FINAL REPORT

NEIWPCC Job Code: 0100-328-002

Project Code: L-2019-085

Contractor: Ausable River Association

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Project Period: 10/4/2019 to 12/31/2022

Date Submitted: December 2022

Date Approved: March 2023

QUANTIFYING THE DE-ICING SALT POLLUTION LOAD TO MIRROR LAKE AND THE CHUBB RIVER

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This is a Great Lakes Fishery Commission funded project.

This project was funded by an agreement awarded by the Great Lakes Fishery Commission to the New England Interstate Water Pollution Control Commission in partnership with the Lake Champlain Basin Program. NEIWPCC manages LCBP's personnel, contract, grant, and budget tasks and provides input on the program's activities through a partnership with the LCBP Steering Committee. The viewpoints expressed here do not necessarily represent those of NEIWPCC, the LCBP Steering Committee, or GLFC, nor does mention of trade names, commercial products, or causes constitute endorsement or recommendation for use.

EXECUTIVE SUMMARY

De-icing salt is an important regional pollutant identified as a contaminant of concern in the Lake Champlain Basin Program’s (LCBP) *Opportunities for Action*. It is of particular concern in areas of dense urban development where runoff from roads, parking lots, sidewalks, and driveways can contain high concentrations of salt. This is true for Mirror Lake and the Chubb River, located in the headwaters of the West Branch Ausable River subwatershed. In the case of Mirror Lake, direct stormwater discharge to the lake has resulted in a reduction in spring mixing due to salt-induced density differences within the water column. The primary objectives of this three-year LCBP-funded project were to 1) establish a continuous water quality monitoring program capable of quantifying de-icing salt pollutant load to Mirror Lake and the Chubb River, 2) estimate the de-icing salt pollutant load to Mirror Lake from direct stormwater runoff, 3) estimate the total amount of de-icing salt applied within the Chubb River watershed, and 4) educate the public about the effects of de-icing salt on the environment and BMPs for de-icing salt reduction.

Three continuous monitoring stations were added in June 2020 at the inlet and outlet of Mirror Lake and the outlet of Lake Placid to complement existing stations located in the Upper Chubb River watershed and near the outlet of the Chubb River before it enters the West Branch Ausable River. These stations include data loggers that record stage, conductivity, and temperature every 30 minutes from June 2020 to June 2022. Long-term bi-weekly monitoring of Mirror Lake, begun in 2016, was continued for the project's duration. Discrete monitoring of stormwater entering the lake was also conducted during this period and drew upon a delineation of the watershed area that drains to each stormwater outfall entering Mirror Lake. De-icing salt application within the watershed was estimated through municipal salt tracking devices, and a salt survey was distributed to businesses and residents. Finally, education and outreach campaigns were executed, including installing interpretive signage around Mirror Lake.

Utilizing data from the continuous monitoring system with the Chubb River, we estimate that over 1,000 metric tons per annum of chloride were exported from the Chubb River subwatershed from anthropogenic sources, primarily road de-icing salt. For Mirror Lake, we estimate that approximately 90 metric tons of chloride from anthropogenic sources are exported from the watershed annually. Utilizing municipal salt tracking data gathered by our study, previously published estimates of salt application to state roads, and considering lake chloride retention, we estimate that a minimum of 15-16% of the annual de-icing salt load comes from local roads, 33-35% from state roads, 3-4% from sidewalks, and 42-49% is unaccounted for. The unaccounted salt likely originates from commercial and private applications to sidewalks, driveways, and parking lots. This underscores the importance of addressing these sources of de-icing salt in urban environments. The stormwater data indicates that the highest loads of chloride entering the lake come from the western side. The current data suggest that de-icing salt reduction practices and stormwater improvements in the watershed are working. Still, the lake would benefit from further reductions in de-icing salt application.

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1. PROJECT SYNOPSIS

Increasingly, de-icing salt is acknowledged as an important regional pollutant, and it is also listed as a contaminant in the narrative of the LCBP Opportunities for Action (LCBP 2022). In the Adirondacks, the pollutant load from de-icing salt since the 1980s has been nearly six times the total sulfate and nitrate deposition due to acid deposition (Kelting 2017). The result is the regional salinization of Adirondack waters, affecting both surface and groundwater in the region. Emerging research on impacts on biota further elevates concerns about de-icing salt (Coldsnow et al. 2017; Hintz et al. 2017; Hintz & Relyea 2017a; Hintz & Relyea 2017b; Schuler et al. 2017). Perhaps the most pressing concerns are regional contamination of groundwater supplies and the human health implications of contaminated private drinking water wells (Kelly et al. 2018; Pieper et al. 2018).

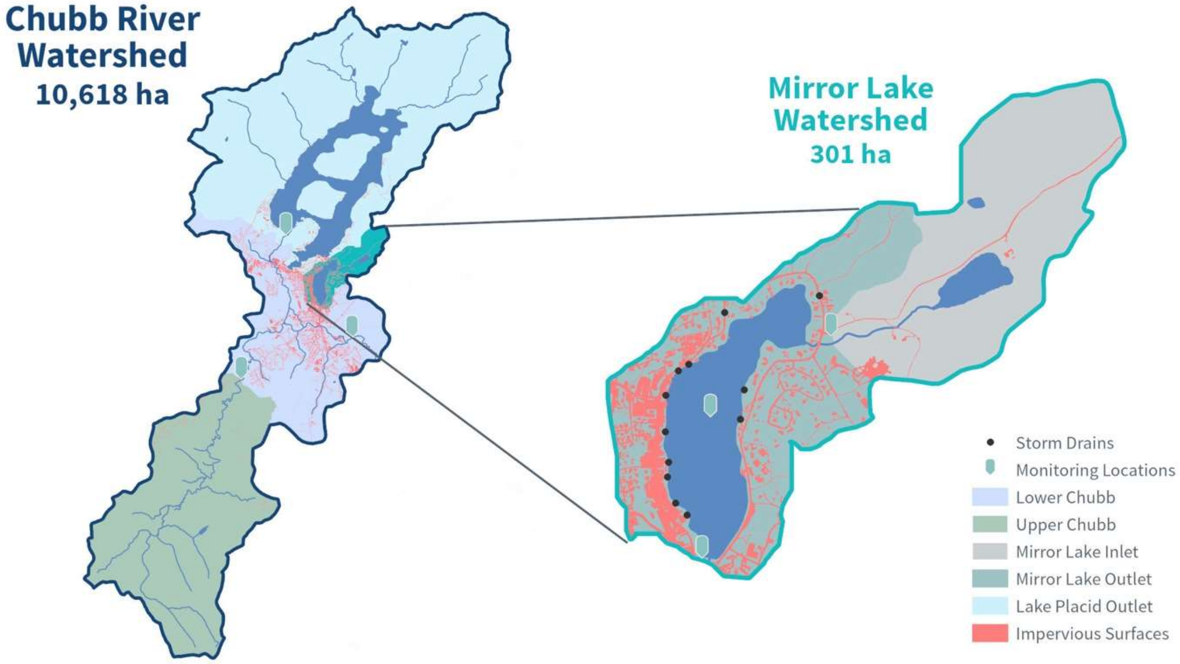

Figure 1. General overview of the Chubb River and Mirror Lake watersheds and the impervious surfaces within them. Stream, lake, and stormwater sampling locations are noted. Data sources: USGS, LCBP.

The Ausable River watershed has the second highest load of salt applied in the Adirondack Park, second only to the Lake George basin (Kelting 2017.). Within the Ausable River watershed, the Chubb River sub-watershed (Figure 1; HUC12) is the most developed and urbanized (Tucker & Treadwell-Steitz 2016; Wiltse et al. 2017). The Chubb River watershed is in the headwaters of the Lake Champlain basin, and heavy urban development is relatively uncommon in this part of the basin. The high density of development, in a small watershed, particularly around Mirror Lake, makes this a model location to study the influence of de-icing salt on Lake Champlain Basin surface waters.

The project directly addresses LCBP FY18 technical funding priority one: Research or innovative demonstration projects that reduce pollution to Lake Champlain, especially nutrients, de-icing agents, and other emerging contaminants of concern. It builds on ongoing work by the

Ausable River Association (AsRA) related to de-icing salt pollution in and around the Village of Lake Placid. AsRA, in partnership with the Paul Smith's College Adirondack Watershed Institute (AWI), regularly monitors Mirror Lake and maintains two continuous monitoring stations on the Chubb River.

In addition, direct runoff from de-icing salt is inhibiting spring turnover in Mirror Lake. Lake water chloride concentrations (40-120 mg/L) range from 160- to 480-times the median concentration observed (0.24 mg/L) in Adirondack lakes not impacted by paved roads (Wiltse et al. 2020; Wiltse et al. 2018; Kelting et al. 2012). Much of the stormwater runoff in the Village of Lake Placid discharges directly to either Mirror Lake or the Chubb River. Understanding the sources and movement of de-icing salt is essential to identifying solutions and monitoring their effectiveness.

With the support of LCBP, this project added continuous monitoring stations to the outlet of Lake Placid, as well as the inlet and outlet of Mirror Lake, completing a continuous monitoring network in the Chubb River subwatershed (Figure 1). Each station consists of a level logger and a temperature/conductivity logger. These, coupled with regular discharge measurements and water samples, allow stage-discharge and conductivity-chloride relationships to be established at each location. Combined with the current work on the Chubb River and Mirror Lake, this network will enable us to quantify the chloride export from the Village of Lake Placid. Stormwater sampling, coupled with LiDAR-derived stormwater runoff models, was used to characterize the salt load to Mirror Lake for individual stormwater outfalls. Additionally, a survey of salt use was conducted to understand private and commercial salt use within the Mirror Lake watershed.

The project included purchasing and installing data loggers on the town and village trucks applying de-icing salt. Resulting data established baseline application rates within the Chubb River watershed at the municipal level. These data helped local road crews optimize and reduce de-icing salt application rates throughout the Village of Lake Placid. Preliminary estimates of salt loads based on the fine-scale delineation of parking lots, sidewalks, and roads, coupled with industry average application rates, indicated that 52% of the lake's chloride load might be coming from parking lot and sidewalk application, 16% from local road application through salt mixed with sand, and 32% from state road application within the Mirror Lake watershed. Applying data loggers and vehicle tracking devices to two town plow trucks, one village plow truck, and the village sidewalk sweeper/drop spreader, along with previously published NYS DOT data, has allowed us to determine a more accurate total salt load and partition that across various application categories. Our preliminary estimates revealed that the parking lot and sidewalk application is potentially a significant load in urban environments and is an area where there has not been much regional focus on implementing BMPs. This project allowed us to develop better measures of the contribution of parking lot and sidewalk salting to the total salt load in urban areas.

The Chubb River watershed size and characteristics present a great opportunity to closely monitor and estimate de-icing salt application rates and monitor how that pollutant moves through an urban lake and a river. A critical component of this project is linking the application rates to the water quality conditions measured in Mirror Lake and the Chubb River. These two aspects of the project will aid in better defining needed reductions in de-icing salt pollutant load, informing target reductions needed through implementing BMPs.

Finally, an essential component of this project has been education and outreach within the Village of Lake Placid and surrounding communities on the impact of de-icing salt on our waterbodies. Public watershed meetings, business outreach, interpretive displays and signage, and school and summer programs were designed and offered to maximize awareness among residents and visitors. A portion of this work was provided as match through established AsRA programs.

This project sought to develop loading estimates for all de-icing salt use in the highly developed Chubb River subwatershed. To date, much of the regional focus has been on state and, to a lesser degree, local road applications. Comparatively little is known about contributions from municipal sidewalk applications, and commercial and private applications. The relatively small area of this watershed, along with existing monitoring programs that have documented significant water quality impairments (lack of turnover in Mirror Lake), offers an excellent opportunity to study and quantify the de-icing salt pollutant load from various of sources. This data collection effort, and the systems established through it, will continue to collect the necessary information to identify, implement, and assess the effectiveness of best management practices to reduce de-icing salt impacts. The outcomes of this work have broad implications regarding understanding de-icing salt pollution in the Lake Champlain basin and understanding how optimization can reduce de-icing salt pollution while still maintaining safe roads, parking lots, and sidewalks. The Chubb River watershed is a good model system for much larger and harder-to-study urban areas in the basin.

This project was organized into three primary objectives: 1) establish a continuous water quality monitoring program capable of quantifying de-icing salt pollutant load to Mirror Lake and the Chubb River, 2) estimate de-icing salt pollutant load to Mirror Lake from direct stormwater runoff, 3) estimate total amount of de-icing salt applied within the Chubb River watershed, and 4) educate the public about the effects of de-icing salt on the environment and best management practices for de-icing salt reduction.

