changes in acidic deposition. Environmental Science & Policy 1: 185–198.

Driscoll, C.T., Lawrence, G.B., Bulger, A.J., Butler, T.J., Cronan, C.S., Eagar, C., Lambert, K.F., Likens, G.E., Stoddard, J.L., and Weathers, K.C. 2001. Acidic deposition in the northeastern United States: Sources and inputs, ecosystem effects, and management strategies. BioScience 51: 180–198.

Driscoll, C.T., Driscoll, K.M., Roy, K.M., and Mitchell, M.J. 2003. Chemical response of lakes in the Adirondack region of New York to declines in acidic deposition. Environmental Science & Technology 37: 2036–2042.

Driscoll, C.T., Driscoll, K.M., Roy, K.M., and Dukett, J. 2007. Changes in the chemistry of lakes in the Adirondack region of New York following declines in acidic deposition. Applied Geochemistry 1181–1188.

Driscoll, C.T., Driscoll, K.M., Mitchell, M.J., Raynal, D.J., and Roy, K.M. 2009. Human impacts from afar. In The Great Experiment in Conservation: Voices from the Adirondack Park. Edited by W.F.Porter, J.D.Erickson, and R.S.Whaley. Syracuse University Press, Syracuse, NY pp. 114–127.

Dukett, J.E., Aleksic, N., Houck, N., Snyder, P., Casson, P., Cantwell, M. 2011. Progress toward clean cloud water at Whiteface Mountain New York, Atmospheric Environment, doi:10.1016/j.atmosenv.2011.08.070

Falconer, R.E. and Falconer, P.D. 1980. Determination of cloudwater acidity at a mountain observatory in the Adirondack Mountains of New York State. Journal of Geophysical Research 85: 7465–7470.

Hughes, R.M., Paulsen, S.G., and Stoddard, J.L. 2000. EMAP-Surface Waters: A multiassemblage, probability survey of ecological integrity in the U.S.A. Hydrobiologia 422/423: 429–443.

Ito, M., Mitchell, M.J., Driscoll, C.T., Newton, R.M., Johnson, C.E., and Roy, K.M. 2006. Controls on surface water chemistry in two lake watersheds in the Adirondack region of New York: differences in nitrogen solute sources and sinks. Hydrological Processes 21: 1249–1264.

Jenkins, J., Roy, K., Driscoll, C., and Buerkett, C. 2005. Acid Rain and the Adirondacks: A Research Summary. Adirondack Lakes Survey Corporation, Ray Brook, NY. 1–244.

Jenkins, J., Roy, K., Driscoll, C., and Buerkett, C. 2007. Acid Rain and the Adirondacks: An Environmental History. Cornell University Press, Ithaca and London. 1–246.

Khwaja, H.A., Brudnoy, S., and Husain, L. 1995. Chemical characterization of three summer cloud episodes at Whiteface Mountain. Chemosphere 31: 3357–3381.

Kretser, W.A., Simonin, H.A., Bath, D.W., Gallagher, J., and Olson, M.L. 1992. Episodic acidification and associated fish and benthic invertebrate responses of four Adirondack headwater streams: Methods report. U.S. Environmental Protection Agency No. 815189–01.

Lawrence, G.B. 2002. Persistent episodic acidification of streams linked to acid rain effects on soil. Atmospheric Environment 36: 1589–1598.

Lawrence, G.B., Momen, B., and Roy, K.M. 2004. Use of stream chemistry for monitoring acidic deposition effects in the Adirondack region of New York. Journal of Environmental Quality 33: 1002–1009.

Lawrence, G.B., Baldigo, B.P., Roy, K.M., Simonin, H.A., Bode, R.W., Passy, S.I., and Capone, S.B. 2008a. Results from the 2003–2005 Western Adirondack Stream Survey. New York State Energy Research and Development Authority No. 08–22.

Lawrence, G.B., Roy, K.M., Baldigo, B.P., Simonin, H.A., Capone, S.B., Sutherland, J.W., Nierzwicki-Bauer, S.A., and Boylen, C.W. 2008b. Chronic and episodic acidification of Adirondack streams from acid rain in 2003–2005. Journal of Environmental Quality 37: 2264–2274.

Li, Z. and Aneja, V.P. 1992. Regional analysis of cloud chemistry at high elevations in the eastern United States. Atmospheric Environment 26A: 2001–2017.

Mohnen, V.A. 1989. Cloud chemistry research at Whiteface Mountain. Tellus 41B: 79–91.

Momen, B., Lawrence, G.B., Nierzwicki-Bauer, S.A., Sutherland, J.W., Eichler, L.W., Harrison, J.P., and Boylen, C.W. 2006. Trends in summer chemistry linked to productivity in lakes recovering from acid deposition in the Adirondack region of New York. Ecosystems 9: 1306–1317.

Morrison, M., Newell, A.D., and Hjort, R. 1991. Data User's Guide to the United States Environmental Protection Agency's Long-Term Monitoring Project: Quality Assurance Plan and Data Dictionary. U.S. Environmental Protection Agency No. EPA 600/3–91/072.

National Academies. 2008 Edition. Understanding And Responding To Climate Change: Highlights of National Academies Reports. National Academics Press, Washington, DC.

Newton, R.M. and Driscoll, C.T. 1990. Classification of ALSC Lakes. In Adirondack Lakes Survey: An Interpretive Analysis of Fish Communities and Water Chemistry, 1984–1987. Adirondack Lakes Survey Corporation, Ray Brook pp. 2–70-2–91.

Passy, S.I. 2006. Diatom community dynamics in streams of chronic and episodic acidification: The roles of environment and time. Journal of Phycology 42: 312–323.

Passy, S.I., Ciugulea, I., and Lawrence, G.B. 2006. Diatom diversity in chronically versus episodically acidified Adirondack streams. International Review of Hydrobiology 91: 594–608.

Ross, D.S., Lawrence, G.B., and Fredriksen, G. 2004. Mineralization and nitrification patterns at eight northeastern USA forested research sites. Forest Ecology and Management 188: 317–335.

Stemberger, R.S. 1995. Pleistocene refuge areas and postglacial dispersal of copepods of the northeastern United States. Canadian Journal of Fisheries and Aquatic Sciences 52: 2197–2210.

Stemberger, R.S., Herlihy, A.T., Kugler, D.L., and Paulsen, S.G. 1996. Climatic forcing on zooplankton richness in lakes of the northeastern United States. Limnological Oceanography 41: 1093–1101.

Stemberger, R.S. and Miller, E.K. 1998. A zooplankton-N:P-ratio indicator for lakes. Environmental Monitoring and Assessment 51: 29–51.

Stoddard, J.L., Urquhart, N.S., Newell, A.D., and Kugler, D. 1996. The Temporally Integrated Monitoring of Ecosystems (TIME) project design 2. Detection of regional acidification trends. Water Resources Research 32: 2529–2538.

Stoddard, J.L., Kahl, J.S., Deviney, F.A., DeWalle, D.R., Driscoll, C.T., Herlihy, A.T., Kellogg, J.H., Murdoch, P.S., Webb, J.R., and Webster, K.E. 2003. Response of surface water chemistry to the Clean Air Act Amendments of 1990. United States Environmental Protection Agency No. EPA620/R-03/001.

Sullivan, T.J., Fernandez, I.J., Herlihy, A.T., Driscoll, C.T., McDonnell, T.C., Nowicki, N.A., Snyder, K.U., and Sutherland, J.W. 2006a. Acid-base characteristics of soils in the Adirondack Mountains, New York. Soil Science Society of America Journal 70: 141–152.

Sullivan, T.J., Driscoll, C.T., Cosby, B.J., Fernandez, I.J., Herlihy, A.T., Zhai, J., Stemberger, R.S., Snyder, K.U., Sutherland, J.W., Nierzwicki-Bauer, S.A., Boylen, C.W., McDonnell, T.C., and Nowicki, N.A. 2006b. Assessment of the extent to which intensively-studied lakes are representative of the Adirondack Mountain region. New York State Energy Research and Development Authority No. 06–17.

U.S. Environmental Protection Agency 1993a. Environmental Monitoring and Assessment Program Project Descriptions. U.S. Environmental Protection Agency No. EPA/620/R-93/009.

U.S. Environmental Protection Agency 1993b. Environmental Monitoring and Assessment Program Guide. U. S. Environmental Protection Agency No. EPA/620/R-93/012.

U.S. Environmental Protection Agency 1995. Acid Deposition Standard Feasibility Study: Report to Congress. U.S. Environmental Protection Agency No. EPA 430-R-95-001a.

Van Sickle, J., Baker, J.P., Simonin, H.A., Baldigo, B.P., Kretser, W.A., and Sharpe, W.E. 1996. Episodic acidification of small streams in the northeastern United States: Fish mortality in field bioassays. Ecological Applications 6: 408–421.

Waller, K., Driscoll, C., Lynch, J., Newcomb, D., and Roy, K. 2012. Long-term recovery of lakes in the Adirondack region of New York to decreases in acid deposition. Atmospheric Environment 46: 56–64.

Whittier, T.R. and Paulsen, S.G. 1992. The surface waters component of the Environmental Monitoring and Assessment Program (EMAP): An overview. Journal of Aquatic Ecosystem Health 1: 119–126.

Whittier, T.R. and Hughes, R.M. 1998. Evaluation of fish species tolerances to environmental stressors in lakes in the northeastern United States. North American Journal of Fisheries Management 18: 236–252.

Whittier, T.R., Halliwell, D.B., and Daniels, R.A. 2000. Distributions of lake fishes in the Northeast-II. The minnows (cyprinidae). Northeastern Naturalist 7: 131–156.

Whittier, T.R., Paulsen, S.G., Larsen, D.P., Peterson, S.A., Herlihy, A.T., and Kaufmann, P.R. 2002. Indicators of ecological stress and their extent in the population of northeastern lakes: A regional-scale assessment. BioScience 52: 235–247.

Wigington,P.J.Jr., Baker,J.P., DeWalle,D.R., Kretser,W.A., Murdoch,P.S., Simonin,H.A., Van Sickle,J., McDowell,M.K., Peck,D.V., and Barchet,W.R. 1996a. Episodic acidification of small streams in the northeastern United States: Episodic Response Project. Ecological Applications 6: 374–388.

Wigington,P.J.Jr., DeWalle,D.R., Murdoch,P.S., Kretser,W.A., Simonin,H.A., Van Sickle,J., and Baker,J.P. 1996b. Episodic acidification of small streams in the northeastern United States: Ionic controls of episodes. Ecological Applications 6: 389–407.

This page is intentionally left blank

Appendix A: ALTM Trend Results; Seasonal Kendall Test

	SO$_4$ ueqL^{-1}yr^{-1}								NO$_3$ ueqL^{-1}yr^{-1}								ueqL^{-1}yr^{-1}								F ueqL^{-1}yr^{-1}								ANC ueqL^{-1}yr^{-1}							
LTM Site	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2000**	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2000**	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2000**	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2000**	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2000**
LITTLE HOPE POND	-2.70	-2.59	-2.39	-2.66	-2.50	-2.14	-1.97												-0.17	-0.24	-0.25	-0.28	-0.28		-0.03	-0.03							1.60	1.53	1.46	1.53	1.55	1.89	1.89	
BIG HOPE POND	-2.41	-2.29	-2.12	-2.05	-1.80	-1.49	-1.42										-0.89	-1.08	-1.41	-1.61	-1.78	-1.98	-2.07	-3.38					0.03				2.09	2.08	2.10	2.17	2.18	2.44	2.54	2.98
LITTLE ECHO POND	-1.23	-1.11	-0.94	-1.14	-1.10	-1.15	-1.15	-2.12						0.02			0.18	0.21	0.23	0.21	0.22	0.20	0.24	0.33								-0.01	1.06	1.01	1.07	1.25	1.36	1.32	1.46	2.53
EAST COPPERAS POND	-1.44	-1.30	-1.08																								0.02						0.50	0.51	0.61	0.69	0.68			
MIDDLE POND	-2.08	-2.04	-2.17	-2.21	-2.02	-1.70	-1.56										-0.12	-0.15	-0.19	-0.19	-0.14	-0.09																		
SUNDAY POND	-0.59	-0.46		-0.49	-0.49		-0.55	-1.04	-0.03						-0.04				0.00																					
SOCHIA POND	-1.16	-1.22	-1.11	-1.12	-1.00	-1.04	-1.01	-1.67									0.12	0.14	0.17	0.16	0.19	0.19	0.19			0.01	0.02	0.02	0.02				1.09	1.27	1.37	1.44	1.46	1.71	1.70	1.93
OWEN POND	-3.75	-3.70	-3.79	-3.71	-3.40	-3.43	-3.24	-4.74		0.47	0.71	0.67	0.53																				0.92	1.03			1.41	1.80	2.00	
HEART LAKE	-1.83	-1.78	-1.84	-1.84	-1.77	-1.75	-1.78	-2.23			0.08	0.07		0.09																										
MARCY DAM POND	-2.06	-2.01	-2.03	-2.01	-1.85	-1.77	-1.76	-2.71			0.53	0.47													0.01	0.01	0.01	0.02					0.64	0.63	0.61			0.76	0.83	
GRASS POND	-1.15	-1.09	-1.04	-1.15	-1.11	-1.04	-1.09	-1.67									-0.03				-0.05												0.45	0.37	0.36			0.62	0.71	1.57
BLACK POND OUTLET	-2.41	-2.39	-2.37	-2.34	-2.15	-1.87	-1.87	-1.67									-0.05	-0.04		-0.05	-0.06	-0.06																		
LOON HOLLOW POND	-2.15	-2.03	-1.71	-2.01	-1.97	-2.08	-2.23		-0.54	-0.49	-0.26	-0.34	-0.34				-0.12	-0.11	-0.08	-0.09	-0.09	-0.12	-0.14		-0.02	-0.02							0.87	0.84	0.90	0.84	0.84	1.11	1.22	1.65
WILLYS LAKE (HORSESHOE)	-3.20	-3.07	-2.87	-2.87	-2.87	-3.01	-3.15	-3.54	-1.24	-1.20	-0.91	-0.98	-0.98	-1.12	-1.18		-0.08	-0.07	-0.06	-0.08	-0.08	-0.09	-0.09		-0.08	-0.08	-0.07	-0.05	-0.05	-0.07	-0.07	-0.07	0.76	0.72	0.64	0.60	0.60	0.76	0.73	1.01
MIDDLE SETTLEMENT LAKE	-2.11	-2.03	-2.01	-1.99	-1.84	-1.88	-1.87	-1.74	-0.14	-0.15	-0.12	-0.13	-0.14	-0.15	-0.15		-0.05								-0.02	-0.02							0.95	0.87	0.74	0.67	0.68	0.64		1.32
GRASS POND	-1.94	-1.92	-1.97	-1.96	-1.82	-1.78	-1.79	-1.98								-0.87	-0.06								-0.03	-0.03							0.87	0.75	0.82	0.68	0.95			
MIDDLE BRANCH LAKE	-1.67	-1.52	-1.55	-1.49	-1.35	-1.37	-1.39		-0.13	-0.12	-0.07	-0.09	-0.10	-0.12	-0.12		-0.09	-0.09	-0.09	-0.09	-0.09	-0.10	-0.09		-0.02	-0.03														
LAKE RONDAXE	-2.58	-2.49	-2.50	-2.63	-2.58	-2.58	-2.52	-2.71	-0.70	-0.65	-0.57	-0.63	-0.72	-0.70	-0.73	-0.94									-0.04	-0.04	-0.03	-0.04					1.15	1.11	1.27	1.08	1.18	1.58	1.35	
MOSS LAKE	-2.13	-2.12	-2.21	-2.19	-2.03	-1.96	-1.96	-2.19	-0.64	-0.60	-0.50	-0.61	-0.72	-0.75	-0.82	-1.27									-0.04	-0.04	-0.05						1.07	0.95			0.71			
CASCADE LAKE OUTLET	-2.03	-2.02	-1.99	-2.01	-1.79	-1.72	-1.70	-2.29	-0.50	-0.45			-0.58	-0.59	-0.73	-1.45									-0.05	-0.06	-0.08	-0.10	-0.08											
BUBB LAKE	-1.96	-2.05	-2.29	-2.37	-2.44	-2.62	-2.71	-2.94	-0.23	-0.22						-0.40									-0.05	-0.05	-0.05	-0.05			-0.04							1.15	1.26	1.91
DART LAKE	-2.87	-2.80	-2.80	-2.91	-2.78	-2.81	-2.81	-3.18	-0.86	-0.77	-0.60	-0.71	-0.72	-0.70	-0.75										-0.04	-0.04							1.27	1.20	1.21	1.28	1.35	1.36	1.41	1.41
WINDFALL POND	-3.20	-3.21	-3.21	-3.46	-3.33	-3.45	-3.54	-4.01	-0.37	-0.38							-0.10								-0.06	-0.07	-0.06	-0.07	-0.05	-0.04			1.04	0.79	0.78		0.84	1.13		
BIG MOOSE LAKE	-2.89	-2.83	-2.83	-2.93	-2.87	-2.92	-2.91	-2.91	-0.92	-0.84	-0.68	-0.80	-0.79	-0.76	-0.82										-0.04	-0.03	-0.03	-0.03				-0.05	1.09	1.01	0.90	1.00	0.99	1.08	0.95	1.44
WEST POND	-2.44	-2.23	-2.32	-2.54	-2.48	-2.77	-2.73	-2.97	-0.21	-0.20		-0.18		-0.19	-0.23		-0.10	-0.09	-0.07						-0.04	-0.04				-0.04	-0.05	-0.12	0.43							
SQUASH POND	-2.42	-2.23	-1.87	-2.17	-1.91	-1.88	-1.87	-2.86	-0.20	-0.22							-0.10	-0.08							-0.02	-0.02						-0.04	0.74	0.72	0.81	0.72	0.73	0.81	0.74	0.90
CONSTABLE POND	-3.33	-3.33	-3.25	-3.30	-3.24	-3.05	-3.33	-3.85	-0.61	-0.59	-0.51	-0.52	-0.59	-0.57	-0.58		-0.13	-0.11							-0.05	-0.06	-0.04	-0.05	-0.04		-0.04		0.98	0.93	1.01	0.94	1.23	1.46	1.46	2.03
LIMEKILN LAKE	-2.74	-2.71	-2.71	-2.71	-2.58	-2.57	-2.55	-2.89	-0.55	-0.48	-0.35	-0.42	-0.42	-0.40	-0.38		-0.38	-0.47	-0.59	-0.65	-0.66	-0.64	-0.63		-0.03	-0.02							1.47	1.40	1.49	1.56	1.70	1.82	1.85	2.51
SQUAW LAKE	-3.15	-3.28	-3.59	-3.75	-3.70	-3.90	-3.96	-4.93	-0.40	-0.34		-0.34				-1.13	-0.12	-0.11	-0.08	-0.07				-0.16	-0.02	-0.02							0.80	0.75	0.79	0.83	0.88	0.95	1.01	2.03
INDIAN LAKE	-3.08	-3.07	-2.94	-3.05	-2.79	-2.68	-2.71	-3.79	-0.29	-0.27		-0.26	-0.34	-0.43	-0.41	-1.13	-0.12	-0.10							-0.02	-0.02							0.82	0.80	0.76	0.73	0.76	0.81	0.80	
BROOK TROUT LAKE	-2.78	-2.77	-2.83	-2.98	-2.91	-3.12	-3.20	-4.52	-0.52	-0.49			-0.65	-0.91	-1.01	-1.77	-0.09	-0.07	-0.04					-0.12	-0.02	-0.02						-0.04	0.77	0.81	0.89	1.01	1.16	1.41	1.47	2.10
LOST POND	-1.51	-1.61	-1.55	-1.58	-1.38	-0.97	-0.88		-0.23	-0.21			-0.31		-0.46	-1.61	-0.10	-0.09															0.69	0.47	0.61	0.56	0.65	0.74	0.73	
SOUTH LAKE	-2.15	-2.09	-2.05	-2.05	-1.94	-1.92	-1.92	-1.98	-0.94	-0.87	-0.75	-0.87	-0.82	-0.85	-0.86		-0.09								-0.02	-0.02							1.13	1.07	1.10	1.20	1.28	1.40	1.50	1.64
NORTH LAKE	-2.49	-2.39	-2.23	-2.23	-2.04	-2.01	-2.01	-2.01	-0.67	-0.62	-0.45	-0.52	-0.55	-0.63	-0.76		-0.10	-0.09							-0.02	-0.01							0.96	0.90	0.77	0.84	0.84	0.87	0.92	
WILLIS LAKE	-2.04	-1.85	-1.72	-1.58	-1.45	-1.44	-1.23				0.02																		0.02				1.03		1.15	1.32	1.48			
LOCKEYBUSH LAKE	-2.28	-2.22	-2.23	-2.23	-2.08	-2.14	-2.11	-2.29									-0.09	-0.08							-0.02	-0.01				-0.01			0.88	0.83	0.77	0.77	0.80	0.84	0.90	1.26
CLEAR POND	-2.42	-2.43	-2.44	-2.29	-2.06	-1.75	-1.77	-1.90			0.05	0.04	0.05	0.08	0.05		-0.06	-0.04							0.01	0.01	0.01	0.01	0.02		0.01									
NATE POND	-2.81	-2.74	-2.70	-2.57	-2.29	-2.21	-2.14										-0.11	-0.08							-0.03	-0.03														
LONG POND	-2.91	-2.64	-2.25	-2.44	-2.21	-2.24	-2.22	-3.75	-0.03	-0.03																							1.20	1.00	0.74	0.75	0.93	1.25	1.32	
CARRY POND	-2.52	-2.53	-2.21	-1.87	-1.54	-1.21	-1.11																										1.41	1.53	1.62	1.56	1.26	0.95	0.88	
ARBUTUS LAKE	-2.60	-2.47	-2.29	-2.08	-1.73	-1.53	-1.59	-2.62	-0.19	-0.18			-0.15												-0.03															
LAKE COLDEN	-2.50	-2.34	-2.13	-2.15	-1.89	-1.74	-1.85																										0.74	0.69	0.63	0.60	0.58	0.73	0.79	1.10
AVALANCHE LAKE	-2.89	-2.69	-2.57	-2.73	-2.50	-2.30	-2.40	-3.93									-0.11	-0.09															0.78	0.74	0.71	0.68	0.63	0.73	0.73	0.71
SAGAMORE LKAE	-3.25	-3.23	-3.22	-3.21	-2.98	-3.00	-3.00	-3.96	-0.57	-0.58		-0.57	-0.69	-0.77	-0.81	-1.21	-0.09								-0.03	-0.02	-0.03						0.74	0.71			0.66			
RAQUETTE LAKE RESEVOIR	-4.14	-4.18	-4.12	-4.16	-4.09	-4.16	-4.16	-4.19	-0.39	-0.39	-0.32	-0.32	-0.40	-0.38	-0.38		-0.12								-0.04	-0.04	-0.04	-0.04	-0.03				0.83	0.79	0.85	0.74	0.93			
QUEER LAKE	-2.56	-2.57	-2.65	-2.71	-2.61	-2.73	-2.77	-2.97	-0.65	-0.55	-0.38	-0.48	-0.41	-0.36	-0.34		-0.10	-0.08	-0.06	-0.07					-0.03	-0.03							1.13	1.06	0.99	1.11	1.03	1.03	1.03	1.05
OTTER LAKE OUTLET	-2.46	-2.40	-2.50	-2.46	-2.27	-2.29	-2.43	-2.25					-0.18	-0.14	-0.16										-0.01								0.86	0.85	0.78	0.70	0.83	0.74	0.74	1.32
G LAKE	-2.13	-2.06	-1.96	-1.87	-1.63	-1.60	-1.53	-1.35									-0.11	-0.09							-0.02	-0.02							0.74	0.72	0.79	0.72	0.85	1.05	1.11	

