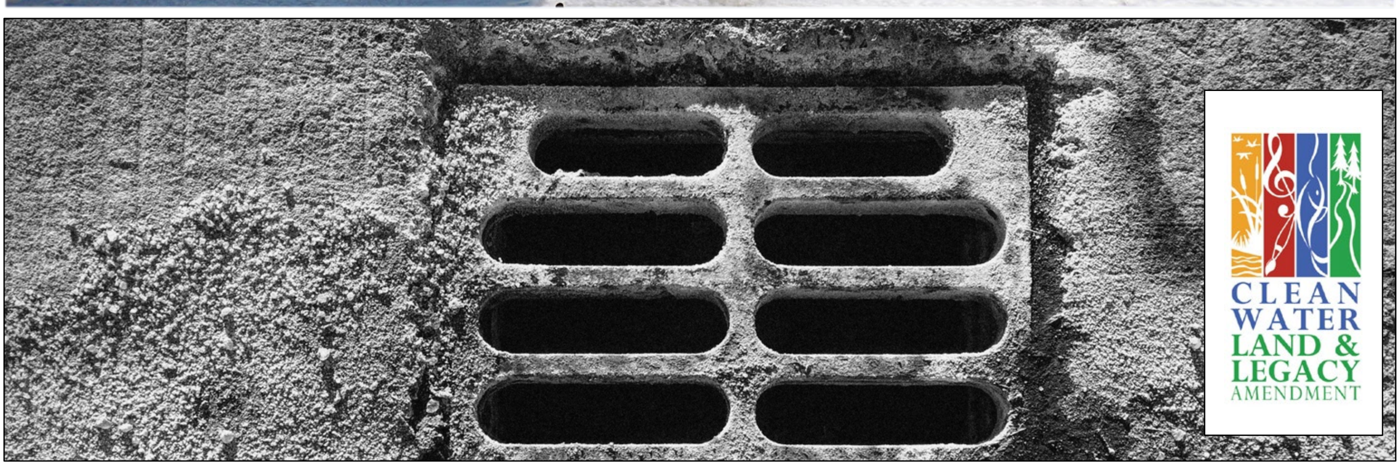
Twin Cities Metropolitan Area Chloride Management Plan

February 2016



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Acknowledgements

The development of this plan was accomplished through a partnership approach with several organizations across the metro and the state. Their contribution to this plan and commitment to the issue has allowed us to develop this comprehensive and strategic approach to reducing salt use while maintaining public needs.

American Public Works Association - Minnesota Chapter
Bassett Creek Watershed Management Commission
Board of Soil and Water Resources
Capitol Region Watershed District
City of Burnsville
City of Minneapolis
City of Plymouth
City of Shoreview
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Minnesota Cities Stormwater Coalition
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Minnesota Department of Transportation
Minnesota Pollution Control Agency
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Rice Creek Watershed District
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Scott County
Scott County Watershed Management Organization
Three Rivers Park District
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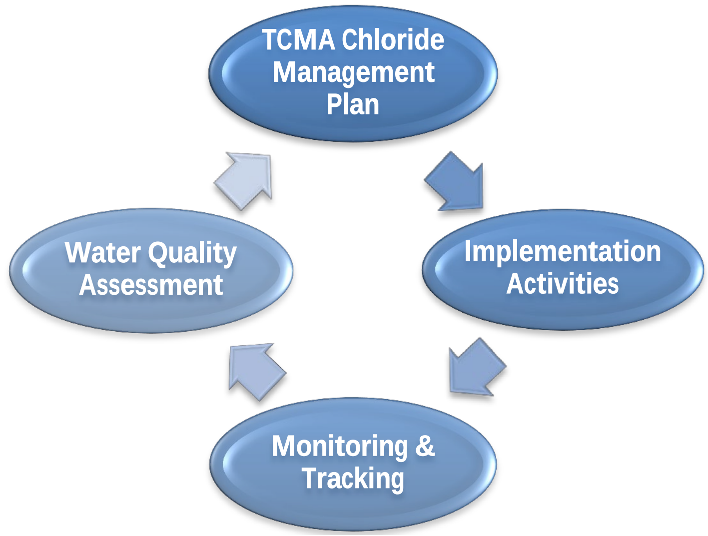
Acronyms

AUID	Assessment unit identification
BMP	Best management practice
BWSR	Board of Water and Soil Resources
CFR	Code of Federal Regulations
CMP	Chloride Management Plan
DNR	Minnesota Department of Natural Resources
EOC	Education and Outreach Committee
EPA	Environmental Protection Agency
EQuIS	Environmental Quality Information System
IPP	Industrial Pretreatment Program
KCl	Potassium chloride
LA	Load allocation
lbs	pounds
MCES	Metropolitan Council Environmental Services
mg/L	milligrams per liter
MCWD	Minnehaha Creek Watershed District
MnDOT	Minnesota Department of Transportation
MPCA	Minnesota Pollution Control Agency
MPRB	Minneapolis Park & Recreation Board
MS4	Municipal Separate Storm Sewer System
MWMO	Mississippi Watershed Management Organization
NaCl	Sodium Chloride
NMCWD	Nine Mile Creek Watershed District
NPDES	National Pollutant Discharge Elimination System
RO	Reverse osmosis
RWMWD	Ramsey-Washington Metro Watershed District
SWCD	Soil and Water Conservation District
TCMA	Twin Cities Metropolitan Area (Anoka, Carver, Dakota, Hennepin, Ramsey, Scott, Washington)
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
WD	Watershed District
WLA	Wasteload allocation
WMAt	Winter Maintenance Assessment tool
WMO	Watershed Management Organization
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

What is the TCMA Chloride Management Plan?

The Minnesota Pollution Control Agency (MPCA) has worked with stakeholders in the Seven County Twin Cities Metropolitan Area (TCMA) to assess the level of chloride in water resources, including lakes, streams, wetlands and groundwater. There are two primary sources of chloride to the TCMA water resources: 1) salt applied to roads, parking lots and sidewalks for deicing; and 2) water softener brine discharges to municipal wastewater treatment plants (WWTPs). The MPCA and stakeholders also worked together to develop a plan to restore and protect waters impacted by chloride.



This Chloride Management Plan (CMP) incorporates **water quality assessment, source identification**, **implementation strategies**, **monitoring recommendations,** and **measurement and tracking of results** into a performance-based adaptive approach for the TCMA. The goal of this plan is to develop the framework to assist local partners in minimizing salt (chloride) use and provide safe and desirable conditions for the public.

The CMP is intended to characterize water resources across the TCMA and the overall impacts of chloride. As part of the CMP, waters not meeting state standards have been listed as impaired and Total Maximum Daily Loads (TMDLs) developed. However, water quality is not the only factor driving the need to reduce chloride entering TCMA waters. Improved practices for anti-icing and deicing roads, parking lots and sidewalks not only reduce chloride impacts on water quality, but they can also lead to long-term cost-savings as a result of purchasing less salt for winter maintenance and reduced impacts on vegetation and corrosion of infrastructure and vehicles. A key challenge in reducing salt usage is balancing the need for public safety with the growing expectation for clear, dry roads, parking lots, and sidewalks throughout the mix, severity, and duration of winter conditions in the TCMA. Notable efforts have already been made by the Minnesota Department of Transportation (MnDOT) and some TCMA cities, counties, and others to improve winter maintenance while reducing salt usage. This CMP is intended to learn from and build on these efforts. The CMP will guide and assist agencies, local governments, and other TCMA stakeholders in determining how best to restore and protect water resources impacted by elevated chloride levels while balancing the need for public safety, level of service considerations, as well as water softening needs. This CMP is not intended to resolve all issues. Rather, it provides understanding and guidance for management activities over the next 10 years. While this plan was developed to address chloride impacts specifically to waters in the TCMA, the restoration and protection goals, implementation strategies, and monitoring and tracking recommendations can be applied statewide.

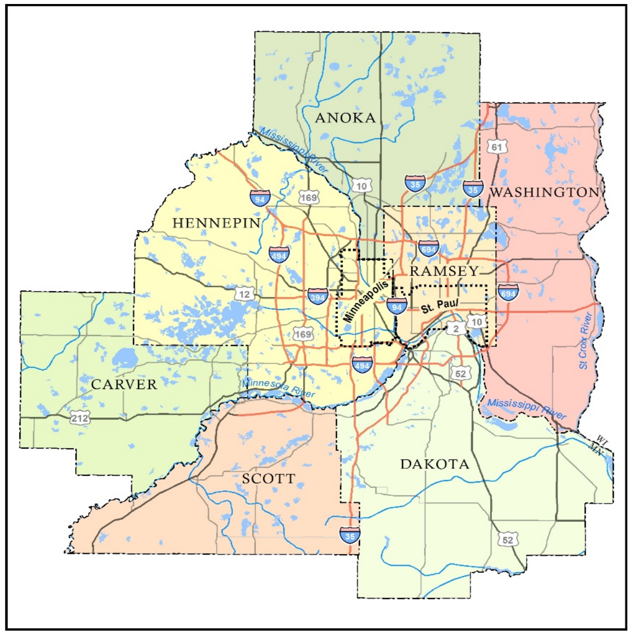
The purpose, scope and audience for the CMP are presented on the next page.

Chloride Management Plan
Purpose - Scope - Audience

Purpose	• Highlight the impacts of chloride on TCMA water quality • Develop an appreciation of the competing demands of level of service and reduced salt usage • Set performance-based goals for restoration and protection • Inform and guide implementation of improved winter maintenance practices and policy needs • Demonstrate the success and economic benefits of improved practices
Scope	• Status and trends of chloride levels in lakes, wetlands, streams, and groundwater • Sources of chloride • Restoration and protection goals • Implementation strategies to reduce chloride impacts • Educational and training resources • Continued monitoring, tracking and adaptive management
Audience	• Local working groups (local governments, watershed management groups, etc.) • Winter maintenance groups (MnDOT, local governments, private applicators, commercial property owners, residents, etc.) • Elected officials and policy-makers • State agencies (MPCA, MnDOT, DNR, BWSR, etc.)

1. Background and Description

The TCMA includes 186 cities and townships and a population of approximately 3,000,000 people. It covers approximately 3,000 square miles with about one-third in urbanized areas. It is a vibrant and growing community. The area is fortunate to be home to nearly 1,000 lakes and wetlands, small streams and large rivers, as well as shallow and deep groundwater aquifers. These water resources hold high value to the community and visitors to the area.



Twin Cities 7-County Metropolitan Area (TCMA)

The Twin Cities receives approximately 54 inches of snow each year on average. The thousands of miles of streets and highways in the TCMA, along with parking lots and sidewalks, must be maintained to provide safe conditions throughout the winter. Winter maintenance of these surfaces currently relies heavily on the use of salt, primarily sodium chloride (NaCl), to prevent ice build-up and remove ice where it has formed. The chemical properties of NaCl make it effective at melting ice, but these properties also result in the chloride dissolving in water and persisting in the environment. The dissolved chloride moves with the melted snow and ice, largely during warm-up events, and ends up in the water resources. Salt applied in winter for deicing in urban areas is a major source of chloride to Minnesota surface waters and groundwater.

Residential water softener use is also a significant source of chloride. Residential water softeners use chloride to remove hardness, which is typically caused by high levels of calcium and/or magnesium. In areas with hard water, residential water softeners which use salt are common. The chloride from water softeners makes its way to the environment either through discharge to a septic system or by delivery to a municipal WWTP. Chloride is not removed from wastewater using conventional treatment methods. However, chloride can be removed from wastewater by using reverse osmosis (RO) technology, which is considered cost-prohibitive for an issue of this scale.

Elevated chloride concentrations have been found in waterbodies throughout the TCMA. At levels exceeding the WQS, chloride is toxic to aquatic life. Water quality samples from lakes, wetlands, streams and groundwater show increased chloride levels in urban areas across the state. While monitoring has only been conducted for about 10% of all the surface waterbodies in the TCMA, the available data indicates 39 waterbodies in the TCMA currently exceed chloride levels protective of the aquatic community. Two of these impaired waterbodies have approved TMDLs (Shingle Creek and Nine Mile Creek). These high concentrations call for immediate attention to the issue, the development of a plan to restore waters already impaired, and for protection of waters at risk of further degradation.

A Chloride Feasibility Study for the TCMA (Phase 1) was completed in December 2009. This study improved understanding of the extent, magnitude, and causes of chloride contamination of surface waters and explored options and strategies for addressing impacts. This project included extensive data analysis, a literature review, a telephone survey, and analysis of potential strategies for further research, public education, and potential regulation.