Task #	Task Title	Objective	Deliverable or Output	Timeline
1	Develop a QAPP	Describe quality assurance procedures that will maintain project performance.	QAPP approval	April 2020
2	Install Stations	Purchase equipment and install continuous stream monitoring stations.	Three continuous monitoring stations installed.	June 2020
3-6	Monitoring 1-4	Collect water samples, establish stage-discharge curves, establish conductivity-chloride relationship. Continue Mirror Lake data collection effort.	100% of continuous data on sodium & chloride.	June 2020 – June 2022

7	Stormwater System Mapping	Ground truth stormwater system pour points and outfalls.	Map of stormwater pour points and outfalls.	July 2020 – April 2021
8	Storm-watershed Delineation.	Delineate storm-watersheds for each outfall.	LIDAR based stormwater runoff model.	June 2021 – November 2022
9	Install Stormwater Monitoring	Purchase equipment and install in stormwater outfalls.	Data loggers installed in two outfalls.	June 2020
10-13	Stormwater Monitoring 1-4	Collect and analyze stormwater samples for ~28 runoff events.	100% of data on chloride concentrations in stormwater runoff.	June 2020 – June 2022
14	Distribute Survey	Design and distribute survey.	Survey developed and distributed to area businesses and residents.	March 2022
15	Survey Follow-up	Follow-up with businesses as necessary and compile survey results.	Estimate of private contractor/businesses and residential salt load	March - June 2022
16	Purchase and Install Municipal Salt Tracking Equipment and Plows	Coordinate installation of fleet tracking and data logging equipment on municipal vehicles.	Salt tracking equipment and Live Edge plows installed on municipal vehicles.	April 2020 – September 2020
17-20	Municipal Salt Tracking 1-4	Coordinate training on calibration; ensure ongoing data collection.	100% of municipal salt use data collected.	September 2020 – June 2022
21	First Water Quality Workshop	Host a water quality workshops; incorporate de-icing salt monitoring in one youth program.	Workshop and youth program held.	NA

22	Second Water Quality Workshop	Host a water quality workshops; incorporate de-icing salt monitoring in one youth program.	Workshop and youth program held.	NA
23	Interpretive Displays	Work with designer to develop interpretive displays.	Final displays developed and printed.	October 2022
24	Data analysis and reporting	Compile and analyze project data, write up results into final report.	Quarterly & final LCBP reports	June 2022 – December 2022

2. TASKS COMPLETED

Objective 1: Establish a continuous water quality monitoring program capable of quantifying de-icing salt pollutant load to Mirror Lake and the Chubb River.

Task 2-6: Continuous Monitoring Stations and Lake Monitoring.

Before starting this project, AsRA & AWI maintained two continuous water quality monitoring stations on the Chubb River. One station is above Averyville Road (Upper Chubb), which primarily drains New York State Forest Preserve, and the other is located near the mouth

Figure 2. AWI Research Associate, Lija Treibergs, teaching an AWI Seasonal Research Technician and Paul Smith's College undergraduate student how to measure discharge using an acoustic Doppler velocimeter at the Lower Chubb River site.

of the Chubb River (Lower Chubb) before entering the West Branch Ausable River. Three more stations were added to this network; Mirror Lake Inlet, Mirror Lake Outlet, and Lake Placid Outlet. Each station was outfitted with a Solinst Levelogger to measure stage height and HOBO conductivity logger to measure conductivity. Throughout the project, the sites were visited to collect discrete water samples and discharge measurements to relate stage height to discharge and conductivity to chloride (Figure 2). These stations allow us to monitor water quality entering Mirror Lake and discharging from Mirror Lake to the Chubb River and the contribution of de-icing salt to the Chubb River from Lake Placid. Collectively, these stations, along with those already established, allow us to isolate the chloride load coming from the Village of Lake Placid.

All field equipment was manually inspected for invasive aquatic species and organic matter before use. Equipment was cleaned and dried within the manufacturer's specifications to prevent the spread of invasive species. To the extent possible, equipment was explicitly designated for Mirror Lake (integrated tube sampler, Secchi disc, sample bottles, etc.). A designated canoe was used to sample Mirror Lake and kept at a resident's house.

Objective 2: Estimate de-icing salt pollutant load to Mirror Lake from direct stormwater runoff

Task 7-8: Storm-watershed Delineation.

To estimate the de-icing salt loading to Mirror Lake from the stormwater system, we need to better understand the drainage area for each stormwater outfall that enters the lake. This involved taking the mapped stormwater system from the Village of Lake Placid, ground truthing and updating it where necessary, and delineating storm watersheds for all entry points for each outfall. We used GIS analysis of recently captured LiDAR data to delineate storm watersheds for the entire stormwater system that drains into Mirror Lake.

This task was complicated because the Village of Lake Placid began a multi-year construction project to completely redesign the stormwater system and replace water and sewer lines under Main St. in 2021. The changes to the stormwater system presented challenges with ground truthing storm drain locations, as many were moved or replaced during this process. The data shown represents the stormwater system before its redesign.

Task 9-13: Stormwater Monitoring

In addition to delineating storm watersheds, we monitored the stormwater runoff entering Mirror Lake for sodium and chloride. Water samples and discharge estimates were collected during runoff events, and winter/spring runoff events were the highest priority for sampling. A small fraction of the total sampling effort occurred in the summer and fall to assess the relative contribution of de-icing salt, or lack thereof, during these times of the year. In addition, conductivity data loggers were installed in two outfalls to monitor stormwater discharge continuously.

Objective 3: Estimate the total amount of de-icing salt applied within the Chubb River watershed.

Task 14-15: Private Contractor/Business and Residential Salt Survey

We distributed a survey to private contractors, residences, and businesses within the Chubb River watershed that helped establish a greater understanding of salt used by the private sector. The survey focused broadly on de-icing and winter maintenance, whether chemical de-icing agents were used, and questions that could help estimate application rates. The largest applicators were followed up with to request annual purchase records for de-icing salt to help better estimate the total load of salt applied.

AsRA has good personal relationships with many members and leaders in the Lake Placid business community, including connections to the Lake Placid Business Association, which helped get survey responses. The survey was delivered in electronic and paper format through various sources, including distribution through local utility bills, and personal follow-up calls or visits were conducted to encourage participation.

Task 16-20: Municipal Salt Tracking

Fleet tracking and data logging devices were added to four municipal vehicles used to maintain the roads and sidewalks in the Chubb River watershed, specifically focusing on Mirror Lake. This included: one tandem plow truck from the Town of North Elba, one tandem and one small plow truck from the Village of Lake Placid, and the sidewalk sweeper/drop spreader used by the Village of Lake Placid to maintain the sidewalk around Mirror Lake. Applying fleet tracking and data logging devices to the entire fleet of vehicles used by the Town of North Elba and the Village of Lake Placid was not feasible within this project's scope. The data collected were used to estimate the salt load on all road and sidewalk surfaces maintained by the Town and Village.

Objective 4: Educate the public about the effects of de-icing salt on the environment and BMPs for de-icing salt reduction.

Task 21-23: Water Quality Workshops and Displays

Two water quality workshops were initially planned as part of this project but had to be canceled due to COVID restrictions and challenges. In place of these workshops, AsRA led a working group that convened local government, businesses, NYS DOT, and watershed groups to discuss de-icing salt reduction strategies within the Village of Lake Placid. This group met regularly throughout the project to discuss progress, share updates, and identify opportunities for further salt reduction.

A briefing of the project's achievements and takeaways was offered to the community in the summer of 2022. Held at the Uihlein Foundation’s Heaven Hill Farm, the briefing included presentations by Brendan Wiltse and Leanna Thalmann. Attendees included residents and town administrative personnel.

A critical aspect of addressing de-icing salt pollution holistically is to foster an engaged and informed public. Coupled with the working group, we designed interpretive signs around Mirror Lake. These displays tell the story of the Mirror Lake ecosystems, the challenges associated with stormwater runoff and de-icing salt, and the work being done to address these challenges.

3. METHODOLOGY

Task 2-6: Continuous Monitoring Stations and Lake Monitoring.

Each station consists of a Solinist Levelogger and a HOBO Conductivity logger. This equipment records stage, temperature, and conductivity at 30-minute intervals year-round. In addition, discharge measurements were taken using an acoustic doppler velocimeter every three weeks on average. Sampling visits were targeted to capture the full range of discharges experienced at each station. Finally, water samples were collected from each station during each visit to measure discharge. These samples were analyzed at the Adirondack Watershed Institute for the following parameters: Lab pH, Specific Conductance, Apparent Color, Chlorophyll-a, Total Phosphorus, Nitrate+Nitrite, Alkalinity, Chloride, Calcium, & Sodium using standard protocols (APHA, APHA 2510 B, APHA 2120 C, APHA 10200 H, APHA 4500-P H, APHA 4500-NO_3 I, EPA 301.2, EPA 300.0, EPA 200.7).

Figure 3. AsRA Water Quality Associate, Leanna Thalmann, collecting a water sample from Mirror Lake.

The discharge data was coupled with stage measurements to develop stage-discharge curves for each station (Figure A1). The logarithm of both stage and discharge were plotted, and a linear regression was used to predict discharge based on stage for each site. These models were used to estimate stream discharge on a 30-minute basis based on the continuous data collected from the Levelogger. A linear relationship between conductivity and chloride was also established for each station (Figure A1). The continuous discharge estimates were multiplied by the continuous chloride estimates to develop a continuous estimate of the chloride mass moving past each gaging station during the study period. Data were plotted continuously and summed from June 15 of one year to June 14 of the next to get annual estimates of the chloride export and yield (export standardized to the watershed area) for each station. The June-to-June window was used to coincide with the project period and fully capture when de-icing salt is applied each year.

To estimate the total chloride mass exported from the Chubb River watershed that exceeds the natural chloride yield, we used the three reference sites to calculate a continuous average chloride yield for the study period. This time series was then applied to the entire Chubb River watershed to estimate the total export of chloride from the watershed attributed to natural sources. The difference between the estimated natural export and the observed export at the lower Chubb site is assumed to be attributed to anthropogenic sources, primarily de-icing salts.

Mirror Lake was sampled bi-weekly during the project, except when it was unsafe to sample from the ice (Figure 3). Sampling included the collection of a 2-meter integrated surface water sample, a discrete sample one meter above the lake bottom, and profiles of temperature, dissolved oxygen, specific conductance, and pH at 1-meter intervals through the entire water column. A Secchi reading will also be recorded during each visit during the open water season.

Task 7-8: Storm-watershed Delineation.

One-meter digital elevation models (DEMs) for the Mirror Lake watershed were downloaded from USGS. The elevation data is of bare-earth surface and derived from high-resolution light detection and ranging (LiDAR) data captured at one-meter or higher solution. Five DEM tiles were needed to cover the Mirror Lake watershed, combined into a mosaic to create one continuous DEM for the watershed. Sinks in the DEM were then filled to facilitate accurate flow accumulation modeling. Flow direction was then determined for each raster cell using the D8 method. Finally, continuous flow accumulation was calculated from the flow direction raster. The flow accumulation raster was used to visually identify flow paths that led to individual stormwater drains. Individual storm drains were tied to outfalls discharging the lake using existing stormwater systems maps and ground truthing. Watersheds draining to each storm drain for a given outfall were delineated and combined to represent the total area draining to a specific outfall. All processing was completed in ArcGIS Pro 3.0.2.

Task 9-13: Stormwater Monitoring

All pipes discharging water to the surface of Mirror Lake were sampled during runoff events throughout the project period. During each sampling event, a water sample was collected, and field measurements of temperature, conductivity, dissolved oxygen, and pH were made. If possible, discharge was measured through a timed collection of water into a container of a known volume. When possible, three consecutive measurements were taken to measure discharge, and their values were averaged. Load and yield (based on the stormwater delineation) of chloride at each outfall were calculated for each sampling trip.

Task 14-15: Private Contractor/Business and Residential Salt Survey

The residential and commercial salt survey was delivered electronically using a Google Form, and paper forms were distributed to local businesses. A notice and link to the survey were also included in Village of Lake Placid utility bills to reach individuals who were not online or associated with a business. A summary of survey responses was developed and used to help guide outreach efforts around de-icing salt reduction practices.

Task 16-20: Municipal Salt Tracking

Salt tracking data was imported into ArcGIS, and points were labeled based on whether they were inside the Mirror Lake watershed. The total material applied within the watershed was summed by month and vehicle over the project period. For the three vehicles spreading a sand salt mixture, we assumed the salt constituted 9% of the mixture by mass based on information provided by the local highway departments. To determine the chloride mass, we multiplied the total salt applied by 0.61, which is the proportion of sodium chloride's mass attributed to the chloride ion. This gave us the total mass of chloride measured through the municipal salt tracking efforts.

4. QUALITY ASSURANCE TASKS COMPLETED

All quality assurance tasks were completed as outlined in the QAPP, except for an oversight on the collection of field blanks during the project's first year. Due to a change in an internal SOP that needed to be updated in a timely manner due to challenges associated with COVID, staff sick leave, and onboarding new personnel, field blanks were not being collected at the frequency described in the QAPP. This was addressed during a site visit with LCBP staff in July 2021 and subsequently determined to be a minor deviation by LCBP and NEIWPCC staff. The SOP was updated in the QAPP and followed for the rest of the project.

5. DELIVERABLES COMPLETED

Installation of three new continuous monitoring stations in the Chubb River sub-watershed with two full years of data collection.

All three stream stations (Mirror Lake Inlet, Mirror Lake Outlet, and Lake Placid Outlet) were installed and brought up to operational status in June 2020 and the two existing stations (Lower Chubb, Upper Chubb) were continued to be maintained. All scheduled field data collection, including discharge measurements and discrete water sampling, was conducted as outlined in the project workplan. Each station had a greater than 90% completeness for all records (Table A4). Gaps in the record were filled with a linear regression for the purposes of future analysis.