Sites with Recent Liming History

LITTLE CLEAR POND	-1.23	-1.16	-1.12	-1.08	-1.04	-1.02	-0.97	-1.15									-0.06	-0.06	-0.07	-0.07	-0.08	-0.09	-0.08	-0.14	-0.01	-0.01											10.28	13.26	14.73	25.86
WOODS LAKE	-3.01	-3.05	-3.03	-3.14	-3.06	-3.03	-2.94	-3.75									-0.07	-0.05							-0.02	-0.02				-0.02										
BARNES LAKE	-0.99	-0.83							-0.04								-0.08	-0.08	-0.09	-0.09		-0.09			-0.01	0.00						-0.02	-0.55	-0.52	-0.63	-0.84	-1.02	-1.16	-1.34	-2.15
LITTLE SIMON POND	-2.68	-2.61	-2.58	-2.50	-2.36	-2.45	-2.46	-3.14	-0.41								-0.06								-0.03	-0.03									1.42	1.76				

	-2.18	-2.12	-1.83	-1.46	-1.25				-0.62	-0.55							-0.07	-0.05							-0.05	-0.06	-0.04						0.84	0.71		0.92				
	-1.87	-1.98	-2.24	-2.33	-2.33																				-0.05	-0.06		-0.08	-0.07											
Windfall	-3.26	-3.33	-3.42	-3.20	-3.03				-0.72	-0.73	-0.47	-0.71	-0.67				-0.09								-0.04	-0.04														
West	-2.53	-2.29	-2.71	-2.52	-2.93				-0.10								-0.09	-0.10							-0.03	-0.03	-0.05	-0.04					0.80	0.71	0.66	0.86	1.12			
	-2.36	-2.08	-1.87	-1.67	-1.53 -												-0.09	-0.07							-0.02	-0.01							1.06	0.93	0.98	1.08	1.09			
	3.29	-3.23	-3.12	-2.91	-2.86				-0.76	-0.75	-0.57	-0.74	-0.75				-0.16	-0.14							-0.06	-0.05							0.89	0.86	0.89	1.05	1.14			
	-2.65	-2.60	-2.60	-2.22	-2.43																							0.03					0.86	0.82	0.65	0.70	0.67			

Notes:
p <= 0.05
Blank = not significant at 95% conf. Interval.

	DIC umolL^{-1}yr^{-1}								umolL^{-1}yr^{-1}								SIO_2 umolL^{-1}yr^{-1}								ueqL^{-1}yr^{-1}								ueqL^{-1}yr^{-1}							
LTM Site	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2000**	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2000**	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2000**	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2000**	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2000**
LITTLE HOPE POND					-1.87	-1.66	-1.39		-10.29	-10.40							1.68	1.92	2.00	2.32	2.00	1.73	1.91	3.16	-0.60	-0.60	-0.80													
BIG HOPE POND	1.67	1.52	1.17														0.96	1.02	0.89	0.95	0.83	0.66			0.47	0.51				0.75								0.41	0.49	
LITTLE ECHO POND														12.74								0.55											0.21	0.21	0.27	0.37	0.46	0.49	0.55	
EAST COPPERAS POND	2.77	3.01	3.08	3.33	4.16	4.17	4.35		13.86	16.62	18.21	19.90	18.86		9.07																		-0.08							
MIDDLE POND										-2.65															-1.00	-0.91		-1.38												
SUNDAY POND	-0.73	-0.83	-0.85	-0.70			-0.64		-6.88	-7.72	-7.96	-6.89	-7.22	-7.27	-7.20		-0.07	-0.05							-0.65	-0.62	-0.70	-0.75	-0.83	-0.78	-0.80	-1.16	-0.49	-0.51	-0.51	-0.52	-0.53	-0.55	-0.55	-0.82
SOCHIA POND									4.85	4.63	4.89	6.74	7.93	9.68	11.01							0.23		0.31																
OWEN POND																									-1.93	-1.83	-2.00	-2.16					-0.55	-0.47						
HEART LAKE									-1.94	-2.19	-2.13	-2.01	-1.91		-2.41									2.89	-1.50	-1.50	-1.69	-1.71	-1.71	-1.50	-1.57	-2.83	-0.24	-0.24	-0.27	-0.27	-0.25			
MARCY DAM POND																						1.20	1.59		-0.93	-0.86						-2.50								
GRASS POND									9.25	10.47	12.74	14.80	14.74	14.18	14.41			0.12						0.46											0.00					
BLACK POND OUTLET LOON				-2.39	-2.71																		3.39		-1.50	-1.78	-2.40	-2.73	-2.74	-2.22	-2.63	-4.24	-0.54	-0.59	-0.66	-0.67				
HOLLOW POND																	-0.67	-0.62	-0.55						-0.63	-0.61	-0.57	-0.67	-0.67	-0.62	-0.64	-1.00	-0.21	-0.21	-0.16	-0.18	-0.16	-0.16	-0.16	
WILLYS LAKE (HORSESHOE)							-0.56		7.58	7.61	5.95						-1.45	-1.37	-1.27	-1.17	-1.17	-1.32	-1.32		-1.40	-1.37	-1.35	-1.41	-1.41	-1.41	-1.50	-1.75	-0.31	-0.30	-0.27	-0.25	-0.25	-0.21	-0.24	-0.33
MIDDLE SETTLEMENT LAKE									3.18	2.90	2.78	2.58	2.52												-0.41	-0.45	-0.54	-0.62	-0.60	-0.58	-0.60		-0.16	-0.16	-0.18	-0.18	-0.16	-0.18	-0.18	
GRASS POND																				1.10	1.36	1.98	2.05		-0.56	-0.65	-0.89	-1.08	-1.00	0.00	-0.93	-1.41		-0.22						
MIDDLE BRACH LAKE																								2.03	-0.78	-0.83	-0.93	-1.15	-1.12	-1.00	-0.90		-0.24	-0.24		-0.27				
LAKE RONDAXE	0.90	0.94	1.25	1.03	1.11		1.50		3.74	3.52	3.48	4.35		4.36			-0.46	-0.39	-0.43	-0.49					-1.08	-1.10	-1.16	-1.43	-1.32	-1.00	-1.19		-0.33	-0.33		-0.33				
MOSS LAKE																	-0.62	-0.72	-0.79						-1.25	-1.38	-1.75	-2.00	-1.85	-1.65	-1.75	-2.62	-0.30	-0.31	-0.37	-0.41				
CASCADE LAKE OUTLET																13.68								2.89	-1.50	-1.88	-2.08	-2.50	-2.44	-2.33	-2.71	-4.62	-0.36	-0.43	-0.45	-0.55				
BUBB LAKE																					-1.15	-1.45	-1.51		-1.12	-1.27	-1.34	-1.44	-1.25	-0.87	-1.00	-1.75	-0.41	-0.47	-0.49	-0.55	-0.48	-0.41	-0.41	
DART LAKE	0.72	0.69	0.62	0.71	0.83	0.71	0.74		4.46	4.42	4.40	5.70		5.69	4.87		-0.55	-0.54							-1.16	-1.16	-1.25	-1.43	-1.33	-1.09	-1.25	-2.59	-0.35	-0.36	-0.31	-0.34	-0.27			
WINDFALL POND											2.98	4.59	4.72	6.15	6.13		-0.89	-0.88							-1.44	-1.75	-1.75	-2.25	-2.00	-1.47	-1.79		-0.41	-0.44		-0.41		-0.21		
BIG MOOSE LAKE									5.27	5.18	5.11	6.53	5.48	6.66			-0.50	-0.57	-0.52						-1.05	-1.12	-1.25	-1.41	-1.37	-1.15	-1.37	-2.00	-0.33	-0.35	-0.33	-0.34	-0.27	-0.27	-0.27	
WEST POND																	-0.50	-0.62	-0.67						-1.14	-1.25	-1.58	-1.71	-1.75	-1.75	-1.84	-3.29	-0.37	-0.41	-0.49	-0.55	-0.51	-0.51	-0.55	-1.23
SQUASH POND									4.21												0.54	0.60			-0.83	-0.83	-0.81	-0.92	-0.87	-0.75	-0.83	-1.60	-0.22	-0.22	-0.18	-0.21	-0.14			
CONSTABLE POND									5.35	5.49	6.00	5.94	5.04	6.33	5.56		-0.95	-0.91	-0.74	-0.55					-1.60	-1.65	-1.64	-1.75	-1.64	-1.30	-1.50		-0.41	-0.41	-0.37	-0.41	-0.27			
LIMEKILN LAKE	1.09	0.98	1.19	1.06	1.46	1.67	1.82	2.68	3.34	3.62	3.80	3.85	3.29	3.36	3.68			0.53	0.75	0.90	1.00	0.00	1.03		-0.95	-1.00	-1.00	-1.05	-0.93	-0.75	-0.73		-0.34	-0.35	-0.27	-0.27				
SQUAW LAKE	0.64	0.77	0.83	0.83	1.08	1.11	0.69				4.31	5.54	5.00	5.51	6.05				0.94	1.10	1.31	1.54	1.71	3.00	-1.71	-1.83	-2.06	-2.20	-2.25	-2.25	-2.25	-3.59	-0.49	-0.55	-0.59	-0.62	-0.57	-0.55	-0.55	-0.82
INDIAN LAKE	1.04	1.04	1.06	1.25	1.25	1.30	1.11		4.29																-1.49	-1.50	-1.69	-1.85	-1.91	-1.92	-1.94	-3.08	-0.38	-0.41	-0.41	-0.41	-0.41	-0.36	-0.37	-0.82
BROOK TROUT LAKE	0.65	0.58		0.54	0.65				6.43	6.89	8.75	10.94	13.22	16.02	17.44	20.33	-0.95	-0.97	-0.87	-0.70	-0.67	-0.78	-0.83		-1.07	-1.06	-1.05	-1.10	-1.10	-1.00	-1.00	-1.67	-0.27	-0.27	-0.21	-0.19				
LOST POND																									-1.25	-1.33	-1.41	-1.50	-1.62	-1.50	-1.56	-3.24	-0.37	-0.41	-0.41	-0.41	-0.41	-0.33	-0.33	-0.82
SOUTH LAKE	0.62	0.56				0.65			3.80	3.51	4.04	4.68	4.29	4.41	4.74										-0.75	-0.75	-0.75	-0.75	-0.64			-1.25	-0.27	-0.30	-0.25					
NORTH LAKE																	-0.45	-0.50							-1.14	-1.19	-1.28	-1.33	-1.25	-1.21	-1.25	-2.10	-0.33	-0.35	-0.33	-0.31				
WILLIS LAKE	3.12	2.78							-4.80	-5.18																							-0.21	-0.21						
JOCKEYBUSH LAKE											1.30						0.41	0.37	0.41	0.36					-0.85	-0.80	-0.87	-0.95	-1.00	-0.87	-0.80	-1.00	-0.27	-0.27	-0.21	-0.24	-0.21	-0.16		
CLEAR POND				-1.67					2.04	2.34	2.34	2.82													-2.00	-2.22	-2.54	-2.78	-2.66	-2.40	-2.50	-4.99	-0.33	-0.34	-0.33	-0.33				
NATE POND									3.55	3.50		5.19	4.01												-1.21	-1.22	-1.25	-1.33					-0.55	-0.55						
LONG POND	2.60	2.83	2.64	2.08	2.00	2.08	2.43		14.57	15.62	17.19	22.13	19.24	21.19			0.85			1.27												-1.75	-0.32							
CARRY POND									7.41	7.12	5.03														-0.64	-0.62	-0.50					-1.06	-0.24	-0.26	-0.25	-0.25	-0.21			
ARBUTUS LAKE																	-0.70	-0.71	-0.93		-0.78				-1.50	-1.50	-1.46	-1.50				-3.31	-0.55	-0.55	-0.47	-0.48				
LAKE COLDEN									3.31														1.14		-0.99	-0.86	-0.79	-0.92					-0.18							
AVALANCHE LAKE																									-1.12	-1.04	-1.00	-1.11				-2.62	-0.27	-0.24						
SAGAMORE LAKE									5.13																-1.77	-1.90	-2.25	-2.41	-2.25	-2.15	-2.16	-2.91	-0.50	-0.51	-0.55	-0.58				
RAQUETTE LAKE RESEVOIR	1.77	1.87	1.74	1.96	1.94	2.66	2.79		7.31	7.35	8.08	9.21	10.25	10.66	12.41		-1.62	-1.50							-2.22	-2.38	-2.50	-2.77	-2.74	-2.70	-2.92	-3.24	-0.82	-0.82	-0.82	-0.82	-0.72	-0.59	-0.64	
QUEER LAKE	0.46	0.45							4.10	4.19	4.21	4.36						0.19	0.31	0.30	0.33				-0.84	-0.89	-1.00	-1.07	-1.00	-1.00	-0.98	-2.25	-0.29	-0.31	-0.27	-0.27	-0.25	-0.22	-0.22	
OTTER LAKE OUTLET									1.55																-0.91	-0.91	-1.00	-1.14	-1.19	-1.16	-1.28		-0.29	-0.27	-0.24	-0.27				
G LAKE																									-0.87	-0.87	-0.80	-0.87	-0.78											
Sites with Recent Liming History																																								
LITTLE CLEAR POND					7.68	10.41	10.77	####								13.84					0.17	0.23		0.44					6.79	8.88	9.73	16.66					3.29	4.20	4.81	8.39
WOODS LAKE								-3.33									-1.04	-1.13	-1.33	-1.39	-1.34	-1.22	-1.11		-1.91	-2.00	-2.00	-2.25	-2.25	-2.25	-2.28	-4.74	-0.21	-0.22	-0.16	-0.16				
BARNES LAKE	-1.54	-1.39		-1.55	-1.67	-1.67	-1.85				-10.36	-11.83	-12.62	-12.77	-14.67	-11.92									-1.66	-1.71	-1.81	-1.87	-1.87	-1.66	-1.75	-2.99	-0.13	-0.14	-0.14	-0.14	-0.13	-0.14	-0.14	
LITTLE SIMON POND								-6.66												0.67	0.94	0.91	0.94									-6.53	-0.64	-0.66	-0.64	-0.68	-0.66	-0.69	-0.72	-1.44

									2.36	2.55	3.72	3.12								0.69	1.00				-0.94	-1.00	-1.10	-0.87					-0.33	-0.33						
			-1.25	-1.63	-1.23																				-0.86	-1.00	-1.04	-1.06	-0.97				-0.39	-0.45	-0.51	-0.55	-0.55			
Windfall									4.16	4.87	4.20	4.15	3.40				-0.82	-0.95	-1.00	-1.00					-2.58	-2.85	-2.89	-2.58	-2.66				-0.55	-0.60	-0.55	-0.47	-0.41			
West	0.62	0.62		1.11	1.67				7.18	6.21	7.32	7.18	9.73												-0.90	-0.90	-1.21	-1.16	-1.21				-0.21	-0.22	-0.37	-0.27				
									8.17	8.08											0.33				-0.50	-0.45	-0.42	-0.37					-0.15	-0.14						
	0.83	0.83	1.11	1.11	1.31				9.43	9.42	10.66	10.47	9.64				-1.29	-1.25	-0.74	-0.62					-1.40	-1.40	-1.33	-1.22	-1.00				-0.41	-0.41	-0.37	-0.27				
	0.84	0.92							3.70	3.32	3.77	3.44	3.86						d						-0.82	-0.80	-1.00	-1.16	-1.16				-0.31	-0.29	-0.31	-0.27	-0.24			