In 2010, the MPCA initiated the TCMA Chloride Project. It built on the previous work to improve and maintain water quality with respect to chloride for the TCMA. A robust stakeholder involvement process was undertaken to develop partnerships and gain insight into winter maintenance activities and other sources of chloride. This process allowed the stakeholders to assist in the development of the CMP and has generated the support of local partners. This effort consisted of over 115 participating stakeholders on seven teams; an inter-agency team (IAT) made up of state government agencies, a technical advisory committee (TAC) consisting of local stakeholders, a monitoring advisory group (MSG) with local and state water quality monitoring experts, an Education and Outreach Committee (EOC) that included local education specialists throughout the TCMA, a technical expert group (TechEx) which was comprised of winter maintenance professionals, and an implementation plan committee (IPC), which was a combination of all the teams.

The Problem with Too Much Chloride

Low levels of chloride can be found naturally in the TCMA lakes and streams and is essential for aquatic life to carry out a range of biological functions. However, high concentrations of chloride in the surrounding water harm aquatic life as a result of a disruption in the cellular process called osmosis which moves molecules, such as water, through cell membranes. Too much chloride in the surrounding water can cause water to leave the cell and also prohibit the transport of needed molecules into the cell. If elevated concentrations of chloride persist in the water, aquatic life such as fish, invertebrates, and even some plant species become stressed and/or die. The MPCA has adopted the United States Environmental Protection Agency's (EPA) recommended water quality criteria for chloride, which is designed to protect aquatic life from the harmful effects of excessive chloride. The allowable chloride concentration to protect for acute (short-term) exposure is 860 mg/L. The allowable chloride concentration to protect for chronic (long-term) exposure is 230 mg/L. These values were developed based on toxicity test results for a range of freshwater aquatic organisms. Short-term exposure (one hour or more) to concentrations greater than 860 mg/L or continued exposure (four days or more) to chloride concentrations greater than 230 mg/L can be expected to have detrimental effects on community structure, diversity, and productivity of aquatic life.

Increased chloride concentrations due to salt applied to paved surfaces in winter can also have indirect effects on biota. Additives and contaminants such as phosphorus, cyanide containing compounds, copper, and zinc may cause additional stress or accumulate to a potentially toxic level (Wenck 2009).

Impacts on water quality in lakes, wetlands and streams are not the only concern related to high levels of chloride in the environment. Chloride can affect groundwater and drinking water supplies, infrastructure, vehicles, plants, soil, pets, and wildlife. The Phase 1 Feasibility Study documented the results of a literature review on the impacts of chloride from salt. Research identifies the negative impacts that chloride has on the environment, whether from pavement salt sources or water softeners, but there are still many unknowns. Continued research will help us understand how chloride interacts with the environment and therefore, how to protect our water resources. Additional concerns associated with chloride in the environment, including an analysis of the estimated cost of those impacts, are discussed below.

Chloride is persistent in the environment

Once chloride is in water, the only known technology for its removal is RO through massive filtration plants, which is not economically feasible. This means that chloride will continue to accumulate in the environment over time. A study by the University of Minnesota (UMN) found that about 78% of salt applied in the TCMA for winter maintenance is either transported to groundwater or remains in the local lakes, and wetlands (Stefan et al. 2008).

Surface Water

Chloride concentrations in lakes, wetlands and streams in the TCMA, as well as in many cold climate states have been increasing (Novotny et al. 2007; Novotny at al. 2008). Thirty-nine lakes, wetlands, and stream reaches are impaired for aquatic life due to high concentrations of chloride in the TCMA according to the MPCA's 2014 Draft 303(d) List of Impaired Waters (MPCA 2014). Impacts on lakes include toxicity to aquatic life as well as the potential interruption of the vertical mixing (turnover) process.

It is difficult to put a financial value on the impacts of chloride impairments. However, the Adirondack Watershed Institute (Kelting and Laxson 2010) did a simulation of road salt impacts on surface waters and forests and showed a $2,320 per lane mile per year reduction in environmental value. If this value is applied to the 26,000 lane miles of roadways in the TCMA (Sander et al. 2007), the resulting estimate of economic impacts on surface waters and forests in the TCMA is roughly $60 million per year. On a cost per ton of salt basis, using 349,000 tons per year applied in the TCMA (Sander et al. 2007), the resulting reduction in environmental value is $172 per ton of salt. These are not actual out-of-pocket costs, but indicate the cost of the loss of environmental value.

Groundwater and drinking water

Groundwater is another important resource in Minnesota; about 75% of Minnesotans rely on groundwater for their drinking water supply (MPCA 2013). Groundwater also contributes flow to lakes, wetlands, and streams. Deicing salt application is resulting in higher chloride concentrations in groundwater. A recent MPCA study found that 30% of monitoring wells tested in shallow sand and gravel aquifers in the TCMA exceeded the state chronic standard for surface waters of 230 mg/L for chloride (MPCA 2013). The amount of sodium (a common component of salt) in drinking water is a human health concern, particularly for individuals on sodium restricted diets (EPA 2003; EPA 2014).

The cost of mitigating groundwater contamination is substantial. The EPA has set a Secondary Maximum Contaminant Level of 250 mg/L for chloride in drinking water, which is a guideline for protection based on taste (EPA 2014). According to a 1991 report, $10 million is spent nationally each year on mitigating impacts to groundwater from salt (Transportation Research Board 1991). The United States uses approximately 20 million tons of deicing salt per year (Anning and Flynn 2014). This equates to a cost of about $0.50/ton for mitigating groundwater impacts. A 1976 estimate (Murray and Ernst) was much higher, with a figure of $150 million per year for damages due to contamination of water supplies by deicing salt. This estimate includes more direct and indirect costs such as treating water, replacing wells, supplying bottled water, adding practices to prevent additional contamination, human health concerns, and property value damage. Using an estimate of 9 million tons of salt used in 1976, this equates to $16.67 per ton for damages to water supplies.

Lake Ecosystems

Chloride changes the density of water, which can negatively affect the seasonal mixing of lake waters (Novotny et al. 2008). Mixing increases oxygen levels required by aquatic life. Changes in mixing can also affect nutrient cycling processes, phytoplankton community composition and productivity, zooplankton community composition and phenology, and fish.

No value has been assigned to impacts on aquatic life due to chloride toxicity or impacts on lake ecosystems whose natural turnover is disrupted due to formation of a chemocline caused by salt. Prevention of turnover can result in anoxia in the bottom of lakes and potential death of aquatic biota (Michigan DOT 1993). Increased salinity can result in a loss of native plant species and invasion by invasive salt tolerant species such as Common Reed (*Phragmites australis*), Narrowleaf cattail (*Typha angustifolia*) and Eurasian watermilfoil (*Myriophyllum spicatum*) (Kelting and Laxson 2010). Salt can be toxic to fish at fairly high concentrations (Evans and Frick 2001).

Plants

Direct deicing salt splash can kill plants and trees along roadsides and plants can also be harmed by taking up salty water directly through their roots. When chloride flows into lakes, wetlands, and streams, it harms aquatic vegetation and can change the plant community structure.

Vitaliano estimated that the aesthetic damage to trees in the Adirondacks due to road salt was $75 per ton (1992). Research in the Adirondacks has shown that the application of deicers and abrasives on roads has severely changed the chemical and physical structure of soil along roads (Langen et al. 2006). The New York State Department of Transportation spent $10,000 per mile to replant and reestablish natural vegetation along a two-mile stretch of highway in the Adirondacks (NYSDOT Press Release 2008).

Soil

Soil along roadsides can be impacted by road salt (primarily the sodium) in a number of ways, including change in soil structure, effects on the nutrient balance, accelerated colloidal transport, mobilization of heavy metals, reduced hydraulic conductivity and permeability (Amundsen 2010; Michigan DOT 1993). These changes can lead to reduced plant growth. Soil structure changes also may result in increased erosion and sediment transport to surface waters (Kelting and Laxson 2010).

Pets and Wildlife

Pets may consume deicing materials by eating them directly, licking their paws, or by drinking snow melt and runoff, which can be harmful to pets. Exposure to deicing salt can cause pets to experience painful irritation, inflammation, and cracking of their feet pads. Some birds, like finches and house sparrows, have an increased risk of death if they ingest deicing salt. Deer and other large mammals consume the salt on roadsides and roadside ponds to fulfill their sodium needs, resulting in increased traffic incidents (Environment Canada 2001; Amundsen 2010). Exposure of amphibians to road salt can result in abnormalities, reduced growth, behavior changes, lower survival rates, and changes in community structure (Environment Canada 2001; Denoël et al. 2010; Karraker 2008; Collins and Russel 2009). Deicing salt may also cause a decline among populations of salt sensitive species, reducing natural diversity.

Infrastructure

Chloride corrodes road surfaces and bridges and damages reinforcing rods, increasing maintenance and repair costs. The costs associated with infrastructure are based on damage to infrastructure and maintenance and replacement costs associated with this damage. A study by economist Vitaliano, included an estimate of expenditures of an additional $332 per ton of salt per season for bridge maintenance (1992). One ton of road salt results in $1,460 in corrosion damage to bridges, and indirect costs may be much higher (Sohanghpurwala 2008). The total annual cost of bridge decks damages due to road salt was estimated at greater than $500 million nationwide (Murray and Ernst 1976). Costs would be substantially higher now.

In addition to damage to bridges, chloride deicers also damage concrete pavement, requiring higher maintenance costs. Vitaliano (1992) estimates an overall increase in roadway maintenance costs of over $600 per ton. This figure is believed to include the extra cost due to damage to bridges. Salt applied to pavement is also damaging to parking garages and underground utilities (Michigan DOT 1993).

Vehicle Corrosion

Deicing salt also accelerates rusting, causing damage to vehicle parts such as brake linings, frames, bumpers. Vitaliano (1992) estimated that vehicle depreciation due to corrosion from road salt results in a cost of $113 per ton of salt. Automobile manufacturers have improved corrosion resistance in cars since the 1992 study; however, measures to protect vehicles against corrosion cost auto manufacturers an estimated $4 billion each year, which is passed on to consumers (Adirondack Council 2009).

Cumulative Costs

Estimates of damage to infrastructure, automobiles, vegetation, human health and the environment due to road salt were found in the literature from several sources. They ranged from $803 to $3,341 per ton of road salt used.

Table 1 shows the overall range of the cost estimate with a low and high range as well as the estimated associated cost for the TCMA based on 349,000 tons of salt applied per season.

Table 1. TCMA Overall Cost Considerations

	Low Overall Estimate		High Overall Estimate	
Cost component	**Rate per ton of salt**	**Cost * (millions) per year**	**Rate per ton of salt**	**Cost * (millions) per year**
Material	$73	$25	$73	$25
Labor and equipment	$150	$52	$150	$52
Overall damages	$803	$280	$3,341	$1,166
Combined Cost	**$1,026**	**$358**	**$3,564**	**$1,243**

** Calculated using TCMA annual salt use of 349,000 tons/season*

The money saved from reducing damage to infrastructure, vehicles, plants, water supplies, and human health is much higher than that from the material and labor savings. At a 10% salt use reduction, annual savings in the TCMA for reduced material and applications costs plus reduced damages would amount to an estimated $36 million to $124 million each year. At a 70% salt use reduction, savings would amount to $251 to $870 million each year (Fortin 2014).

2. TCMA Chloride Conditions

Chloride data across the TCMA was compiled and assessed to support the development of the CMP. As part of the TCMA Chloride Project, the MPCA worked with local partners to develop and implement a chloride monitoring program. The objective of the monitoring program was to better inform an understanding of chloride conditions across the TCMA, including seasonality, trends over time, and the potential for high chloride concentrations in the deepest part of lakes. Seventy-four lakes, 27 streams, and eight storm sewers were monitored as part of this effort from 2010-2013. The Chloride Monitoring Guidance for Lakes and Chloride Monitoring Guidance for Streams and Stormsewers were developed by the MPCA and local experts from the TCMA Chloride MSG and can be found on the MPCA's TCMA Chloride Project website. The monitoring guidance provides recommendations on sample collection, times of the year to sample, as well as guidance for monitoring high risk waters. In addition to data collected in 2010-2013 following the TCMA Chloride Project monitoring program, chloride data from a host of other sources and timeframes were compiled. The data were collected by several local organizations including the MPCA, the United States Geological Survey (USGS), Capitol Region Watershed District (CRWD), Metropolitan Council Environmental Services (MCES), Minneapolis Park &

Recreation Board (MPRB), Minnehaha Creek Watershed District (MCWD), Mississippi Watershed Management Organization (MWMO), Ramsey County Environmental Services, Ramsey-Washington Metro Watershed District (RWMWD), Rice Creek Watershed District, Scott County Watershed Management Organization, and Three Rivers Park District. A large portion of the data were compiled and submitted to the State of Minnesota's Environmental Quality Information System database (EQuIS). All data collected by Metropolitan Council are available on their Environmental Information Management System (EIMS) database: es.metc.state.mn.us/eims, and data collected by USGS are available on their water-quality data for the Nation database: waterdata.usgs.gov/nwis/qw.