Rating curves for each site were developed using a linear fit to log-transformed data for both stage and discharge. All curves had significant relationships (alpha = 0.05) and explained between 86% and 99% of the variation in discharge (Table A3, Figure A1.). These curves were applied to the level (stage) data recorded by the data loggers. Discharge at all five sites exhibited seasonal variation typical for the region, with the highest flows recorded during periods of spring runoff and the lowest flows during summer and early fall (Figure 4).

Conductivity chloride relationships were developed at each site using linear regression. Three of the five sites had significant relationships (alpha = 0.05). Mirror Lake Inlet and Mirror Lake Outlet did not have a significant relationship between conductivity and chloride due to the low chloride concentration at these sites and a limited range of variation (Table A3, Figure A1). The linear regression was used at these sites despite the non-significance because it better approximates the anticipated chloride variation than applying a mean or median. Additionally, the regression slope at the Mirror Lake inlet is close to zero, which means the fit line approximates the global mean at this site. And at the Lake Placid outlet, a trend is observed in the data even though the relationship is deemed non-significant at an alpha of 0.05. Given the low concentrations of chloride at these sites, using the regressions or an estimate of central tendency would keep the overall conclusions of this analysis the same.

The chloride concentrations at the five sites vary from less than 1 mg/L to 60 mg/L. The Lower Chubb, Upper Chubb, and Mirror Lake inlet sites show clear dilution patterns during high-flow events. The Lake Placid Outlet and Mirror Lake Outlet do not display this trend as clearly because the retention capacity of the respective lakes dominates these sites. Therefore, large runoff events at these sites do not translate as directly to reduced chloride concentrations (Figure 5).

The chloride export from each site was largely driven by changes in discharge. The exception is the Lower Chubb site which had more short-period variation in chloride concentration and export than the other sites. Exports ranged from less than 1 to over 120 g/s across the five sites. Because export is primarily a function of watershed area and discharge, the data were standardized by watershed area through the calculation of yield (g/s/ha). Yields at the reference sites (Mirror Lake Inlet, Lake Placid Outlet, Upper Chubb) were all much lower than the impacted sites (Mirror Lake Outlet, Lower Chubb; Figure 6).

Chloride yields from the three unimpacted sites were used to estimate the total background or natural chloride export from the Chubb River subwatershed (Figure 7). This equaled 53.26 metric tons over the 2020-2021 season and 61.40 metric tons over the 2021-2022 season. Subtracting these values from the total observed export at the Lower Chubb site provides an estimate of the additional chloride loading in the watershed due to anthropogenic sources, primarily road de-icing salts. Over the 2020-2021 season, 1,140.56 metric tons of excess chloride were exported from the watershed, and over the 2021-2022 season, 1,019.70 metric tons of excess chloride were exported.

The same process outlined above was used to estimate the background export from the Mirror Lake watershed. This equaled 0.70 metric tons over the 2020-2021 season and 0.92 metric tons over the 2021-2022 season. The additional export estimates for Mirror Lake are 29.20 metric tons for the 2020-2021 season and 37.88 metric tons for the 2021-2022 season. It is important to note that these estimates are only for export through the lake outlet and do not account for export to groundwater. Based on the mass of chloride in the lake and the retention time of the lake, we estimate the total net export from the lake to be 94.45 metric tons over the 2020-2021 season and 89.45 metric tons over the 2021-2022 season.

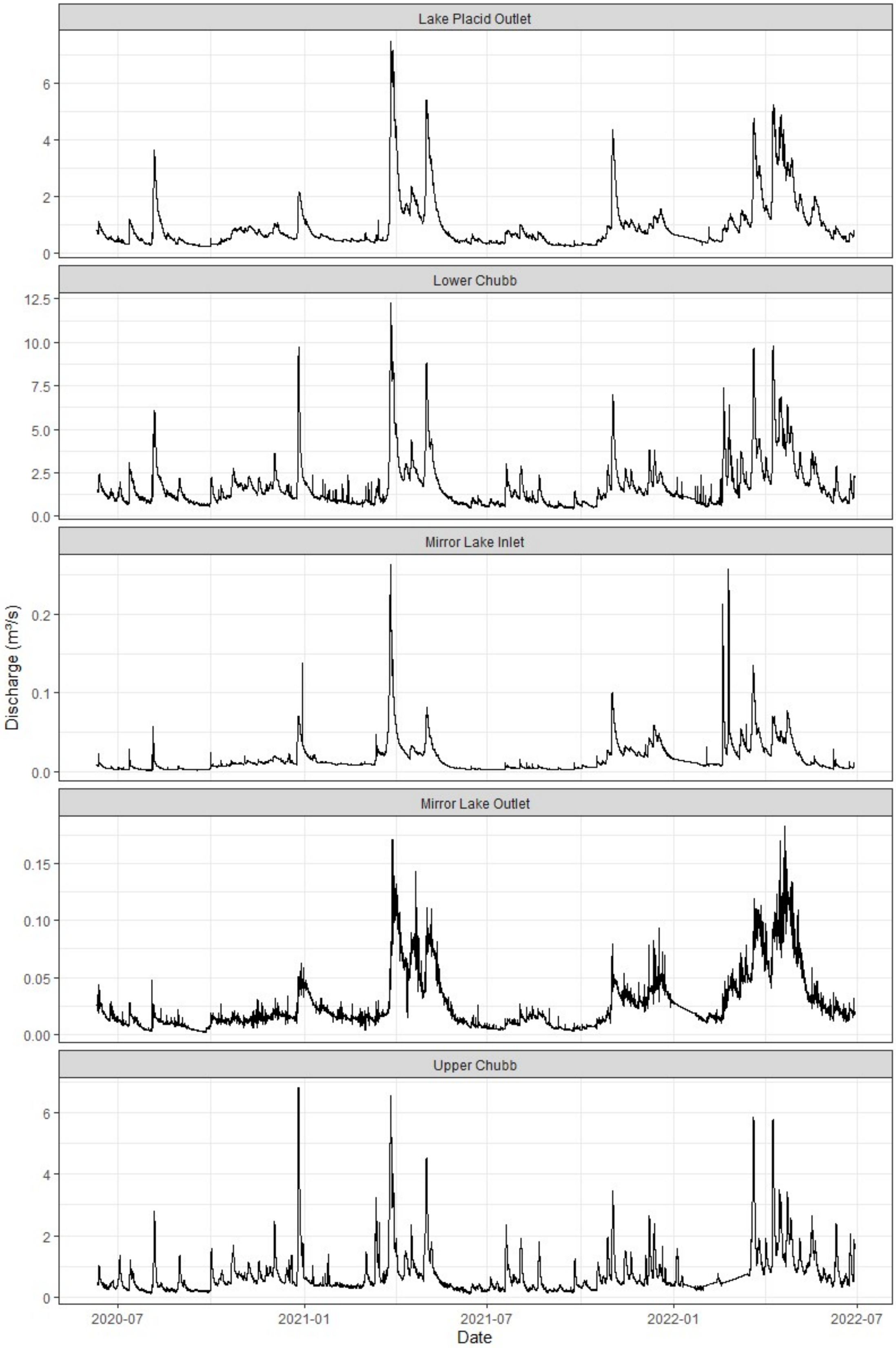

Figure 4. Discharge for the five stream sites in the Chubb River subwatershed.

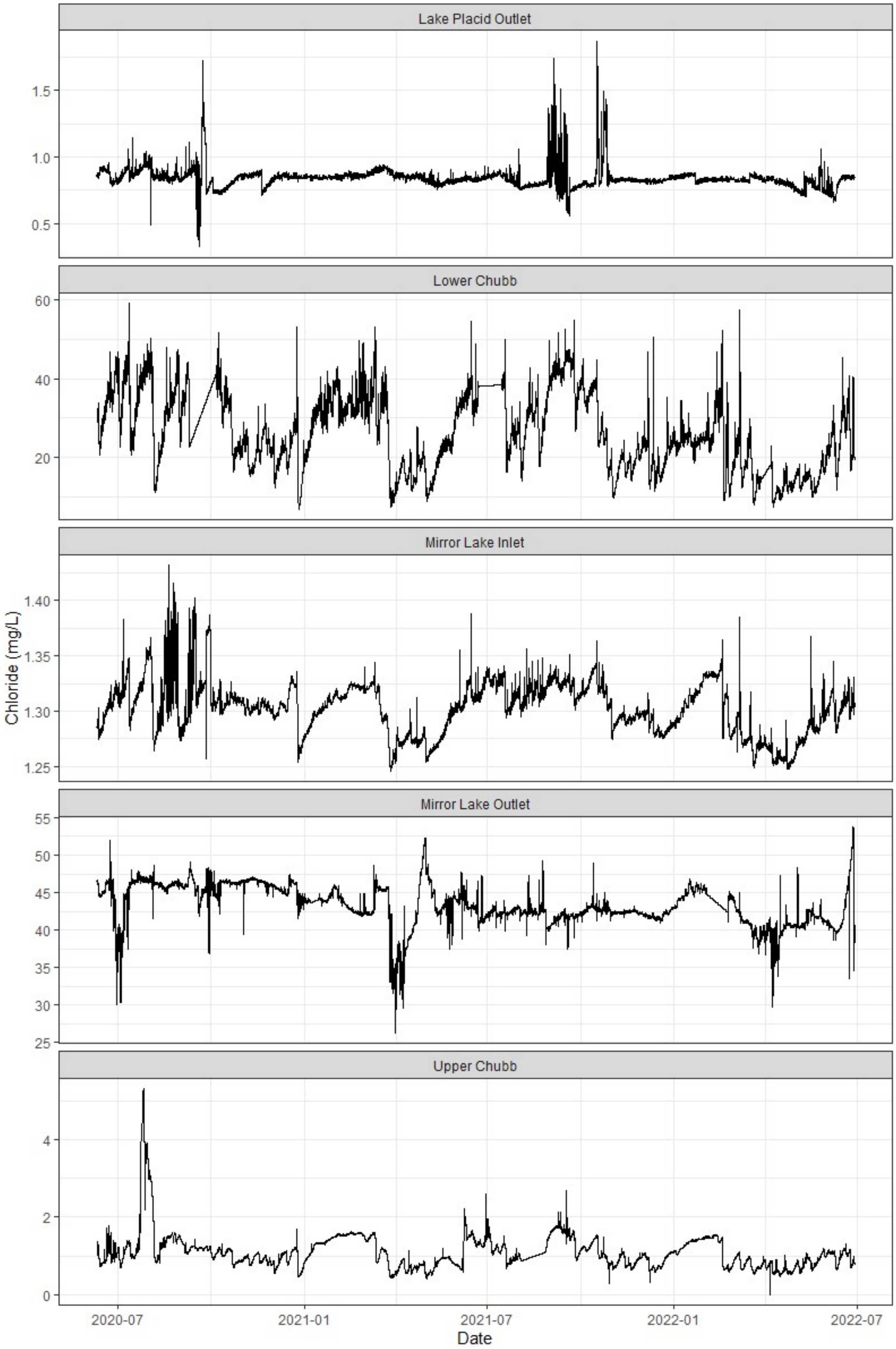

Figure 5. Chloride concentration for the five stream sites in the Chubb River subwatershed.

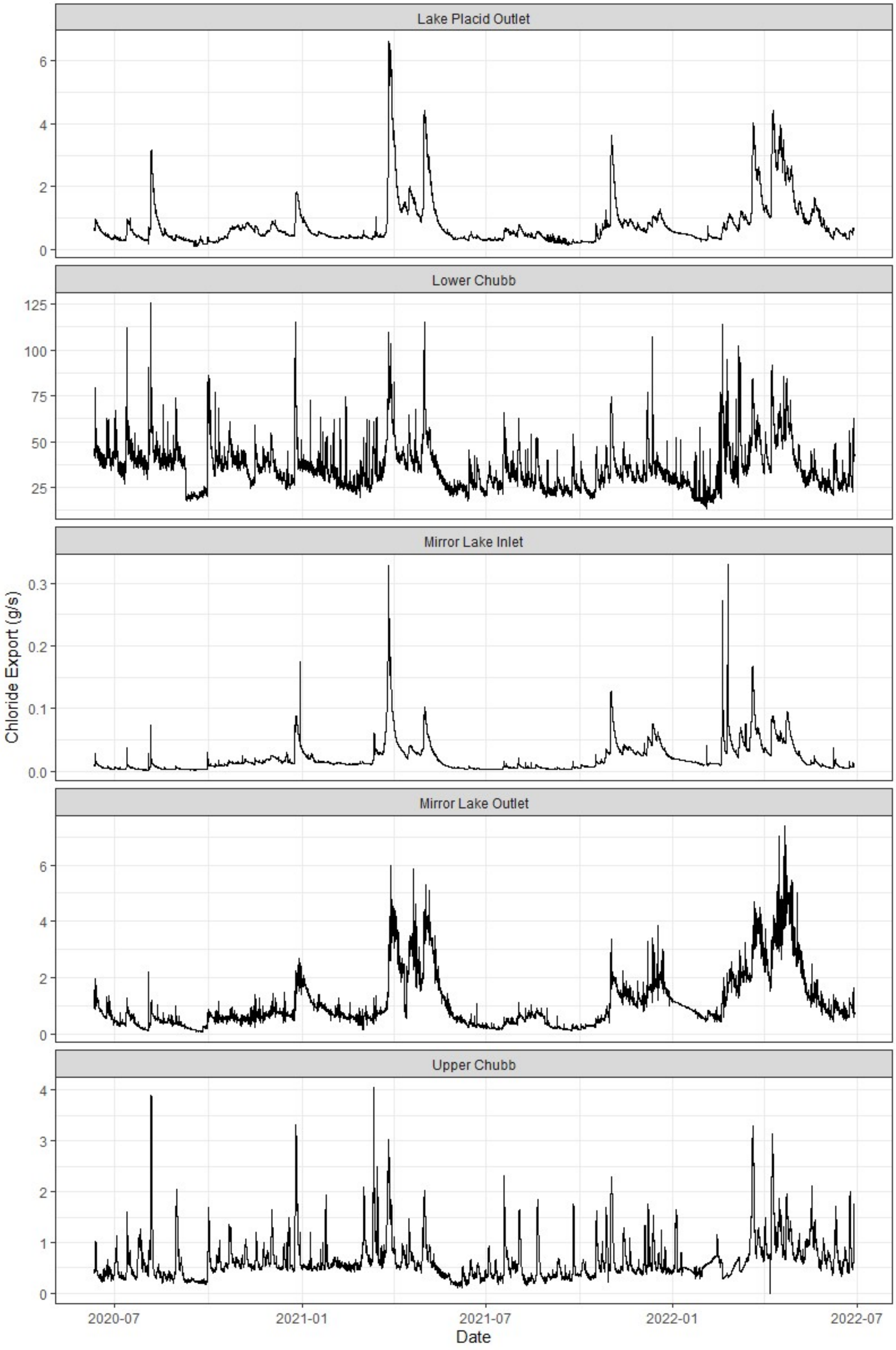

Figure 6. Chloride export for the five stream sites in the Chubb River subwatershed.

