Crane Lake Chloride Reduction Demonstration Project (CL-4) Study

Prepared for
Bassett Creek Watershed Management Commission

Prepared by
Barr Engineering Co.

June 2026

4300 MarketPointe Drive, Suite 200
Minneapolis, MN 55435
952.832.2600

barr.com

Certification

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly licensed Professional Engineer under the laws of the state of Minnesota.

Greg Wilson
PE #: 25782

6-11-26
Date

Crane Lake Chloride Reduction Demonstration Project (CL-4) Study

June 2026

Contents

Tables

Figures

Abbreviations

BCWMC	Bassett Creek Watershed Management Commission
BMP	Best Management Practice
GISWQM	Geographic Information System Water Quality Model
MCES	Metropolitan Council Environmental Services
MNDOT	Minnesota Department of Transportation
MPCA	Minnesota Pollution Control Agency
P8	Program for Predicting Polluting Particle Passage Thru Pits, Puddles, and Ponds
RFP	Request for Proposals

1 Executive Summary

Crane Lake is a BCWMC priority 2 shallow lake in the City of Minnetonka, adjacent to the Ridgedale Mall area. Approximately half (252 acres) of the watershed is commercial and multi-family residential land use that drains to the lake, mostly through stormwater ponds (Figure 2.1). Major landholders include Ridgedale Center (77 acres) and Hennepin County (17 acres). The lake is listed as impaired for chloride by the MN Pollution Control Agency (MPCA) and drains to Medicine Lake. The City of Minnetonka explored several chloride management options to reduce chloride loading and concentrations within Crane Lake as a part of the Bassett Creek Watershed Management Commission's (BCWMC) 2019-2020 Crane Lake Water Quality Improvement Project, including working with the Metropolitan Council Environmental Services (MCES) to dispose of the chloride contaminated effluent from the lake into the sanitary sewer system. Despite the extensive review of chloride management options as part of that effort, no solution was identified.

The current study was approved by the BCWMC at their July 2024 meeting and involves watershed and in-lake chloride monitoring, watershed source load assessment and mass balance modeling, estimating the chloride reduction needed in Crane Lake and analyzing multiple alternatives to meet the project goals. Results of this study are intended to inform the implementation of a demonstration project to advance chloride reduction measures in Crane Lake and other parts of the watershed. This project will also inform options and methods for salt application and other winter maintenance materials, options for the removal of chlorides prior to reaching Crane Lake, and potential partnerships with Ridgedale Center and road authorities within the study area.

Because high chloride concentrations can harm fish and plant life, the MPCA established maximum and chronic chloride standards for surface waters within the state. A lake is considered impaired if two or more measurements exceed the chronic criterion (230 mg/L) within a 3-year period or one measurement exceeds the maximum criterion (860 mg/L). Recent monitoring shows that chloride concentrations in Crane Lake have been trending higher over the past several years with the potential for significant interannual variability. Crane Lake has very high chloride levels that do not meet MPCA water quality standards and may pose a risk to aquatic life. For example, 2025 chloride measurements ranged from 237 mg/L in August to 369 mg/L in mid-April, which was comparable to 2016, but not as high as was observed in 2021 and 2022. Chloride concentrations in the lake more than doubled between 2016 and 2022, and all concentrations from 2021, 2022 and 2025 failed to meet the MPCA chronic chloride standard.

Chloride monitoring, watershed source load assessment (i.e., determining the source of the pollution from the watershed draining to the lake), and mass balance modeling developed for this study indicated the following:

- Geographic Information System water quality modeling (GIS WQM) developed for the Crane Lake watershed showed that the estimated chloride load from Ridgedale Center, Hennepin County's Ridgedale Campus, and the other (smaller) private properties in the watershed account for 82 percent of the total chloride load to Crane Lake (this includes drainage through all the stormwater ponds that discharge to Crane Lake). None of the public road authorities account for more than 9 percent of the total chloride load, individually—collectively, it is estimated that public road authorities contribute 18 percent of the total average annual chloride load to Crane Lake.

- Effluent from the two Ridgedale ponds accounted for 81 percent of the total chloride load to Crane Lake during the 2024-25 monitoring period, with the south Ridgedale pond contributing 60 percent of the overall watershed chloride load, itself.

- Chloride mass balance modeling from the 2024-25 monitoring season indicated that the watershed chloride load would need to be reduced by 50,700 pounds (25.4 tons), or at least 25 percent of the existing watershed loading. Since the two Ridgedale ponds accounted for 81 percent of the total chloride load to Crane Lake, a 31 percent chloride load reduction from the Ridgedale ponds would have met the water quality goal during the 2024-25 monitoring period.

The following structural measures were considered and evaluated for management concepts, but were not individually recommended for implementation because of the high cost or inability to meet the water quality goals:

- Adaptive level control systems at Ridgedale ponds

- Adaptive level control systems and chloride treatment at Ridgedale ponds

- Plumb Ridgedale roof runoff for direct discharge to Crane Lake

It is possible that implementation of one or more of the structural measures would be beneficial at a future time, in conjunction with chloride source control measure(s). Based on a survey and follow-up correspondence, neither private landowners (including Ridgedale Mall) nor their applicators are tracking the amount of salt applied each winter. In addition, the landowner contracts with private applicators may inadvertently lead to increased salt usage in some cases, either because of the contract pricing and/or because the terms do not provide for or incentivize low salt application techniques. As a result, there are several places or situations where source control measures would greatly reduce the chloride load to Crane Lake. The nonstructural or source control measures that were considered and evaluated for this study included:

- Track application rates in winter deicing operations

- Assist private properties with procuring/contracting winter maintenance

- Implement deicing equipment loan/purchase program

- Provide abrasives to reduce salt use

- Develop watershed business agreement for joint winter maintenance

- Develop alternative salt storage options for private properties

- Develop smart salting retrofit plan at Ridgedale

- Continue to advocate for regulatory controls at broader jurisdiction

Based on consultation with City of Minnetonka staff and the BCWMC Technical Advisory Committee, a three-phased sequence of implementation activities is recommended for next steps within the Crane Lake watershed. Work will start by contacting private landowners in the Crane Lake watershed to report on the results of this study and offer technical assistance for the relevant source control measures based on the phased approach. The initial phase of implementation will prioritize educating and working with private properties to better understand their existing approach for procuring and contracting for winter maintenance, and offering technical assistance for incentivizing best practices and ensuring that salt application rates are tracked as a part of their winter maintenance contracts. Subsequent phases of implementation will proceed based on the results of the initial phase of implementation. The projected goals for these later phases are to focus on activities such as cost-sharing for upgrades to salt storage and potentially deicing equipment, along with smart salting retrofits involving alternative pavements and snowmelt systems.

2 Introduction and Background

Crane Lake is a BCWMC priority 2 shallow lake in the City of Minnetonka, adjacent to the Ridgedale Mall area. It is impaired for chloride and drains to Medicine Lake which is threatened for chloride impairment. The Bassett Creek Watershed Management Commission's (BCWMC) 2019-2020 Crane Lake Water Quality Improvement Project, constructed by the City of Minnetonka in conjunction with the reconstruction of Ridgedale Drive from Plymouth Road to I-394, had the goal of improving water quality and addressing pollutant loads to Crane Lake, which is impaired for chloride. The project included water quality improvements and now all drainage areas within the Ridgedale Drive and Ridgedale Mall area will be treated with a best management practice (BMP) before draining to Crane Lake. Unfortunately, while the project reduces total phosphorus and solids loadings, it was preliminarily unsuccessful in identifying a feasible solution to address the chloride levels in Crane Lake. The City of Minnetonka explored several chloride management options, including working with the Metropolitan Council Environmental Services (MCES) to dispose of the chloride contaminated effluent in the sanitary sewer system. Despite the extensive review of chloride management options, no solution was identified, and the project schedule required moving forward without the chloride management component.