The impacts of climate change create uncertainty related to winter salt application and chloride levels in TCMA waters in the future. Predictions provided by the United States Global Change Research Program for the TCMA area include warmer winter temperatures by 5 - 6 degrees Fahrenheit, longer freeze-free seasons increasing by 20-30 days, greater winter precipitation, and the likelihood of more frequent extreme events (Kunkel et al. 2013). On the one hand, these predictions of climate change may result in reduced salt use. On the other hand, more frequent snow events, more extreme events, and potentially more frequent ice storms may result in greater needs for deicing roads. Continued monitoring of climate change and chloride concentrations in the TCMA waters, tracking of salt use on all paved surfaces, and an adaptive process will be needed to restore and protect the TCMA waters from chloride impairments with the prospects of a changing climate.

A STREAM, LAKE OR WETLAND IS IMPAIRED BY CHLORIDE IF:

Two or more samples exceed 230 mg/L within a three-year period;

Or,

One sample exceeds 860 mg/L.

The remainder of this section will present an overview of the assessments conducted based on the available data, including determinations of impairment, time and spatial trends in chloride concentrations, the TMDLs developed for impaired waters, and waters showing a high-risk for future impairment.

2.1 Condition Status

This section describes the current status of water resources within the TCMA with respect to applicable chloride criteria. The status of surface waters including lakes, wetlands and streams is presented first. The status of groundwater resources is presented second.

Surface Water

The MPCA's approach to determining whether or not a stream, lake, or wetland is impaired by chloride relies on an assessment of available data. The MPCA conducted an assessment for chloride in the TCMA waterbodies in 2013. Two or more exceedances of the chronic criterion of 230 mg/L within a three-year period are considered an impairment. One exceedance of the acute criterion of 860 mg/L is considered an impairment. The 2013 TCMA chloride assessment resulted in 29 new chloride impairments (6 streams, 19 lakes, and 4 wetlands) added to the 2014 draft impaired waters list, resulting in a total of 39 chloride impairments in the TCMA. Shingle Creek and Nine Mile Creek were previously listed as impaired with completed chloride TMDLs. Approximately 11% of the 340 waterbodies assessed were determined to be impaired. An additional 38 (11%) were classified as high risk and 11% did not have enough data. High risk was defined as a waterbody having one sample in the last 10 years that was within 10% of the chronic criteria (207 mg/L). An interactive map showing assessed, impaired, not impaired, and high risk waters is on the MPCA Chloride Project website (MPCA Chloride Project Website Map of Assessments and Impairments). The assessed lakes, wetlands, and streams are shown on Figure 1. The highest density of impairments is in the heavily urbanized area in Hennepin and Ramsey Counties, though three streams in the outlying suburban areas are also impaired by chloride. The chloride causing impairments in the streams in the outlying areas of the metro is largely effluent from the WWTPs, rather than deicing salt.

It is important to keep in mind that of the over 1,000 lakes, wetlands and streams in the TCMA, less than one-third had chloride data to make an assessment of impairment/attainment of water quality criteria. Also, of those waters with adequate data to make an assessment, only 30% were part of the TCMA Chloride Project monitoring program, which was developed to collect samples at critical times of the year and critical locations. As a result, data used to evaluate water quality conditions in waters not part of the TCMA Chloride Project monitoring program, may not have been representative of critical conditions. Critical times of the year for collecting chloride samples are typically during the winter snowmelt runoff (February through March) and during low flow periods, and critical areas for collecting chloride samples in a lake are near the bottom.

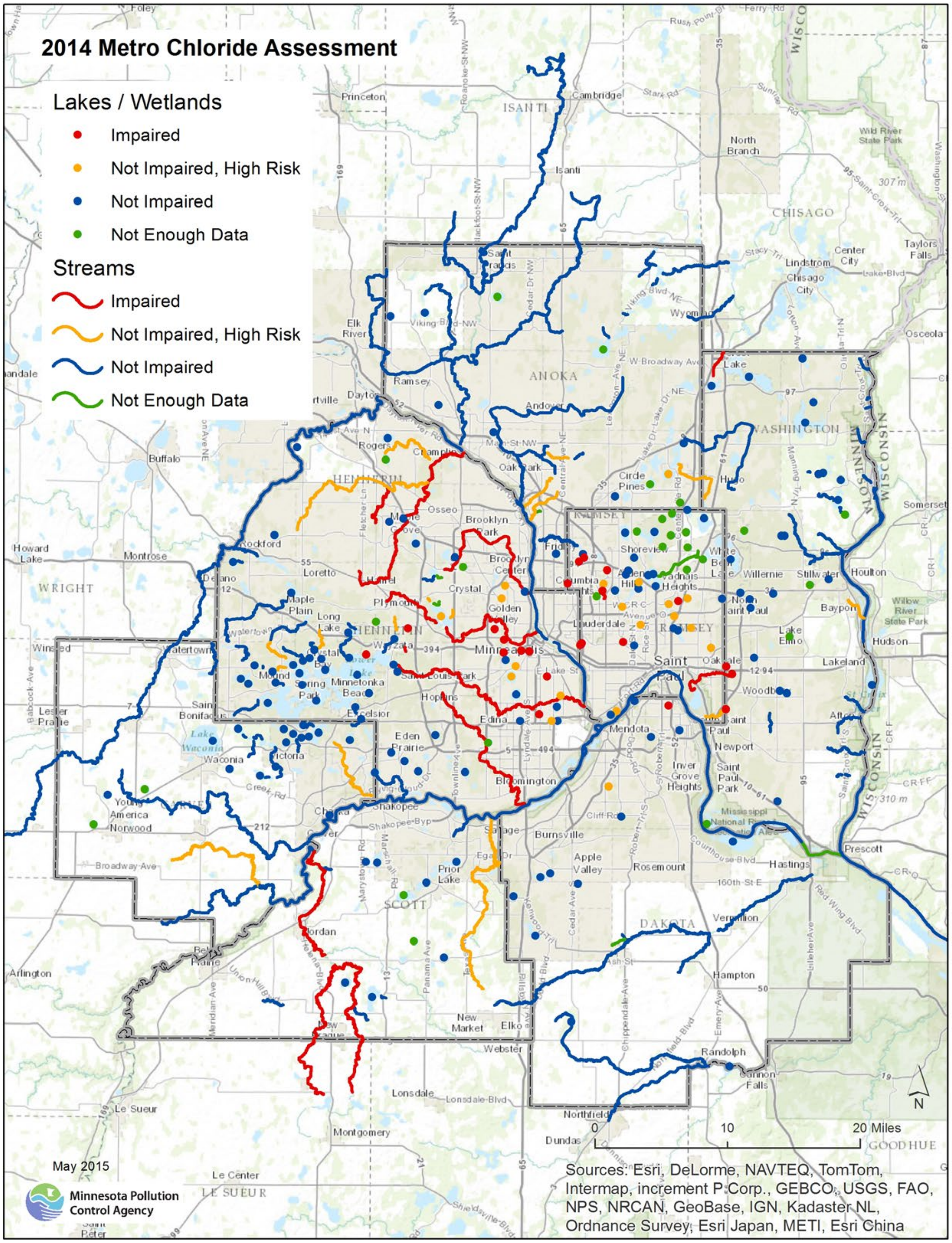


Figure 1. 2014 Chloride Assessment Results in the TCMA

The impaired lakes, wetlands, and streams were compared by the concentrations of chloride ranked from highest to lowest concentrations. These rankings are presented in Figure 2 and Figure 3. These figures are not a direct reflection of the 303(d) listing assessment; they are intended to make a relative comparison of the extent of impairment across impaired waters. The values presented in these figures were calculated by identifying the maximum chloride concentration measured in a waterbody on individual sampling days, then averaging all individual sampling day maximums that exceeded the standard of 230 mg/L from 2003-2013. These figures indicate the variability in one waterbody or watershed to the next by the severity of the impairment. These rankings can be used by chloride users to prioritize management activities by area. Since only a portion of the TCMA waters have chloride monitoring data, the rankings can also be used to determine specific areas that are close to impaired and high-risk watersheds for further monitoring and higher levels of management.

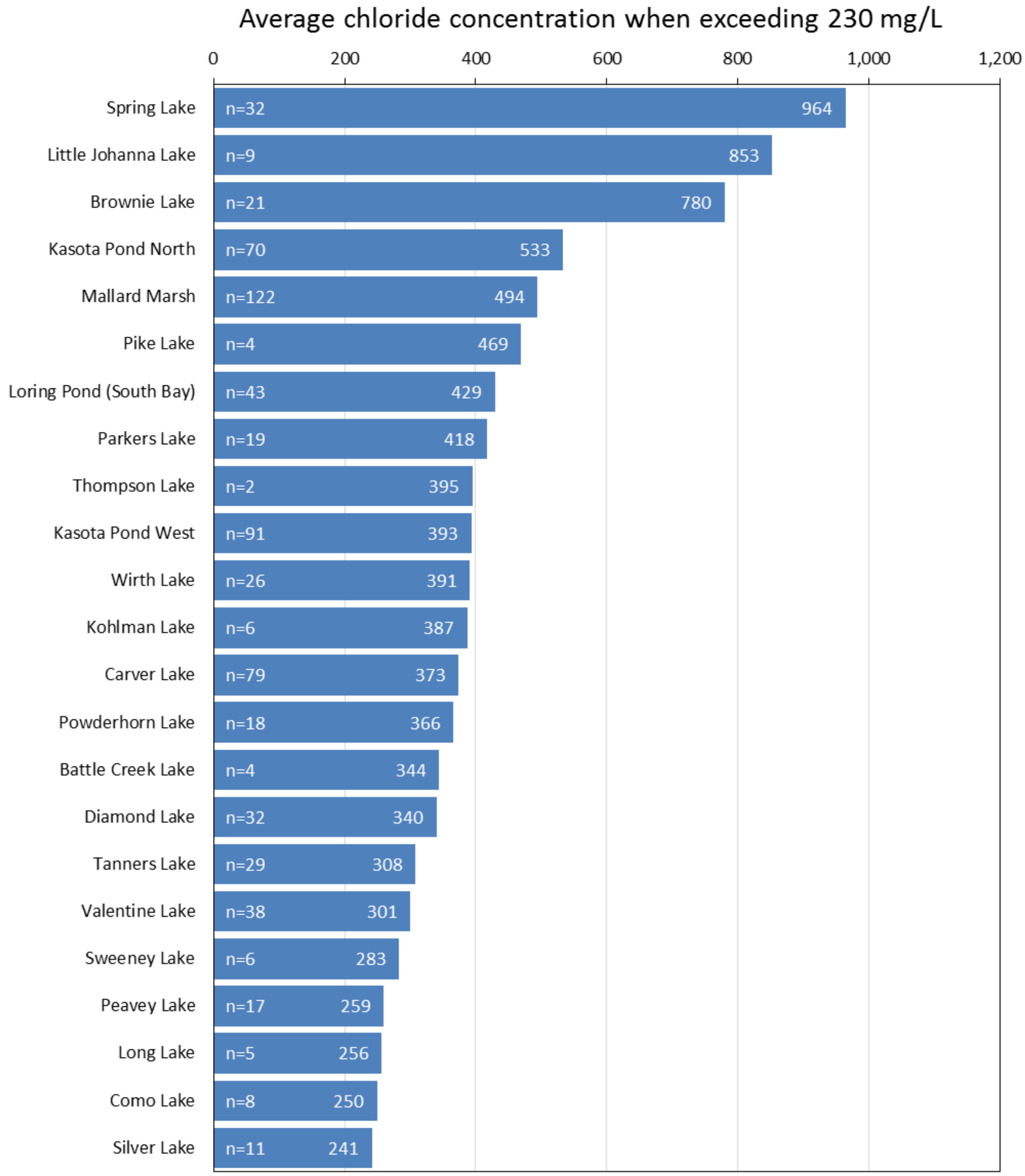


Figure 2. Comparison of Impaired Lakes and Wetlands in the TCMA
Data from 2003-2013; average chloride concentration of samples exceeding 230 mg/L; n is the number of days with samples exceeding 230 mg/L.