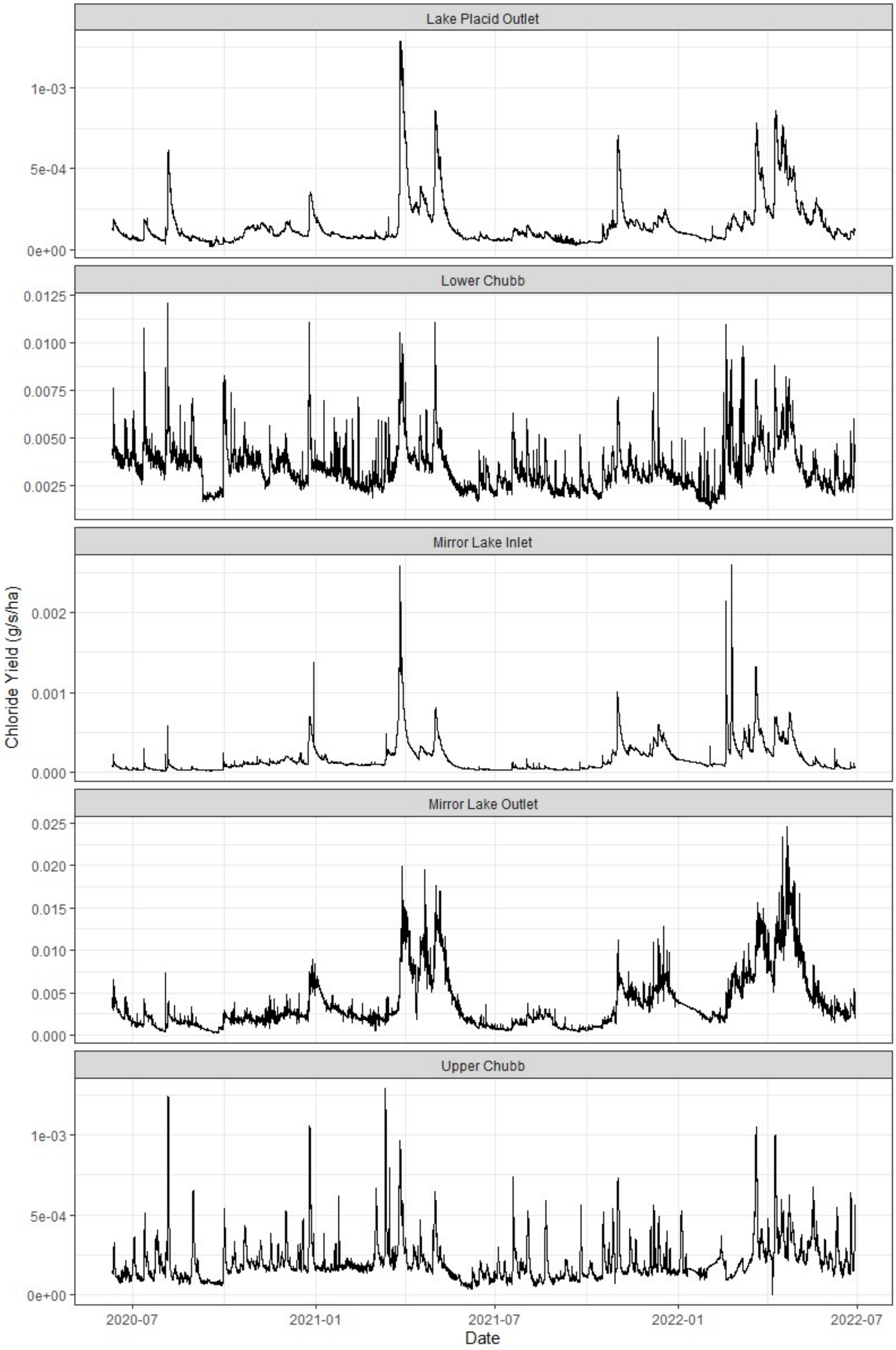

Figure 7. Chloride yield for the five stream sites in the Chubb River subwatershed.

Vertical conductivity profiles and the conductivity-chloride relationship published by Wiltse et al. (2020) were used to develop vertical chloride profiles. The concentration of chloride in Mirror Lake varies through both space and time. Historically, strong vertical gradients of chloride existed in Mirror Lake, driven by the elevated density of stormwater runoff with high salt concentrations. These density differences reduce spring mixing, which has a variety of implications for the physics, chemistry, and biology of the lake. Over the winter of 2019-2020, we saw a noticeable reduction in chloride concentrations at the lake bottom. This season preceded the execution of this grant but coincided with the grant award announcement, which helped motivate local government, businesses, and residents to start exploring salt reduction strategies in the watershed. Further reductions were seen over the 2020-2021 and 2021-2022 winter seasons. The lake completely turned over, or mixed, in the spring of 2020 and 2022, something that had not occurred since 2016 following an abnormally mild winter (Figure 8).

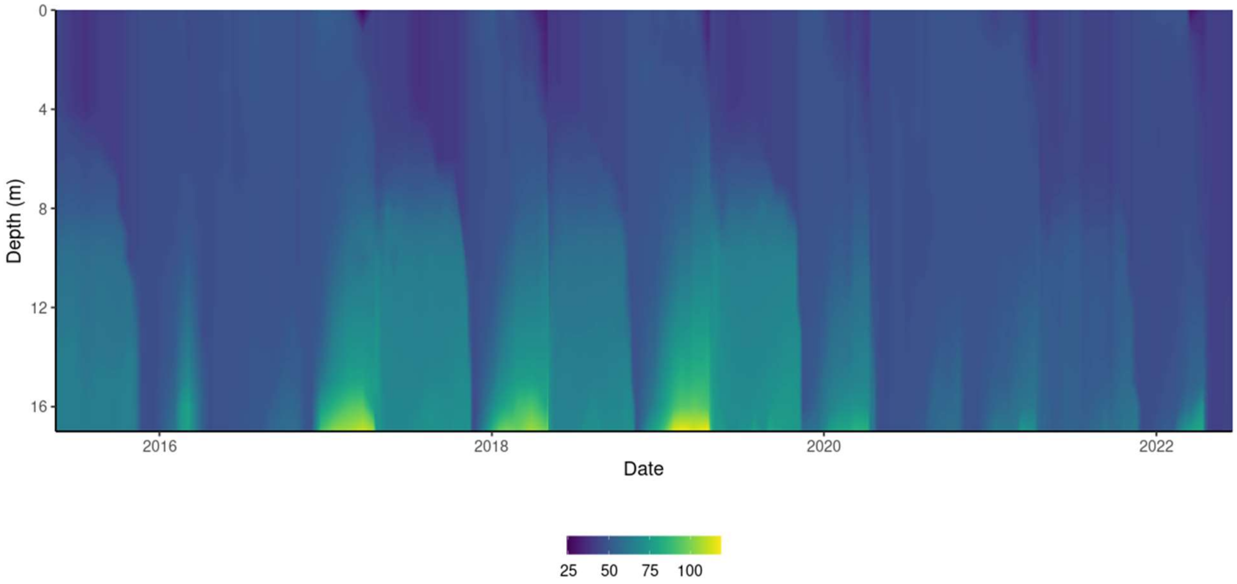

Figure 8. Heatmap plot of chloride concentration in Mirror Lake from May 2015 through July 2022.

The in-lake chloride data was combined with bathymetric data for the lake to determine the total mass of chloride retained. From 2016 through 2019, the chloride retention in the lake followed a distinct seasonal pattern, with retention increasing during the winter while de-icing salt application was occurring in the watershed and retention decreasing during the spring when elevated runoff is occurring. Overall retention in the lake was also trending upward during this period. Beginning with the winter of 2019-2020, this pattern changed, with a much-reduced increase in retention occurring in the winter. An overall decline in retention started at this time as well. This is tied to a combination of changes in de-icing salt practices and stormwater improvements, as are discussed in later sections of this report. Though, the onset of this decline in retention pre-dates the stormwater system changes, suggesting that the best management practices implemented positively affect Mirror Lake (Figure 9).

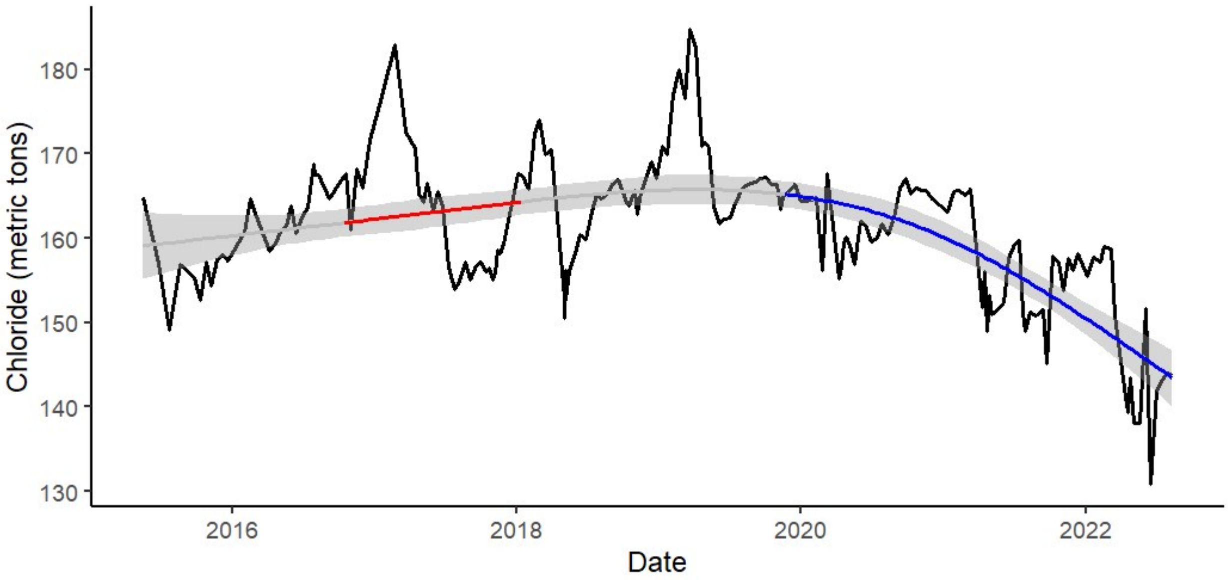

Figure 9. Chloride retention in Mirror Lake from May 2015 to July 2022. The fit line is a generalized additive model (GAM). The red line represents periods when the first derivative (slope) of the GAM is positive, and the blue line represents where the first derivative is negative.