This project in the City of Minnetonka is intended to further quantify all chloride sources in the Crane Lake watershed and identify/prioritize opportunities or practices for reducing chloride levels. Results of this study are intended to inform the implementation of a demonstration project to advance chloride reduction measures in the Crane Lake area and other parts of the watershed. This project is also intended to inform options and methods for salt application and other winter maintenance materials, options for the removal of chlorides prior to reaching Crane Lane, and potential partnerships with Ridgedale Center and road authorities.

This study involves watershed and in-lake chloride monitoring, watershed source load assessment and mass balance modeling, estimating the chloride load reduction needed to the lake, and analyzing multiple alternatives to meet the project goals. As part of this study, Barr also considered permit requirements for the different alternatives and held a meeting with the City of Minnetonka and the BCWMC administrator to discuss and present study results and recommendations.

2.1 Crane Lake and Watershed

Figure 2-1 shows the Crane Lake watershed and notes the stormwater monitoring locations used for this study. In 2020 and 2022, the city sampled and monitored chloride concentrations in the Ridgedale Center north and south ponds (RDG-N and RDG-S, shown in Figure 2-1). The monitoring results provided an understanding about seasonal chloride levels and relative source variability from the Ridgedale Center area, as well as potential chloride treatment/improvement options. All monitoring locations were established by Barr staff for this study, and the equipment was deployed between November 30, 2024 and September 30, 2025.

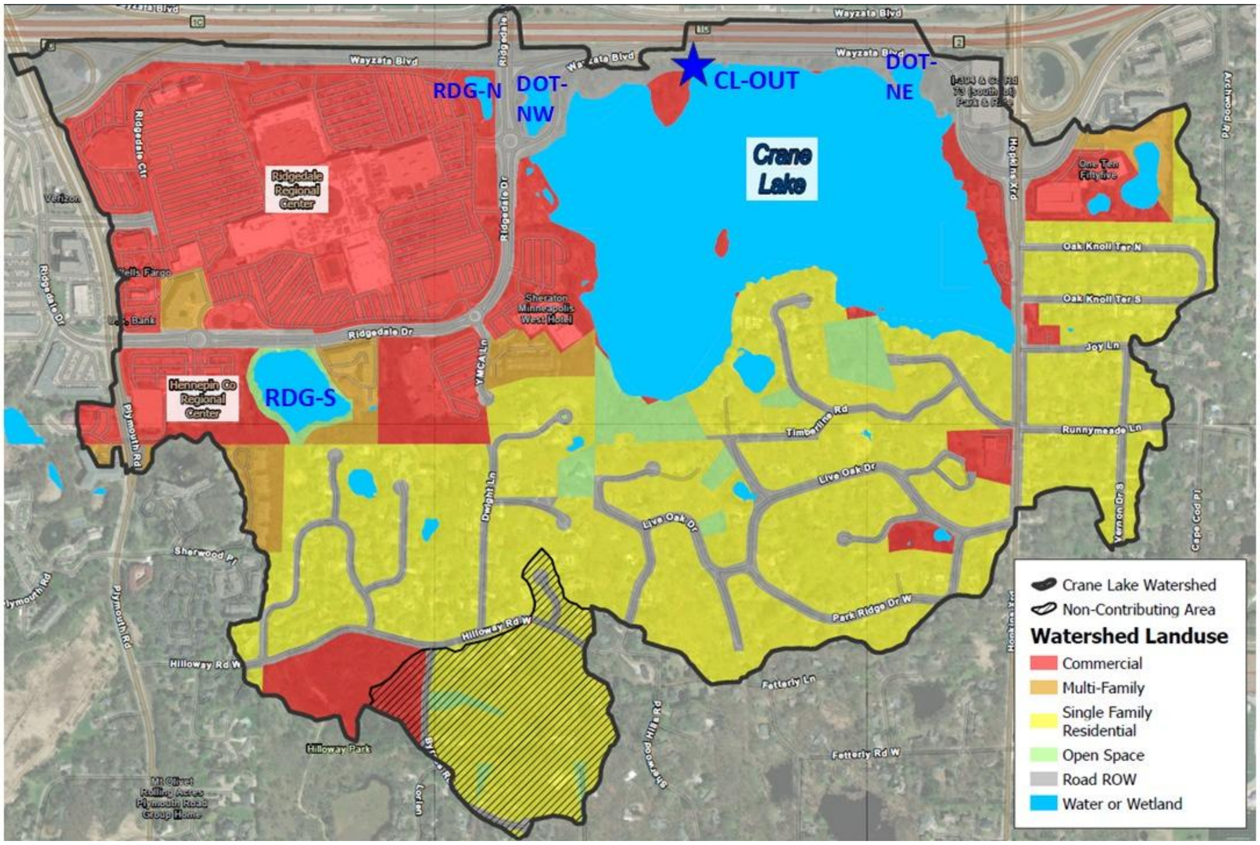


Figure 2-1 Crane Lake Watershed Land Use and Monitoring Locations

Table 2-1 summarizes information on Crane Lake and its contributing watershed. This information was used for mass balance modeling and evaluating treatment objectives. The lake volume, surface area and average depth were calculated from lake bathymetric data. Crane Lake is polymictic, which means that it typically is fully mixed throughout year. Historical lake level monitoring on Crane Lake indicates that water surface elevations have typically exceeded the normal level of the lake during the open water season. As a result, lake outflow (and flushing) is common during all, but the driest years. The lake outlets to the north through locally-named “Ridgedale Creek” and enters Medicine Lake in the southwest bay.

Table 2-1 Crane Lake Information

Parameter	Value
Watershed Area	591 acres
Lake Size	30 acres
Average Depth	3.3 feet
Maximum Depth	5.0 feet
Volume	99 acre-feet
Ordinary High Water Level (OHWL)	920.5 ft
Normal Water Level (NWL)	917.1 ft
Downstream Receiving Waterbody	Medicine Lake

2.2 Water Quality and Comparison with State Chloride Standard

Chloride concentrations in lakes throughout the Twin Cities Metropolitan Area have increased since the early 1990s, when many government agencies switched from sand or sand/salt mixtures to salt for winter road maintenance. When snow and ice melt, the salt goes with it, washing into lakes, streams, wetlands, and groundwater. It only takes 1 teaspoon of road salt to permanently pollute 5 gallons of water. And, once in the surface water system, there is no practical way to remove chloride.

Because high chloride concentrations can harm fish and plant life, the MPCA established maximum and chronic chloride water quality standards. The maximum standard is the highest concentration of chloride that aquatic organisms (zooplankton, bugs, fish, frogs, etc.) can be exposed to for a brief time with zero-to-slight mortality. The chronic standard is the highest chloride concentration that aquatic life can be exposed to indefinitely without causing chronic toxicity. Chronic toxicity is defined as a stimulus that lingers or continues for a long period, often one-tenth of the life span or more. A chronic effect can be mortality, reduced growth, reproduction impairment, harmful changes in behavior, and other nonlethal effects. A lake is considered impaired for chloride if two or more measurements exceed the chronic criterion (230 mg/L) or one measurement exceeds the maximum criterion (860 mg/L) within a 3-year period.