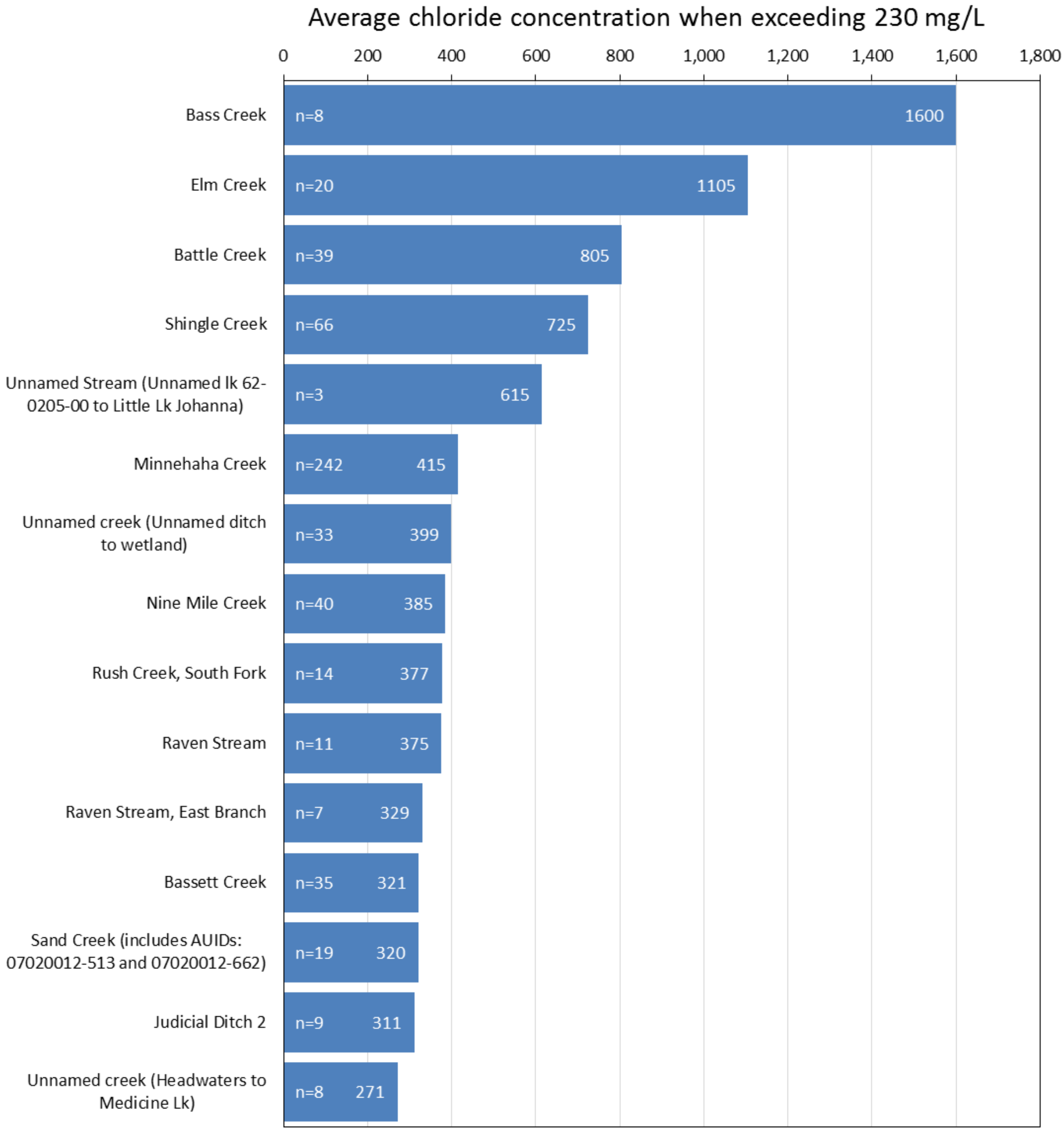


Figure 3. Comparison of Impaired Streams in the TCMA

Data from 2003-2013; average chloride concentration of samples exceeding 230 mg/L; n is the number of days with samples exceeding 230 mg/L.

Groundwater

Chloride concentrations in shallow groundwater are increasing, likely as a result of the application of deicing salt. This correlation is observed in a recent study by the MPCA, The Condition of Minnesota's Groundwater, 2007-2011, which found that chloride concentrations were higher in wells sampled in urban areas, where salt is more commonly applied in winter months, compared to wells sampled in areas that were undeveloped (Table 2).

Table 2. Average chloride concentrations in groundwater based on land use

Land Use	Chloride (mg/L)
Residential	45 mg/L
Commercial/Industrial	60 mg/L
Undeveloped	15 mg/L

The median chloride concentration in sand and gravel aquifers in the TCMA was 86 mg/L, compared to a median concentration of 17 mg/L in sand and gravel aquifers outside the TCMA. Twenty-seven percent of sand and gravel monitoring wells in the TCMA had chloride concentrations greater than 250 mg/L, the secondary maximum contaminant level set by the EPA (Figure 4). Very few monitoring wells outside the TCMA (about 1%) had chloride concentrations exceeding 250 mg/L.

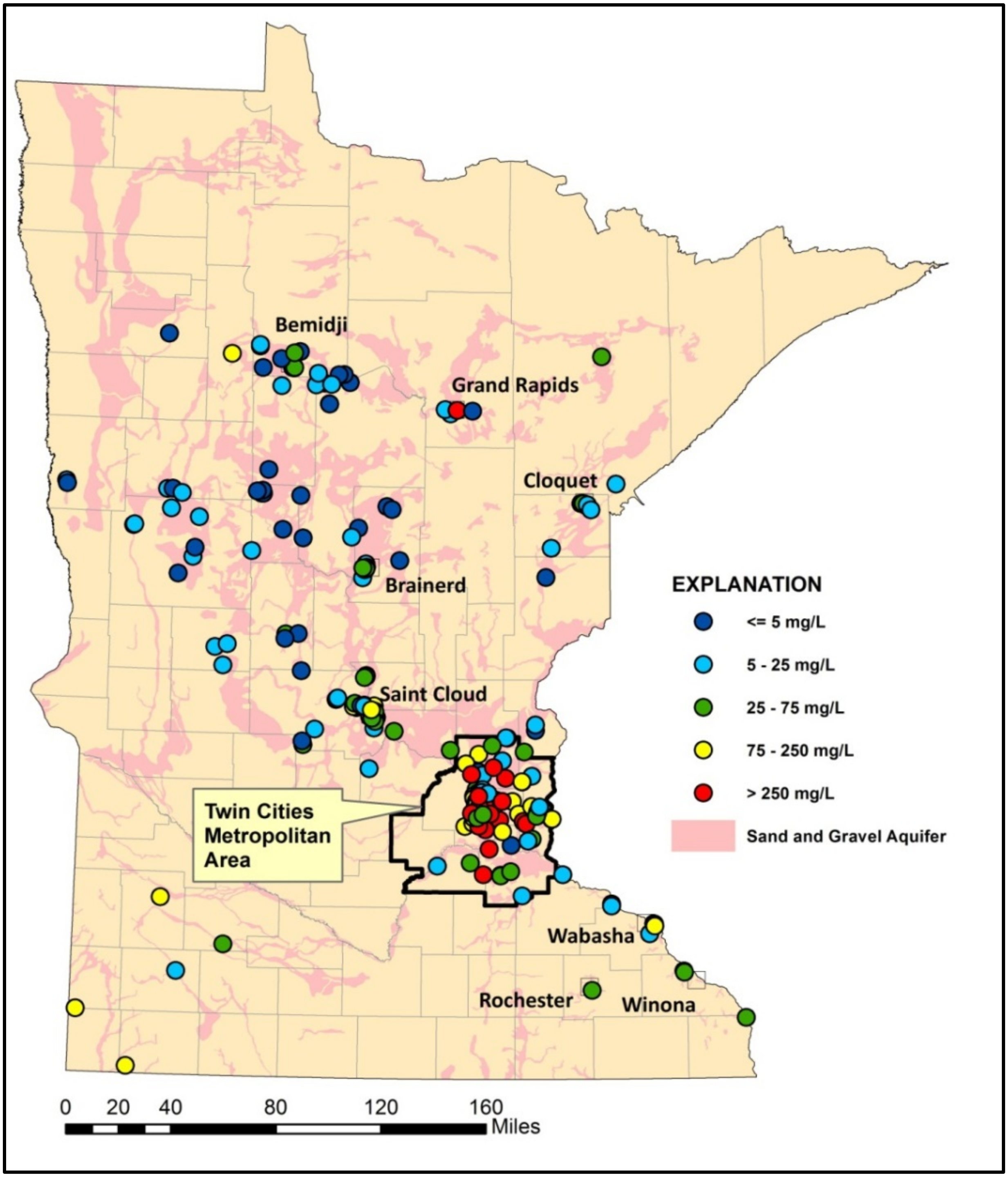


Figure 4. Chloride concentrations in ambient groundwater from the sand and gravel aquifers
Data from 2007-2011; figure taken from the MPCA's Ambient Groundwater Monitoring Network (MPCA 2013, p. 29).

2.2 Chloride Sources

Chloride enters the TCMA lakes, streams, wetlands, and groundwater from a variety of sources. The relative significance of each source of chloride is dependent on the watershed. For highly developed urban areas, winter maintenance activities are typically the primary source. In less developed areas where point source discharges exist, the municipal wastewater treatment facilities may be the primary source of chloride, which in most cases is due to water softening. A conceptual model diagram of the primary anthropogenic sources is shown in Figure 5. A chloride budget for the TCMA estimated that only 22%-30% of the chloride applied in the TCMA was exported out of the TCMA via streamflow in the Mississippi, Minnesota, and St. Croix Rivers (Stefan et al. 2008). Therefore, 70%-78% of the applied chloride remains in TCMA lakes, wetlands, and groundwater and it may also be stored in soil-water where infiltration is slow. Since chloride is an element and does not breakdown over time, the high percentage retained in the TCMA suggests that chloride will continue to accumulate and eventually make its way to the deep aquifers. This implies that, on average, chloride concentrations in the TCMA waterbodies are increasing with time. If the chloride loading remains steady, the concentrations will level out when equilibrium develops between loadings and transport out of the TCMA. By the same token, if loadings are reduced sufficiently and persistently, the chloride concentrations in the TCMA waterbodies will begin to decrease and will continue to decrease until a new equilibrium is reached. Each of these sources is briefly described below.