LIDAR based stormwater runoff model

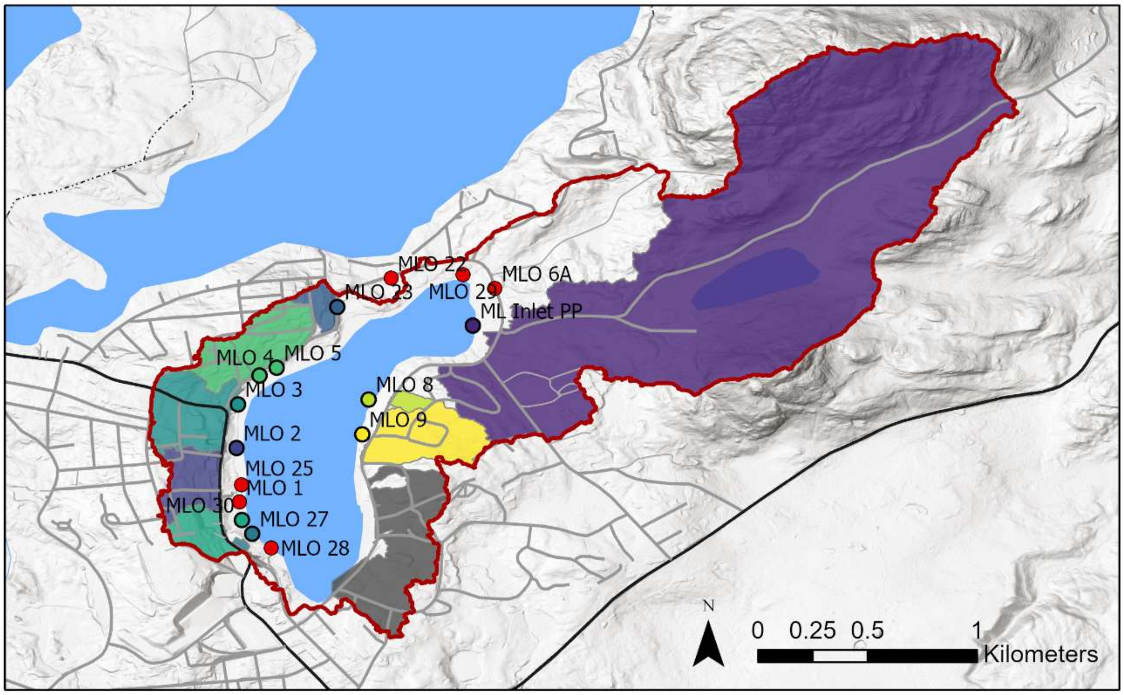

Figure 10. Map showing the areas of the Mirror Lake watershed draining to specific stormwater outfalls. Colors correspond to the associated outfall points. Red points indicate outfalls that were either not in the watershed or determined not to be part of the stormwater system. The grey area drains to storm drains that discharge to a small pond on the Lake Placid Club golf course that is outside of the Mirror Lake watershed. Note that the inlet pour point (Inlet PP) is different from the inlet stream station, which is located upstream. The inlet of Mirror Lake combines with the stormwater system at Mirror Lake Drive before flowing to the lake.

The LiDAR-based stormwater runoff model identifies areas of the Mirror Lake watershed draining to specific stormwater outfalls flowing to the lake (Figure 10). During the project execution, the Village of Lake Placid made substantial changes to the stormwater system along Main Street. The map produced here represents the system before the recent changes. We anticipate that the current system is similar, except that the flows along Main St. now enter underground retention basins and will only flow directly to the lake when runoff exceeds the capacity of those basins to retain runoff.

While sampling outfalls entering the lake, several were identified that appeared not to be tied to the stormwater system, or the runoff model identified them as not being in the Mirror Lake watershed. Many of these were smaller diameter PVC pipes not commonly used as part of a stormwater system and are likely connected to gutters, French drains, or sump pumps. Additionally, a series of outfalls along the lake's southeastern shore are no longer connected to the stormwater system due to prior improvements. This area is shaded grey in the stormwater runoff map and is now draining to a system that routes discharge underground to a pond on the Lake Placid Club golf course outside the Mirror Lake watershed. This creates an interesting and complex hydrological situation in this portion of the watershed. Surface runoff in the grey area is no longer part of the Mirror Lake watershed, but infiltration in this area likely is.

Stormwater Conductivity Data Loggers

The data loggers installed in two stormwater outfalls entering the lake revealed noticeable differences in conductivity at the two sites. The logger installed in the outfall that drains only local roads, parking lots, and sidewalks exhibited episodic spikes in conductivity throughout the winter season of both years associated with the de-icing salt application. The logger installed in the outfall that drains local roads, parking lots, sidewalks, and state roads exhibited higher and more frequent spikes in conductivity. The logger regularly exceeded the operating specifications during the 2020-2021 winter season. A noticeable change in the conductivity occurred at this outfall in the second season of deployment (2021-2022) that reflect changes in the stormwater system leading to the outfall. This outfall was one of several on Main St. with large underground retention basins installed within the stormwater system before the outfall. A marked decline in conductivity spikes occurred, demonstrating the effectiveness of the new stormwater system in reducing direct discharge to the lake (Figure 11).

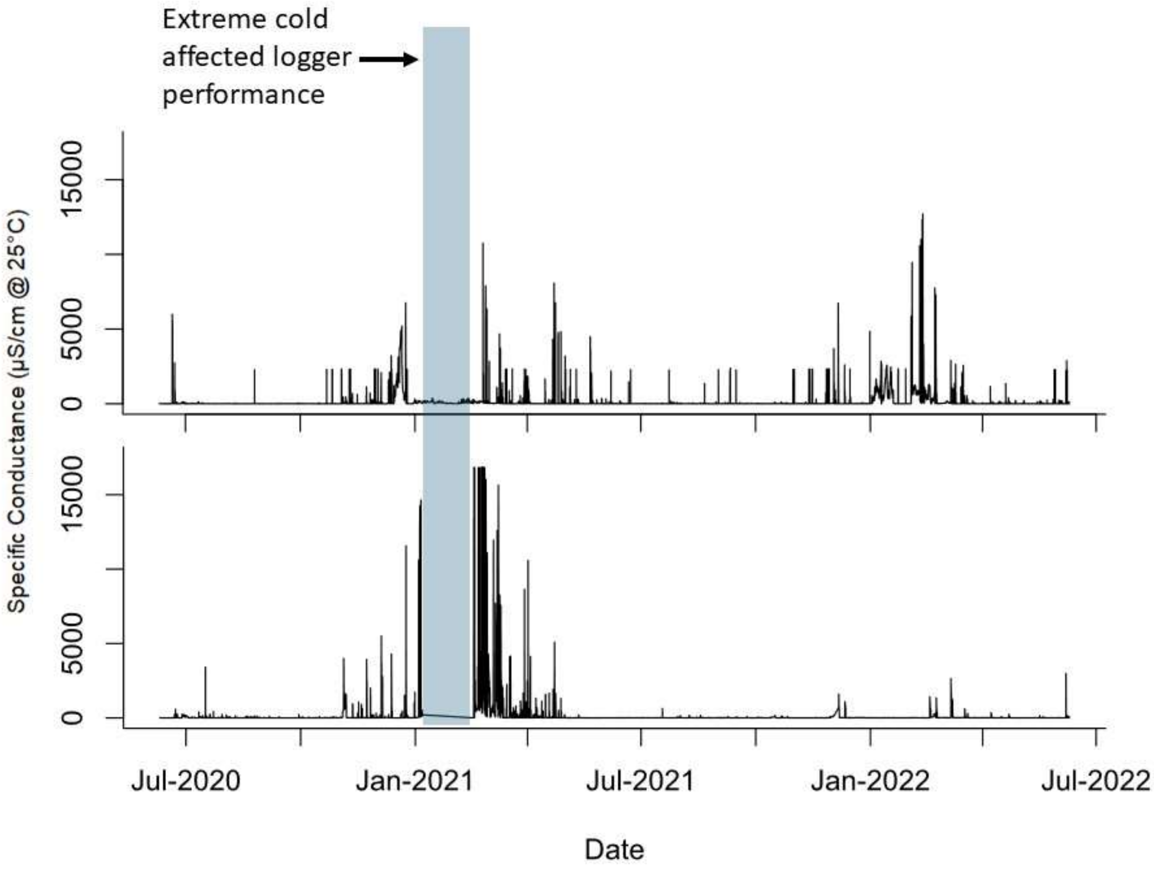

Figure 11. Continuous conductivity logger data for two stormwater outfalls. Top panel: MLO 4, bottom panel: MLO 3. The top panel drains an area that includes local roads, parking lots, sidewalks, and driveways. The bottom panel drains all the same areas plus state road.

Stormwater Data

Stormwater samples were collected from any pipe or outfall flowing into Mirror Lake. Upon completion of the stormwater runoff model and review of the data collected, it was determined that several of these sites are discharging water other than stormwater; this may be from a French drain, roof runoff, sump pumps, etc. Additionally, some outfalls were either difficult or impossible or impossible to sample because they discharge below or partially below the lake's surface (ex. MLO 30). In some cases, water samples could be collected from an outfall, but the discharge was not because the discharge pipes were too close to the lake surface to fit a bucket beneath to measure discharge volume (ex. MLO 2 & MLO 27). Finally, these site-specific challenges varied by time of year based on ice, snow, and water level. Here we are presenting data from the nine outfalls that were mapped as part of the runoff model (Figure 10).

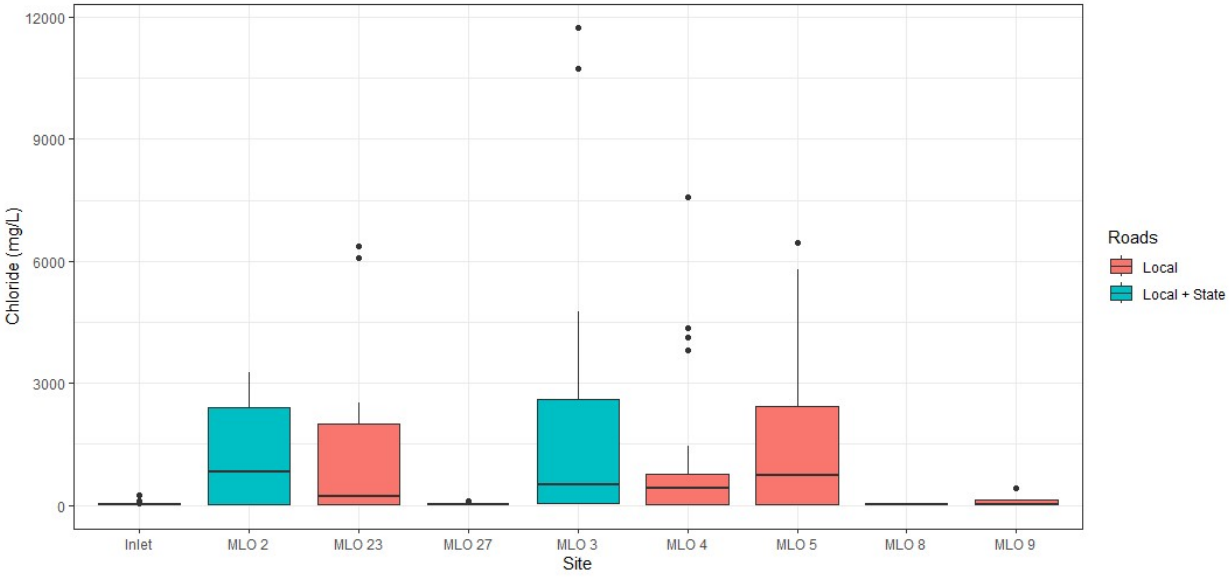

Figure 12. Box plot of chloride concentrations for outfalls discharging directly to Mirror Lake.

Chloride concentrations ranged from a minimum of 2.98 mg/L at MLO 8 to 11,738 mg/L at MLO 3. In general, we saw higher concentrations at outfalls along the western side of the lake and similar concentrations among the western outfalls regardless of whether they were draining only local roads or local and state roads. One exception to this is MLO 27 which enters the lake on the southwestern shore of the lake and is only draining runoff from the Golden Arrow Lakeside Resort parking lot (Figure 12).

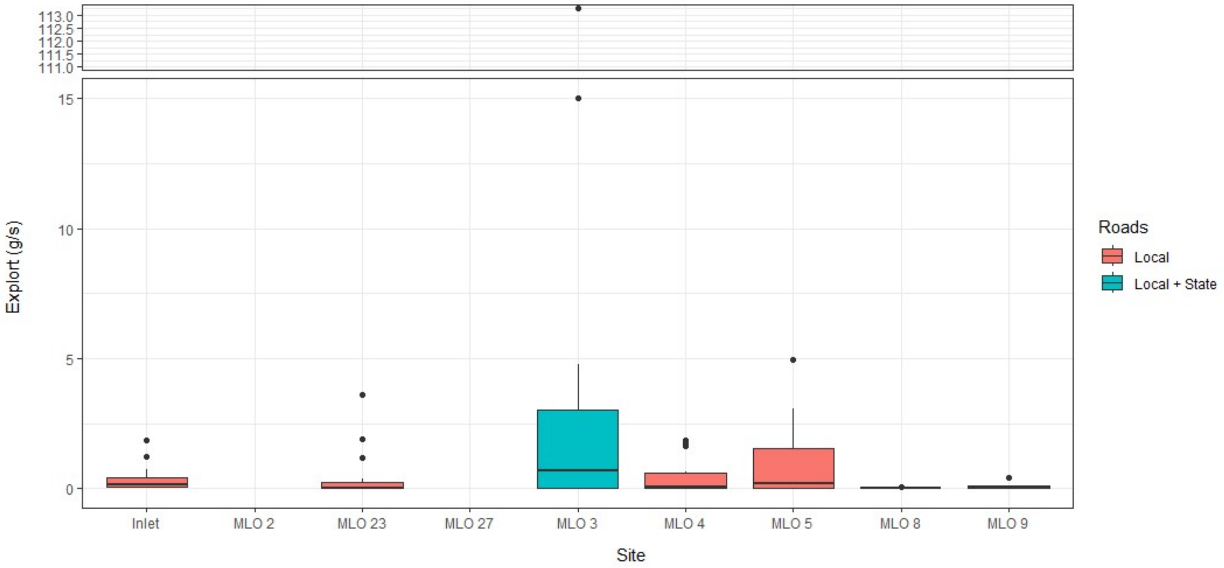

Figure 13. Box plot of chloride export for outfalls discharging directly to Mirror Lake. Note the axis break associated with the outlier for MLO 3.