Recent monitoring data shows that Crane Lake has very high chloride concentrations that do not meet MPCA water quality standards and may pose a risk to aquatic life (Figure 2-2). 2025 chloride measurements in the lake ranged from 237 mg/L in August to 369 mg/L in mid-April, which was comparable to 2016, but not as high as 2021 and 2022. All measurements from 2016 through 2025 were well above the chronic chloride standard and below the maximum. Figure 2-2 shows that chloride concentrations in Crane Lake have been trending higher over time with the potential for significant interannual variability. Chloride measurements from 1972 through 1988 met the MPCA chronic chloride standard except for concentrations of 267 mg/L in June 1976, 287 mg/L in June 1977, and 268 mg/L in late August 1977 (see figure below). More than half of the chloride concentrations estimated from specific conductance measurements collected between 1997 through 2011 failed to meet the MPCA chronic chloride standard. 2016 chloride measurements failed to meet the MPCA chronic standard from April through August but met the standard in September. Chloride concentrations in the lake more than doubled between 2016 and 2022, and all concentrations from 2021, 2022 and 2025 failed to meet the MPCA chronic chloride standard.

Crane Lake is located within the larger Medicine Lake subwatershed. BCWMC lake-level data show that Crane Lake frequently discharges, which means that chlorides from Crane Lake eventually reach Medicine Lake. This is a concern because Medicine Lake is also close to being added to the Impaired Waters List for chlorides.

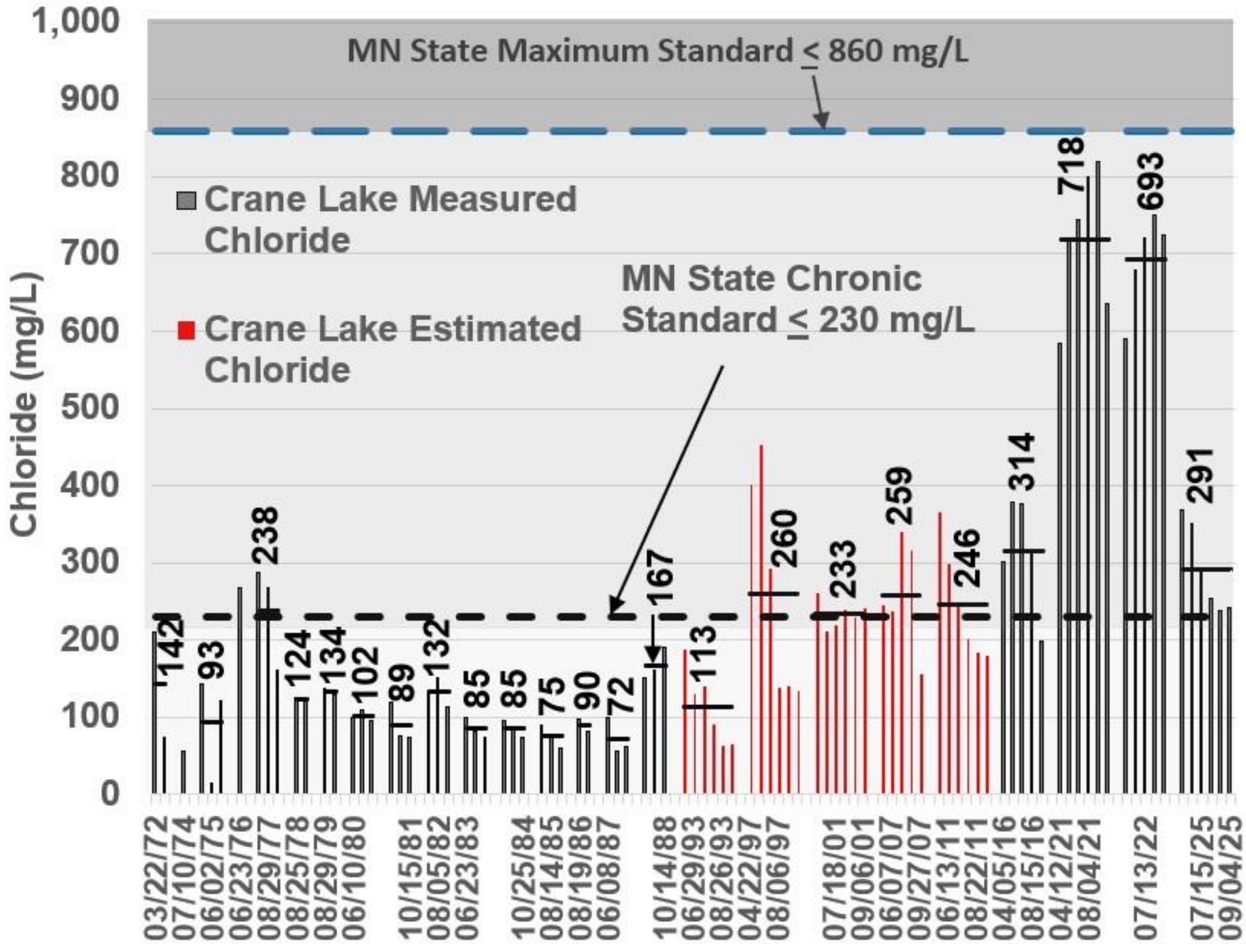


Figure 2-2 Historical Crane Lake Chloride Monitoring Data

Statistically significant increases in chloride concentrations over the past 50 years (95-percent confidence level) have reduced zooplankton species diversity in Crane Lake (Barr, 2022). Declines in the number of species and abundance of zooplankton reduce the food supply for planktivorous fish and other organisms in the lake. Studies have documented reductions in zooplankton diversity with increasing chloride concentrations. Consistent with these studies, the number of zooplankton species (diversity) in Crane Lake during the past 22 years has declined significantly (Barr, 2022). The total abundance of zooplankton in Crane Lake also declined during the past 22 years, but a trend analysis indicates the decline was not statistically significant (Barr, 2022).

To remove the lake from the impaired waters list (delist) for chlorides, the MPCA evaluates exceedances of standards for toxic pollutants (including chloride) over consecutive three-year periods. Two or more exceedances of the chronic standard (230 mg/L), or one exceedance of the maximum standard (860 mg/L for chloride), in three years is considered an impairment.

3 Monitoring, Modeling and Watershed Load Assessment

3.1 Monitoring and Watershed Modeling

The BCWMC purchased water quality monitoring equipment for this study. Barr programmed and installed the equipment and chloride sampling was performed at outflow locations from Ridgedale north pond (RDG-N), Ridgedale south pond (RDG-S), Crane Lake outlet (CL-OUT), the northwest MNDOT pond (DOT-NW) and MNDOT subwatershed drainage to the northeast pond (DOT-NE) (Figure 2-1). A water quality monitoring probe was installed at each site to collect continuous conductivity and temperature readings which were converted to chloride concentration estimates. Daily outflow volumes at each location were estimated based on P8 modeling estimates using area climatic inputs (hourly precipitation and temperatures) and the information summarized in Table 2-1. Daily outflow volumes were combined with the average daily chloride concentration estimates at each location to estimate daily chloride loads delivered to Crane Lake from the four watershed monitoring locations, as well as the chloride load leaving Crane Lake from the lake outlet during the monitored period (November 30, 2024 to September 30, 2025). The P8 modeling results were also used to estimate the daily unmonitored watershed chloride inflow loads to Crane Lake using an assumed chloride concentration of 100 mg/L (which corresponds with average annual chloride runoff estimates for low density development).

Figure 3-1 shows the continuous chloride concentration estimates from the 2024-25 monitoring season for the two Ridgedale ponds and the Crane Lake outlet. Considering the daily watershed chloride load estimates, the two Ridgedale ponds accounted for 81 percent of the total chloride load into Crane Lake during the 2024-25 monitoring period (see Figure 3-2). The drainage area into these ponds includes 77 acres and 17 acres of which includes the Ridgedale Center and Hennepin County's Ridgedale Campus, respectively, and the other 158 acres of which consists of other commercial and residential areas (shown in Figure 2-1).