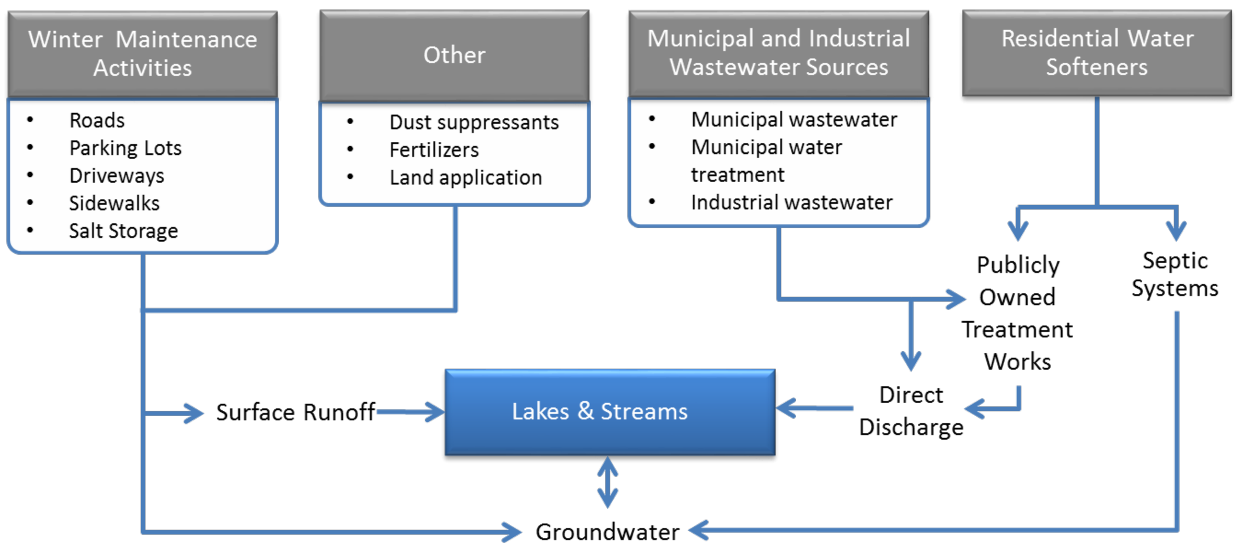


Figure 5. Conceptual model of anthropogenic sources of chloride and pathways

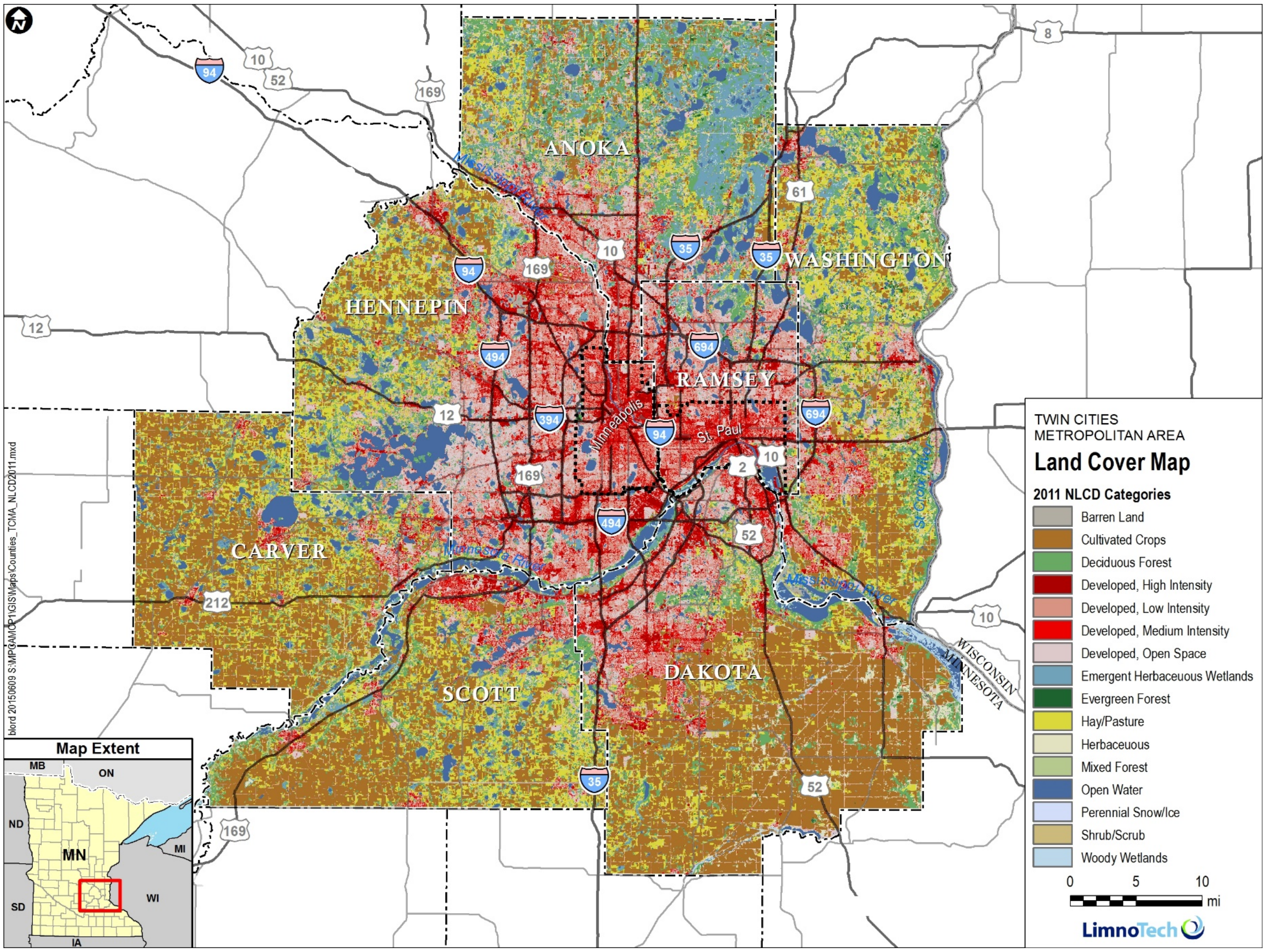


Figure 6. Land Use in the TCMA *(based on the National Land Cover Database from 2011)*

As shown in Figure 6, land use in the TCMA is largely urban in the core of Minneapolis and St. Paul with a transition to rural and agricultural moving outward through the suburbs. The primary source of chloride may shift locally depending on land use. Section 2.3 discusses the correlation of road density and chloride concentrations in surface waters.

Winter Maintenance Activities

Winter maintenance activities include snow and ice removal. Application of deicing and anti-icing chemicals, primarily salt, is common. Salt is applied to a variety of surfaces including roads, parking lots, driveways, and sidewalks. Runoff from salt storage facilities is another potential source of salt. The St. Anthony Falls Laboratory at the UMN developed an inventory of salt uses in the TCMA for a Minnesota Department of Transportation (MnDOT) Local Roads Research Board study (Sander et al. 2007). The inventory estimated the total amount of salt used for winter maintenance activities in the TCMA, based on purchasing records, to be 349,000 tons per year. Estimates of use by various entities are shown in Figure 7.

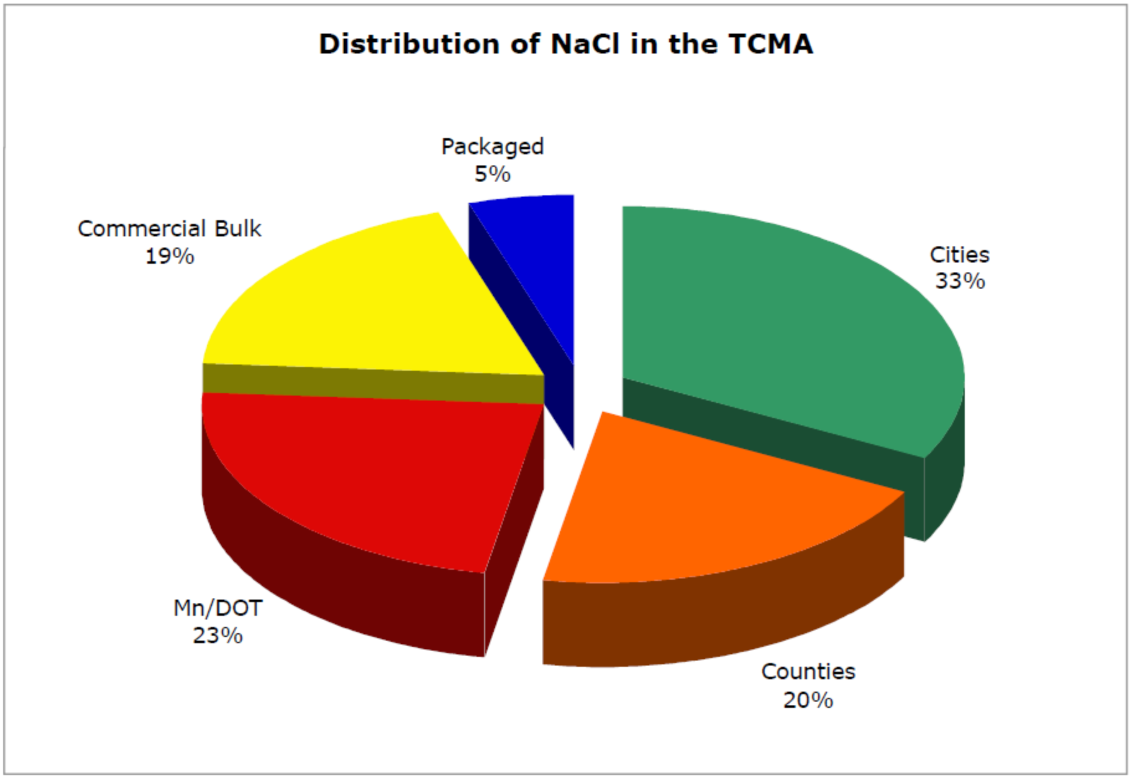


Figure 7. Distribution of NaCl in the TCMA (*Figure adapted from Sander et al., 2007)*

Salt sales data in the United States shows a dramatic increase in the amount of salt being purchased. Figure 8 below from the Salt Institute illustrates this increasing trend. Along with the increased use of salt, increasing levels of chloride in lakes, wetlands, and streams should be expected.

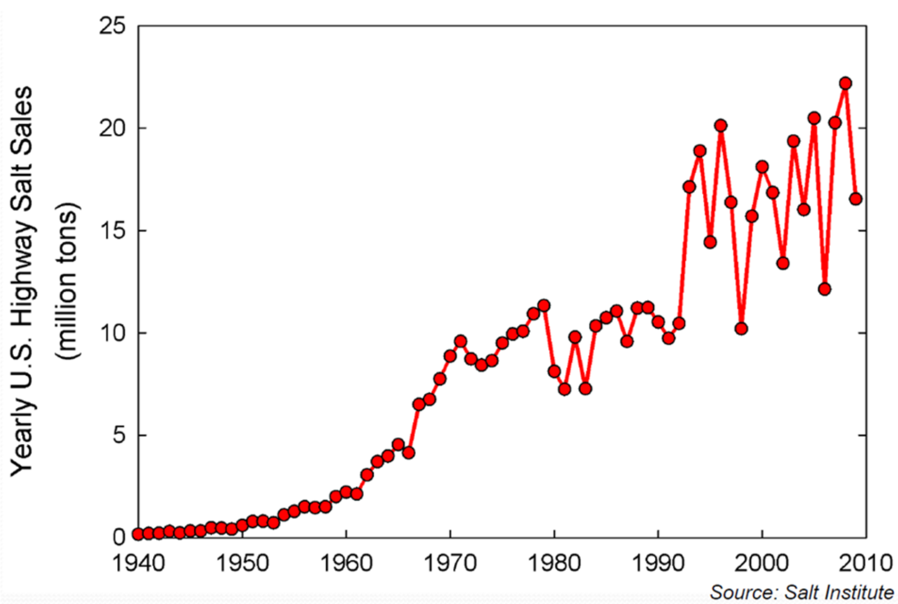


Figure 8. Road Salt Sales Trend in the United States

Roads

The TCMA is estimated to have over 26,000 lane miles of roadways (Sander et al. 2007). Application rates range from 3 to 35 tons of road salt, per lane mile, per year, based on the salt purchasing records and the number or lane miles of MnDot, counties, and cities in the TCMA (Wenck 2009)

A survey of municipal winter maintenance professionals in the TCMA, done by LimnoTech in 2013, found that typical application rates range from 100 - 600 pounds of salt applied per lane mile per event, which is consistent with previous evaluations of road salt application rates. However, rates can be much higher on hills, near intersections, and other ice problem areas. Higher speed roadways will typically have higher road salt application rates. Some events may require multiple passes of salt application and increase the application rate per event.

Commercial Parking Lots, Driveways, and Sidewalks

Commercial sources of deicing salt can vary greatly between different watersheds and includes salt applied to parking lots, driveways, and sidewalks on commercial property. The land owner or tenant may conduct winter maintenance activities, or winter maintenance may be contracted with private winter maintenance providers. Commercial sources are likely responsible for 10% and 20% of the total salt applied to paved surfaces in the TCMA (Wenck 2009). The MPCA and Fortin Consulting conducted research to validate and refine assumptions regarding commercial and private salt application rates specific to Minnesota (Fortin 2012a). There is a range of reported application rates, which is to be expected, because rates should vary based on temperature, type of snow event, surface to where material is applied, number of passes over an area during an event, and type of material used. Application rates of salt on parking lots are estimated to range from 0.1 to 1 ton per acre per event, and typically 6.4 tons per acre per year. For sidewalks, the application rate is estimated to range from 8 to 25 pounds per 1,000 square feet per event (0.2 to 0.5 tons per acre per event). More area specific residential and commercial estimates of chloride usage can be determined on a watershed basis by digitizing all of the residential and commercial impervious surfaces and multiplying by the estimated application rates.

Review of available information and additional research included application rates from across the United States' and Canada's snowbelt, with an emphasis on Minnesota specific data. It was determined that an average rate of 6.4 tons per acre per event is the appropriate application rate to expect on parking lots. As a percent of the total deicing salt usage, it is estimated that anywhere between 5% and 45% is used for commercial applications (parking lots, sidewalks, residential, private roads). The amount of chloride from commercial sources is variable, and is dependent on the characteristics of the watershed, including the amount of impervious area. Additional estimates of commercial salt use are presented below.

- The Nine Mile Creek Chloride TMDL report, used data on salt purchases from Sander et al. (2007) and Novotny et al. (2008), but weighted the data based on land use. It was determined that the relative contribution for commercial and packaged deicer in the Nine Nile Creek watershed was 38% of the total amount of road salt that is applied (Barr Engineering 2010).
- In the Shingle Creek TMDL, it was estimated that 7.5% of salt application was by commercial/private applicators. This figure was based on the estimates used in Canada. “Cheminfo (1999) estimated that commercial and industrial consumers represented

approximately 5 to 10% of the deicing salt market. In quantifying total deicing salt application in Canada, Environment Canada used the midpoint of these data (7.5%) to represent commercial and industrial salt application (Environment Canada 1999)." (Wenck 2006).