Chloride export ranged from 2.9×10^{-6} g/s at MLO 23 to 113 g/s at MLO 3. The median export at MLO 3 (0.706 g/s) was 4.9 times higher than the next highest outfall (MLO 5). This outfall drains a large portion of the state road that runs through the watershed, including a stretch of road that is on a steep hill going down to the lake. Unfortunately, discharge data could not be collected at MLO 2, another outfall that drains Main St. and state road. MLO 3 had generally higher chloride export than any other outfall. However, it is worth noting that this outfall was part of the stormwater redesign and had a significant reduction in discharge as a result. This is the outfall with a conductivity logger that showed a reduction in conductivity spikes over the 2021-2022 season (Figure 13).

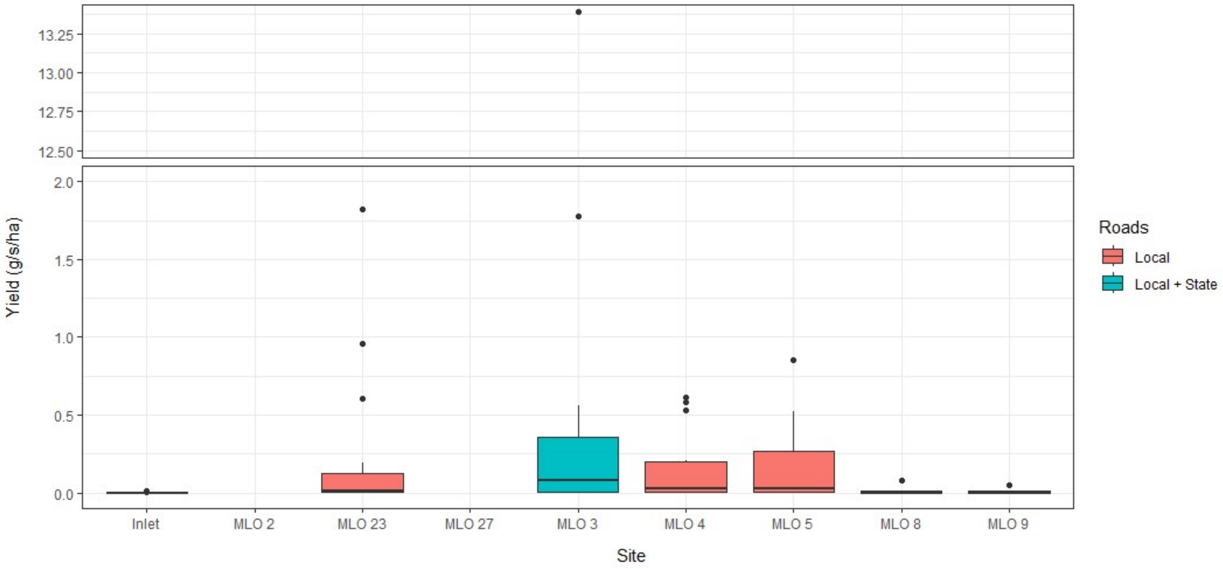

Figure 14. . Box plot of chloride yield for outfalls discharging directly to Mirror Lake. Note the axis break associated with the outlier for MLO 3.

Utilizing the storm-watershed delineation, we can calculate the chloride yield from each outfall. This standardizes the chloride mass exported to the watershed area, allowing better comparisons between sites. The minimum yield was observed at the inlet outfall at 5.7 x 10^{-7} g/s/ha, and the maximum was observed at MLO 3 at 13.4 g/s/ha. The highest median yield was also observed at MLO 3 (0.71 g/s/ha). Similar to the pattern seen with the concentration data, the highest yields were observed at outfalls along the western side of the lake, regardless of road type draining to the outfall (Figure 14).

Municipal Salt Application Data

Salt use data were collected from the Town of North Elba and the Village of Lake Placid within the Mirror Lake watershed. At the start of the project, two salt tracking units were installed on the Town of North Elba’s trucks, one unit on the Village of Lake Placid’s truck, and one unit on the village’s sidewalk sweeper. It was later discovered that one of the two Town of North Elba trucks was not operating in the Mirror Lake watershed and one village truck without tracking equipment was. The tracking hardware from the North Elba truck was moved to the village truck to address this deficiency in December 2020.

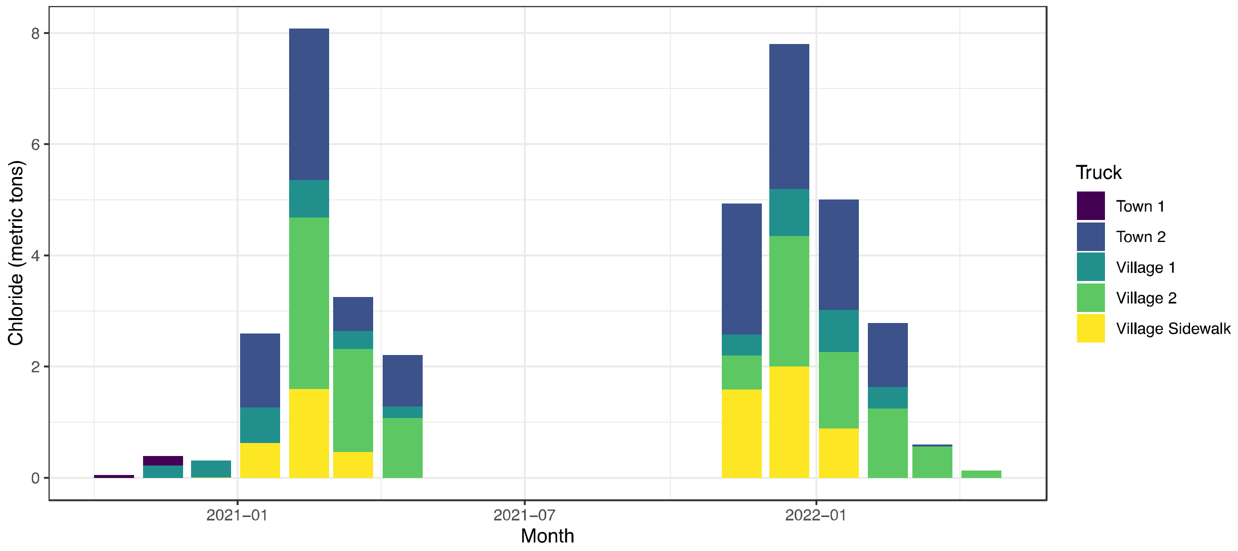

Figure 15. Estimate of chloride load from municipal application to road and sidewalks within the Mirror Lake watershed.

The salt tracking effort faced several challenges throughout the project. One major initial challenge was outfitting the village sidewalk sweeper with the appropriate data loggers. The technology depends on measuring the rotations of the material auger to monitor material application. Installing this technology on a small sidewalk sweeper required unanticipated modifications to the equipment, given that this is a non-standard application of the technology. There were also instances of vehicles being out of service for maintenance and repairs. It was challenging to fully document these issues due to the complex and seasonally demanding nature of local highway department operations. The most consistent and complete record exists for the 2021-2022 season. All data should be viewed as minimum material applied.

In total, we measured 16.86 metric tons of chloride applied to the watershed over the 2020-2021 season and 21.22 metric tons over the 2021-2022 season. Of this, 14.18 & 16.76 metric tons were from road application, and 2.68 & 3.46 metric tons were from sidewalk application over these two seasons, respectively. State salt application data was not applied to be obtained in time for this report due to a requirement to go through a lengthy freedom of information law request process. Estimates of the average salt application rates for state roads indicate that the average chloride load from the state road would be 31.58 metric tons annually (Kelting & Laxson 2010). This brings the total estimated chloride load to the watershed to 48.44 & 52.8 metric tons annually over the two winter seasons. The increase in estimated chloride load between the two seasons may not be real, given the uncertainty in the salt tracking data. In fact, it is possible that the increase is simply a reflection of better data collection in the second season (Figure 15).

Throughout this project, several changes in road and sidewalk management occurred that complicated our understanding of the deicing salt pollution load to Mirror Lake and the Chubb River. Both municipalities and the state were implementing and assessing various best management practices; these include the use of “live edge” plows supported through this grant, targeted reduction of material application within the watershed, a reduction in overall material application rates, changes in sidewalk sweeping and salt application practices, road and stormwater improvements, and other practices. Therefore, application data collected as part of this project is likely not representative of the historical practices that resulted in the pollution of Mirror Lake. While we do not have data to quantify the reduction in de-icing salt application that has occurred over the past several years, the in-lake chloride data suggests that these practices have been effective because the decline in chloride retention began before the stormwater improvements made in 2021.

*Table 1. Estimate of the chloride load to Mirror Lake from different sources over the project period. *State road application is estimated from Kelting & Laxson (2010). **Unaccounted is the difference between the total and accounted-for sources (local roads, sidewalks, state roads).*

	2020-2021		**2021-2022**	
Source	Chloride (mt)	Percentage	Chloride (mt)	Percentage
Local Roads	14.18	15%	16.76	19%
State Road*	31.58	33%	31.58	35%
Sidewalk	2.68	3%	3.46	4%
Unaccounted**	46.01	49%	37.65	42%
Total***	94.45	100%	89.45	100%

Salt Survey

We received 116 responses to the salt survey sent to businesses, contractors, and residents. 101 of the responses to the salt survey were in the target area. The salt survey was broken down by maintenance areas, including sidewalks, driveways, and parking lots.

Sidewalks

Of the 101 responses, 66 of the respondents maintain a sidewalk. Winter maintenance practices used on sidewalks varied. Of the respondents that maintained a sidewalk, all used a shovel, and 13 people responded that they used salt (Figure 16). Respondents were also asked what level of service they hoped to achieve with their sidewalk maintenance practices. 26 of the respondents aimed for hardpack snow that may have ice present (Figure 17). Survey takers were given the option to respond with “other,” and those who did emphasized their concern with safety. Fourteen of the responses used a sidewalk or entryway deicing product (Table A6). Of the responses, 13 out of 14 used a chloride-based deicing product. One responder used an alternative to chloride. Only three people used two products, and one person used three different deicing products (Table A6). These additional products were all chloride-based.

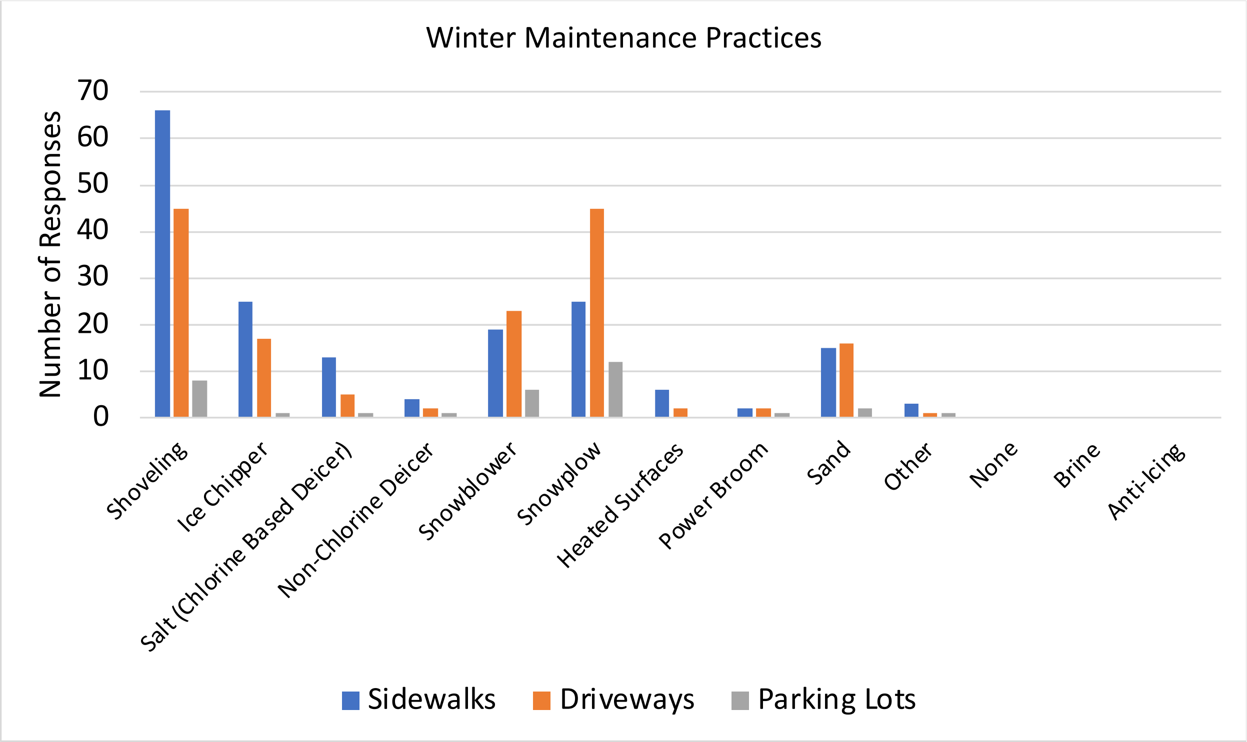

Figure 16. Winter maintenance practices summary by sidewalk, driveway, or parking lot.

Figure 17. Level of service aimed to achieve in winter sidewalk maintenance.