Results shown in Figure 3-1 highlight how high chloride from the watershed pond discharges contributed to increasing chloride concentrations in Crane Lake immediately following snowmelt and ice-out conditions (noted in the increases in pond effluent concentrations during these time periods). Based on the modeled climate records, it took 8 inches of rainfall runoff (which occurred between the middle of March and May 21, 2025) before the winter chloride load had flushed through the discharge from both watershed ponds and began to dilute the Crane Lake chloride concentration (Figure 3-1). Figure 3-1 shows that the Crane Lake chloride concentration closely follows the chloride concentration in the outflow from the south Ridgedale pond, which contributes approximately 60 percent of the watershed chloride load (Figure 3-2). The Crane Lake chloride concentration did not drop below the 230 mg/L standard during the rest of the 2025 monitoring season.

Figure 3-1 also shows that chloride concentrations in the north Ridgedale pond are significantly higher than the south Ridgedale pond during the early spring runoff events as it receives all its runoff from the mall area, whereas the south Ridgedale pond receives runoff from the surrounding mixed-use development. Based on the P8 modeling results, the estimated residence times of the north and south Ridgedale ponds are 22 and 57 days, respectively, while the estimated water residence time of Crane Lake is 95 days. Chloride monitoring results shown in Figure 3-1 confirm that it takes more time to flush the chloride and dilute the concentration in Crane Lake than the upstream ponds given its longer residence time.

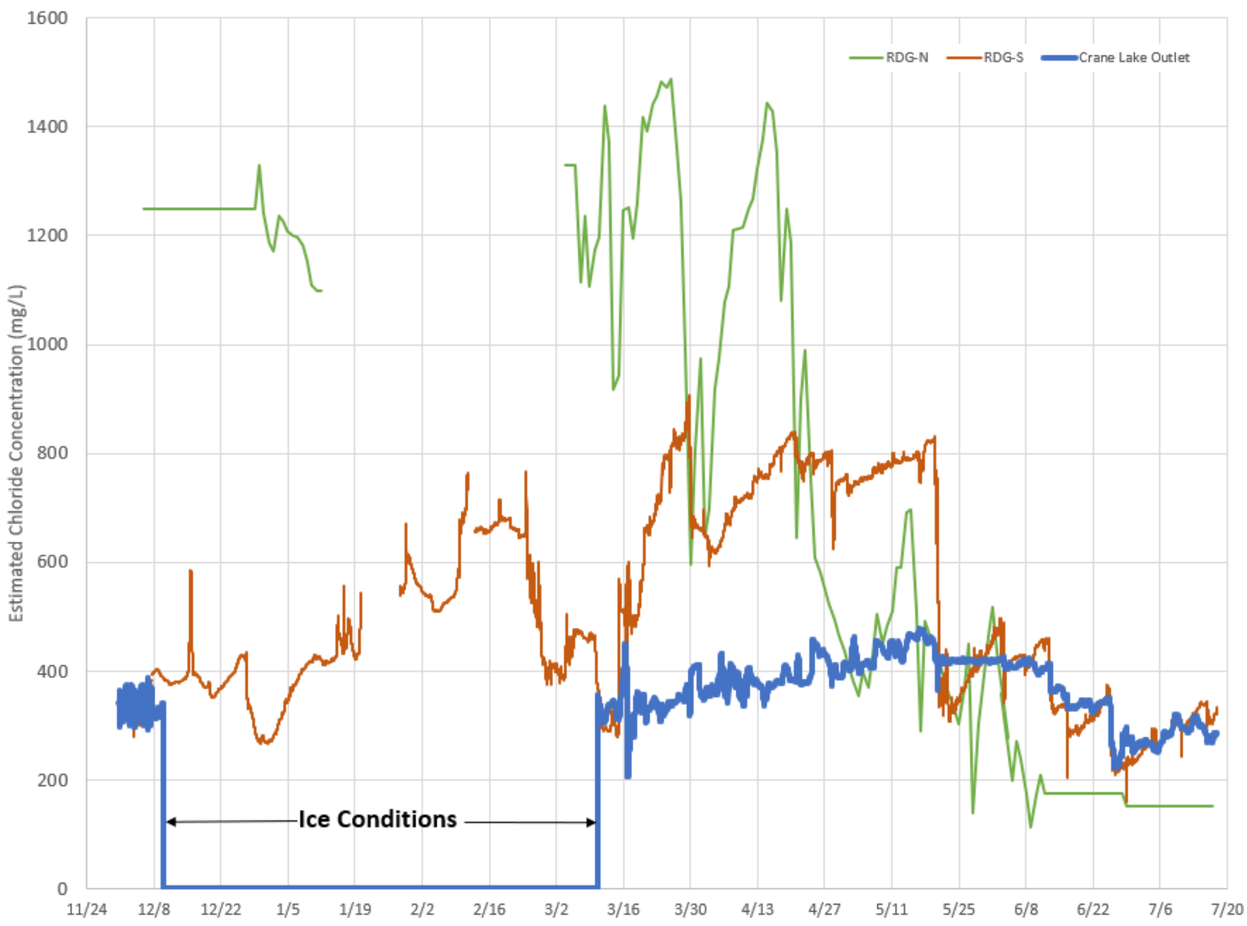


Figure 3-1 2024-25 Continuous Chloride Monitoring

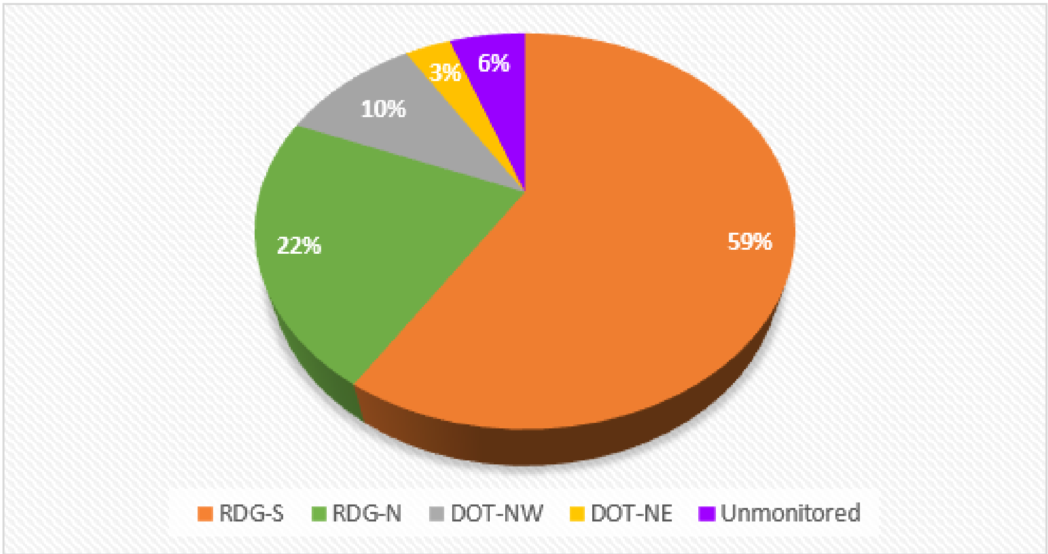


Figure 3-2 Relative Watershed Chloride Load (2024-25 Monitoring Season)

3.2 Watershed Load Assessment

In addition to collecting the 2024-25 monitoring data, Barr also worked with City of Minnetonka staff to solicit and compile data and input from the Minnesota Department of Transportation (MNDOT), City of Minnetonka, Ridgedale and other private properties on any available existing monitoring data within the study area, as well as deicing methods and salt application rates that could be used to better define the watershed source load assessment and refine the chloride mass balance modeling. The following information was obtained during this process:

- Annual salt application rates from the City of Minnetonka, 2018-2025
- Annual salt application rates from MNDOT, 2017-2025
- Past Ridgedale pond monitoring from City of Minnetonka, 2018-2020 and 2021-22 winter seasons
- Crane Lake water quality monitoring, shown in Figure 2-2

In addition, the City of Minnetonka received survey responses from five private landowners and the Ridgedale Center. Ridgedale Center referred Barr to communicate directly with the private contractor that has completed snow and ice removal at the Mall for the past six years. The information gathered from this effort is further discussed in Section 4 and was used to inform and suggest potential management actions.