- Sander et al. (2007) estimated that the bulk deicing salt applied by commercial snow and ice control companies accounted for 19% of the total salt used in the TCMA, while packaged deicer for home and commercial use was estimated to account for 5% of the total in the TCMA.
- Novotny et al. (2008) used market share amounts from the USGS annual mineral reports and the market share report published annually from the Salt Institute. TCMA amounts were estimated based on national amounts combined with the commercial bulk (19%) and packaged (5%) deicer estimates for a total of 24%.
    - On a national basis, the Salt Institute estimated that 20% of bulk road salt purchases were by non-governmental entities.
    - The USGS estimated 13% of ice control salt is for commercial use.
- A chloride TMDL study in New Hampshire reported a chloride application rate of 5.7 to 6.4 tons per acre per year for parking lots and drives (Sassan and Kahl 2007). Parking lots were 47% of paved surfaces in the watershed and accounted for 36% of the chloride load. The study also estimated that 45% of salt was applied by private applicators.

Private Parking Lots, Driveways, and Sidewalks (residential)

Residential winter maintenance salt use has been estimated from purchasing records. Packaged deicer for home and commercial use is estimated to account for 5% of the total in the TCMA (Sander et al. 2007). See Figure 7.

A Sidewalk Salt Survey was conducted to qualitatively assess the use of sidewalk salt by the general public in the TCMA. The survey was disseminated by local partners including RWMWD, MCWD, and MnDOT. The survey was administered through an on-line Survey Monkey link on the MCWD website (www.minnehahacreek.org) from November 2011 through March 2012. The survey was completed by 606 people online and 148 completed a paper survey. Approximately 47% of the respondents lived in St. Paul or Minneapolis, and other respondents lived in surrounding cities including Woodbury, Richfield, Plymouth, and Maplewood. Although the survey sampled 754 residents, the results represent a small percentage of the TCMA population and are non-random/voluntary; therefore, the survey is not representative of all residents in the TCMA. However, the data provide valuable information on the use of sidewalk salt by TCMA residents.

The majority of residents that responded to the survey used sidewalk salt (57%), particularly on sidewalks and steps. Most people selected products based on performance in colder temperatures and environmental safety. The majority of respondents did not know how much sidewalk salt to use (59%), and if they did know, they determined how much to use based on the instructions on the packaging or used as little as possible. For complete results of the survey see Appendix C.

Municipal and Industrial Treatment Facilities

Municipal wastewater, backwash from municipal WWTPs, and industrial facilities with waste streams may contain chloride. The primary source of chloride in a municipal waste stream comes from water softeners. Many cities do not soften drinking water before it is distributed to residents. Many residents soften the water in their home with personal water softeners. The most common water softening systems use NaCl or potassium chloride (KCl). Salt that contaminates the groundwater can enter the sanitary sewer system through cracks and/or leaks in the pipes and pipe joints. Industrial facilities that discharge to the municipal wastewater collection system can be another source of chloride. Some industries have chloride in their discharge due to the products they produce or chemicals they use (Henningsgaard 2012).

Industrial facilities may discharge directly to surface waters following treatment or may discharge to a sanitary sewer system, which transports the wastewater to a wastewater treatment plant (WWTP) for further treatment prior to discharge to surface water. A range of industrial facilities discharge directly to waters that are already impaired by chloride, these include food processing facilities, manufacturing, pipeline terminals, biofuel facilities, and groundwater treatment systems. Discharges of chloride from municipal and industrial wastewater sources are covered by individual or general permits. Chloride data for wastewater and industrial sources is currently not widely available. However, chloride monitoring is being required for many facilities as permits are re-issued.

As part of the TMDL component of this project, several facilities were identified that likely discharge chloride within the impaired watershed. A table listing these facilities and their location is shown in Appendix A-3. There are likely additional facilities with the potential to contain chloride in their discharge; however, since they are not contributing to an impairment they were not evaluated at this time.

Residential Water Softeners

In areas with high hardness in the water supply, like the TCMA (See Figure 9), residential water softeners that use salt are common. Hardness is a measure of the calcium and magnesium carbonate concentration in water. Most water softeners use chloride ions to replace the calcium and magnesium ions. Chloride from this salt is delivered to the environment either through discharge to a septic system or by delivery to a WWTP. Septic systems become more prevalent in the rural areas outside of the TCMA urban core. The chloride that comes from septic systems enters the shallow groundwater or local streams through subsurface flow. Chloride loading from any individual home water softener is dependent on many variables and is specific to the individual homeowner's water chemistry, water use, hardness preferences, and softener efficiency. Estimates of the amount of salt discharged from residential water softeners in the TCMA are not available at this time. However, where the primary source of household water is hard and it is not softened by municipal water utility, residential water softeners are the primary source of chloride to WWTPs. Figure 10 shows the hardness values of drinking water supply wells for the entire state of Minnesota. The Sand Creek watershed, located in Scott County of the TCMA, is an example where the primary source of chloride to surface waters is from water softening; chloride concentrations in WWTP effluent for three WWTPs located in the watershed average from 521 mg/L to 618 mg/L.

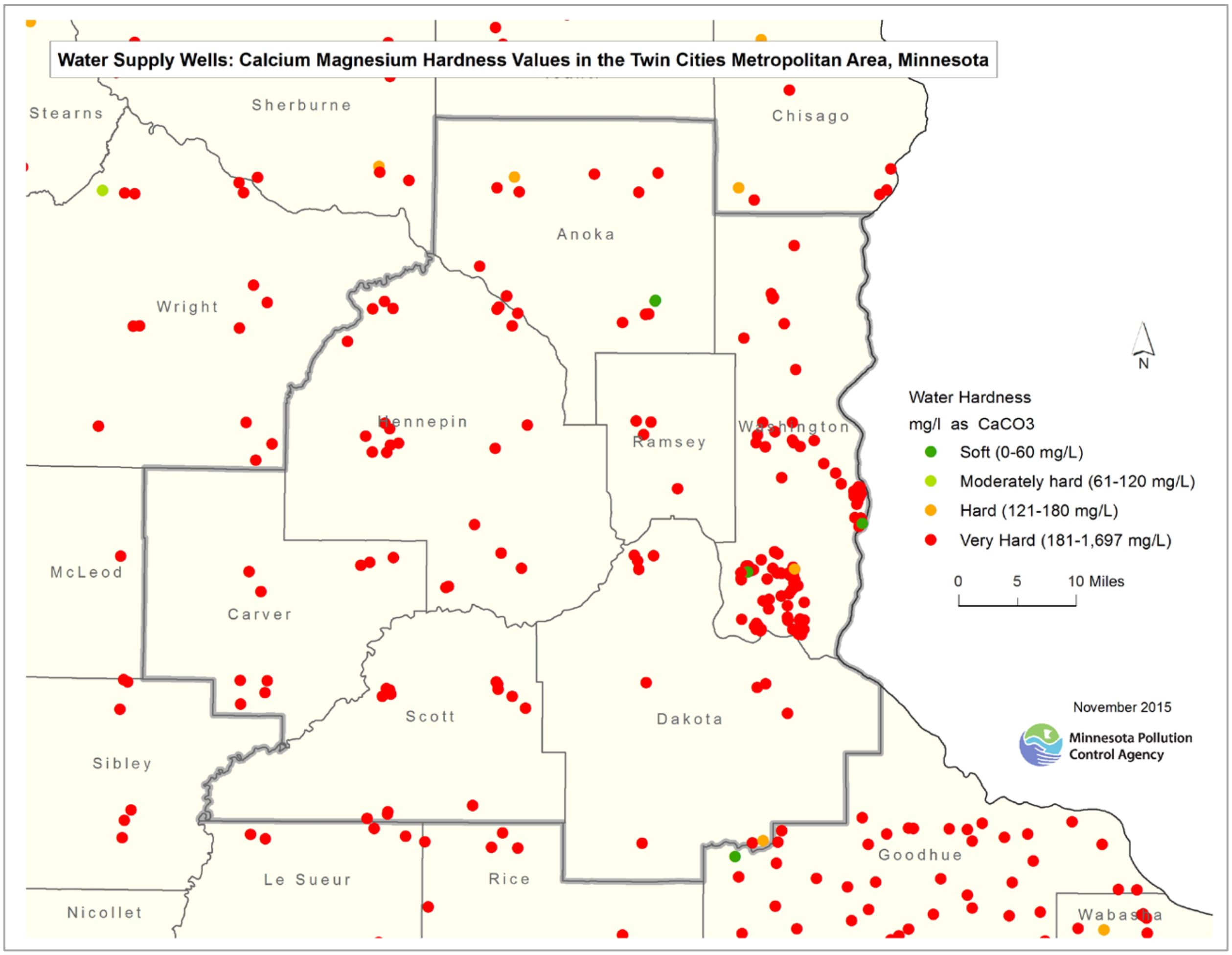


Figure 9. Hardness values of drinking water supply wells in the TCMA

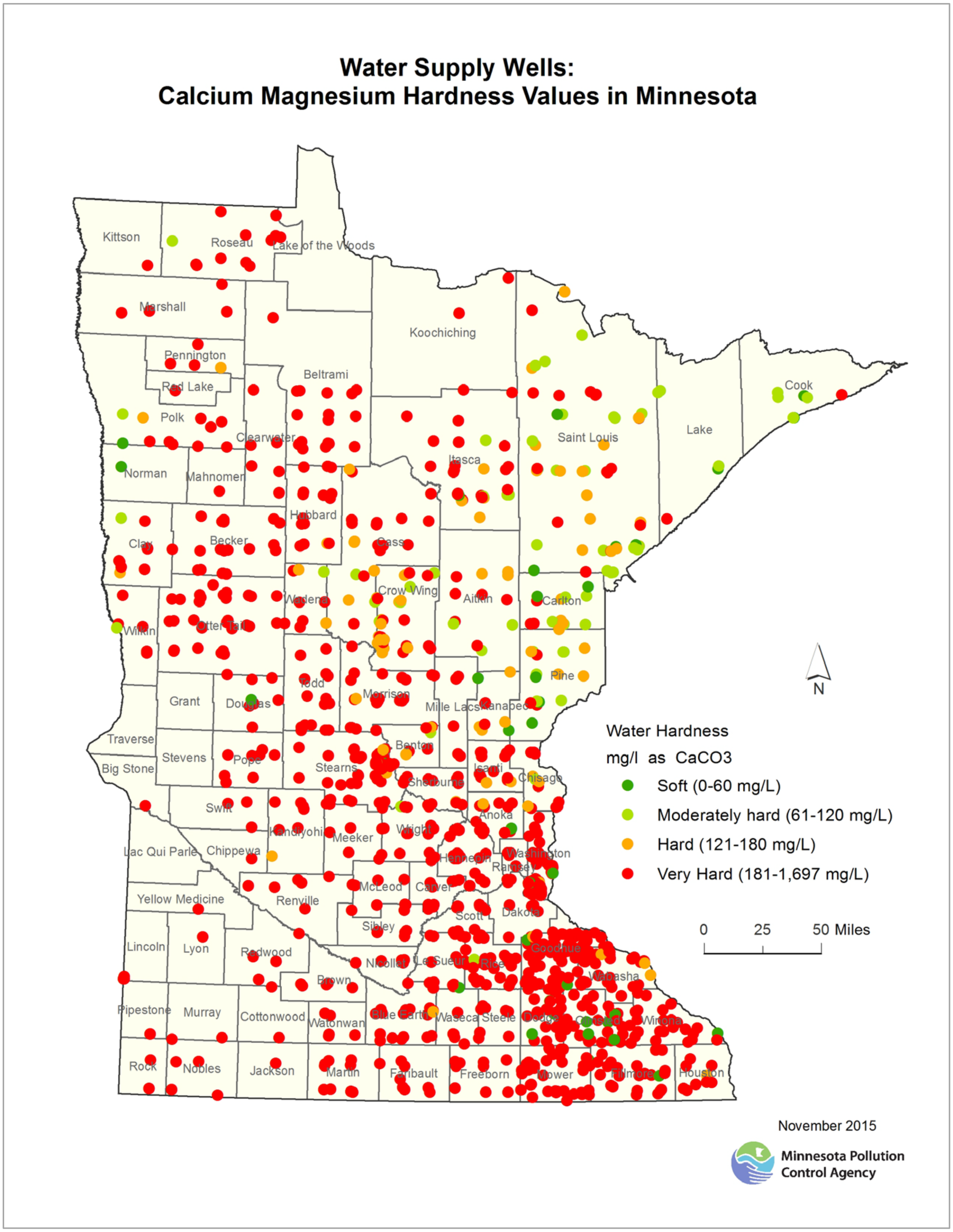


Figure 10. Hardness values of drinking water supply wells in Minnesota

Natural Background Sources of Chloride

Chloride occurs naturally in soil, rock, and mineral formations. Chloride is naturally present in Minnesota's groundwater due to the natural weathering of these formations. Glacial deposits from eroded igneous rocks and clay minerals with chloride ions attached are potential sources in the TCMA. Natural background levels of chloride in surface runoff and groundwater vary depending on the geology. The natural background concentration in small streams in the TCMA has been estimated to be 18.7 mg/L (Stefan et al. 2008). A natural background concentration for lakes has not been estimated; however, the natural background load from surface runoff to lakes was assumed to be at a concentration of 18.7 mg/L as well. This background concentration characterizes runoff that is not impacted by current or historical applications of anthropogenic sources of chloride. Concentrations of chloride in precipitation are estimated to be 0.1 mg/L to 0.2 mg/L (Chapra et al. 2009).