Notes:
$p <= 0.05$
Blank = not significant at 95% conf. Interval

	ueqL^{-1}yr^{-1}								ueqL^{-1}yr^{-1}								**NH$_4$** ueqL^{-1}yr^{-1}								**ALTD** umolL^{-1}yr^{-1}								**ALTM** umolL^{-1}yr^{-1}							
LTM Site	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2000**	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2000**	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2000**	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2000**	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2000**
LITTLE HOPE POND									-0.21	-0.21															-0.16	-0.15							-0.18	-0.19	-0.21	-0.20	-0.20	-0.24	-0.25	
BIG HOPE POND	-0.51	-0.65	-0.87	-1.03	-1.14	-1.16	-1.16	-1.96	-0.25	-0.26	-0.21	-0.21					-0.07	-0.07															-0.06	-0.06	-0.07	-0.07	-0.08	-0.10	-0.10	
LITTLE ECHO POND	0.22	0.24	0.27	0.29	0.31	0.30	0.33	0.22	-0.06												0.04												-0.09	-0.10	-0.13	-0.13	-0.13	-0.12	-0.14	
EAST COPPERAS POND		0.05	0.08	0.10	0.12	0.11	0.11									-0.43										0.01		0.02	0.03	0.03	0.03		-0.06	-0.07	-0.09	-0.09	-0.10	-0.11	-0.10	
MIDDLE POND						0.44	0.50		-0.13	-0.12															-0.03	-0.03				-0.05	-0.05		-0.03	-0.04	-0.06	-0.06	-0.06	-0.07	-0.07	
SUNDAY POND	0.02	0.00	0.00																																-0.03	-0.03	-0.03	-0.03		
SOCHIA POND	0.10	0.10	0.12	0.12	0.14	0.12	0.11				0.05	0.05										0.63	0.62							s				-0.03	-0.04	-0.04	-0.04	-0.04		
OWEN POND						0.58	0.64										-0.05	-0.06	-0.03																					
HEART LAKE			0.24	0.24	0.25	0.29	0.29		-0.02	-0.01																														
MARCY DAM POND						0.43	0.44																		-0.14	-0.12			-0.18	-0.22	-0.20		-0.11	-0.11	-0.11	-0.11	-0.13	-0.17	-0.16	
GRASS POND	0.05	0.06	0.08	0.07					-0.12	-0.10	-0.09	-0.09													0.01	0.02	0.01	0.02	0.02	0.02	0.02	0.04			-0.04	-0.04	-0.04	-0.05	-0.05	
BLACK POND OUTLET LOON																																			-0.04	-0.04				
HOLLOW POND			0.13	0.14					-0.12	-0.12																						-0.91	-0.46	-0.44	-0.44	-0.51	-0.62	-0.72	-0.78	-1.19
WILLYS LAKE (HORSESHOE)			0.14	0.17	0.17	0.17																			-0.57	-0.55	-0.56	-0.63	-0.63	-0.70	-0.72	-0.88	-0.66	-0.66	-0.67	-0.78	-0.78	-0.88	-0.93	-1.07
MIDDLE SETTLEMENT LAKE				0.20	0.25	0.25	0.25										-0.08	-0.11	-0.08	-0.11		-0.09			-0.10	-0.11	-0.13	-0.12	-0.14	-0.15	-0.13	-0.30	-0.10	-0.10	-0.11	-0.11	-0.13	-0.14	-0.14	-0.20
GRASS POND					0.50																				-0.13								-0.10	-0.10	-0.11	-0.11	-0.13	-0.16	-0.15	-0.26
MIDDLE BRANCH LAKE							0.33																												-0.03					
LAKE RONDAXE			0.33	0.31	0.37	0.37	0.44		-0.07																								-0.04	-0.04	-0.06	-0.05	-0.07	-0.06	-0.07	
MOSS LAKE					0.33				-0.09	-0.09		-0.06	-0.06																						-0.04		-0.05			
CASCADE LAKE OUTLET									-0.09	-0.09		-0.09	-0.09	-0.13	-0.09									-0.03	-0.07								-0.03							
BUBB LAKE									-0.09	-0.08																							-0.02	-0.03	-0.04		-0.04		-0.05	
DART LAKE			0.26	0.31	0.39	0.40	0.44		-0.11	-0.09	-0.05	-0.06	-0.04												-0.11	-0.11			-0.17	-0.21	-0.20		-0.14	-0.13	-0.15	-0.16	-0.19		-0.22	
WINDFALL POND																									-0.10								-0.07	-0.06	-0.07		-0.08			
BIG MOOSE LAKE			0.26	0.32	0.39	0.39	0.44		-0.09	-0.06							-0.04								-0.14	-0.14	-0.14		-0.17	-0.22			-0.18	-0.17	-0.19	-0.20	-0.22	-0.20	-0.26	
WEST POND									-0.10	-0.10												0.10	0.07										-0.15	-0.16	-0.18	-0.19	-0.23	-0.22	-0.24	
SQUASH POND					0.27	0.26	0.27		-0.06	-0.06								-0.05		-0.04				-0.16									-0.40	-0.37	-0.37	-0.41	-0.44	-0.39	-0.49	-0.65
CONSTABLE POND									-0.11								-0.04	-0.04							-0.25	-0.21	-0.22	-0.23	-0.28	-0.28	-0.25		-0.34	-0.33	-0.36	-0.37	-0.45	-0.42	-0.49	-0.52
LIMEKILN LAKE									-0.08	-0.07	-0.04								-0.03						-0.04								-0.03	-0.03	-0.04	-0.05	-0.06	-0.06	-0.06	
SQUAW LAKE					0.19	0.22	0.22		-0.05							-0.15								-0.17													-0.03			
INDIAN LAKE													-0.06	-0.07	-0.09	-0.15									-0.20	-0.20	-0.21	-0.18	-0.22	-0.23			-0.27	-0.26	-0.26	-0.26	-0.31	-0.34	-0.34	-0.38
BROOK TROUT LAKE				0.21	0.26	0.29	0.29		-0.04	-0.04	-0.03	-0.03	-0.03												-0.18	-0.19		-0.29	-0.35	-0.42	-0.46	-0.75	-0.15	-0.15	-0.20	-0.23	-0.28	-0.35	-0.37	-0.58
LOST POND					0.30	0.44	0.44									-0.19									-0.17	-0.14	-0.13	-0.13	-0.13	-0.11			-0.21	-0.19	-0.21	-0.24	-0.26	-0.30	-0.33	-0.47
SOUTH LAKE					0.36	0.44	0.44		-0.09	-0.07	-0.04	-0.04													-0.17	-0.17	-0.18	-0.22	-0.27	-0.30	-0.29	-0.46	-0.14	-0.14	-0.17	-0.19	-0.23	-0.26	-0.26	-0.32
NORTH LAKE						0.34			-0.06	-0.06	-0.05	-0.05	-0.06	-0.07	-0.09	-0.13									-0.20	-0.19	-0.20		-0.20	-0.20			-0.27	-0.27	-0.28	-0.30	-0.33	-0.34	-0.33	-0.44
WILLIS LAKE	0.25	0.22																							-0.03	-0.04	-0.04							-0.04	-0.05	-0.06	-0.06	-0.06		
JOCKEYBUSH LAKE				0.22	0.25	0.29	0.31		-0.05								-0.07	-0.06						0.13	-0.13	-0.13			-0.22	-0.27	-0.28		-0.13	-0.13	-0.15	-0.17	-0.22	-0.26	-0.27	-0.37
CLEAR POND									-0.03	-0.02							-0.03								0.06	0.06	0.06	0.07	0.06											
NATE POND						0.43	0.44		-0.09							-0.26																								
LONG POND					0.30	0.33	0.33																		0.20	0.24	0.28	0.39	0.33	0.36	0.29		-0.10							
CARRY POND			0.07						0.14	0.17	0.23	0.18	0.13																				-0.03	-0.04	-0.06	-0.06	-0.06	-0.07	-0.07	-0.07
ARBUTUS LAKE									-0.13	-0.12	-0.07	-0.09	-0.10			-0.26										-0.01														
LAKE COLDEN				0.25	0.31	0.40	0.44		-0.04																-0.23	-0.22	-0.28	-0.20	-0.23	-0.33	-0.34		-0.37	-0.38	-0.39	-0.36	-0.41	-0.50	-0.51	-0.47
AVALANCHE LAKE						0.29	0.31																		-0.20	-0.17				-0.33	-0.31		-0.42	-0.41	-0.41	-0.42	-0.47	-0.57	-0.59	-0.47
SAGAMORE LAKE																																	-0.09	-0.09				-0.16		
RAQUETTE LAKE RESEVOIR																					0.03				-0.16	-0.14							-0.18	-0.17	-0.18	-0.17	-0.19			
QUEER LAKE			0.16	0.19	0.22	0.22	0.24		-0.13	-0.10	-0.06	-0.06	-0.06	-0.07	-0.07	-0.13	-0.05	-0.05	-0.03						-0.09	-0.08	-0.07	-0.10	-0.12				-0.08	-0.08	-0.09	-0.11	-0.12	-0.13	-0.14	
OTTER LAKE OUTLET							0.29										0.02								-0.12	-0.12	-0.12	-0.12	-0.17				-0.09	-0.09	-0.10	-0.09	-0.13	-0.09	-0.13	-0.19
G LAKE					0.33	0.43	0.44		-0.08	-0.06		-0.05	-0.06	-0.08	-0.09																		-0.06	-0.06	-0.07	-0.07	-0.09	-0.10	-0.09	

Sites with Recent Liming History

LITTLE CLEAR POND	0.04	0.04	0.05																						-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.03		-0.03	-0.04	-0.06	-0.06	-0.06	-0.07	-0.07	-0.04
WOODS LAKE																									-0.05	-0.05	-0.07		-0.08						-0.04					
BARNES LAKE									-0.10	-0.11	-0.13	-0.14	-0.16	-0.17	-0.19	-0.19	-0.20	-0.20	-0.11	-0.11	-0.10	-0.10	-0.13	-0.31	-0.03	-0.03	-0.03	-0.03	-0.03	-0.03				-0.04	-0.05	-0.05	-0.05	-0.06	-0.05	
LITTLE SIMON POND			0.29	0.33	0.39	0.44	0.44		-0.11	-0.10	-0.06	-0.07	-0.06																						-0.04					

			0.36	0.43	0.55				-0.08	-0.06	-0.04	-0.03					-0.03	-0.02	-0.03																	-0.04				
					0.29																																			
Windfall				0.14	0.19						0.06	0.06	0.09				-0.11	-0.12	-0.07	-0.07																				
West																																	-0.07	-0.06						
				0.29	0.33																												-0.28	-0.24	-0.22	-0.28	-0.30			
				0.22	0.27				-0.10								-0.07	-0.08	-0.05						-0.21	-0.19		-0.25					-0.28	-0.28	-0.27	-0.35	-0.40			
				0.29	0.35					0.05							0.02								-0.13	-0.13		-0.16					-0.10	-0.10	-0.09	-0.11	-0.11			

Notes:
p <= 0.05
Blank = not significant at 95% conf. Interval

LTM Site	ALOM umolL^{-1}yr^{-1}								ALIM umolL^{-1}yr^{-1}																SCONDUCT µScm^{-1} yr^{-1}															
	2010	2009	2008	2007	2006	2005	2004	2000	2010	2009	2008	2007	2006	2005	2004	2000	2010	2009	2008	2007	2006	2005	2004	2000	2010	2009	2008	2007	2006	2005	2004	2000	2010	2009	2008	2007	2006	2005	2004	
LITTLE HOPE POND	-0.12	-0.13	-0.15	-0.14	-0.14	-0.17	-0.16		-0.05	-0.05	-0.05	-0.06	-0.06	-0.09	-0.07		0.03	0.03	0.03	0.03	0.03	0.04	0.04		-0.30	-0.29	-0.28	-0.29	-0.26	NA	NA	NA	-0.15	-0.14	-0.16	-0.16	-0.17	-0.21	-0.20	-0.04
BIG HOPE POND									-0.01	-0.01	-0.02	-0.02	-0.02	-0.04	-0.03		0.03	0.02	0.03	0.03	0.03	0.04	0.04		-0.20	-0.20	-0.21	-0.23	-0.21				-0.04	-0.04	-0.05	-0.05	-0.06	-0.06	-0.79	-0.78
LITTLE ECHO POND	-0.06	-0.07	-0.10	-0.10	-0.10	-0.10	-0.11		0.00	0.00				-0.04	-0.07		0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	-0.25	-0.24	-0.26	-0.27	-0.25				-0.90	-1.05	-1.09	-1.02	-1.21			
EAST COPPERAS POND			-0.04	-0.05	-0.06	-0.06	-0.05		-0.03	-0.03	-0.04	-0.04	-0.04	-0.07	-0.04										-0.12															
MIDDLE POND			-0.04						0.00	0.00	0.00	0.00	0.00	-0.03	-0.01										-0.19	-0.18														
SUNDAY POND								0.09	-0.01	-0.01	-0.02	-0.02	-0.03	-0.04	-0.03	-0.04	-0.01	-0.01	-0.02	-0.02	-0.02	-0.02	-0.02		-0.07								0.18	0.23	0.29	0.27	0.28	0.25	0.25	
SOCHIA POND								0.09	-0.02	-0.02	-0.02	-0.03	-0.04	-0.05	-0.04	-0.05	0.01	0.02	0.02	0.02	0.02	0.03	0.03	0.03	-0.27	-0.29	-0.29	-0.28	-0.25				-0.63	-0.74	-0.87	-0.94	-1.01	-1.18	-1.21	
OWEN POND																							0.01		-0.27	-0.23													-0.01	
HEART LAKE															-0.02										-0.21	-0.21	-0.19	-0.19	-0.17											
MARCY DAM POND	-0.04	-0.04	-0.06	-0.06	-0.06	-0.07	-0.07		-0.06	-0.06	-0.05		-0.06	-0.09	-0.07		0.01	0.01							-0.19	-0.16	-0.10						-0.02	-0.02						
GRASS POND			-0.03						-0.01	-0.01	-0.01	-0.01	-0.01	-0.04										0.01	-0.13	-0.11														
BLACK POND OUTLET									0.00	0.00	-0.01	-0.01	-0.01	-0.02	-0.03										-0.19	-0.22	-0.20	-0.19												
LOON HOLLOW POND									-0.44	-0.42	-0.40	-0.44	-0.51	-0.58	-0.63	-1.09	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.03	-0.48	-0.45	-0.40	-0.43	-0.44				-0.53	-0.49	-0.51	-0.55	-0.64	-0.83	-0.87	
WILLYS LAKE (HORSESHOE)									-0.67	-0.67	-0.65	-0.75	-0.75	-0.83	-0.89	-1.15	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02	-0.60	-0.58	-0.53	-0.52	-0.52				-0.38	-0.33	-0.27	-0.30	-0.30	-0.39	-0.37	
MIDDLE SETTLEMENT LAKE									-0.08	-0.08	-0.08	-0.09	-0.11	-0.14	-0.11	-0.20	0.03	0.03	0.02	0.02	0.02	0.02	0.02	0.05	-0.23	-0.23	-0.23	-0.22	-0.21				-0.15	-0.15	-0.15	-0.15	-0.16	-0.16	-0.15	
GRASS POND	-0.04	-0.04	-0.05	-0.05	-0.06	-0.06	-0.05		-0.06	-0.05	-0.06		-0.07	-0.11		-0.21	0.02		0.02		0.02	0.03	0.03	0.06	-0.20	-0.19	-0.16	-0.16	-0.15				-0.04	-0.03	-0.04		-0.05	-0.06	-0.06	
MIDDLE BRANCH LAKE			-0.03		-0.03																			0.02	-0.19	-0.18	-0.16	-0.17	-0.15											
LAKE RONDAXE									-0.03	-0.02	-0.02	-0.02	-0.03	-0.04	-0.06	-0.06	0.01								-0.25	-0.23	-0.19	-0.20	-0.18				-0.01							
MOSS LAKE																									-0.23	-0.24	-0.24	-0.24	-0.22											
CASCADE LAKE OUTLET																									-0.24	-0.26	-0.24	-0.28	-0.25											
BUBB LAKE															-0.02										-0.25	-0.25	-0.24	-0.24	-0.19											
DART LAKE									-0.12	-0.11	-0.12	-0.14	-0.16	-0.13	-0.17	-0.25	0.03	0.03	0.02	0.02	0.03	0.03	0.03		-0.35	-0.33	-0.29	-0.31	-0.29				-0.13	-0.12	-0.12	-0.13	-0.16	-0.18	-0.16	
WINDFALL POND	-0.04	-0.04	-0.05		-0.05				-0.02								0.01	0.01			0.01	0.01			-0.35	-0.36	-0.30	-0.33	-0.30				-0.01	-0.01			-0.01	-0.01		
BIG MOOSE LAKE									-0.15	-0.14	-0.14	-0.16	-0.18	-0.15	-0.20	-0.27	0.03	0.03	0.02	0.03	0.03	0.03	0.03		-0.36	-0.34	-0.31	-0.32	-0.30				-0.17	-0.16	-0.16	-0.18	-0.20	-0.22	-0.20	
WEST POND		-0.06	-0.08	-0.08	-0.10	-0.11	-0.12		-0.09	-0.08	-0.09	-0.10	-0.10											-0.04	-0.31	-0.29	-0.28	-0.28	-0.28											
SQUASH POND									-0.37	-0.36	-0.32	-0.36	-0.36	-0.27	-0.38	-0.51	0.01	0.01	0.01	0.01	0.01	0.01	0.01		-0.43	-0.41	-0.34	-0.35	-0.32				-0.51	-0.47	-0.45	-0.43	-0.39	-0.44	-0.45	
CONSTABLE POND									-0.29	-0.27	-0.28	-0.30	-0.35	-0.33	-0.36	-0.41	0.02	0.01	0.01		0.02	0.02	0.02		-0.47	-0.45	-0.40	-0.41	-0.41				-0.21	-0.16	-0.16		-0.25	-0.32	-0.27	
LIMEKILN LAKE SQUAW									-0.02	-0.01	-0.01	-0.01	-0.02	-0.04	-0.02		0.02	0.02	0.02	0.02	0.02	0.03	0.02		-0.32	-0.32	-0.29	-0.29	-0.25				-0.04	-0.04	-0.04	-0.04	-0.05	-0.05	-0.05	
LAKE INDIAN LAKE									-0.01	-0.01			-0.01	-0.04			0.01							0.05	-0.37	-0.37	-0.38	-0.39	-0.38				-0.03							
BROOK TROUT LAKE									-0.28	-0.28	-0.27	-0.28	-0.30	-0.33	-0.32	-0.38	0.02	0.01	0.01	0.01	0.01	0.02	0.02		-0.46	-0.45	-0.43	-0.43	-0.43				-0.33	-0.31	-0.30	-0.29	-0.34	-0.39	-0.38	
LOST POND									-0.14	-0.14	-0.16	-0.21	-0.25	-0.36	-0.35	-0.67	0.03	0.03	0.03	0.03	0.04	0.05	0.05	0.08	-0.39	-0.38	-0.37	-0.40	-0.42				-0.23	-0.22	-0.25	-0.31	-0.36	-0.43	-0.46	
SOUTH LAKE				-0.06	-0.07	-0.10	-0.10		-0.15	-0.13	-0.13	-0.14	-0.17	-0.19	-0.20	-0.30									-0.33	-0.33	-0.30	-0.29	-0.28											
NORTH LAKE									-0.14	-0.14	-0.16	-0.19	-0.23	-0.28	-0.28	-0.43	0.04	0.03	0.03	0.04	0.04	0.05	0.05	0.06	-0.34	-0.32	-0.29	-0.29	-0.26				-0.24	-0.24	-0.28	-0.31	-0.35	-0.39	-0.39	
WILLIS LAKE		-0.04	-0.06	-0.06	-0.06	-0.07	-0.07		-0.23	-0.22	-0.22	-0.25	-0.26	-0.27	-0.26	-0.38	0.02	0.02	0.01	0.01	0.01	0.02	0.02		-0.39	-0.36	-0.31	-0.31	-0.28				-0.20	-0.19	-0.17	-0.18	-0.20	-0.21	-0.20	
JOCKEYBUSH LAKE		-0.04	-0.05	-0.05					0.00					-0.03				0.00		0.01	0.02	0.02	0.02		-0.09											-0.03	-0.03	-0.03	-0.03	
CLEAR POND									-0.14	-0.13	-0.14	-0.15	-0.19	-0.24	-0.24	-0.39	0.03	0.03	0.02	0.02	0.03	0.03	0.03	0.05	-0.33	-0.30	-0.27	-0.28	-0.29				-0.28	-0.26	-0.24	-0.26	-0.31	-0.35	-0.36	
NATE POND								0.08	-0.01	-0.01					-0.02	-0.31		0.00	0.00						-0.27	-0.28	-0.25	-0.24	-0.20					0.00	0.00					
LONG POND																									-0.27	-0.26	-0.21	-0.19												
CARRY POND									-0.14	-0.13	-0.10	-0.08	-0.08				0.01	0.01	0.01		0.01	0.01	0.01		-0.35	-0.31	-0.21	-0.17	-0.18				-0.61	-0.52	-0.42		-0.57	-0.69	-0.75	
ARBUTUS LAKE	0.04	0.04	0.03						-0.06	-0.06	-0.07	-0.07	-0.07	-0.08	-0.08		0.04	0.04	0.04	0.04	0.03	0.02	0.02		-0.43	-0.43	-0.40	-0.34	-0.27				-0.64	-0.68	-0.70	-0.70	-0.63	-0.49	-0.45	
LAKE COLDEN									-0.01	-0.01	-0.01	-0.01	-0.01	-0.02	-0.02			-0.01	-0.01	-0.01					-0.30	-0.29	-0.22	-0.20						0.01	0.01	0.01				
AVALANCHE LAKE						-0.09			-0.36	-0.34	-0.35	-0.33	-0.37	-0.43	-0.43	-0.54	0.02	0.02	0.01	0.01	0.01	0.02	0.02	0.02	-0.35	-0.32	-0.25	-0.22					-0.27	-0.26	-0.24	-0.21	-0.22	-0.29	-0.30	
SAGAMORE LAKE									-0.37	-0.35	-0.34	-0.35	-0.36	-0.42	-0.42	-0.41	0.01	0.01	0.01	0.01		0.01	0.01		-0.43	-0.37	-0.30	-0.28					-0.26	-0.22	-0.20	-0.19		-0.25	-0.26	
RAQUETTE LAKE RESEVOIR									-0.05	-0.05				-0.08											-0.36	-0.35	-0.32	-0.32	-0.27											
QUEER LAKE							0.04		-0.13	-0.11	-0.10	-0.09	-0.10	-0.14				0.00							-0.51	-0.50	-0.44	-0.44	-0.42											
OTTER LAKE OUTLET									-0.07	-0.07	-0.07	-0.09	-0.11	-0.13	-0.13	-0.24	0.03	0.03	0.03	0.03	0.03	0.03	0.03		-0.31	-0.30	-0.27	-0.28	-0.26				-0.11	-0.11	-0.11	-0.12	-0.14	-0.15	-0.14	
G LAKE									-0.07	-0.07	-0.07	-0.07	-0.09	-0.09	-0.12	-0.22	0.02	0.02	0.02		0.02	0.02		0.04	-0.27	-0.25	-0.24	-0.24	-0.25				-0.10	-0.10	-0.10		-0.13	-0.15		
									-0.05	-0.04	-0.05	-0.05	-0.06	-0.11	-0.08	-0.11	0.02	0.02	0.02		0.02	0.03	0.03	0.05	-0.25	-0.22	-0.15	-0.14	-0.11				-0.07	-0.06	-0.07		-0.08	-0.11	-0.10	
Sites with Recent Liming Hstory																																								
LITTLE CLEAR POND		-0.03	-0.05	-0.04	-0.04	-0.05	-0.04			0.00	0.00	0.00	0.00	-0.04	0.00					0.07	0.09	0.11	0.12	0.25												-0.06	-0.10	-0.20	-0.26	
WOODS LAKE									-0.01	-0.01				-0.03	-0.02										-0.35	-0.35	-0.31	-0.33	-0.31											
BARNES LAKE									-0.01	-0.01	-0.01	-0.01	-0.02	-0.03	-0.03		-0.03	-0.03	-0.03	-0.03	-0.04	-0.04	-0.05	-0.08	-0.21	-0.21	-0.20	-0.17	-0.14				0.31	0.29	0.29	0.32	0.36	0.36	0.42	
LITTLE SIMON POND			-0.04						-0.01	-0.01				-0.02											-0.27	-0.25														