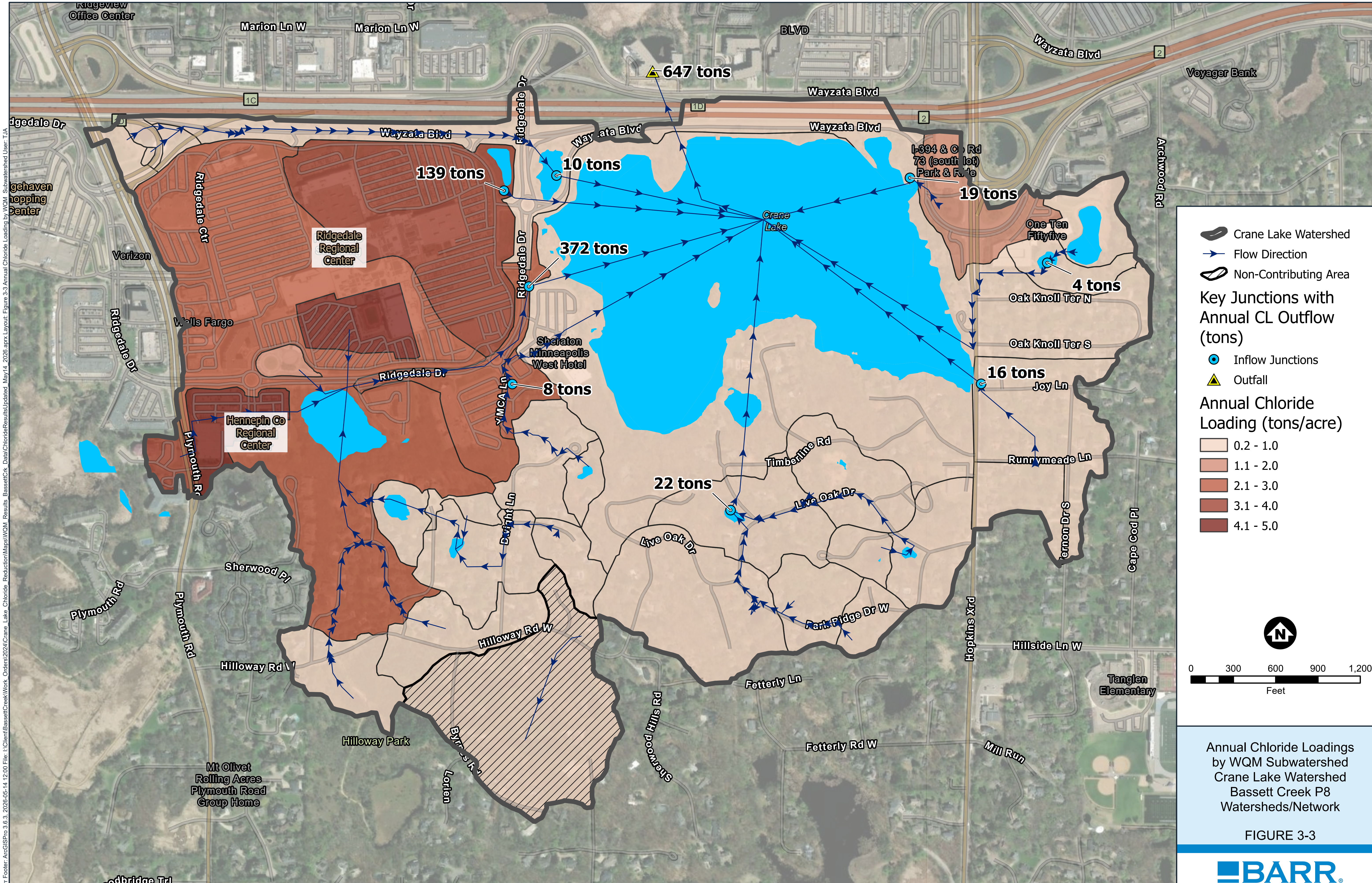
Based on the information received, a GIS water quality model (GIS WQM) was developed and calibrated for the Crane Lake watershed to provide parcel-scale estimates of chloride applied as well as average annual chloride loadings. Figure 3-3 shows the estimated average annual amount of chloride applied within each subwatershed along with the estimated chloride load discharged downstream at key stormwater discharge locations (in tons). Figure 3-4 shows the estimated flow-weighted mean chloride concentration within the discharge from each subwatershed, based on the same GIS WQM results. Both figures show that the high-density development west of Crane Lake is contributing a significantly higher proportion of the watershed chloride load, while the residential land use areas of the watershed are contributing substantially less.

Based on the GIS WQM overall results, Figure 3-5 highlights that the estimated chloride load from Ridgedale Center and the other private watershed sources within the watershed account for approximately 82 percent of the total chloride load to Crane Lake. The Hennepin County component shown in Figure 3-5 includes both Hennepin County Regional Center and the county roads. None of the public road authorities account for more than 9 percent of the total chloride load, individually—collectively, it is estimated that public road authorities contribute approximately 18 percent of the total chloride load to Crane Lake.

3.3 Crane Lake Chloride Mass Balance Modeling

The daily Crane Lake water and chloride mass balance modeling results from the 2024-25 monitoring season were used to estimate the chloride load reduction needed to meet the lake chloride goals, along with the potential water quality benefit of source reduction measures and controlling or treating stormwater pond discharge volumes (further discussed in Section 4).