Agriculture

Agricultural crop land may be a small source of chloride to lakes and streams. Fertilizers and biosolids from food processing and publicly owned treatment works contain chloride. The application of fertilizers and biosolids on crop land can result in chlorides being transported to lakes and streams through surface runoff, as well as infiltration into shallow groundwater and subsequent transport to lakes and streams. KCl is the most commonly used fertilizer containing chloride. While not expected to be a significant source of chloride, estimates of the amount of chlorides in land applied fertilizers and biosolids in the TCMA are not available.

An on-going evaluation of agricultural drainage water quality done by North Dakota State University – Department of Agriculture and Biosystems Engineering indicates that chloride concentrations from agricultural drainage can range from 8.6 mg/L to 37.4 mg/L. [The results of this study have not been published].

Other Potential Sources

Sources of chloride to TCMA lakes, wetlands, and streams other than those discussed above exist, but are considered to be small. One such source of chloride is the use of dust suppressants on gravel roads and parking areas. Chloride is a common constituent found at high concentrations in dust suppressants. Landfill leachate has also been shown to contain elevated levels of chloride (Mullaney et al. 2009). The use of aluminum chloride for treatment of lake sediments or ferric chloride for treatment of stormwater are sources of chloride and should be avoided in waters and watersheds with chloride impairments.

2.3 Chloride Trends

This section of the CMP presents evaluations of chloride water quality conditions in the TCMA considering:

- Seasonal chloride trends in surface waters
- Long-term chloride trends
- Chloride trends within lakes
- Chloride relationships to watershed characteristics
- Chloride concentrations in stormwater
- Chloride relationships between surface and groundwater

This information is intended to help inform management decisions such as where and when to focus monitoring efforts and where to prioritize implementation activities.

Seasonal Chloride Trends in Surface Waters

Chloride data were evaluated for seasonal trends by looking at monthly chloride concentrations. Seasonal trends can help determine the cause of elevated chloride concentrations. Causes can be direct runoff from winter maintenance practices using chloride, groundwater inputs (primarily from infiltrated chloride containing deicers) during low flow, and WWTP inputs.

For the majority of impaired lakes, chloride concentrations were highest January through May. Figure 11 presents an example of the seasonal variability observed in Powderhorn Lake. Powderhorn Lake does not have a natural outlet and has little opportunity to flush chloride from the lake. For streams, chloride concentrations were highest December through April. Lakes tended to show less variation seasonally than streams, as would be expected due to the longer residence time and mixing that occurs in a lake.

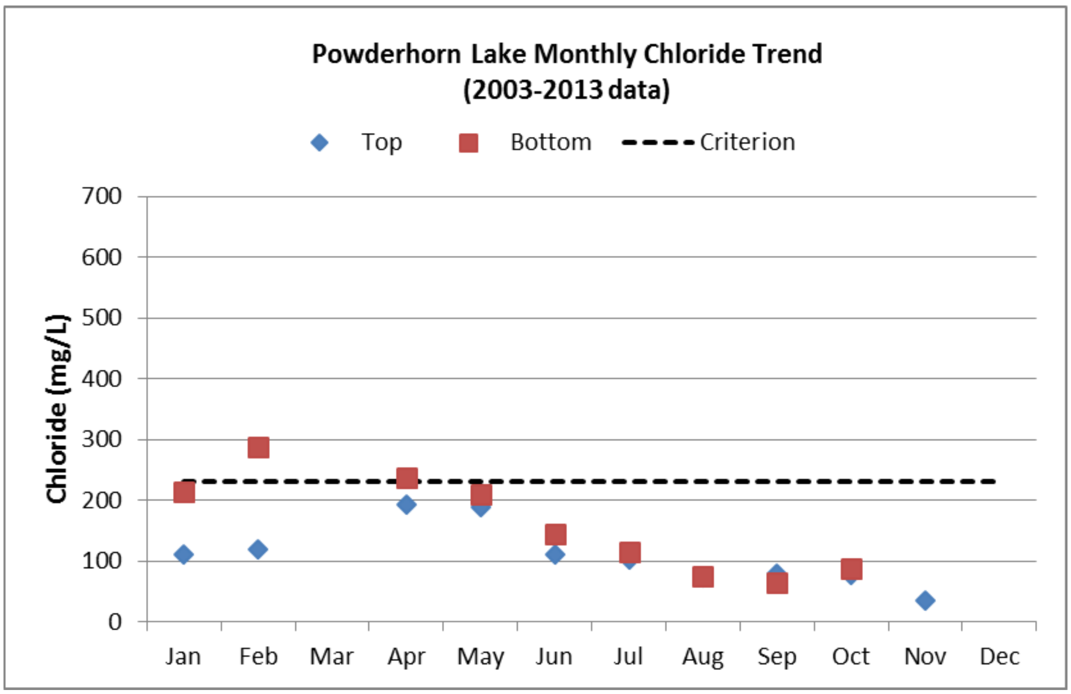


Figure 11. Monthly average chloride concentations in Powderhorn Lake

Figure 12 and Figure 13 present examples of the seasonal variability observed in Bassett Creek and Battle Creek, respectively.

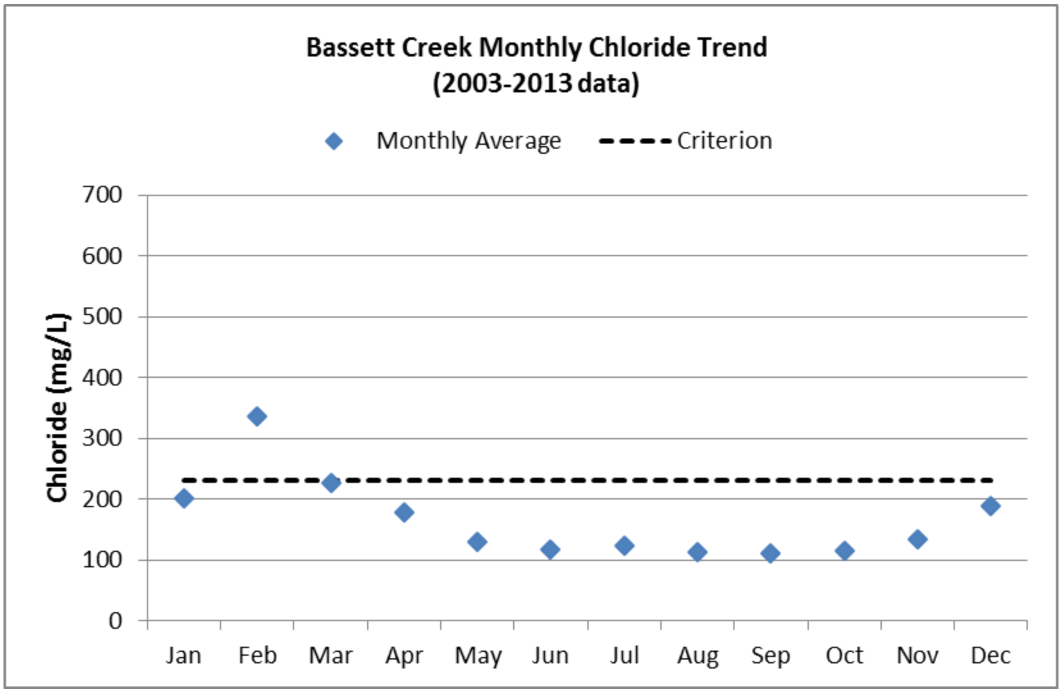


Figure 12. Monthly average chloride concentations in Bassett Creek

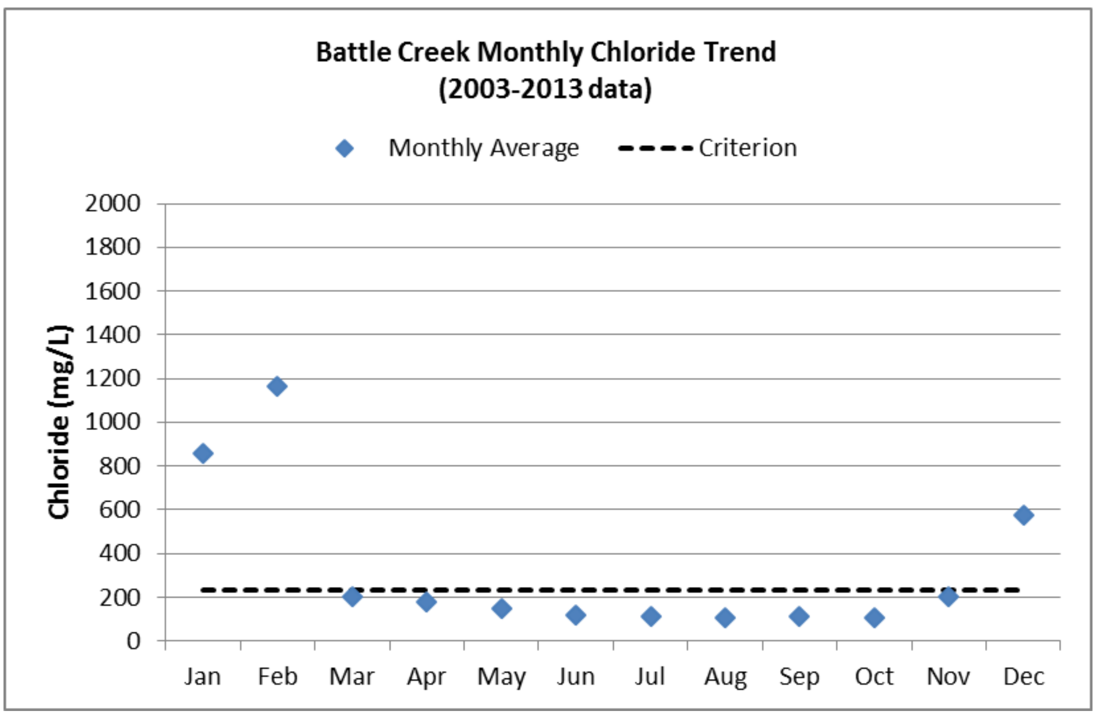


Figure 13. Monthly average chloride concentations in Battle Creek

There are some streams where chloride concentrations are influenced significantly by sources other than winter maintenance activities, such as WWTPs. These streams tended to show the highest chloride concentrations when flows were low. Low flows generally occur during winter months and dry summer months (July through September) when runoff is low. Sand Creek is an example and is shown in Figure 14. Chloride concentrations in Sand Creek were highest in late summer and winter and lowest in spring and early summer. Limited chloride data from the WWTPs discharging to Sand Creek confirm this as a significant source of chloride. Elm Creek is another stream that exhibits highest chloride concentrations in summer, as shown in Figure 15, but does not have the WWTPs contributing to the chloride concentration, indicating a different source is present that requires further investigation.