Driveways

Sixty-four people responded that they maintained a driveway. Of those, 64 people primarily used a snowplow or blower, 16 used sand, five used salt, and two used a non-chloride-based de-icer (Figure 16). Most respondents aimed to achieve a hard snowpack with some ice present, but 12 respondents did aim to achieve wet pavement with residual snow and ice present (Figure 18). Of the 64 responses for driveways, five people responded yes to using a deicing product (Table A7). For the survey, most of the salt used was on driveways.

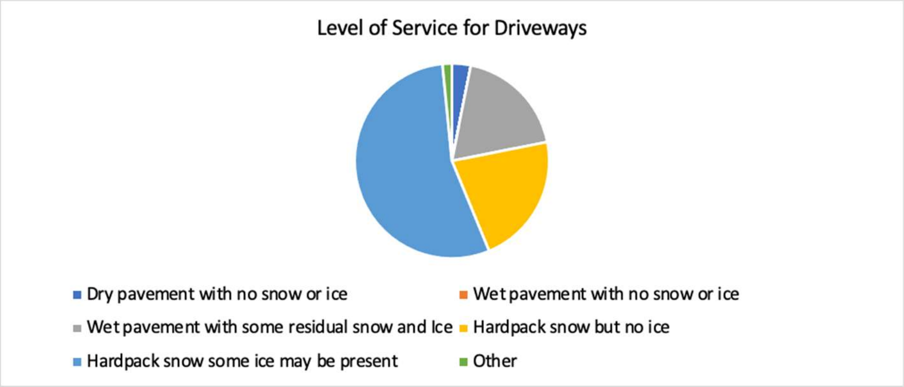

Figure 18. Respondents who maintained a driveway aimed to achieve this level of service.

Parking Lots

Twelve people who completed the survey maintained a parking lot. All responded that they use a plow, half use a snow blower, and eight use a shovel (Figure 16). Although one person said they used salt, and one used a non-chloride de-icer, no one responded that they use a deicing product on their parking lot. Attempts were made to reach these responders for more details, but product names and types were not collected. For the level of service question, most people aim for hardpack snow that may have some ice present (Figure 19).

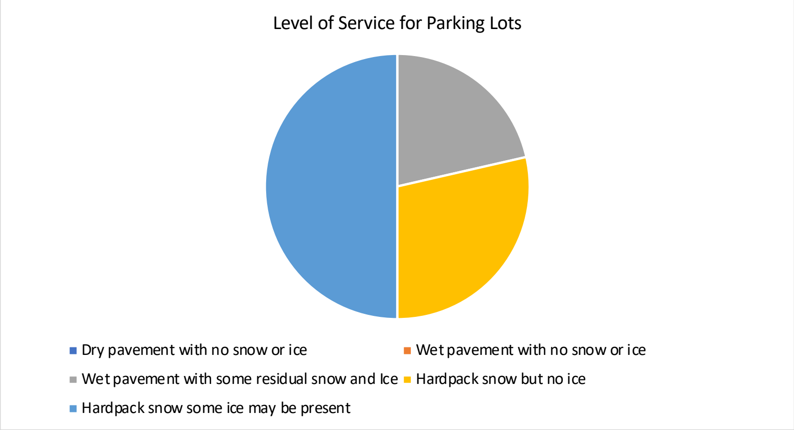

Figure 19. Parking lot level of service.

Education & Outreach

Four colorful and accessible interpretive signs were installed in early October 2022 (Figure 20). They provide information on the aquatic food web, the watershed, de-icing salt impacts, and monitoring efforts on Mirror Lake. The signs were installed by the Village of Lake Placid Highway Department. A visitor can walk around Mirror Lake and see all four signs. The signs are located around Mirror Lake at Mid's Park, Brewster Parkette, the public beach, and at the boat launch easement. A press release was picked up by local news outlets and businesses in the area. A blog was produced and added to the Ausableriver.org website and was featured in the Ausable River Association's e-newsletter.

Press Release Link:https://www.adirondackalmanack.com/2022/10/new-educational-signs-installed-around-mirror-lake.html

Blog Link: https://www.ausableriver.org/blog/new-educational-signs-installed-around-mirror-lake

Figure 20. Visitors reading an interpretive sign next to Mirror Lake installed with the support of LCBP.

AsRA and AWI staff held fourteen events that reached 282 people over the course of this project. These education and outreach efforts include outreach to businesses, municipal partners, high school classes, college classes, and community groups (Table 2). Presentations to regional groups and academic institutions represent an interest in using Mirror Lake as a case-study for salt reduction efforts. Additionally, both AWI and AsRA engaged with local school to get high school aged youth involved with water quality monitoring and salt reduction efforts.

Table 2. Summary of education and outreach events held over the course of this project.

Date	Event	Summary	# of Attendees
August, 2020	Adirondack Water Week	Presentation given at Adirondack Water Week 2020.	75
April, 2021	Salt Use Reduction Initiative Working Group Meeting	Working group meeting with the Village of Lake Placid, the Town of North Elba, highway departments, and local leaders to discuss salt use reduction in Lake Placid.	13
July, 2021	Mirror Lake Watershed Monthly Meeting	The Mirror Lake Watershed Association holds monthly meetings. An update on Mirror Lake work was given.	10
September, 2021	Lake Placid High School	Presentation given to Lake Placid High School students on de-icing salt best management practices to aid in their school project.	8

November, 2021	University of Albany	Presentation given to University of Albany Adirondack Environment class on de-icing salt impacts to the region with emphasis on Mirror Lake as a case study.	22
February, 2022	Salt Use Reduction Initiative Working Group Meeting	Working group meeting with the Village of Lake Placid, the Town of North Elba, highway departments, and local leaders to discuss salt use reduction in Lake Placid.	15
February, 2022	Paul Smith's College	Presentation given to Paul Smith's College Environmental Chemistry class on de-icing salt and impacts to Mirror Lake.	15
March, 2022	Skaneateles Lake Municipal Partnership	Presentation given to the Skaneateles Lake Municipal Partnership as a case study for addressing de-icing salt pollution.	43
April, 2022	Lake Placid Rotary Club Meeting	Leanna led a presentation on the Mirror Lake grant work with emphasis on the Salt Survey.	15
August, 2022	Mirror Lake Public Meeting	We discussed the work on Mirror Lake, findings of the study, and outreach efforts.	16
September, 2022	Northwood School	Leanna gave a lesson to Marcy Fagan's biology class. We discusses nonpoint, and point source pollution, de-icing salt, and delineated the Mirror Lake watershed.	15
September, 2022	Shipman Youth Center Event at Lake Placid Outlet	Leanna led a field based activity. The students sampled the Lake Placid outlet for chloride, phosphorus and nitrogen.	5
October, 2022	Mirror Lake Watershed Monthly Meeting	The Mirror Lake Watershed Association holds monthly meetings. An update on Mirror Lake work was given.	10
October, 2022	Lake Placid Lions Club Meeting	Leanna led a presentation on Mirror Lake, de-icing salt, the salt use reduction initiative, and watershed science.	20

6. CONCLUSIONS

This project captured data essential to understanding the de-icing salt pollution load to the Mirror Lake and Chubb River watersheds. The stream, in-lake, and stormwater data provide an important reference for chloride yields and loads from urban areas within the Lake Champlain basin and underscore the importance of de-icing salt best management practices and stormwater management. Importantly, this work determined that de-icing salt application to roads accounts for approximately half the total salt load in urban environments. This finding highlights the importance of working with commercial and private applicators in these areas. This project also highlights the challenges of quantifying the de-icing salt pollution load using salt tracking equipment on municipal and state trucks. Better and improved standard practices around municipal salting tracking are needed if this technology is going to be used to estimate pollutant loads. From a practical perspective, ecosystem monitoring was more effective and reliable in understanding the de-icing salt load in the Mirror Lake and Chubb River subwatershed. Future work in the basin should focus on understanding external factors influencing de-icing salt application, such as weather and climate. While at the same time, it is critical that long-term monitoring efforts capable of quantifying the chloride load to lakes, streams, and rivers continue to track progress toward salt reduction.

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8. APPENDICES

Appendix 1: Stream Regressions Statistics & Completeness Report

Table A3. Rating curve and conductivity chloride relationship regression equation and statistics for each site.

	Rating Curves			Conductivity Chloride Relationship		
Site	Equation	R^2	p-value	Equation	R^2	p-value
Lake Placid Outlet	y = 2.8x + 0.94	0.99	<0.001	y = 0.0x + 0.18	0.04	0.25
Lower Chubb	y = 2.0x + 1.02	0.93	<0.001	y = 0.2x + 2.14	0.69	<0.001
Mirror Lake Inlet	y = 4.0x + 0.39	0.89	<0.001	y = 0.0x + 1.18	0.00	0.71
Mirror Lake Outlet	y = 3.8x + 0.81	0.86	<0.001	y = 0.2x + 1.30	0.58	<0.001
Upper Chubb	y = 1.8x + 1.05	0.97	<0.001	y = 0.0x – 0.03	0.54	<0.001

Table A4. Summary of the total duration of missing and quality control flagged points within each record.

	Level Logger		Conductivity Logger	
Site	Days	% of Record	Days	% of Record
Lake Placid Outlet	56.5	7.7	0.0	0.0
Lower Chubb	11.3	1.5	62.5	8.6
Mirror Lake Inlet	20.4	2.8	0.0	0.0
Mirror Lake Outlet	20.4	2.8	39.9	5.5
Upper Chubb	40.8	5.6	25.1	3.4

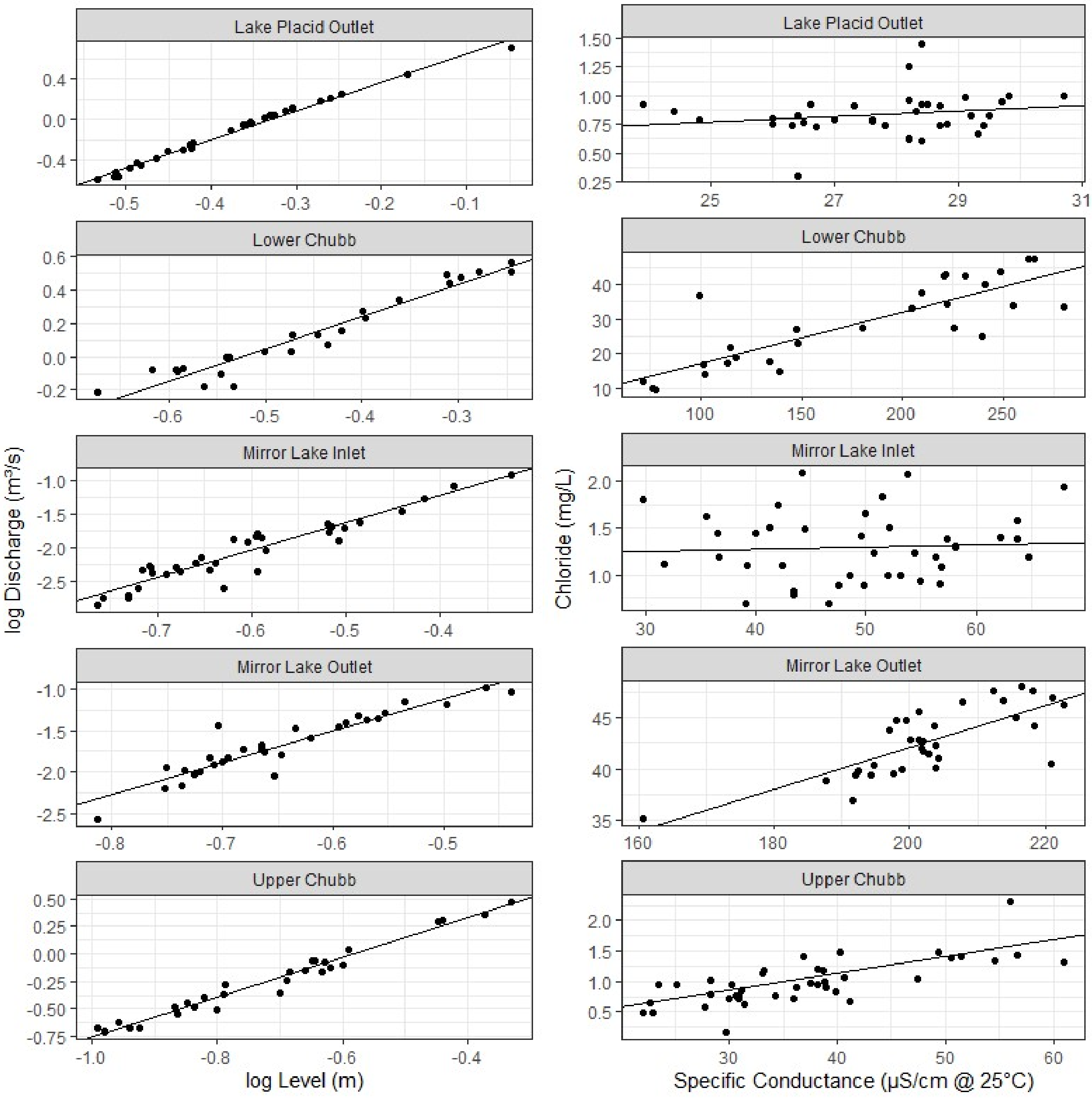

Figure A21. Stage-discharge and conductivity-chloride relationships for the five continuous stream monitoring sites.