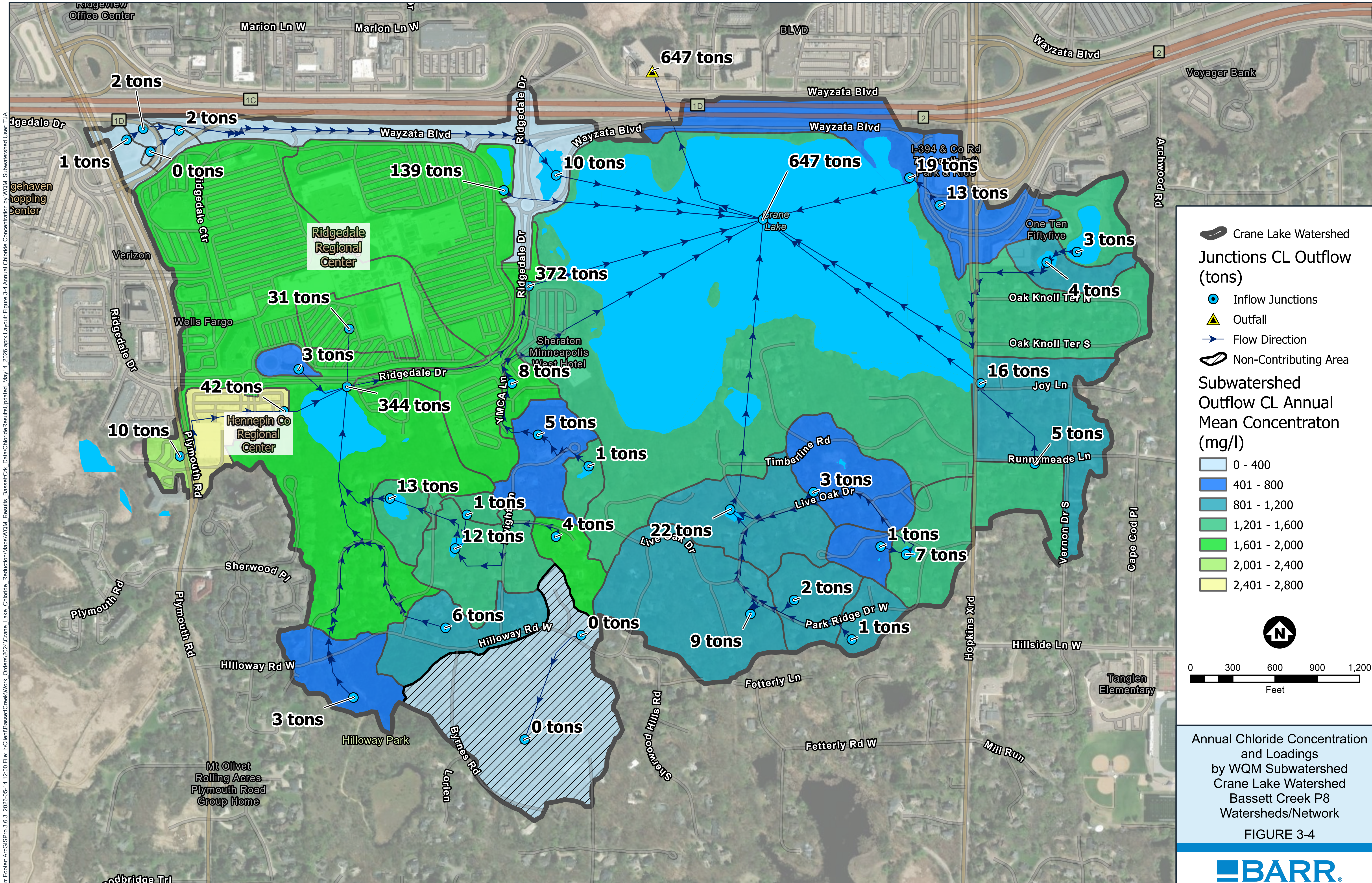
Chloride mass balance modeling from the 2024-25 monitoring season indicates that the watershed chloride load to Crane Lake would need to be reduced by 50,700 pounds (25.4 tons), or at least 25 percent (November 30, 2024—July 17, 2025) in order to meet chloride goals within the lake. Since the two Ridgedale ponds accounted for 81 percent of the total chloride load to Crane Lake (see Section 3.1), a 26 percent chloride load reduction from the Ridgedale ponds would have met the water quality goal during the 2024-25 monitoring period.



Annual Chloride Loadings
by WQM Subwatershed
Crane Lake Watershed
Bassett Creek P8
Watersheds/Network

FIGURE 3-3

BARR



Annual Chloride Concentration and Loadings by WQM Subwatershed Crane Lake Watershed Bassett Creek P8 Watersheds/Network

FIGURE 3-4

BARR

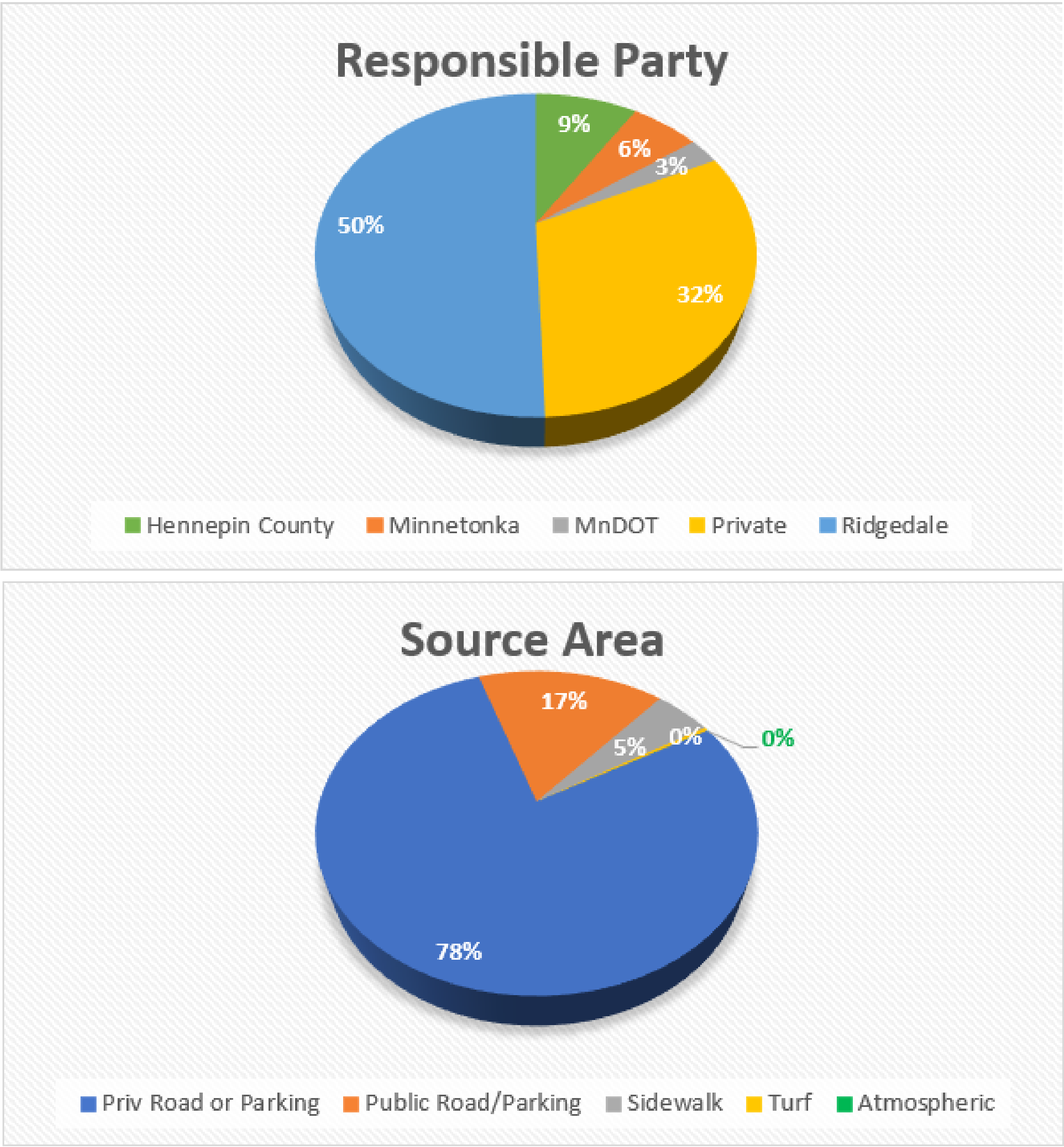


Figure 3-5 GIS WQM Chloride Load Breakdown by Responsible Party and Source Area

4 Evaluation of Management Concepts

The Crane Lake contributing watershed area was evaluated to develop potential management strategies, considering all chloride sources or source areas that could potentially be controlled and management practices that could be used for chloride reductions (including pond drawdowns, treatment, source control, etc.). The feasibility of each concept was evaluated and, where possible, optimized based on life-cycle cost-benefit and future assurances for project implementation and compliance.

4.1 Structural Measures

4.1.1 Adaptive Level Control Systems at Ridgedale Ponds

Analyses completed within this study estimate that a 26 percent (25.4 tons) chloride load reduction from the Ridgedale ponds in 2024 and 2025 would have resulted in Crane Lake meeting its chloride water quality goal during the November 30, 2024—July 17, 2025 monitoring period.