									-0.01	-0.01															-0.26	-0.26	-0.20	-0.13	-0.09											
																									-0.24	-0.27	-0.28	-0.29	-0.23											
Windfall													-0.01												-0.51	-0.55	-0.48	-0.44	-0.44											
West									-0.07	-0.06							0.01								-0.29	-0.27	-0.27	-0.25	-0.28				-0.09							
									-0.25	-0.20	-0.15						0.01	0.01	0.01	0.01	0.01				-0.48	-0.43	-0.36	-0.34	-0.34				-0.70	-0.63	-0.66	-0.73	-0.75			
									-0.32	-0.29	-0.32	-0.36	-0.39				0.01			0.02	0.02				-0.50	-0.48	-0.40	-0.43	-0.42				-0.24			-0.34	-0.40			
									-0.10	-0.10		-0.11					0.02	0.01							-0.28	-0.26	-0.24	-0.26	-0.26				-0.18	-0.16						

Notes:
$p <= 0.05$
Blank = not significant at 95% conf. Interval

	SO_4+NO_3 μ eqL^{-1}yr^{-1}								ueqL^{-1}yr^{-1}							
LTM Site	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2000**	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**	**2004**	**2000**
LITTLE HOPE POND	-2.82	-2.66	-2.48	-2.70	-2.56		-1.92		-0.95							
BIG HOPE POND	-2.51	-2.36					-1.45									
LITTLE ECHO POND	-1.30	-1.15	-0.97	-1.20	-1.15		-1.25	-2.09	0.34							
EAST COPPERAS POND	-1.54	-1.52	-1.13													
MIDDLE POND	-2.21	-2.12	-2.24	-2.28	-2.12		-1.68		-1.30	-1.21						
SUNDAY POND	-0.72	-0.55		-0.61	-0.63		-0.74		-1.11	-1.07	-1.12	-1.16	-1.28	-2.20	-1.33	-2.02
SOCHIA POND	-1.27	-1.28	-1.17	-1.20	-1.00		-0.98	-1.49								
OWEN POND	-3.54	-3.28	-3.10	-3.02	-3.00		-2.92		-2.47	-2.19						
HEART LAKE	-1.90	-1.79	-1.75	-1.75	-1.70		-1.69	-2.07	-1.67	-1.62	-1.77	-1.80	-1.73	-1.44	-1.58	-3.27
MARCY DAM POND	-1.75	-1.55	-1.27	-1.13	-1.29		-1.61	-2.66	-1.02							
GRASS POND	-1.21	-1.15	-1.05	-1.20	-1.13		-1.93	-1.66								
BLACK POND OUTLET LOON	-2.56	-2.49	-2.46	-2.47	-2.32		-1.93	-1.87	-1.97	-2.23	-2.97	-3.26	-2.97			
HOLLOW POND	-2.91	-2.63	-2.24	-2.46	-2.42		-2.72	-3.95	-0.94	-0.91	-0.69	-0.78	-0.77			
WILLYS LAKE (HORSESHOE)	-4.67	-4.51	-4.04	-4.14	-4.14		-4.67	-5.11	-1.69	-1.63	-1.48	-1.48	-1.48	-1.48	-1.55	-2.11
MIDDLE SETTLEMENT LAKE	-2.34	-2.28	-2.28	-2.26	-2.08		-2.14	-1.91	-0.51	-0.57	-0.57	-0.61		-0.54	-0.57	
GRASS POND	-2.16	-2.08	-2.05	-2.02	-2.10		-1.15	-3.33								
MIDDLE BRANCH LAKE	-1.92	-1.75	-1.79	-1.76	-1.65		-1.78		-0.94	-0.97		-1.31				
LAKE RONDAXE	-3.24	-3.11	-3.00	-3.20	-3.22		-3.21	-3.47	-1.45	-1.45		-1.57				
MOSS LAKE	-2.72	-2.66	-2.71	-2.81	-2.80		-2.84	-3.33	-1.48	-1.68	-2.06	-2.29	-1.99	-1.67	-1.74	
CASCADE LAKE OUTLET	-2.59	-2.53	-2.38	-2.51	-2.54		-2.59	-3.94	-1.77	-2.21	-2.39	-2.88	-2.67	-2.54	-3.23	-5.14
BUBB LAKE	-2.26	-2.29	-2.42	-2.44	-2.51		-2.77	-3.04	-1.54	-1.76	-1.71	-1.85	-1.49	-1.18		
DART LAKE	-3.74	-3.62	-3.42	-3.70	-3.60		-3.60	-4.31	-1.55	-1.57	-1.35	-1.55				
WINDFALL POND	-3.72	-3.73	-3.45	-3.62	-3.83		-3.98	-4.30	-2.00	-2.23	-2.05	-2.64	-2.15			
BIG MOOSE LAKE	-3.82	-3.68	-3.49	-3.80	-3.71		-3.73	-4.26	-1.47	-1.51	-1.38	-1.55	-1.38	-1.19		
WEST POND	-2.68	-2.47	-2.46	-2.66	-2.65		-2.94	-3.43	-1.58	-1.68	-1.93	-2.25	-2.20		-2.29	-4.68
SQUASH POND	-2.68	-2.39	-1.90	-2.11	-1.90		-1.97	-3.66	-1.12	-1.10	-0.86	-0.92		-2.55		-2.07
CONSTABLE POND	-4.20	-4.16	-3.96	-3.96	-4.03		-4.08	-4.18	-2.14	-2.18	-1.83	-1.93	-1.66			
LIMEKILN LAKE	-3.32	-3.20	-3.09	-3.17	-2.99		-2.93	-3.34	-1.55	-1.63	-1.55	-1.58	-1.24			
SQUAW LAKE	-3.61	-3.66	-3.92	-4.16	-4.17		-4.53	-6.01	-2.25	-2.40	-2.53	-2.68	-2.60	-1.28	-2.57	-4.67
INDIAN LAKE	-3.74	-3.69	-3.50	-3.70	-3.61		-3.69	-5.31	-1.88	-2.01	-2.05	-2.21	-2.13	-2.10	-2.11	-4.27
BROOK TROUT LAKE	-3.35	-3.32	-3.30	-3.59	-3.77		-4.31	-6.52	-1.43	-1.37	-1.22	-1.20	-1.09	-0.91	-0.92	-2.02
LOST POND	-2.39	-2.46	-2.41	-2.51	-2.51		-2.30	-4.04	-1.66	-1.91	-1.89	-1.92	-1.89	-1.68	-1.81	-4.56
SOUTH LAKE	-3.11	-3.03	-2.89	-2.99	-2.83		-2.93	-3.12	-1.07	-1.08	-0.91					
NORTH LAKE	-3.21	-3.10	-2.71	-2.82	-2.55		-2.70	-3.26	-1.47	-1.52	-1.50	-1.53	-1.28			
WILLIS LAKE	-2.07	-1.86	-1.68	-1.55	-1.46		-1.23	-0.72								
JOCKEYBUSH LAKE	-2.63	-2.45	-2.18	-2.39	-2.44		-2.45	-2.48	-1.12	-1.02	-0.85	-0.95	-0.87	-0.66		
CLEAR POND	-2.44	-2.43	-2.34	-2.23	-1.97		-1.65	-1.95	-2.34	-2.60	-2.77	-3.06	-2.69	-2.32		-5.67
NATE POND	-2.99	-2.84	-2.67	-2.53	-2.33		-2.21	-1.60	-1.88	-1.86						
LONG POND	-2.96	-2.73	-2.32	-2.47	-2.25		-2.21	-3.65								
CARRY POND	-2.63	-2.64	-2.23	-1.91	-1.55		1.07	-1.39	-0.69	-0.63						-1.55
ARBUTUS LAKE	-2.83	-2.65	-2.36	-2.20	-1.93		-1.69	-2.65	-2.25	-2.23	-1.98					-5.00
LAKE COLDEN	-2.71	-2.35	-1.82	-1.74				-2.63	-1.19	-0.99						
AVALANCHE LAKE	-3.13	-2.76	-2.18	-2.17	-1.98			-3.79	-1.51	-1.38						
SAGAMORE LAKE	-3.76	-3.73	-3.56	-3.63	-3.59		-3.77	-5.15	-2.33	-2.38	-2.68	-2.85	-2.31			
RAQUETTE LAKE RESEVOIR	-4.67	-4.72	-4.58	-4.52	-4.60		-4.69	-4.65	-3.15	-3.28	-3.15	-3.43	-3.22	-2.86	-3.15	
QUEER LAKE	-3.24	-3.15	-3.01	-3.17	-3.05		-3.08	-3.34	-1.30	-1.33	-1.30	-1.33	-1.20	-1.08	-1.05	-3.26
OTTER LAKE OUTLET	-2.60	-2.48	-2.45	-2.46	-2.61		-2.67	-2.59	-1.15	-1.12	-1.06	-1.32	-1.25	-1.28	-1.43	
G LAKE	-2.35	-2.17	-1.80	-1.67	-1.53		-1.44	-2.19	-1.17	-1.14						
Sites with Recent Liming History																
LITTLE CLEAR POND	-1.29	-1.21	-1.17	-1.14	-1.07		-1.04	-0.97					10.29	13.04	14.40	24.94
WOODS LAKE	-3.25	-3.28	-3.06	-3.28	-3.21		-2.95	-3.37	-2.32	-2.39	-2.10	-2.40	-2.33	-2.23	-2.21	-5.04
BARNES LAKE	-1.15	-0.90						0.46	-1.94	-2.02	-2.14	-2.22	-2.22	-1.98	-2.13	-3.44
LITTLE SIMON POND	-3.07	-2.89	-2.69	-2.78	-2.62		-2.48	-3.25								-8.06

	-2.77	-2.64	-2.30	-2.13	-1.93		NA	NA	-1.21	-1.33						
	-2.05	-2.09	-2.25	-2.31	-2.39		NA	NA	-1.24	-1.43	-1.43	-1.57	-1.33			
Windfall	-4.06	-4.10	-4.012	-4.06	-3.70		NA	NA	-3.17	-3.40	-3.22	-3.03	-2.95			
West	-2.72	-2.45	-2.74	-2.69	-3.13		NA	NA	-1.06	-1.09	-1.41					
	-2.55	-2.24	-1.75	-1.59	-1.44		NA	NA	-0.58							
	-4.25	-4.11	-3.73	-3.73	-3.65		NA	NA	-2.00	-2.00	-1.53	-1.32				
	-2.80	-2.68	-2.48	-2.61	-2.71		NA	NA	-0.99	-0.95	-1.07	-1.07	-1.03			

Notes:
p <= 0.05
Blank = not significant at 95% conf. Interval

This page intentionally left blank.

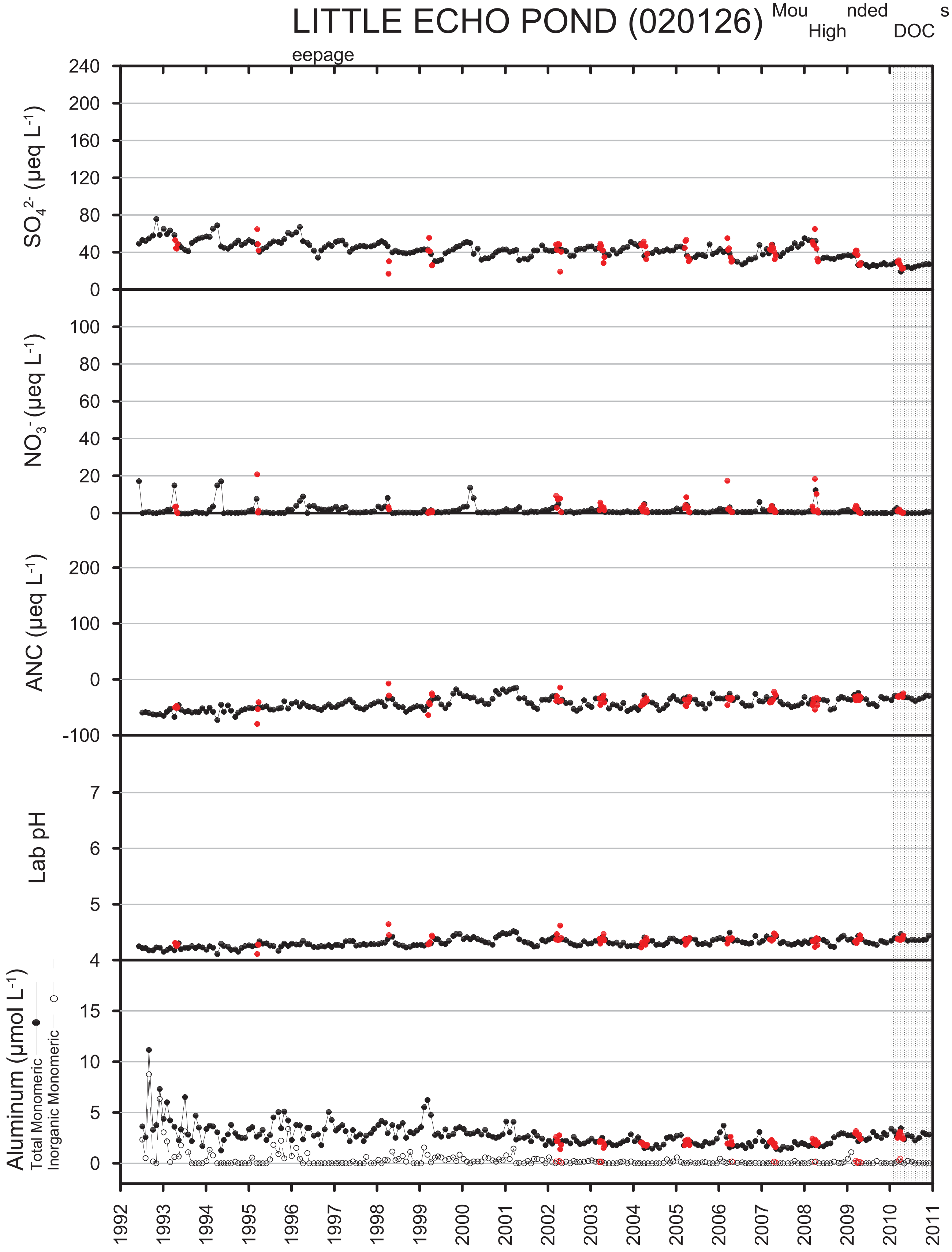
Appendix B: Seasonal Medians; ALTM Streams 2005–2010

W = Dec through March
= April
= May through July
= August through September
Fall = October through November
= Buck Creek
= Bald Mountain Brook
AB = Acid Buck Creek a.k.a. North Tributary
= Basic Buck Creek a.k.a. South Tributary
Each value is the median for that particular season and year.