Appendix 2. Mirror Lake Profile Data

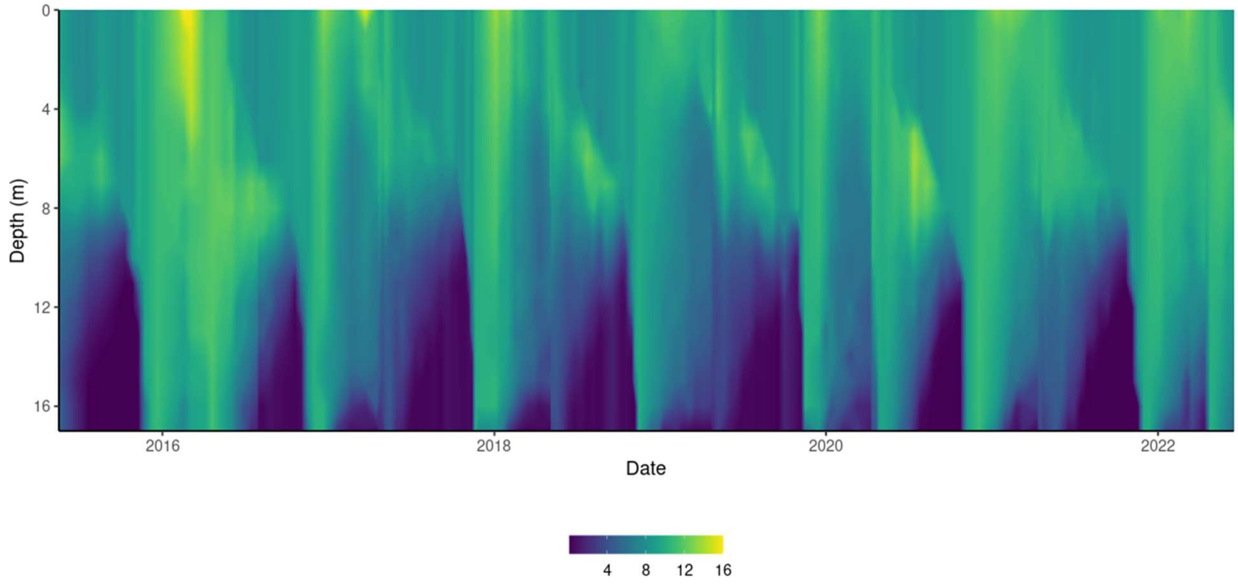

Figure A22. Dissolved oxygen concentraiton in Mirror Lake from May 2015 to July 2022.

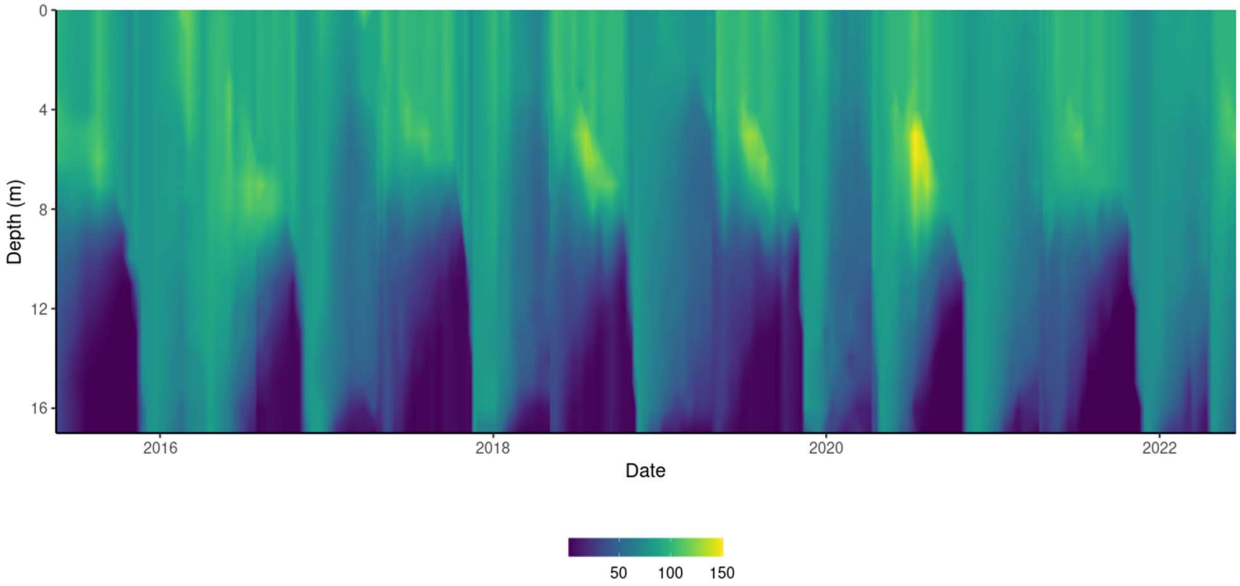

Figure A23. Dissolved oxygen saturation in Mirror Lake from May 2015 to July 2022.

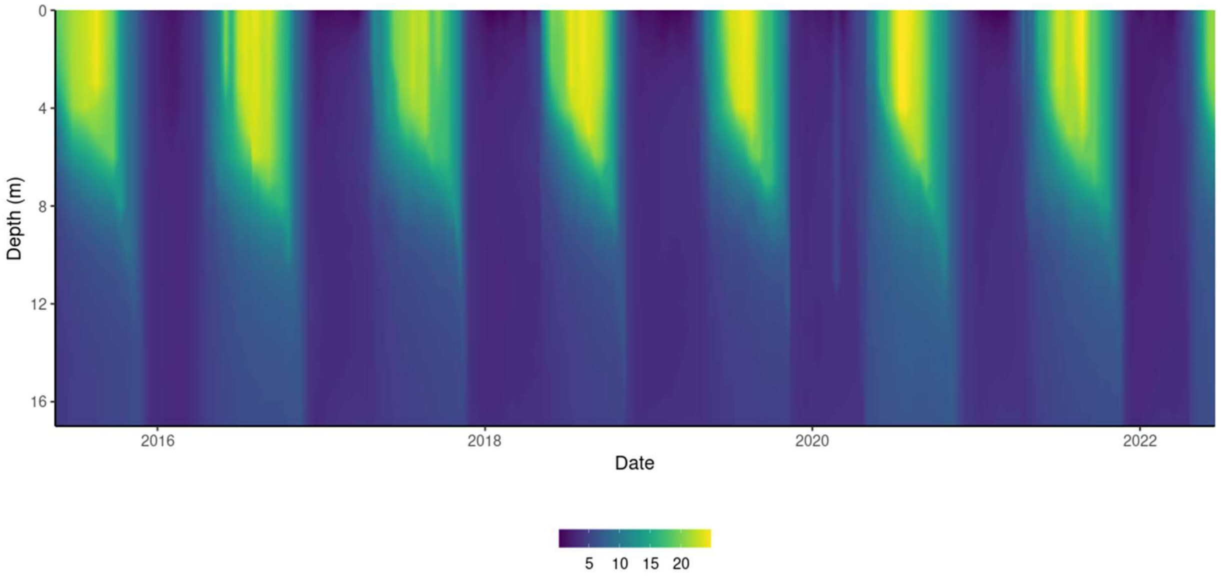

Figure A24. Temperature in Mirror Lake from May 2015 to July 2022.

Appendix 3. Salt Survey Responses

Table A5. Deicing products used on sidewalks from survey responses.

Product Manufacturer	Product Name	Unit Quantity	Number of Units
SWT	Ice melt	40 lb tub/bucket	1
SWI	Miracle melt	50 lb	2
Uline	Ice melt	50 lb	2
Various	Various	Only when the snow turns to all ice	as little as possible
Prestone	Driveway Heat	20 lb	1
Earth Innovations Inc.	eco traction	40 lb	40
Salted sand 80/20	Salted Sand	200 lbs	5 gallon buckets
Vaporizer	Pet safe ice melt	20 lbs	2
Paw Safe	Paw safe ice melt	10 lb	1
Uline	Ice melt	50 lb	2
North American Salt	Safe Step Sure Paws	20 lb	4
North American Salt	Safe Step Sure Paws	50 lb	One bag
North American Salt	Safe Step Sure Paws	20 lb	3
Uline	Ice melt	50 lb	1

Table A6. Supplemental products used by responders.

	Product Manufacturer	Product Name	Unit Quantity	Number of Units
2nd Product	Uline	Pet safe ice melt	20 lb	6
2nd Product	Uline	Ice melt	50 lb	10
2nd Product	SWI	Ice melt	25 lb	1
3rd Product	Staples SWI road runner salt	Ice melt	50 lb	5

Table A7. Deicing products used on driveways from survey responses.

Product Manufacturer	Product Name	Unit Quantity	Number of Units
Safe Paws	Safe Paws	Very little each season	Very little each season
Various	Various	Small amounts only when driveway turns to all ice in spring	Small amounts
Trudeau Sand and Gravel (10% Salt)	Sand Salt Mix	1 Ton	7
Salted Sand (6% Salt)	Salted Sand	18.23 tons	1
Uline	Ice melt	50 lbs	2

Trudeau Sand and Gravel (10% Salt)	Sand Salt Mix	1 Ton	3

Appended Documents:

Press Release AsRA – LCBP Award.pdf – Press release issued announcing the grant award.

Wiltse – ADK Water Week 2020.pdf – Presentation given at Adirondack Water Week 2020.

Wiltse – Lake Placid High Schoool 2021.pdf – Presentation was given to Lake Placid High School students on de-icing salt best management practices to aid in their school project.

Wiltse – Mirror Lake Public Meeting.pdf – Public meeting held to present work related to this project.

Wiltse – PSC Env Chem 2022.pdf – Presentation given to Paul Smith’s College Environmental Chemistry class on de-icing salt and impacts to Mirror Lake.

Wiltse – SLMP 2022.pdf – Presentation given to the Skaneateles Lake Municipal Partnership as a case study for addressing de-icing salt pollution.

Wiltse – UAlbany 2021.pdf – Presentation given to University of Albany Adirondack Environment class on de-icing salt impacts to the region with emphasis on Mirror Lake as a case study.

Photos:

Photo 01.jpg – AWI Research Associate Lija Treibergs drilling through the ice on Mirror Lake for winter sampling.

Photo 02.jpg – Reference gage installed along an old bridge abutment at the Lower Chubb site.

Photo 03.jpg – Reference gage installed next to a large boulder at the Upper Chubb site.

Photo 04.jpg – Close-up of the reference gage at the Upper Chubb site.

Photo 05.jpg – Reference gage, stilling well, and conductivity logger installed in the outlet of Mirror Lake.

Photo 06.jpg – Reference gage installed in the Lake Placid outlet.

Photo 07.jpg – AWI staff downloading loggers at the Upper Chubb site.

Photo 08.jpg – AWI Research Technician Connor Vara collecting a water sample using a Kemmerer sampler on Mirror Lake.

Photo 09.jpg – Close-up of stormwater discharge into Mirror Lake.

Photo 10.jpg – AWI and AsRA staff collecting stormwater samples and data during a winter runoff event.

Photo 11.jpg – AWI education staff visiting AsRA & AWI staff while out sampling Mirror Lake.

Photo 12.jpg – AWI & AsRA staff sampling Mirror Lake.

Photo 13.jpg – AWI Research Technician Connor Vara measuring discharge at the outlet of Lake Placid using an acoustic Doppler velocimeter.

Photo 14.jpg – Same as Photo 13.jpg

Photo 15.jpg – AsRA Water Quality Associate Leanna Thalmann sampling Mirror Lake with a Kemmerer sampler.

Electronic Data:

Laboratory and Discrete Data

- LCBP Mirror Lake and Chubb River Data.xlsx – Laboratory and discharge data for discrete chemistry data.
- Mirror Lake Raw Data.csv – Profile data for Mirror Lake.

Municipal Salt Tracking Data

- Lake Placid 2022.csv – Municipal salt tracking data for the Village of Lake Placid over the 2021-2022 winter season.
- Lake Placid and North Elba 2021.csv – Municipal salt tracking data for the Town of North Elba and Village of Lake Placid over the 2020-2021 winter season.
- North Elba 2022.csv – Municipal salt tracking data for the Town of North Elba over the 2021-2022 season.

Salt Survey

- Lake Placid Salt Use Survey (Responses).xslx – Private and contractor salt survey responses.

Stormwater Runoff Model

- Mirror Lake Storm Watersheds.shp – Shapefile of the storm watersheds within the Mirror Lake watershed.

Stream and Stormwater Continuous Data

- Lake Placid Outlet.xlsx – Continuous stage, discharge, conductivity, and chloride data for the Lake Placid outlet.
- Lower Chubb.xlsx - Continuous stage, discharge, conductivity, and chloride data for the Lower Chubb site.
- Mirror Lake Inlet.xlsx - Continuous stage, discharge, conductivity, and chloride data for the Mirror Lake inlet.
- Mirror Lake Outlet.xlsx - Continuous stage, discharge, conductivity, and chloride data for the Mirror Lake outlet.
- MLO 3.csv – Continuous conductivity and temperature data for the MLO 3 stormwater outfall.
- MLO 4.csv – Continuous conductivity and temperature data for the MLO 4 stormwater outfall.

- Upper Chubb.csv - Continuous stage, discharge, conductivity, and chloride data for the Upper Chubb site.