One approach to controlling chloride loading from the Ridgedale Ponds might be to consider the retrofit of the ponds with adaptive level control systems. Adaptive level control systems typically involve retrofitting the pond outlet so that it can be programmed to be drawn down in advance of stormwater runoff events. This concept has been shown to mitigate downstream flooding and improve the water quality treatment capacity of existing ponds for conventional pollutants (such as total suspended solids and phosphorus). To-date, however, it has not been applied as a way of reducing downstream chloride levels. This concept for this management approach would be to draw down the pond levels and/or close the pond outlets in advance of the winter season, collect and store the high chloride spring runoff and then slowly release the outflow from each pond based on the Crane Lake chloride concentration during the spring and summer seasons.

One implication of this concept is that stormwater runoff that occurred after the pond was full would have to be bypassed until more storage became available. However, as indicated in Section 3.1, chloride concentrations in Crane Lake remain higher than the standard throughout the entire year under current conditions. As a result, adaptive level control systems in the Ridgedale ponds cannot feasibly meet the project goals without some level of chloride treatment and/or source reductions also being implemented.

4.1.2 Combined Adaptive Level Control Systems and Chloride Treatment at Ridgedale Ponds

Chloride treatment options involving ion exchange and reverse osmosis were previously evaluated for the study of chloride extraction/dilution for Parkers Lake (PL-7) (Barr, 2023). Reverse osmosis (RO) was slightly less expensive with life-cycle costs that resulted in a cost of $11 per pound of chloride removed and a treatment efficiency of 95 percent. Another proprietary treatment option has recently been identified and successfully tested on a pilot scale at a cost of $8 per pound of chloride removed and a treatment efficiency of 70 percent.

Table 4-1 shows the available storage volumes of both the north and south Ridgedale Ponds, both at their current normal water level and fully drawn down, as well as the potential chloride load that could be captured and treated with RO or via the proprietary treatment technology to improve water quality in Crane Lake. To meet the water quality treatment goal for Crane Lake the estimated annual treatment costs (based on the estimated unit costs noted above) would range from roughly $565,000 to use proprietary treatment with both ponds fully drawn down to $647,000 to use RO treatment with both ponds maintained at the existing normal water level. Regardless of the pond treatment or level control option, the annual costs for this concept are not recommended without first implementing source control measures (i.e, reducing the potential overuse of deicers in the watershed first).

Table 4-1 Storage and Treatment Potential for Ridgedale Pond Adaptive Level Control Systems

Pond/Condition	Available Storage Volume (ac-ft)	Chloride Load RO Treated (tons)	Annual RO Treatment Cost	Chloride Load w/ Proprietary Treatment (tons)	Annual Proprietary Treatment Cost
Ridgedale North @ Current NWL	4.91	3.8	$97,000	2.9	$54,000
Ridgedale North Completely Drawn Down	11.3	8.9	$227,000	6.7	$124,000
Ridgedale South @ Current NWL	30.7	21.6	$550,000	16.4	$304,000
Ridgedale South Completely Drawn Down	49.1	31.7	$807,000	23.8	$441,000

4.1.3 Plumb Ridgedale Roof Runoff for Direct Discharge to Crane Lake

It is anticipated that chloride concentrations in roof runoff from Ridgedale Center is more than an order of magnitude lower than the runoff from the surrounding parking lots and roadways year-round. Under current conditions, this roof runoff is mixed with runoff from areas that have been salted during the winter, which increases the water volume requiring management and the unit costs of treatment, while also correspondingly decreasing the potential for water quality improvement in Crane Lake.

This concept would involve separating the Ridgedale Center roof drain connections from the existing storm sewer system and storing the flow in cisterns for pumping or gravity-piping the flow directly to Crane Lake to improve the chloride assimilation capacity of the lake. This management concept would only be cost-effective if it is implemented with one of the treatment options described in Section 4.1.2 and would not be cost-effective if done in conjunction with nonstructural or source control measures.

4.2 Nonstructural/Source Control Measures

As previously discussed, the City of Minnetonka surveyed and received responses from five property owners within the Crane Lake area for use within this study. Ridgedale Center directed Barr to coordinate directly with the private contractor that has completed snow and ice removal on that property for the past six years. The information gathered from this effort follows, including implications for suggested management concepts:

- All private properties utilize private contractors for snow and ice removal

- Contract arrangements typically involve a lump sum amount for the winter season, although a couple landowners are paying the contractor by the number of deicing events with one of those landowners reimbursing the contractor for time and materials
- A couple of landowners initiate the service for each event while the remaining landowners indicated that the contractor decides when to initiate the service, based on weather conditions
    - One contractor indicated that a trace of snow will initiate the service
    - In some cases, the landowner will ask the contractor to return to the site if there are any reports of slippery areas
- Half of the landowners had salt storage on-site while the other contractors working for the other half brought salt to the site for each event
- None of the private landowners or contractors maintained any records about the amounts of salt or alternative deicers applied during any of the past winter seasons.

4.2.1 Track Application Rates in Winter Deicing Operations

This management concept involves working with City of Minnetonka staff to approach private landowners in the Crane Lake watershed to report on the results of this study and offer technical assistance for the development of a chloride management plan and ongoing tracking of deicing use at their sites. This concept may also require additional incentives to ensure participation and the return of useful information, which in turn, could be used to incentivize the implementation of other nonstructural or source control measures.

4.2.2 Assist Private Properties with Procuring/Contracting Winter Maintenance

Since some landowners are paying private contractors by the number of deicing events, including instances where the contractor is reimbursed for time and materials, it follows that the methods that some landowners use to solicit and procure winter maintenance services may lead to the overuse of deicers. Oftentimes, private applicators provide bids after receiving a request for proposals (RFP) from private landowners. In this instance, even State certified/trained applicators may need to produce pricing for the same level of service and expected deicers as competitors that may not be trained or certified in smart salting practices. There may also be instances where the RFP does not allow for alternative pricing for other services such as use of deicing liquids such as brine. In these scenarios, it can be very difficult for certified applicators to add on the costs of liquids or other snow management and deicing alternatives after the contract is awarded, making it important to help the landowner to understand the benefits of using better (smart salting) products or methods before the RFP is posted for solicitation.

This management concept recommends, at a minimum, technical assistance to landowners in the review and development of winter maintenance RFPs and procurement documents to support the promotion of smart salting strategies. Alternatively, this concept could involve the development of RFP language or providing other existing examples or guidance that have resulted in implementation of successful practices and/or reductions in salt use at similar sites.

4.2.3 Deicing Equipment Loan/Purchase Program

Traditional winter maintenance practices include the use of plows, rock salt, and a mixture of sand and salt. The predominant strategy for minimizing salt usage during winter road maintenance involves the integration of liquid products rather than relying exclusively on granular materials. Two principal techniques are employed for the administration of liquid winter maintenance agents. The initial method, known as “pre-wetting,” consists of applying both liquid brine and granular salt to the roadway (Minnesota Department of Transportation, 2019). This approach enhances ice melt efficiency and reduces overall salt consumption due to decreased loss from material bounce and scatter (Minnesota Pollution Control Agency, 2020). The second technique, termed “direct liquid application,” entails the exclusive use of a liquid agent. Frequently referred to as “anti-ice,” this practice is implemented prior to a storm, applying chemicals to inhibit the bonding of snow to the pavement. Additionally, direct liquid applications may be utilized post-storm for de-icing purposes (Minnesota Department of Transportation, 2019).