	Y	W	Y			Freq	SO$_4$	NO$_3$		F	ANC	DIC		SiO$_2$					NH$_4$	ALTD	ALTM	ALOM	ALM	LABRATORY pH	AIR EQUILIBRATED pH	SPECIFIC CONDUCTIVITY
						µ	21 µ	21µ	21 µ	21 µ	21 µ	21 µ	2121 µ	21 µ	21 µ	21 µ	21µ	211 µ	21 µ	21 µ	21 µ	21 µ	21		µ	21
AB	2008		2009	1	Fall	5	40.4	1.5	11.8		-50.3		1336.2	113.0	24.5	9.1	22.6	2.0	0.2	29.8	19.6	14.4	4.3	4.4		
AB	2008-2009		2009	2	Winter	11	43.5	13.3	9.0		-45.9		1150.6	111.6	22.7	9.1	23.5	5.6	0.0	28.9	18.4	11.2	6.9	4.3		
AB	2009		2009	3	Snowmelt	2	36.1	6.5	6.4		-39.5		1189.5	64.4	20.6	7.8	21.5	5.1	-0.1	33.5	16.3	10.7	5.5	4.3		
AB	2009		2009	4	Spring summer	15	24.6	5.6	5.7		-37.8		1512.8	72.2	20.7	7.4	17.4	3.6	1.1	31.0	18.2	12.6	4.4	4.3		
AB	2009		2009	5	Latesummer	11	20.6	5.5	4.6		-39.8		1763.5	70.1	18.9	6.3	14.2	3.9	2.0	30.7	18.3	12.6	4.6	4.3		
AB	2009		2010	1	Fall	4	32.6	0.4	14.2		-47.3		1397.2	107.8	20.5	9.1	24.3	2.6	0.0	28.2	19.0	11.6	6.7	4.3		
AB	2009-2010		2010	2	Winter	10	38.0	14.5	11.3		-36.6		1223.7	138.1	23.3	9.8	27.0	4.5	0.5	26.4	17.5	10.7	5.8	4.4		
AB	2010		2010	3	Snowmelt	2	33.2	6.9	6.8		-41.1		1284.0	71.7	21.0	8.6	27.5	5.0	0.1	28.6	16.2	11.3	4.9	4.4		
AB	2010		2010	4	Spring summer	9	22.8	5.5	8.0		-41.1		1669.2	76.4	19.8	7.6	22.3	4.0	2.1	34.5	18.6	12.1	6.2	4.3		
AB	2010		2010	5	Late summer	8	21.5	3.2	11.3		-36.4		1739.4	106.1	19.5	7.7	20.8	5.6	2.1	30.7	17.1	12.5	4.7	4.3		
BB	2008		2009	1	Fall	10	42.6	8.6	8.5		11.5		364.8	80.2	29.2	7.6	20.7	5.6	0.0	16.4	8.1	4.8	3.2	5.3		
BB	2008-2009		2009	2	Winter	11	41.8	41.1	6.7		-1.9		244.6	87.2	28.9	8.2	23.5	3.6	-0.1	14.5	7.8	3.3	5.1	5.1		
BB	2009		2009	3	Snowmelt	2	40.2	29.0	5.9		3.4		239.0	85.6	27.4	7.8	23.0	3.8	-0.2	13.3	7.2	3.1	4.1	5.1		
BB	2009		2009	4	Spring summer	14	38.2	10.9	7.0		6.9		311.1	83.1	26.2	6.8	21.0	3.6	0.1	16.2	7.6	3.9	3.1	5.1		
BB	2009		2009	5	Late summer	5	38.0	3.2	6.3		8.8		348.4	72.2	26.6	6.4	18.1	2.8	-0.4	13.5	7.3	4.2	2.8	5.0		
BB	2009		2010	1	Fall	4	43.6	6.6	8.8		15.2		504.8	118.3	34.7	12.0	30.3	4.9	0.0	13.7	7.8	4.9	2.85.357			
BB	2009-2010		2010	2	Winter	15	40.8	37.9	7.4		15.5		209.2	115.4	34.1	10.9	30.7	4.5	0.2	8.6	4.0	2.9	1.3	5.6		
BB	2010		2010	3	Snowmelt	2	39.0	27.4	7.6		8.0		239.0	102.0	29.8	9.0	30.1	4.1	0.1	11.7	5.8	3.1	2.7	5.4		
BB	2010		2010	4	Spring summer	16	41.2	13.0	9.3		15.9		260.9	101.6	31.4	9.1	30.6	3.2	0.5	9.2	4.5	3.1	1.4	5.6		
BB	2010		2010	5	Late summer	14	36.2	17.2	9.9		16.6		377.1	101.0	32.7	9.9	26.1	5.0	0.7	6.2	5.1	3.6	1.5	5.7		
BCK	2004-2005		2005	2	Winter		52.2	36.5	9.2	1.8	16.4	59.5	392.8	118.0	41.0	14.6	32.7	6.4	0.2	13.6	8.7	4.6	4.1	5.5	5.8	25.0
BCK	2005		2005	3	Snowmelt		44.2	63.0	8.7	1.9	-2.3	37.5	428.9	87.4	39.4	11.5	23.8	9.0	-0.1	18.6	13.3	5.6	7.7	4.9	4.9	25.1
BCK	2005		2005	4	Spring summer		61.8		10.7	1.8	30.8	68.3	287.9	189.9	47.4	18.1	51.0	9.2	0.2	7.6	3.0	2.4	1.0	6.1	6.4	23.6
BCK	2005		2005	5	Late summer		55.6	10.9	9.2	1.4	49.8	54.5	442.1	159.0	41.9	14.6	40.6	5.6	0.2	10.6	5.6	3.9	1.7	6.3	6.7	25.8
BCK	2005		2006	1	Fall		54.1	9.2	10.3	1.5	6.1	52.0	515.0	148.3	37.9	14.0	35.9	6.3	-0.4	15.3	8.2	5.2	3.0	5.0	5.0	22.3
BCK	2005-2006		2006	2	Winter		48.3	36.7	8.2	1.6	8.7	44.1	360.9	127.5	37.9	11.9	31.9	5.6	0.1	14.7	9.7	4.4	5.3	5.1	5.2	24.1
BCK	2006		2006	3	Snowmelt		43.0	41.1	8.5	1.6	2.6	32.5	416.7	86.4	32.4	9.9	23.4	7.2	0.1	18.9	11.7	5.0	6.7	4.9	4.9	23.2
BCK	2006		2006	4	Spring summer		52.2	15.5	9.6	1.3	15.2	35.8	366.4	119.8	37.9	12.8	32.3	6.4	0.2	10.8	7.1	3.7	3.4	5.5	5.5	20.5
BCK	2006		2006	5	Late summer		54.7	12.1	9.3	1.6	44.1	66.6	428.1	164.1	47.7	16.9	44.2	7.7	-0.2	7.9	3.5	2.9	0.6	6.2	6.5	23.3
BCK	2006		2007	1	Fall		48.1	32.0	8.5	1.5	13.4	42.5	552.6	113.7	39.2	12.3	30.6	5.4	0.2	13.6	8.3	5.8	3.6	5.3	5.3	22.3
BCK	2006-2007		2007	2	Winter		52.7	46.3	8.5	1.6	14.3	50.4	330.0	130.6	43.9	15.0	35.7	7.4	-0.0	12.7	7.2	3.9	3.0	5.5	5.5	24.6
BCK	2007		2007	3	Snowmelt		40.7	66.5	7.5	2.0	-6.6	32.9	431.5	84.4	35.7	10.7	23.4	8.1	0.1	25.3	14.1	5.8	8.4	4.8	4.8	25.9
BCK	2007		2007	4	Spring summer		53.8	21.0	9.3	1.5	35.9	73.3	362.8	170.3	44.4	17.3	50.6	8.7	0.2	9.5	3.9	2.8	1.1	6.0	6.3	23.6
BCK	2007		2007	5	Late summer		56.7	23.8	10.0	1.7	85.4	117.4	279.6	230.4	61.6	24.5	78.6	10.6	0.2	5.9	2.1	1.6	0.5	6.6	7.1	30.5
BCK	2007		2008	1	Fall		54.5	8.3	11.0	1.7	14.0	38.3	530.8	128.2	39.9	14.4	32.7	5.9	-0.1	12.4	7.6	4.9	3.1	5.4	5.5	22.9
BCK	2007-2008		2008	2	Winter	11	47.3	36.5	8.3	1.7	6.4	43.7	395.2	98.6	37.4	11.5	25.3	6.0	0.1	17.6	11.0	5.4	5.9	5.1	5.1	22.3
BCK	2008		2008	3	Snowmelt	13	44.1	30.0	7.3	1.4	3.1	35.8	466.2	87.9	34.7	10.3	22.1	6.4	0.0	17.7	10.4	5.5	4.9	5.0	4.9	20.8
BCK	2008		2008	4	Spring summer	2	53.2	13.8	9.6	1.5	32.8	58.7	370.2	141.0	47.4	15.0	40.2	7.3	0.0	9.9	4.1	3.5	1.1	6.0	6.2	20.9
BCK	2008		2008	5	Late summer	19	51.5	10.3	9.3	1.6	41.3	63.3	399.5	172.1	47.9	16.0	42.1	6.1	0.3	8.5	3.8	3.0	0.8	6.2	6.5	21.7

	Y	W	Y			Freq	SO$_4$	NO$_3$		F	ANC	DIC		SiO$_2$					NH$_4$	ALTD	ALTM	ALOM	ALM	LABRATORY pH	AIR EQUILIBRATED pH	SPECIFIC CONDUCTIVITY
							µ 21	µ 21	µ 21	µ 21	µ 21	µ 21	µ 21	µ 21	µ 21	µ 21	µ 21	µ 21	µ 21	µ 21	µ 21	µ 21	µ 21			µ 21
BCK	2008		2009	1	Fall	16	45.2	8.4	10.2	1.6	13.6	46.2	629.6	99.0	44.7	12.3	24.2	9.2	0.2	19.3	10.0	7.1	3.5	5.4	5.2	19.7
BCK	2008-2009		2009	2	Winter	4	46.4	35.1	8.2	1.6	7.6	52.5	391.8	103.7	37.4	11.9	27.6	5.4	0.1	18.3	8.5	4.5	4.3	5.2	5.2	21.4
BCK	2009		2009	3	Snowmelt	15	46.4	21.3	7.2	1.5	10.5	39.1	372.8	107.6	36.9	11.5	28.7	5.5	-0.0	12.7	6.7	4.1	2.5	5.3	5.3	19.6
BCK	2009		2009	4	Spring summer	2	38.8	7.9	7.4	1.4	11.5	45.0	604.0	97.5	33.2	9.9	23.4	4.9	1.3	20.3	8.5	6.8	2.6	5.2	5.2	19.7
BCK	2009		2009	5	Late summer	16	36.3	6.3	5.8	1.4	17.1	40.3	754.6	88.5	36.0	9.9	21.0	4.7	1.6	18.0	10.7	8.2	2.8	5.2	5.2	18.1
BCK	2009		2010	1	Fall	14	43.6	6.6	7.0	1.5	15.2	44.4	504.4	118.3	34.7	12.0	29.6	4.9	-0.3	13.8	7.8	4.9	2.8	5.4	5.4	18.4
BCK	2009-2010		2010	2	Winter		43.4	35.5	8.9		18.9		438.1	124.1	42.8	13.2	28.6	5.8	0.4	12.8	7.0	4.1	2.8	5.5		
BCK	2010		2010	3	Snowmelt		45.8	18.7	9.3		12.4		383.1	122.2	37.7	12.4	33.8	5.5	0.2	11.2	6.0	3.9	2.0	5.5		
BCK	2010		2010	4	Spring summer		40.7	11.5	10.0		21.5		526.6	120.6	38.3	12.9	34.7	5.0	0.8	14.6	6.1	4.3	2.0	5.6		
BCK	2010		2010	5	Late summer		37.6	10.6	10.7		31.7		682.8	133.9	42.6	14.3	34.4	7.5	0.6	8.4	6.3	4.9	1.4	5.9		
BMB	2005		2005	1	Fall		51.0	15.8	10.3	2.0	21.3	65.8	275.8	172.9	42.7	19.3	42.7	7.2	-0.5	6.4	3.2	2.4	0.8	5.8	5.8	19.7
BMB	2004-2005		2005	2	Winter		46.5	37.3	7.9	1.9	44.0	55.8	243.7	144.2	40.8	18.7	38.9	6.8	0.2	7.0	3.6	2.5	1.2	6.4	6.8	25.3
BMB	2005		2005	3	Snowmelt		41.5	57.5	8.2	1.9	3.5	25.8	286.8	119.5	38.2	13.2	25.5	9.0	-0.1	11.9	8.7	3.6	5.1	5.3	5.3	20.9
BMB	2005		2005	4	Spring summer		46.0	24.6	8.2	2.6	65.3	78.3	241.4	203.4	43.9	21.8	54.0	9.2	0.2	4.9	1.6	1.4	0.3	6.7	6.9	24.3
BMB	2005		2005	5	Late summer		49.2	14.6	8.0	2.3	88.5	64.5	263.3	182.0	40.7	19.5	45.7	7.2	0.2	4.4	1.8	1.6	0.3	6.8	7.1	26.8
BMB	2006		2006	1	Fall		43.4	27.8	8.5	1.6	21.5	34.1	354.5	143.1	35.9	15.2	35.3	6.4	0.1	7.3	3.5	2.7	0.9	5.9	6.1	20.0
BMB	2005-2006		2006	2	Winter		44.5	37.9	7.6	1.6	13.2	33.3	223.9	153.8	35.7	14.8	37.0	5.4	0.2	7.7	4.4	2.7	1.7	5.8	5.9	22.2
BMB	2006		2006	3	Snowmelt		40.2	36.9	7.9	1.7	8.2	22.5	282.5	90.5	29.4	10.3	23.8	6.7	0.1	13.5	8.8	3.4	5.4	5.3	5.3	20.1
BMB	2006		2006	4	Spring summer		42.5	19.4	7.9	1.3	34.6	31.6	270.5	152.3	34.7	16.0	41.2	5.6	-0.1	5.7	2.9	2.1	0.7	6.4	6.5	18.2
BMB	2006		2006	5	Late summer		43.4	19.3	8.5	2.6	91.9	110.7	273.8	195.2	54.4	25.5	52.3	9.0	-0.3	3.9	1.4	1.4	0.1	6.8	7.2	25.6
BMB	2007		2007	1	Fall		57.7	14.3	11.0	1.9	32.8	43.3	376.7	158.9	47.9	21.8	42.5	7.7	-0.3	6.3	3.2	2.5	0.7	6.2	6.5	24.6
BMB	2006-2007		2007	2	Winter		49.1	45.4	7.3	1.7	29.9	43.3	209.1	161.6	41.9	19.5	42.3	7.5	0.0	5.8	2.5	2.1	0.4	6.0	6.2	23.0
BMB	2007		2007	3	Snowmelt		38.3	52.1	15.9	1.6	5.9	24.1	265.9	100.3	33.2	12.1	26.8	7.4	0.2	14.1	8.3	3.6	4.7	5.2	5.2	21.3
BMB	2007		2007	4	Spring summer		45.7	27.9	7.9	2.3	64.9	84.1	236.0	191.7	41.9	21.8	57.8	9.5	0.2	4.9	2.0	1.7	0.4	6.6	6.8	24.3
BMB	2007		2007	5	Late summer		46.2	26.1	8.6	2.5	102.9	130.3	163.4	207.4	52.1	29.0	68.2	10.7	-0.3	2.6	1.3	1.0	0.2	6.8	7.1	28.8
BMB	2008		2008	1	Fall	4	43.9	14.3	8.9	1.7	31.1	43.3	267.1	146.0	37.4	15.2	34.6	5.8	-0.1	7.1	3.7	3.5	0.2	6.2	6.3	18.5
BMB	2007-2008		2008	2	Winter	9	44.6	38.9	7.9	1.7	12.0	35.0	247.0	112.7	36.9	14.4	30.8	6.3	0.1	12.5	5.9	3.2	2.6	5.6	5.6	21.2
BMB	2008		2008	3	Snowmelt	2	40.9	28.6	6.2	1.4	13.8	19.1	308.1	99.2	33.9	11.5	26.3	6.4	0.1	10.2	6.1	3.9	2.4	5.6	5.6	19.4
BMB	2008		2008	4	Spring summer	6	44.9	17.3	7.9	2.3	56.2	71.6	244.1	169.9	44.8	18.3	44.4	6.7	0.1	5.1	1.7	1.9	0.1	6.6	6.8	20.5
BMB	2008		2008	5	Late summer	5	37.9	12.4	8.5	2.4	74.8	89.9	343.0	185.4	48.7	20.2	40.8	5.4	0.3	5.6	2.2	2.1	0.3	6.7	6.9	20.5
BMB	2009		2009	1	Fall	4	39.8	13.2	7.0	1.7	33.4	41.4	304.6	146.4	35.5	15.8	35.0	5.9	-0.3	7.0	3.5	2.9	0.5	6.3	6.4	17.9
BMB	2008-2009		2009	2	Winter	9	47.5	32.4	7.3	1.7	25.7	43.3	225.2	143.8	38.7	16.5	36.1	5.6	-0.1	7.7	3.6	2.5	1.1	6.2	6.3	20.3
BMB	2009		2009	3	Snowmelt	2	44.9	22.3	6.8	1.6	16.6	25.8	232.7	129.2	33.9	13.6	33.6	5.6	0.0	6.8	3.7	2.6	1.1	5.9	5.9	18.2
BMB	2009		2009	4	Spring summer	6	40.5	13.4	6.4	2.0	40.0	48.7	284.9	153.2	36.7	16.7	41.6	5.0	-0.1	6.2	2.7	2.5	0.4	6.4	6.5	18.9
BMB	2009		2009	5	Late summer	5	35.5	11.3	8.0	2.2	66.2	70.8	351.9	163.0	43.9	18.5	39.1	5.9	-0.3	6.3	2.9	2.9	0.0	6.7	6.8	19.5
BMB	2009-2010		2010	2	Winter		45.0	32.1	7.8		52.4		201.0	174.8	44.6	20.9	45.4	6.1	0.3	4.6	2.3	2.2	0.1	6.4		
BMB	2010		2010	3	Snowmelt		43.1	24.3	7.7		33.0		224.4	151.4	38.3	16.7	46.3	6.7	0.0	5.5	2.5	2.4	0.2	6.3		
BMB	2010		2010	4	Spring summer		39.9	16.6	8.5		54.0		260.2	174.7	40.9	18.1	50.3	6.4	0.2	4.8	2.2	2.0	0.1	6.6		
BMB	2010		2010	5	Late summer		41.9	17.9	9.2		109.0		215.0	211.6	51.0	25.7	57.4	7.9	0.0	3.4	1.7	1.9	0.0	6.9		

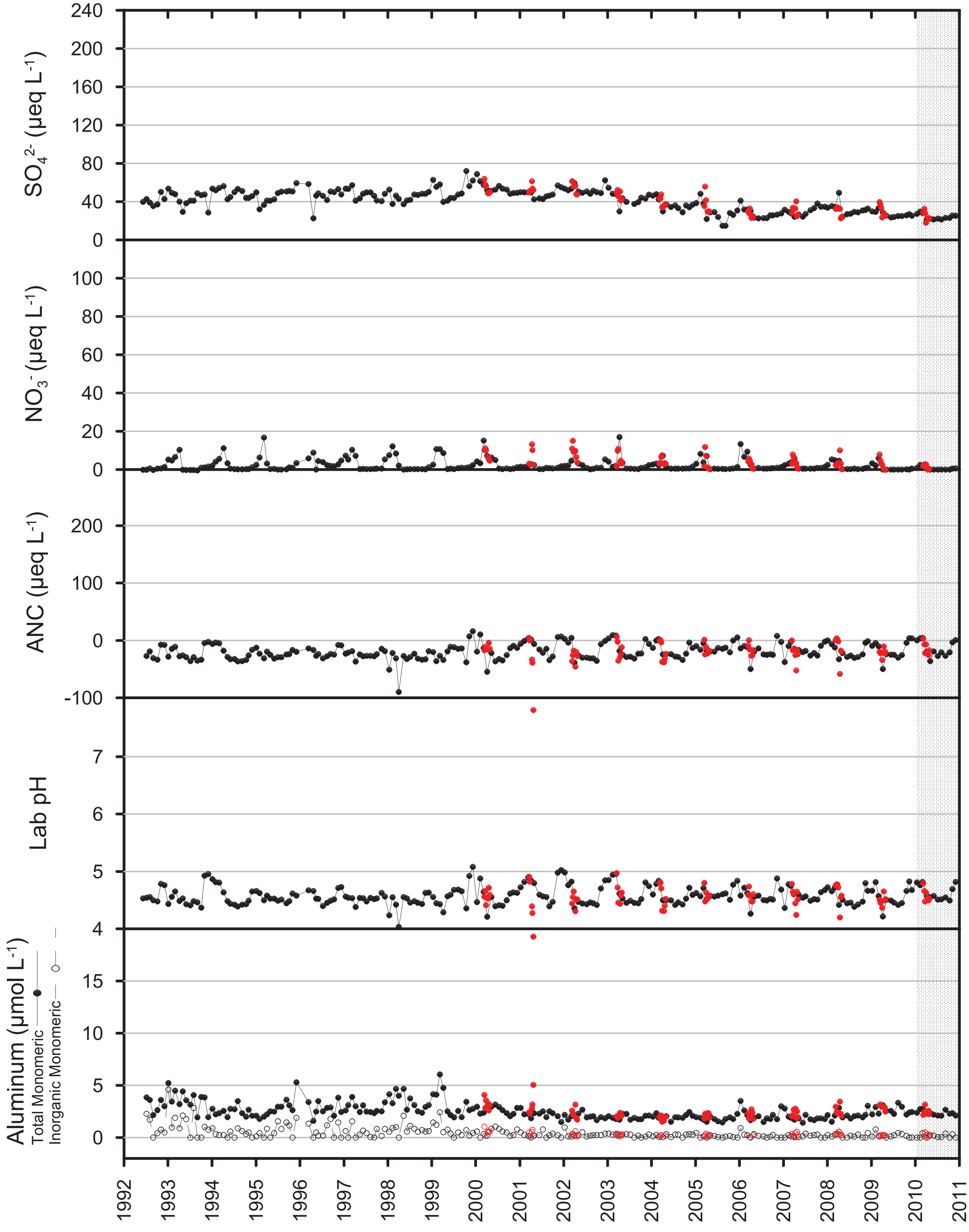
Appendix C: ALTM Time Series 1992–2010



snowmelt data in red

EAST COPPERAS POND (020138)

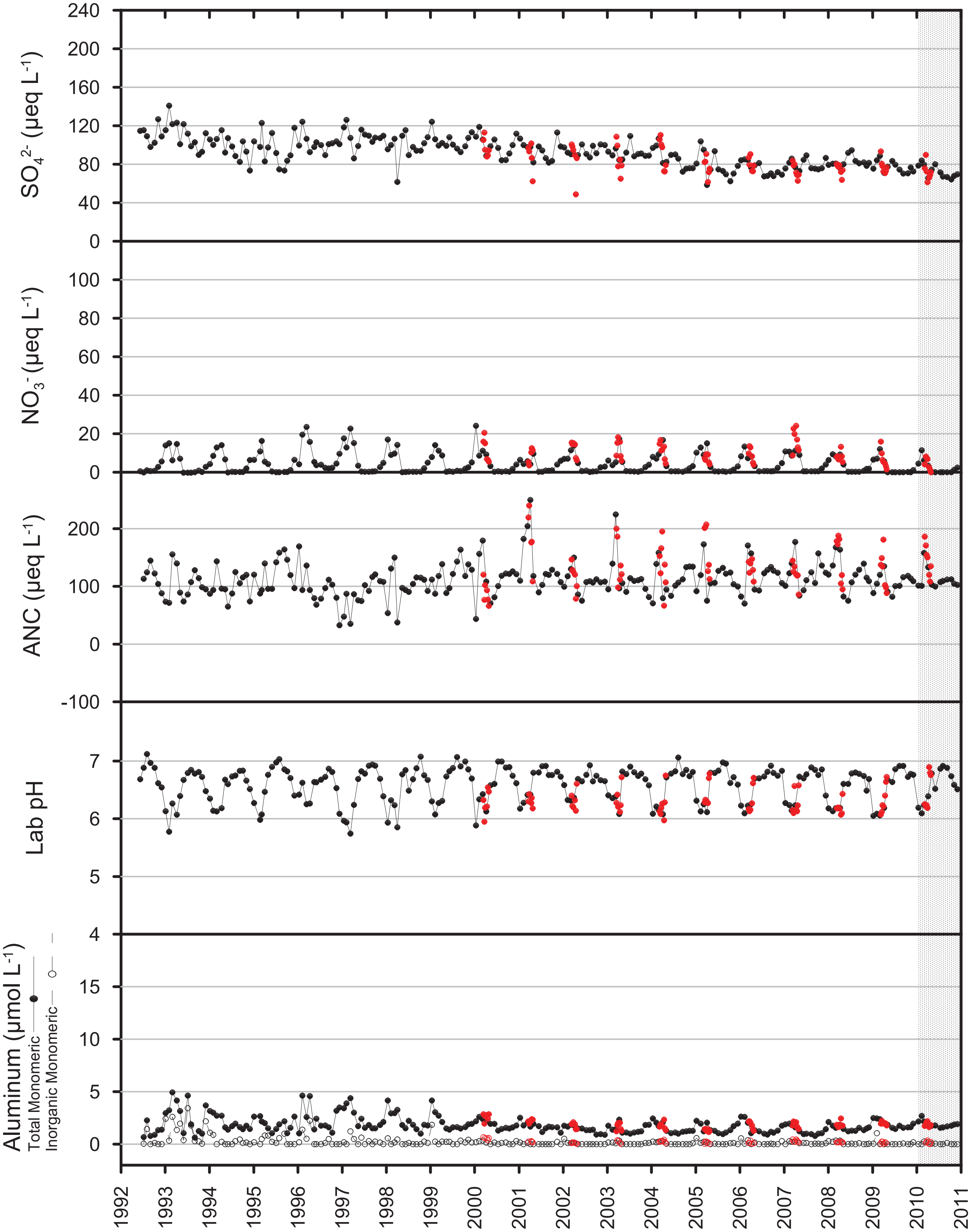
Thin till drainage
High DOC



snowmelt data in red

MIDDLE POND (020143)

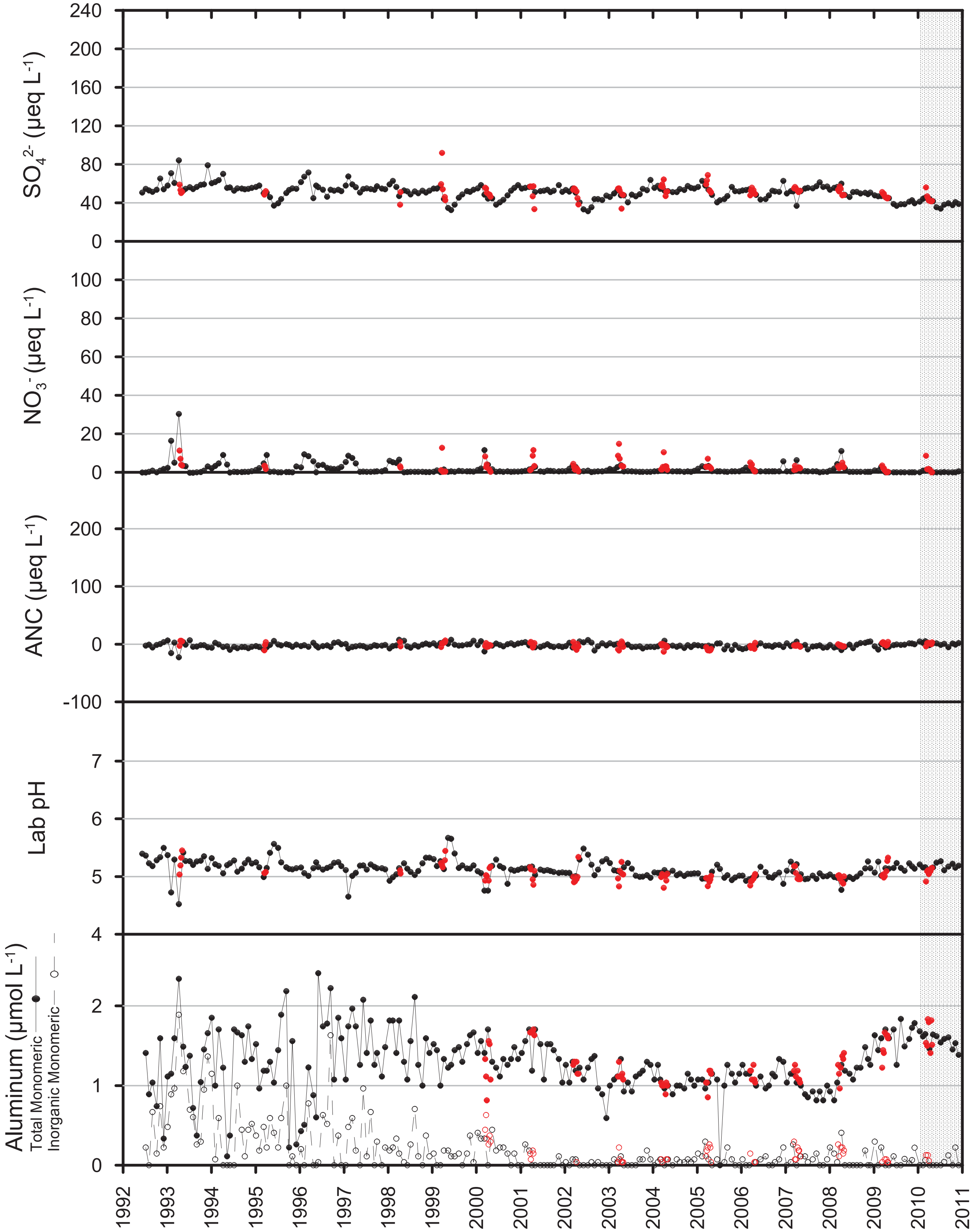
Carbonate influenc ed



snowmelt data in red

SUNDAY POND (020188)

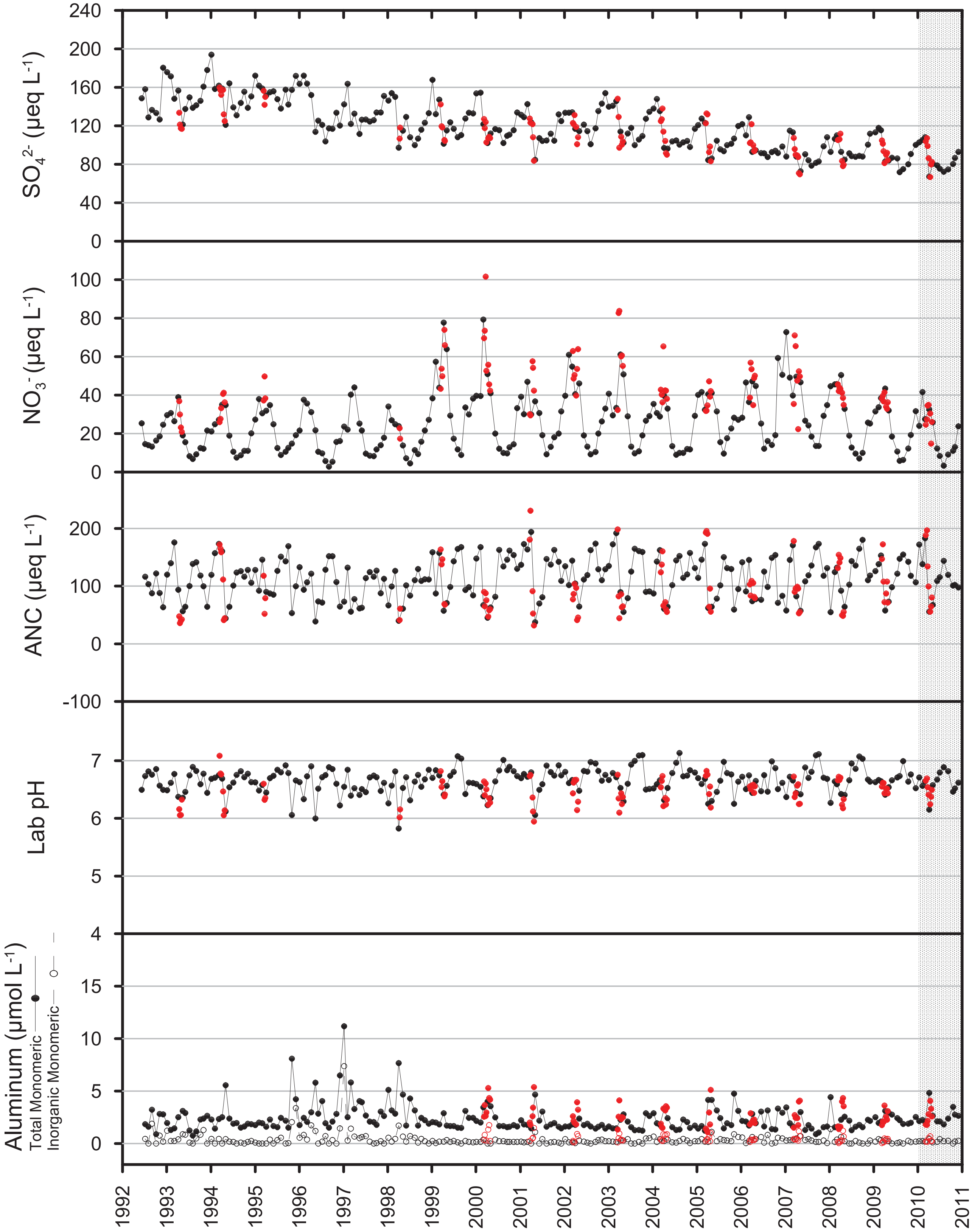
Mounded seepage
Low DOC



snowmelt data in red

OWEN POND (020233)

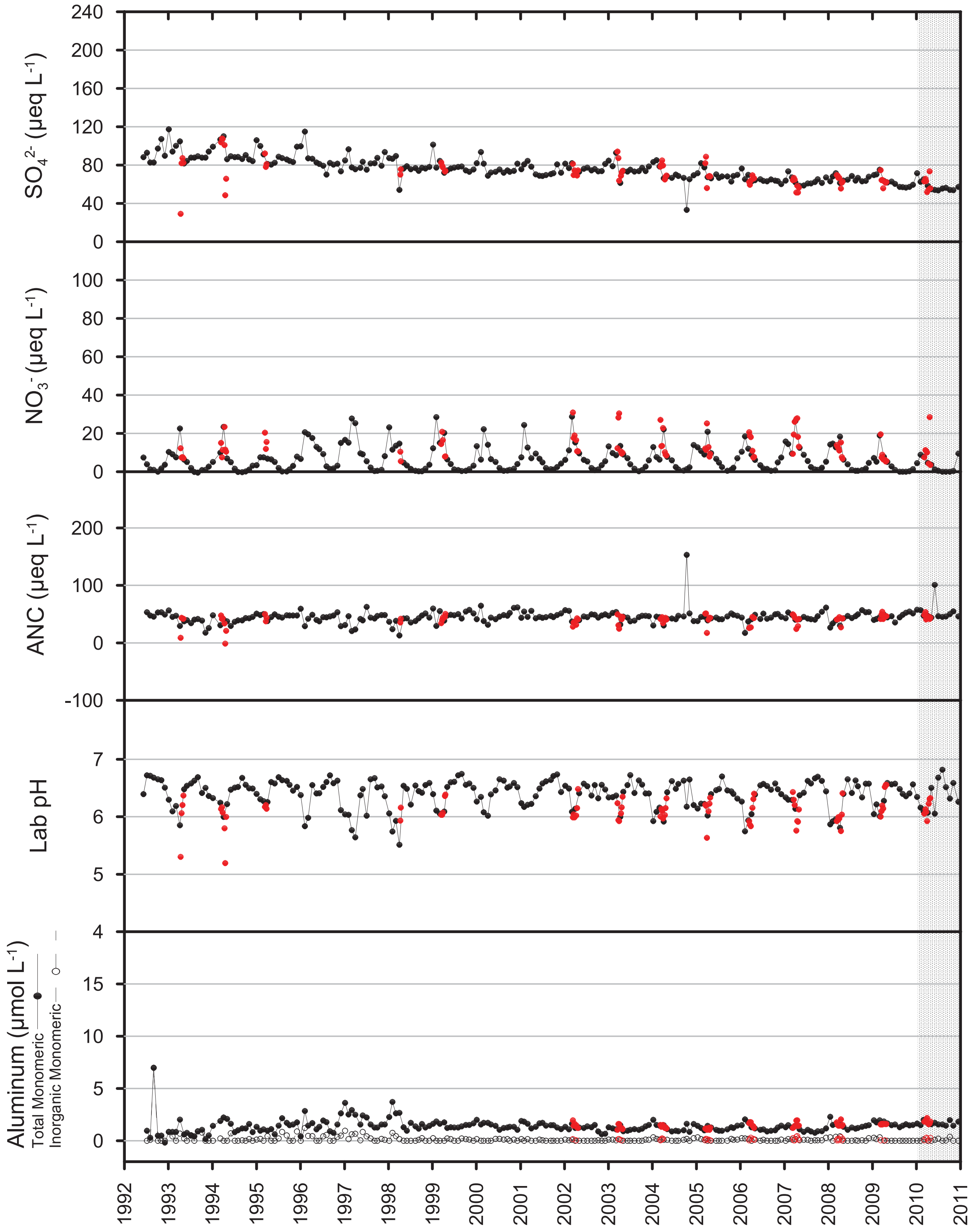
Thick till drainage
Low DOC



snowmelt data in red

HEART LAKE (020264)

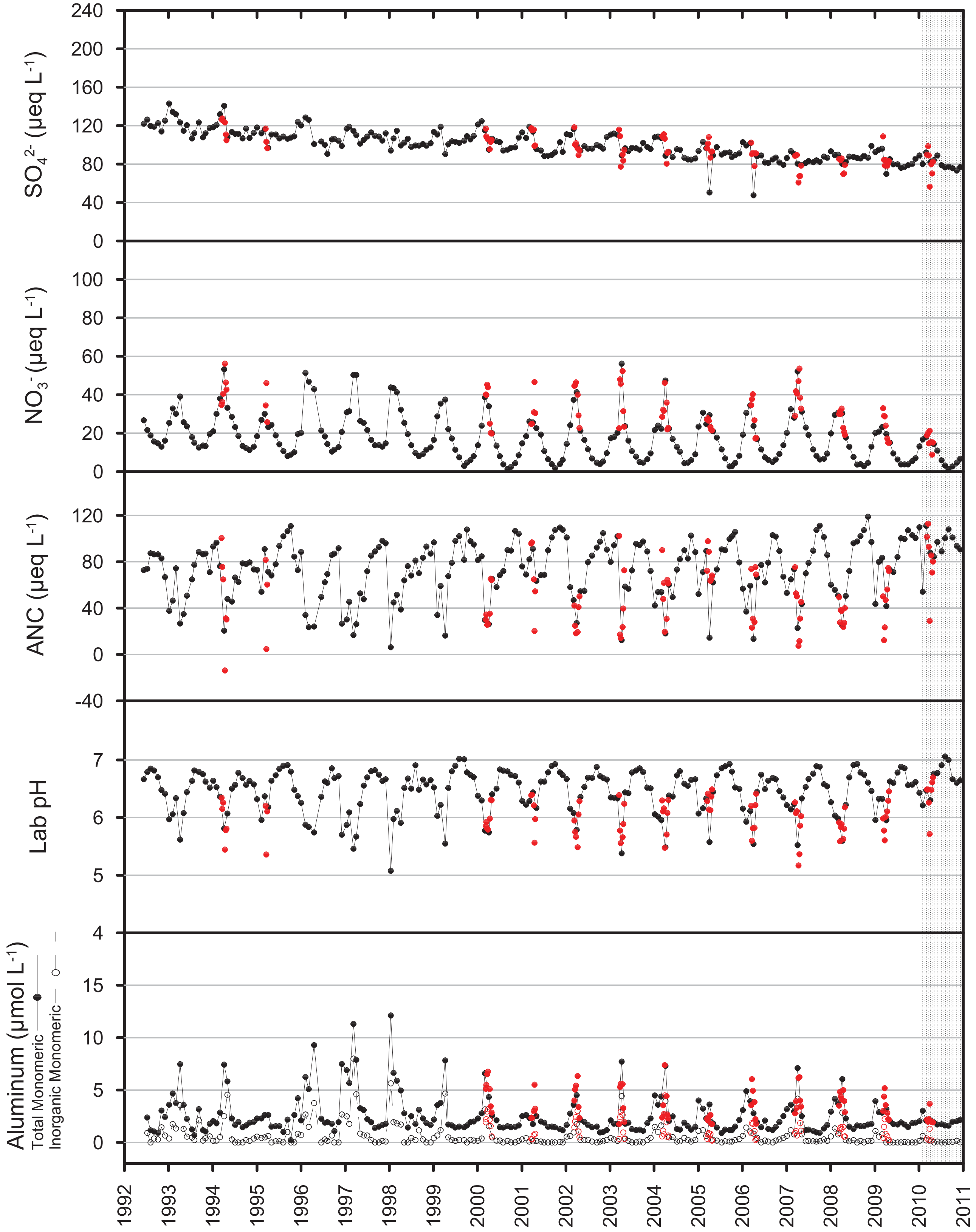
Medium till drainage
Low DOC



snowmelt data in red

MOSS LAKE (040746)