According to MPCA’s Chloride Management Plan (2020), there are several examples where watersheds and cities have funded equipment upgrades for spread control, salt brining and anti-icing systems that have resulted in salt savings between 19 and 70 percent. Based on these individual examples, costs have generally ranged between $65,000 and $80,000 for municipalities to make these upgrades.

One of the survey results for this study indicated that the respondent would like to use liquid deicing products for their winter maintenance activities. The use of liquid deicing products also reduces costs for the landowners with less interior cleaning and corrosion to other building materials. This management concept could involve offering grants or other incentives to private and public winter maintenance entities to upgrade equipment or implement innovative practices.

4.2.4 Provide Abrasives to Reduce Salt Use

In some cases, the addition or use of abrasives will improve traction during colder weather conditions where the conventional salt mixtures are not effective. Likewise, there are other deicer alternatives that work better in colder temperatures. Unfortunately, carbohydrate-based deicers can lead oxygen depletion in downstream water bodies and associated impacts on biota, while acetate-based deicers are more expensive.

This management concept would involve the provision of abrasives to private applicators to discourage the overuse of salt during colder temperatures.

4.2.5 Develop Watershed Business Agreement for Joint Winter Maintenance

A watershed business agreement would provide regular winter maintenance to areas within the Crane Lake watershed through a joint venture with the watershed or city. Businesses in the area would pool resources to fund a third party or local business within the agreement to take over snow removal and winter maintenance for the included parties. The joint business arrangement would additionally aid the maintaining business or third party in designing winter maintenance activities that align with smart salting practices to reduce the amount of chloride entering Crane Lake.

Similar joint business arrangements have already proven effective in the Cities of Edina and Minneapolis. Edina has a joint winter maintenance agreement for the 50th and France Business District that involves the use of city staff for snow management and deicing. The City of Minneapolis service districts have typically involved hiring a private contractor for snow and ice removal. Such a business arrangement has typically involved the appointment of a service district board to gather input and support among local landowners. The service district board or council will typically have to revisit the service agreements and assessments once a year. This concept may also require additional incentives to ensure a good return on chloride load reductions.

4.2.6 Develop Alternative Salt Storage Options for Private Properties

Since about half of the private landowners indicated that salt storage occurs on-site, it is likely that salt exposure to precipitation and equipment tracking is contributing to elevated levels of chloride in stormwater runoff.

This management concept recommends, at a minimum, technical assistance to evaluate whether there are more feasible or cost-effective options for salt storage such as a central storage site that is covered and designed to minimize salt tracking and can be coordinated for use by private applicators. Alternatively, this management concept could also offer grants for storage or equipment upgrades. It is anticipated that costs for storage or equipment upgrades will generally range between $25,000 and $100,000 for temporary structures, after factoring in containment and drainage features.

4.2.7 Develop Smart Salting Retrofit Plan at Ridgedale

Instead of selecting and implementing individual management concepts, including some of the aforementioned practices, this concept would involve more of a holistic approach to review and discuss all the current practices for snow management and deicing at the site with the landowner and private applicator to identify places where salt savings could be realized from the use of alternative equipment or application methods, better salt storage, abrasives, etc.

This concept could also include installation of alternative pavements (such as permeable pavements or snowmelt systems) at high-traffic locations, especially at locations that are subject to refreeze. Snowmelt systems keep surfaces above freezing so snow or ice melts immediately upon contact. These systems may use electric heating cables, surplus heat from boilers, or geothermal energy. Boiler and geothermal methods circulate heated fluids through pipes or tubes embedded in the pavement. Additionally, control units with sensors monitor temperature, shut off the system when surfaces dry out, and can preheat before a snowstorm arrives.

4.2.8 Regulatory Advocacy

There is a recognition among private applicators, especially those that are certified by MPCA, that there are significant differences in salt application equipment, calibration and methods used by different contractors at different sites. It has been suggested that the amount of salt being applied by all vendors should be regulated and tracked, as the State is doing with pesticide and herbicide applications to protect lake water quality and biotic integrity. So many of the private applicators apply far too much salt because of the risk of slip and fall litigation. If the salt applications were regulated and tracked, certified applicators may feel like they could have less liability when there is a slip and fall incident.

This management concept involves working with Minnesota Watersheds and other organizations to advocate for State regulations for private applicators and/or limited liability legislation.

5 Alternatives Assessment and Recommendations

Based on consultation with City of Minnetonka staff and the BCWMC Technical Advisory Committee, a three-phased sequence of implementation activities is recommended for next steps within the Crane Lake watershed. Work would begin by contacting private landowners in the Crane Lake watershed to report on the results of this study and offer technical assistance for the relevant nonstructural measures in Section 4 based on the prioritized and phased approach shown in Table 5-1.

There is agreement that the initial phase of implementation should prioritize educating and working with private properties to better understand their existing approach for procuring and contracting for winter maintenance, offering technical assistance for incentivizing best practices through their winter maintenance contracts, and ensuring that salt application rates are tracked. Subsequent phases of implementation should proceed based on the results of the initial phase of implementation. The projected goals for these later phases are expected to focus on activities such as cost-sharing for upgrades to salt storage and potentially deicing equipment, along with smart salting retrofits involving alternative pavements and snowmelt systems. Table 5-1 summarizes planning cost estimates for the recommended sequence of implementation activities. These cost estimates should be refined following the initial phase of work.

The recommended sequence of implementation activities does not include two options described above (4.2.5 and 4.2.8). Creating a watershed business agreement for joint winter maintenance is not a preferred approach by the city at this time but could be revisited as a potential future action if other actions are unsuccessful. Further, BCWMC has actively considered and, when appropriate, participated in other joint agreements and regulatory advocacy activities. It is expected that this will continue moving forward.

Table 5-1 Recommended Sequence of Implementation Activities and Estimated Costs

Phase	Nonstructural/Source Control Measure	Estimated Capital Costs[1]
1	Assist Private Properties with Procuring/Contracting Winter Maintenance (Section 4.2.2)	$30,000
	Track Application Rates in Winter Deicing Operations (Section 4.2.1)	
2	Develop and Provide Funding Toward Alternative Salt Storage Options for Private Properties (Section 4.2.6)	$200,000
	Develop and Provide Funding Toward Smart Salting Retrofit Plan at Ridgedale (Section 4.2.7)	
3	Deicing Equipment Loan/Purchase Program (Section 4.2.3)	$100,000
	Provide Abrasives to Reduce Salt Use (Section 4.2.4)	
	TOTAL	$330,000

1—Assumes cost sharing for equipment and facility upgrades. Does not include maintenance costs.

The BCWMC's CIP had a placeholder of $300,000 for this project. Approximately $182,100 of the original placeholder budget will remain after feasibility study completion. Staff recommends that the Commission request a levy to implement these three project phases to reduce chloride levels in Crane Lake and remove the lake from the impaired waters list. Minnetonka city staff indicated they do not currently have capacity to lead these activities but can assist as a partner. Project expenses would include the use of consultants or the Commission Engineer and Administrator for outreach and technical assistance activities. Expenses also include financial incentives for equipment upgrades or salt storage reconfiguration with appropriate agreements developed and enforced. Grant funds may also be available through the MN Pollution Control Agency to support targeted chloride reduction initiatives.

6 References

Barr Engineering Co. 2022. Crane Lake Report 2021. Prepared for Bassett Creek Watershed Management Commission.

Barr Engineering Co. 2023. Study of Chloride Extraction/Dilution for Parkers Lake (PL-7). Prepared for Bassett Creek Watershed Management Commission.

Minnesota Department of Transportation. (2019). Winter Maintenance Best Practices.

Minnesota Pollution Control Agency. (2020). *Minnesota Statewide Chloride Management Plan.* Retrieved from https://www.pca.state.mn.us/sites/default/files/wq-s1-94.pdf