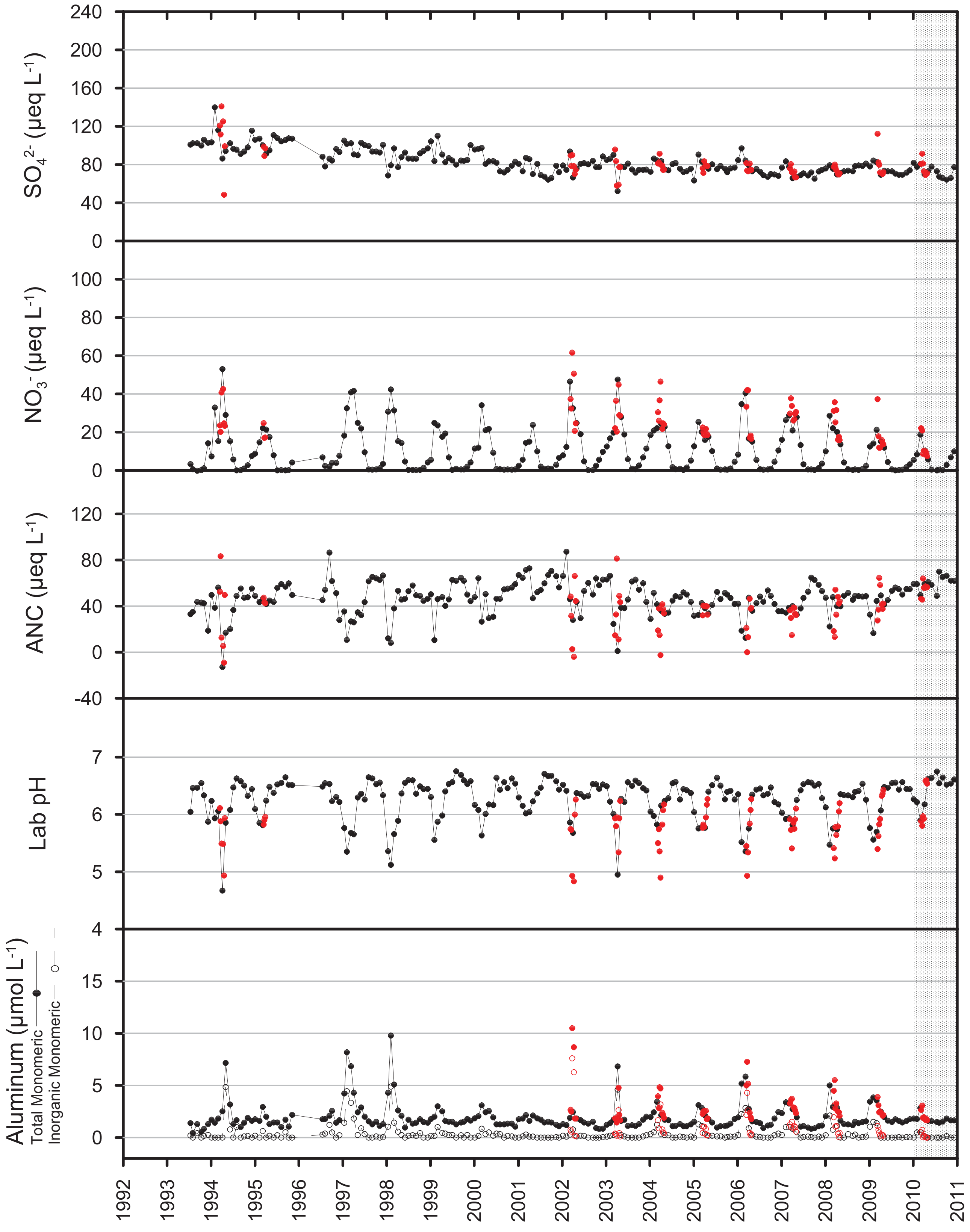
Medium till drainage
Low DOC



snowmelt data in red

BUBB LAKE (040748)

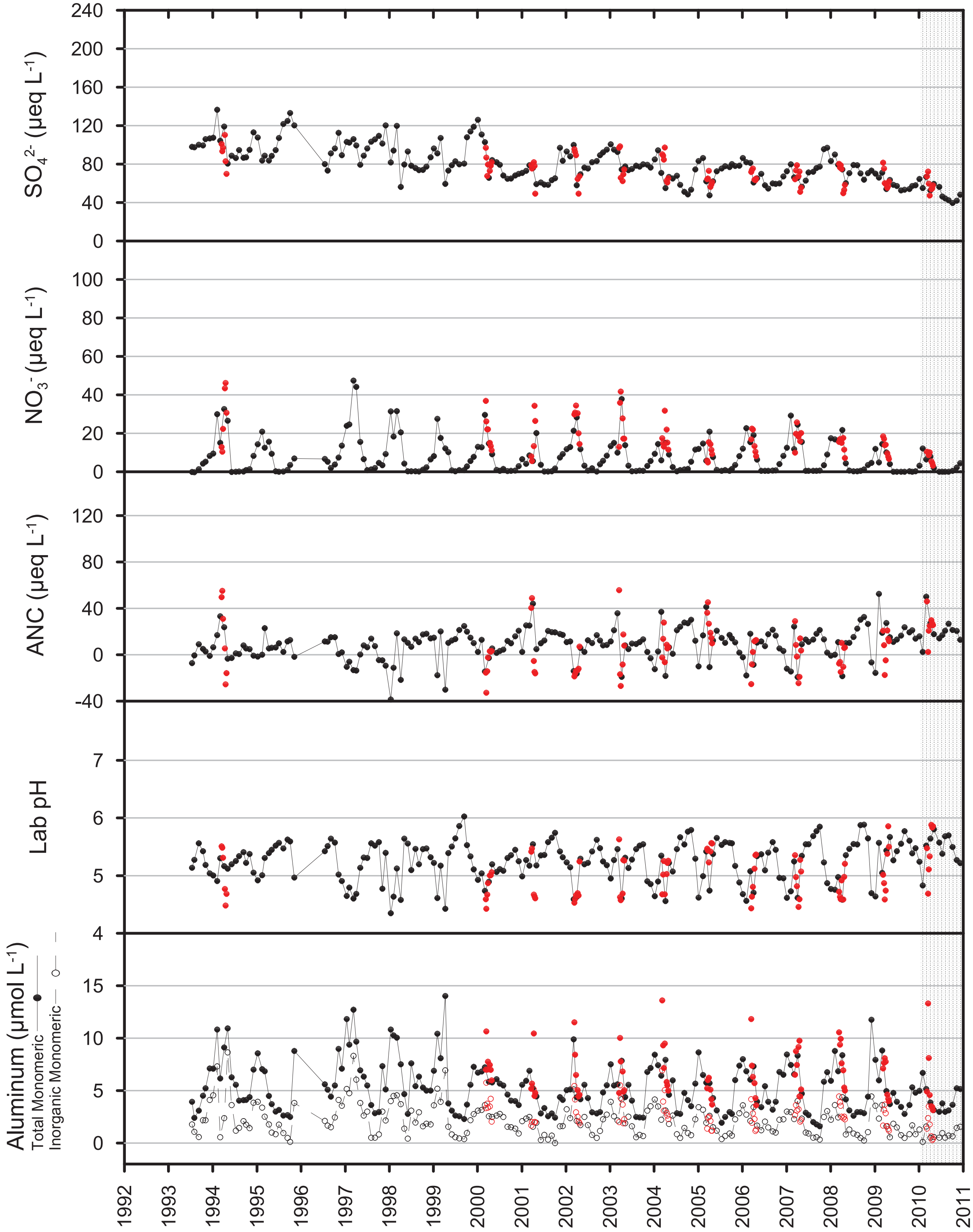
Thin till drainage
Low DOC



snowmelt data in red

WEST POND (040753)

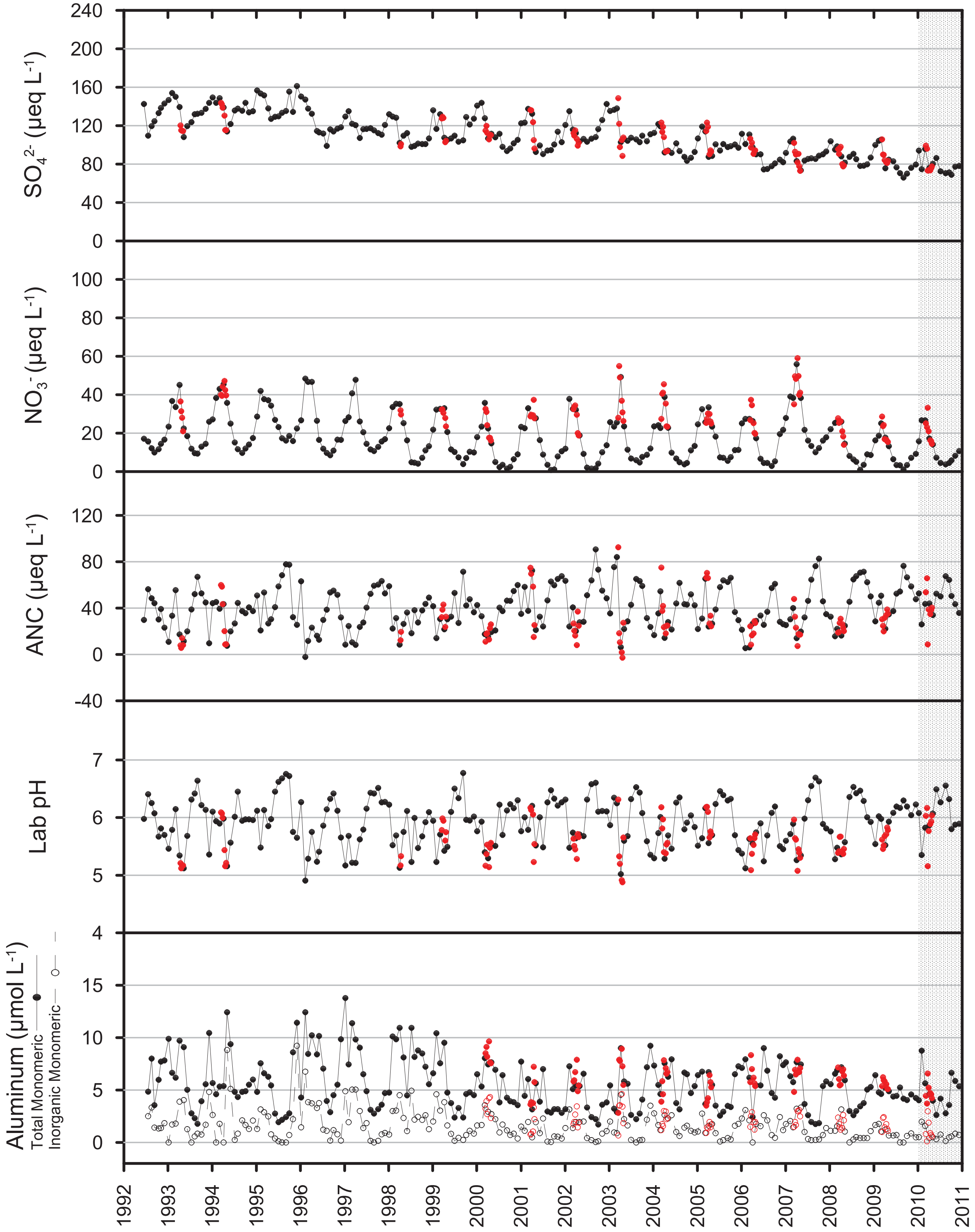
Thin till drainage
Low DOC



snowmelt data in red

SAGAMORE LAKE (060313)

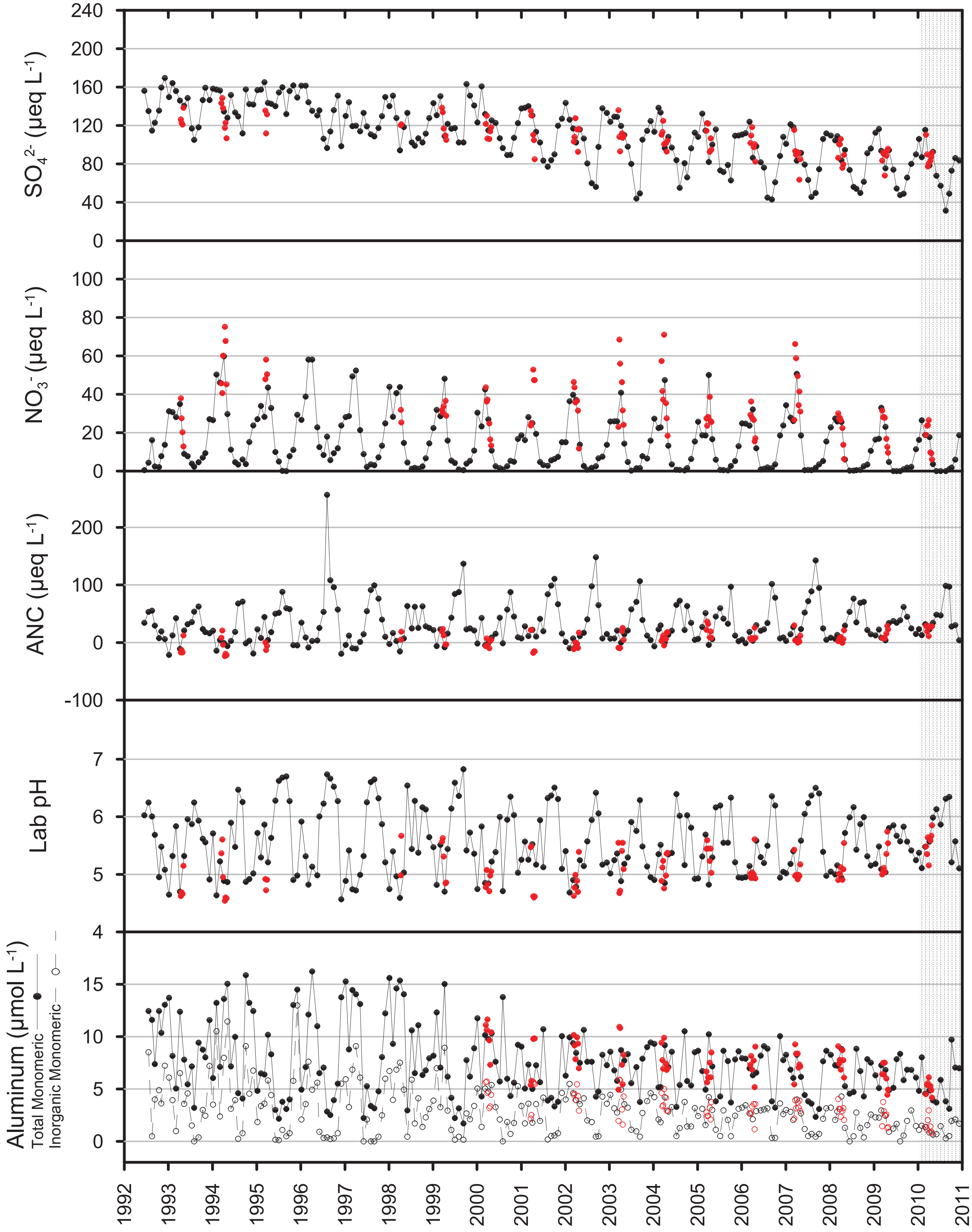
Medium till drainage
High DOC



snowmelt data in red

RAQUETTE LAKE RESERVOIR (060315A)

Medium till drainage
High DOC



snowmelt data in red

This page intentionally left blank.

Appendix D: Presentations, Reports and Papers Delivered 2007–2011

REPORTS, PAPERS

PRESENTATIONS /Location		**TITLE**	**PREPARED BY**	
December 7, 2011 Albany, NY	New York State Department of Environmental Conservation (NYSDEC) PE Continuing Education Seminar	Adirondack acid rain update - acid deposition impacts, monitoring and trends in Adirondack lakes and streams	K.Roy	K.Roy
November 15-16, 2011 Albany, NY	New York State Energy Research and Development Authority (NYSERDA) Environmental Monitoring, Evaluation, and Protection (EMEP) Program Linking Science and Policy Conference	A comparison of the Temporally Integrated Monitoring of Ecosystems and Adirondack long-term monitoring programs in the Adirondack mountain region of New York	K.Civerolo, and K.Roy	Poster Civerolo
November 15-16, 2011 Albany, NY	NYSERDA EMEP Conference	Adirondack long term monitoring lakes: A compendium of site descriptions, recent chemistry, and selected research information	K.Roy, N.Houck, P.Hyde, M.Cantwell, and J.Brown	Poster Roy
November 15-16, 2011 Albany, NY	NYSERDA EMEP Conference	Carbon observations from cloud water at Whiteface mountain New York	J.Dukett, P.Snyder, S.Capone, N.Houck, N.Aleksic, M.Mazurek, and J.Sagona	Poster Dukett
November 15-16, 2011 Albany, NY	NYSERDA EMEP Conference	Fish community changes and mercury in Adirondack long term monitoring lakes	K.Roy and A.Bulger	Poster Roy
November 15-16, 2011 Albany, NY	NYSERDA EMEP Conference	Understanding the molecular composition of highly polar organic compounds in cloudwater and fine particles in the Northeastern US	J.Sagona, M. Mazurek, and J.Dukett	Poster
July 29, 2011 Lake Placid, NY	The Greater Adirondack Resource Conservation and Development Council - Adirondack Waterfest	The Adirondack Lake Survey Corporation	ALSC Staff	Poster
July 10-15, 2011 Lewiston, ME	The Gordon Conference, Bates College	The road to recovery of Adirondack lakes from acidic deposition: are we there yet?	C.T.Driscoll	C.T.Driscoll
June 8, 2011 Croghan, NY	First Annual Black River Watershed Conference	Ongoing research in the western Adirondacks, headwaters to the Black River	G.Lawrence	G.Lawrence
June 6-7, 2011 Durham, NH	USEPA LTM/TIME Cooperators Workshop	Update Adirondack lakes LTM (monthly) trends; TIME (summer) /LTM comparison; and recent stream survey results	K.Roy	K.Roy
May 18-19,2011 Lake Placid, NY	Adirondack Research Consortium Annual Meeting	Progress toward clean cloud water at Whiteface Mountain New York	J.Dukett	J.Dukett

May 18-19, 2011 Lake Placid, NY	Adirondack Research Consortium Annual Meeting	Adirondack long term monitoring lakes: A compendium of site descriptions, recent chemistry, and selected research information	K.Roy, N.Houck, P.Hyde, M.Cantwell, and J.Brown	Poster Houck
May 2011 Troy, NY	Fifth USGS/NYSDEC Summit	Acidification of the Adirondack ecosystem: A park-wide assessment of aquatic and terrestrial effects	G.Lawrence	G.Lawrence
April 26 and June 17, 2011 Tupper Lake, NY	Whiteface Mountain - Olympic Region Scenic Byways Natural History Interpretation Project - Wild Center discussion group	Research at Whiteface Mountain - discussion group	J.Dukett and K.Roy	J.Dukett
April 6-9, 2011 Albany, NY	Northeast Natural History Conference. Special session: Ecological Staus and Recovery of Acidified Adirondack Surface Waters	A comparison of the TIME (summer) and LTM (year-round) programs during 1992-2008	K.Civerolo and K.Roy	K.Roy
April 6-9, 2011 Albany, NY	Northeast Natural History Conference. Special session: Ecological Status and Recovery of Acidified Adirondack Surface Waters	Comparison of methods for estimating critical loads of acidic deposition in the western Adirondack region of New York	G.Lawrence	G.Lawrence
March 14, 2011 Albany, NY	Office of the Attorney General - Briefing to scientific staff	Adirondack long-term monitoring to assess acid rain and emissions policies	G.Lampman, J.Dukett and K.Roy	G.Lampman, J.Dukett and K.Roy
March 2, 2011 Old Forge, NY	Eight Annual Adirondack Research Forum	Progress toward clean cloud water at Whiteface Mountain New York	J.Dukett	J.Dukett
January 14, 2011 Ray Brook Albany teleconference	NYSDEC Bureau of Air Quality Analysis and Research (BAQAR) project overview presentations	Adirondack long term monitoring project - overview to BAQAR staff	K.Roy, J.Dukett, P.Snyder, N.Houck, and S.Capone	K.Roy, J.Dukett, P.Snyder, M.Cantwell, and S.Capone
October 2010 Arlington, VA	USEPA Workshop " Interacting Effects of Climate and Nitrogen on Ecosystem and Their Services"	Invited participant. Purpose: review current science and infom policy-driven scientific needs. Buck Creek, Inlet, NY findings.	G.Lawrence	G.Lawrence
Fall 2010 San Francisco, CA	American Geophysical Union Meeting	Highly polar organic compounds in summer cloudwater from Whiteface Mountain, NY - Poster	J.Sagona, J.Dukett, and M.Mazurek	Poster presentation
May 19, 2010 Lake Placid, NY	17th Annual Conference of the Adirondack Research Consortium	A comparison of contemporary cloudwater pH to pre-industrial values at Whiteface Mountain	J.Dukett	J.Dukett
March 3, 2010 Old Forge, NY	Seventh Annual Adirondack Research Forum	Trends in Adirondack Lake Chemistry	K.Roy	K.Roy
November 16, 2009 Albany, NY	Atmospheric Sciences Research Center Student Faculty Seminar, SUNY Albany	Impacts, Monitoring and Trends in Adirondack Streams and Lakes and Cloud Chemistry Trends at Whiteface Mounatin	K.Roy	K.Roy

October 14-15, 2009 Albany, NY	New York State Energy Research and Development Authority (NYSERDA) Environmental Monitoring, Evaluation, and Protection (EMEP) Program Linking Science and Policy Conference	Acid Deposition Impacts, Monitoring and Trends in Adirondack Lakes and Streams	K.Roy, G.Lawrence and C.Driscoll	K.Roy
October 14-15, 2009 Albany, NY	NYSERDA EMEP Conference	Chlorophyll-a and Total Phosphorus: New to the Compliment of Chemical Parameters Analyzed by the Adirondack Long-Term Monitoring Program	J.E.Dukett, P.Snyder, N. Houck, S.Capone and K.Roy	Poster presentation
October 14-15, 2009 Albany, NY	NYSERDA EMEP Conference	A Comparison of Contemporary Cloud Water pH to Pre-Industrial Values at Whiteface Mountain	J.E.Dukett, N.Aleksic, N.Houck, P.Casson, and M.Cantwell	Poster presentation
October 6-8, 2009 Saratoga Springs, NY	National Atmospheric Deposition Program (NADP) Fall 2009 Annual Meeting and Science Symposium	Changes in Fish Communities in Adirondack Lakes	K.Roy, A.Bulger and C.Driscoll	K.Roy
October 6-8, 2009 Saratoga Springs, NY	NADP Fall 2009 Annual Meeting and Science Symposium	The Response of Acid-Impacted Lake-Watersheds in the Adirondack Region	C.Driscoll, K.Driscoll, K.Roy, Q.Zhao, T.Sullivan and M. Mitchell	C.Driscoll
October 6-8, 2009 Saratoga Springs, NY	NADP Fall 2009 Annual Meeting and Science Symposium	Liquid Water Content and Chemical Composition in Clouds at Whiteface Mountain, NY	N.Aleksic and J. Dukett	Poster presentation
June 9, 2009 Albany, NY	New York State Department of Environmental Conservation (NYSDEC) Division of Air Resources (DAR) Seminar	Analysis of Cloud and Precipitation Chemistry at Whtieface Mountain	N.Aleksic, K.Roy, G.Sistla, J.Dukett, N.Houck and P.Casson	N.Aleksic, K.Roy
June 3-4, 2009 College Park, PA	USEPA Temporally Integrated Monitoring of Ecosystems/Long Term Monitoring Cooperator Workshop	A Regional Perspective for the Adirondack Mountains	K.Roy, C.Driscoll, and G.Lawrence	K.Roy
May 15, 2009 Saranac Lake, NY	Focus Earth Series by Bob Woodruff video interview for The Future of Coal Country" to be aired Summer 2009	Sampling for Acid Rain Effects in the Adirondacks	K.Roy, P. Casson and J.Brown	Video interview
August 26, 2008 Wilmington, NY	Whiteface Mountain Atmospheric Center Ray Falconer Summer Lecture Series	Lakes, Streams and Cloud Monitoring in the Adirondacks		K.Roy
June 2, 2008 Lake Placid, NY	North Country Public Radio (Canton, NY) interview with Brian Mann	Subject: National Air Pollution Cap and Trade Policies and the Battle to Stop Acid Rain in the Adirondacks	K.Roy	Radio interview

May 21-22, 2008 Lake Placid, NY	Adirondack Research Consortium 15th Annual Conference	Adirondack Long-Term Monitoring Recent Findings - Lakes	K.Roy, J.Dukett, S.Capone, N.Houck and S.Capone	K.Roy
May 13, 2008 Ray Brook, NY	Cornell Water Resources Institute Reactive Nitrogen Round Table Teleconference	Presentation of Adirondack Long Term Monitoring Sites and Findings	K.Roy	K.Roy
February 14, 2008 Troy, NY	Meeting of The Nature Conservancy and USGS Research Scientists on Acid Deposition Research in New York State	Adirondack Long Term Monitoring Program - Study Sites	K.Roy	K. Roy
November 15-16, 2007 Albany, NY	New York State Energy Research and Development Authority (NYSERDA) Environmental Monitoring, Evaluation, and Protection (EMEP) Program Linking Science and Policy Conference	Changes in Water Quality of Adirondack Lakes	K.Roy, J.Dukett, S.Capone, N.Houck and P. Snyder	K.Roy
September 30, 2007 Ray Brook, NY	NYSDEC Executive Staff regional visit	Adirondack Lakes Survey Corporation Adirondack Long Term Monitoring Program Overview	K.Roy	K.Roy
May 22-24, 2007 Tupper Lake, NY	Adirondack Research Consortium 14th Annual Conference on Sustainability, Climate Change, and Protected Areas - Setting a Practical Research Agenda for the North Country	Recent Acidification Trends in Adirondack Lakes	K.Roy, C.Driscoll, K.Driscoll, J.Dukett, N.Houck, P.Snyder, and S.Capone	K.Roy
May 4-6, 2007 Hamilton, NY	New York State Federation of Lake Association 24th Annual Conference	Recent Acidification Trends in Adirondack Lakes	K.Roy, C.Driscoll, K.Driscoll, J.Dukett, N.Houck, P.Snyder, and S.Capone	K.Roy
January 10, 2007 Albany, NY	NYSDEC Division of Air Resources, New Staff Orientation	The Adirondack Long Term Monitoring Program (surface water acidification)	K.Roy	K.Roy

PUBLIC	REPORT ARTICLE		
YEAR	Journal Book or Other		Author
July 2011	Environmental Pollution	Changes in the chemistry of acidified Adirondack streams from the early 1980s to 2008	G.B.Lawrence, H.A.Simonin, B.P.Baldigo, K.M.Roy and S.B.Capone
	(2011) 159:2750-2758	http:/ dx.doi.org/10.1016/j.envpol.2011.05.016	
August 2011	Report to NYSERDA	Adirondack long term monitoring lakes: A compendium of site descriptions, recent chemistry, and selected research information http:/ www.nyserda.ny.gov/Publications/Research-and-Development/Environmental EMEP-Publications/~/media/Files/Publications Research/Environmental/11-12-altm-	K.Roy, N.Houck, P.Hyde, M.Cantwell, and J.Brown
August 2011	Atmospheric Environment	Progress toward clean cloud water at Whiteface Mountain, New York	J.Dukett, N.Aleksic, N.Houck, P.Snyder, P.Casson, and M.Cantwell
	45(2011) 6669-6673	doi:10.1016/j.atmosenv.2011.08.070	
August 2011	Report to NYSERDA	A long-term monitoring program for evaluating changes in water quality in selected Adirondack waters: Core program 2007-2011 data summary report 2010. Report 11-20 NYSERDA 4915, Albany, NY http:/ www.nyserda.ny.gov/Publications/Research-and-Development/Environmental EMEP-Publications/~/media/Files/Publications Research/Environmental/11-20%20Water%20Quality%20in%20Selected%20Adirondack%20	K.Roy, J.Dukett, N.Houck, and G.Lawrence
August 2011	Water Air and Soil Pollution	A comparison of the Temporally Integrated Monitoring of Ecosystems and Adirondack Long-Term Monitoring Programs in the Adirondack Mountain Region of New York	K.L.Civerolo, K.M.Roy, J.L.Stoddard, and G.Sistla
	(2011) 222: 285-296	doi: 10.1007/s11270-011-0823-8	

December 2011	Atmospheric Environment 46 (2012) 56-64	Long term recovery of lakes in the Adirondack region of New York to decreases in acidic deposition http:/ www.sciencedirect.com/science/article/	K.Waller, C.Driscoll, J.Lynch, D.Newcomb and K.Roy
December 2011	Office of Science and Technology Report National Science and Technology Council	National Acid Precipitation Assessment Program report to Congress 2011: An integrated assessment	D.A.Burns and others
2010	Atmospheric Research 98(2010) 2-4:400-405	Probabilistic relationship between liquid water content and ion concentrations in cloud water.	N.Alecksic, and J.Dukett
2010	Report to NYSERDA	A sampling design for the 2008-2012 fisheries resurvey of the 52 Adirondack Long-Term Monitoring (ALTM) lakes. NYS Department of Environmental Conservation and Adirondack Lakes Survey Corporation, Ray Brook, NY	K.Roy and S.Capone
2010	Report to NYSERDA	A long-term monitoring program for evaluating changes in water quality in selected Adirondack waters: Core program 2007-2011 data summary report 2009. Report 10-21 NYSERDA 4915, Albany, NY	K.Roy, J.Dukett, N.Houck, and G.Lawrence

REPORT/POLICY		**PROGRAM**	
Year	**Report or Other**		**Author**
2011	Technical Report to NESCAUM	Steady-State Critical Loads and exceedance for Terrestrial and Aquatic Ecosystems in the Northeastern United States Http:/ www.nescaum.org/activities/major-reports	E.K.Miller
2011	National Acid Precipitation Assessment Program Report to Congress	National Acid Precipitation Assessment Program Report to Congress 2011: An Integrated Assessment. Http://ny.water.usgs.gov/projects/NAPAP/	D.A.Burns et al.
2011	Comments of the New York State Department of Environmental Conservation Division of Air Resources to the EPA Proposed Rule	Secondary National Ambient Air Quality Standards for Oxides of Nitrogen and Sulfur Federal Register Notice http:/ www.epa.gov/air/nitrogenoxides/actions.html#mar12	D.Shaw (DEC) to R.Wayland and R.Haeuber (EPA) April 3, 2012
2011	EPA Policy Document	Policy Assessment for the Review of the Secondary National Ambient Air Quality Standards for Oxides of Nitrogen and Oxides of Sulfur, U.S. Environmental Protection Agency, Washington, D.C., EPA-452/R-11-005a.	USEPA
2010	EPA Report	Acid Rain and Related Programs: 2009 Highlights 15 Years of Results 1995 to 2009. EPA-430-R-10-014 Washington, DC http://www.epa.gov/airmarkets/progress/ARP09_4.html	USEPA Clean Air Markets Division
2010	EPA Report	Acid Rain and Related Programs: 2009 Environmental Results, Washington, DC http://www.epa.gov/airmarkets/progress/APR09.html	USEPA Clean Air Markets Division
2010	EPA Report	Policy Assessment for the Review of the Secondary National Ambient Air Quality Standards for NOx and SOx: Second External Review Draft for the Clean Air Scientific Advisory Committee, Washington, DC	USEPA

This page intentionally left blank.

Appendix E: Glossary of Terms

$\mu eq\ L^{-1}$	microequivalent per liter
$\mu g\ kg^{-1}$	microgram per kilogram
$\mu g\ m^{-2}$	microgram per square meter
$\mu mol\ C\ L^{-1}$	micromole carbon per liter
$\mu mol\ L^{-1}$	micromole per liter
$\mu S\ cm^{-1}$	microsiemens per centimeter
ACLP	Adirondack Cooperative Loon Project
AEAP	Adirondack Effects Assessment Program Adirondack
AERP	Episodic Response Project
AIREQPH	air equilibrated pH
ALIM	inorganically complexed aluminum
ALOM	organically complexed aluminum
ALS	Adirondack Lakes Survey (1980s)
ALSC	Adirondack Lakes Survey Corporation
ALTD	total dissolved aluminum
AlTM	total monomerica aluminum
ALTM	Adirondack Long Term Monitoring Program
AMMP	Adirondack Manipulation and Modeling Project
ANC	Acid Neutralizing Capacity
APA	Adirondack Park Agency
BCS	base cation surplus
C_A	summed concentration of acid anions
C^{2+}	calcium ion
$CaCl_2$	calcium chloride
CASTNET	Clean Air Status and Trends Network
CB	summed concentration of base cations
CEC	cation exchange capacity
Cl^-	chloride ion
$cmoles\ kg^{-1}$	centimoles of charge per kilogram
DDRP	Direct/Delayed Response Project
DIC	Dissolved Inorgranic Carbon
DOC	Dissolved Organic Carbon
ELS	Eastern Lakes Survey
EMAP	Environmental Monitoring and Assessment Program
EPA	Environmental Protection Agency (U.S.)
eq	equivalent
$eq\ ha^{-1}\ yr^{-1}$	equivalent per hectare per year
$eq\ L^{-1}$	equivalent per liter
ERP	Episodic Response Project
F^-	flouride ion
g	grams
GIS	Geographic Information System
H^-	hydrogen ion
ha	hectare
Hg	elemental mercury
ILWAS	Integrated Lake-Watershed Acidification Study

K^+	potassium ion
kg	kilogram
km	kilometer
LABPH	laboratory pH
LAMP	Lakes Acidification Mitigation Project
LTD	lower than detectable
LTM	Long Term Monitoring Program
LWC	liquid water content
m	meter
MDN	Mercury Deposition Network
$MeHg^+$	methyl mercury
mg L^{-1}	milligrams per liter
mg L^{-1}-C	milligrams per liter as carbon
mg m^{-3}	milligrams per cubic meter
Mg^{2+}	magnesium ion
ml	milliliter
mm	millimeter
mmol L-1	millimole per liter
NA	not available
Na^+	sodium ion
NADP	National Atmospheric Deposition Program
NAPAP	National Acid Precipitation Assessment Program
NBMR	North Branch Moose River Project
NH_4^+	ammonium ion
NO_3^-	nitrate ion
NOAA	National Oceanic and Atmospheric Administration
NSA	Natural Spawning Adequate
NTN	National Trends Network
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
NYSERDA	New York State Energy Research and Development Authority
pH	negative logarithm of hydrogen ion concentration
PIRLA	Paleoliminological Investigation of Recent Lake Acidification Study
Pt Co	platinum cobalt
RILWAS	Regional Integrated Lake-Watershed Acidification Study
SCONDUCT	specific conductivity
SiO_2	silica
SO_2	sulfur dioxide
SO_4^{2-}	sulfate ion
SUNY-ESF	State University of New York College of Environmental Sciences and Forestry
TIME	Temporally Integrated Monitoring of Ecosystems
TOC	total organic carbon
TRUECOLOR	color defined on the platinum cobalt scale
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey

Appendix F: 2010 Whiteface Cloud Summary Data

Whiteface 2010 Summary Data

A complete record of Whiteface Cloud data may be obtained at www.adirondacklakessurvey.org/ by selecting the Whiteface Info & Data menu tab.

Parameter	Units	Count	Min	Max	Mean	Std. Dev.
Cloud amples (n)		309				
Volume	mL	309	30.000	2887.000	661.741	551.694
LWC	g m^{-3}	309	0.053	1.170	0.520	0.265
$^{2-}$	µeq L^{-1}	309	0.331	725.592	98.723	132.558
NO^{-}	µeq L^{-1}	309	0.416	329.669	47.115	56.434
Cl^{-}	µeq L^{-1}	309	0.000	45.042	4.194	5.959
Ca^{2+}	µeq L^{-1}	309	-0.485	245.953	19.548	34.330
Mg^{2+}	µeq L^{-1}	309	0.152	48.925	5.535	7.547
Na^{+}	µeq L^{-1}	304	-0.419	81.995	3.752	9.000
K^{+}	µeq L^{-1}	304	-0.129	17.125	1.650	2.112
NH^{+}	µeq L^{-1}	309	0.497	749.280	91.281	120.703
TOC	µmol L^{-1}	83	9.182	2319.299	374.756	417.764
SCONDUCT	µS cm^{-1}	276	1.670	193.353	35.556	39.438
LabpH		309	3.471	6.071		
$^{+}$	µeq L^{-1}	309	0.849	338.065	50.191	58. 920

NYSERDA, a public benefit corporation, offers objective information and analysis, innovative programs, technical expertise and funding to help New Yorkers increase energy efficiency, save money, use renewable energy, and reduce their reliance on fossil fuels. NYSERDA professionals work to protect our environment and create clean-energy jobs. NYSERDA has been developing partnerships to advance innovative energy solutions in New York since 1975.

To learn more about NYSERDA programs and funding opportunities visit nyserda.ny.gov

New York State
Energy Research and
Development Authority

17 Columbia Circle
Albany, New York 12203-6399

toll free: 1 (866) NYSERDA
local: (518) 862-1090
fax: (518) 862-1091

info@nyserda.ny.gov
nyserda.ny.gov

A Long-Term Monitoring Program for Evaluating Changes in Water Quality in Selected Adirondack Waters

Program Summary Report 2011
June 2012

Energy. Innovation. Solutions.

State of New York
Andrew M. Cuomo, Governor

New York State Energy Research and Development Authority
Francis J. Murray, Jr., President and CEO