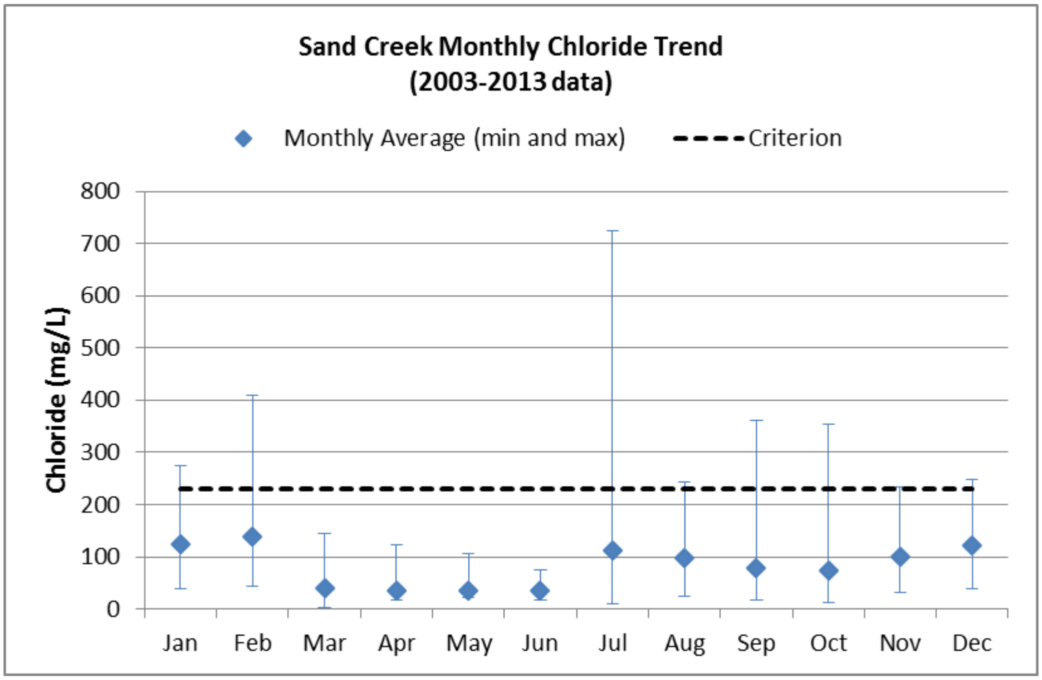


Figure 14. Monthly chloride concentrations (average, maximum, and minimum) in Sand Creek

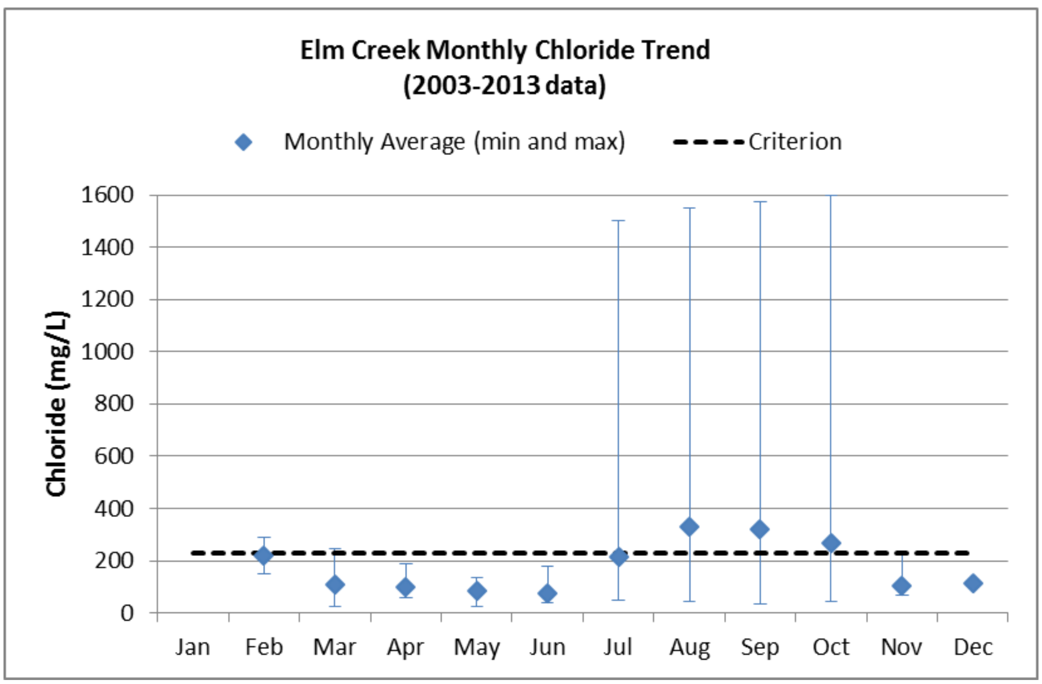


Figure 15. Monthly chloride concentrations (average, maximum, and minimum) in Elm Creek

Long-Term Chloride Trends

Long-term statistical trend analyses require a long, mostly continuous, monitoring record. Sufficient data were available in EQuIS to conduct long-term statistical trend analysis for 11 of the impaired lakes and 9 of the high risk lakes in the TCMA. Trends were determined using the Season Mann Kendall Trend Test with R Statistical Software and are presented in Table 3. Lakes with a minimum of 10 years of data were analyzed and only samples collected from the surface were used in the analyses. Fourteen lakes showed a significant ($p < 0.05$) increasing trend in chloride and eight lakes did not have a significant trend. Figure 16 shows an increasing trend in chloride concentration in Gervais Lake. The other lakes in Table 3 showed similar trends.

Table 3. Long-term chloride trends in lakes in the TCMA.

The Seasonal Mann-Kendall test indicates whether the chloride concentrations versus time are increasing (positive value) or decreasing (negative value). Red rows indicate a degrading trend for chloride.

Lake	Period	Percent change/year	Trend Description
Beaver	1984-2014	+2.42%	Increasing
Bennett	1984-2014	--	No trend
Calhoun	1991-2014	+1.74%	Increasing
Carver	2004-2014	--	No trend
Como	1984-2014	--	No trend
Gervais	1983-2014	+3.72%	Increasing
Hiawatha	1994-2014	--	No trend
Johanna	1988-2014	+3.37%	Increasing
Keller (Main Bay)	1983-2014	+3.85%	Increasing
Kholman	1983-2014	+3.62%	Increasing
Lake of the Isles	1991-2014	--	No trend
Loring	1995-2014	--	No trend
McCarron	1985-2014	+2.41%	Increasing
Powderhorn	1994-2014	--	No trend
Silver	1979-2014	+2.92%	Increasing
South Long Lake	1984-2014	+3.66%	Increasing
Spring	1995-2014	+4.34%	Increasing
Tanners	2004-2014	+3.63%	Increasing
Valentine	1990-2014	+5.56%	Increasing
Wabasso	1984-2014	+1.92%	Increasing
Wakefield	1984-2014	--	No trend
Wirth	1994-2014	+2.49%	Increasing

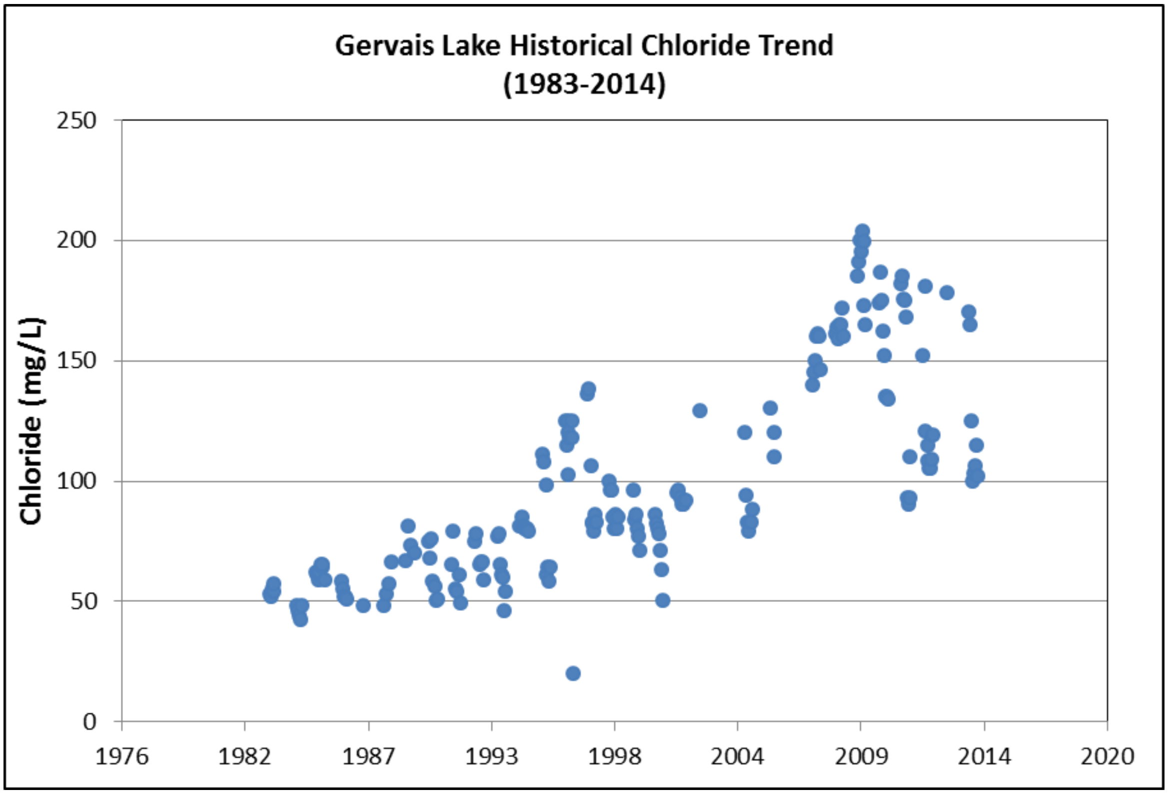


Figure 16. Increasing chloride concentration in surface samples in Gervais Lake from 1983-2014.

The Metropolitan Council is currently analyzing long-term trends in chloride concentrations for some of the streams in the metro area. The results of the analyses will be available on the Metropolitan Council's Stream Monitoring and Assessment webpage.

The Metropolitan Council 2013 Stream Water Quality Summary for the TCMA found that current chloride concentrations within the St. Croix, Minnesota, and Mississippi River basins are at levels higher than the 10-year average (2004-2013).

A multiple regression using both the year and the number of snowfall events in a winter season (precipitation equivalent > 0.01") as the independent variables showed the strongest potential to predict average winter chloride concentrations. Waterbodies with 10 years of data (2004-2013) and a relatively strong correlation over this period include Powderhorn Lake, Wirth Lake, Bassett Creek, and Nine Mile Creek. The results of the multiple regression analyses are presented in Table 3. The results show that average winter chloride concentrations are increasing between 9.7mg/L per year and 19.3 mg/L per year for these waters, though Bassett Creek did not exhibit a significant correlation to year. Average winter chloride concentrations increase between 2.9 mg/L and 7.9 mg/L for every additional snowfall event. Tests of significance for these correlations demonstrated that there is meaningful correlation, though the limited dataset of 10 years results in a fairly wide range in confidence intervals for the coefficients and intercepts.

Table 4. Results of Regression Analyses for Average Winter Chloride Concentrations (2004-2013)

Waterbody	Predicted winter average chloride (mg/L)	Yearly average increase (mg/L/yr)	Average increase per snowfall event (mg/L event)	R-square
Powderhorn Lake	10.5 * year + 2.9 * # of events -20,898	10.5	2.9	0.63
Wirth Lake	9.7 * year + 4.2 * # of events -19,422	9.7	4.2	0.50
Bassett Creek	4.8 * # of events +74	---	4.8	0.61
Nine Mile Creek	19.3 * year + 7.9 * # of events -38,815	19.3	7.9	0.67

Long term trends in groundwater chloride concentrations have also been evaluated (Figure 17). Chloride concentrations in the TCMA groundwater have increased in about one-third of the wells that had sufficient data for trend analysis (MPCA The Condition of Minnesota's Groundwater 2013). In some wells, chloride concentrations have increased by about 100 mg/L in the last 15-20 years. Most of the wells with increasing trends were shallow wells tapping the sand and gravel aquifers; however, increasing concentrations were also found in two deep wells in the TCMA. The high concentrations of chloride found in the shallow sand and gravel aquifers in the TCMA are likely a result of winter deicing materials (MPCA 2013).

Based on the chloride data and associated analyses, it is clear that chloride concentrations continue to increase in both the surface water and groundwater. The increasing trends in chloride concentrations indicate the need to take steps now to reduce chloride use.

Shallow groundwater will eventually either discharge to surface waters or move down to deeper aquifers that contain water that is used for Minnesota's drinking water supplies. If continued trends of increasing chloride in shallow groundwater persist, higher concentrations in deep aquifers will eventually occur, which could result in higher water treatment costs or restrict its use for drinking water supplies (MPCA 2013).

Upward trends in chloride concentrations were not just restricted to shallow wells that tapped the sand and gravel aquifers. Concentrations also significantly increased in two deep wells in the TCMA. One of these wells was 190 feet deep and tapped the Jordan aquifer in the vicinity of Cottage Grove. The other well was 72 feet deep and tapped a buried sand and gravel aquifer in Hennepin County. The Cl/Br ratios in both of these wells; 803 and 822, respectively; also was considerably greater than those expected in groundwater unaffected by human-caused contamination. In these two wells, chloride concentrations increased on average 1.8 mg/L each year. This translated into an increase of about 15-30 mg/L over approximately the past 15 years. Concentrations in the Jordan aquifer well increased from about 12 mg/L in 1999 to 41 mg/L in 2011, and concentrations in the buried sand and gravel aquifer wells increased from about 30 mg/L in 1996 to 46 mg/L in 2011 (MPCA 2013).

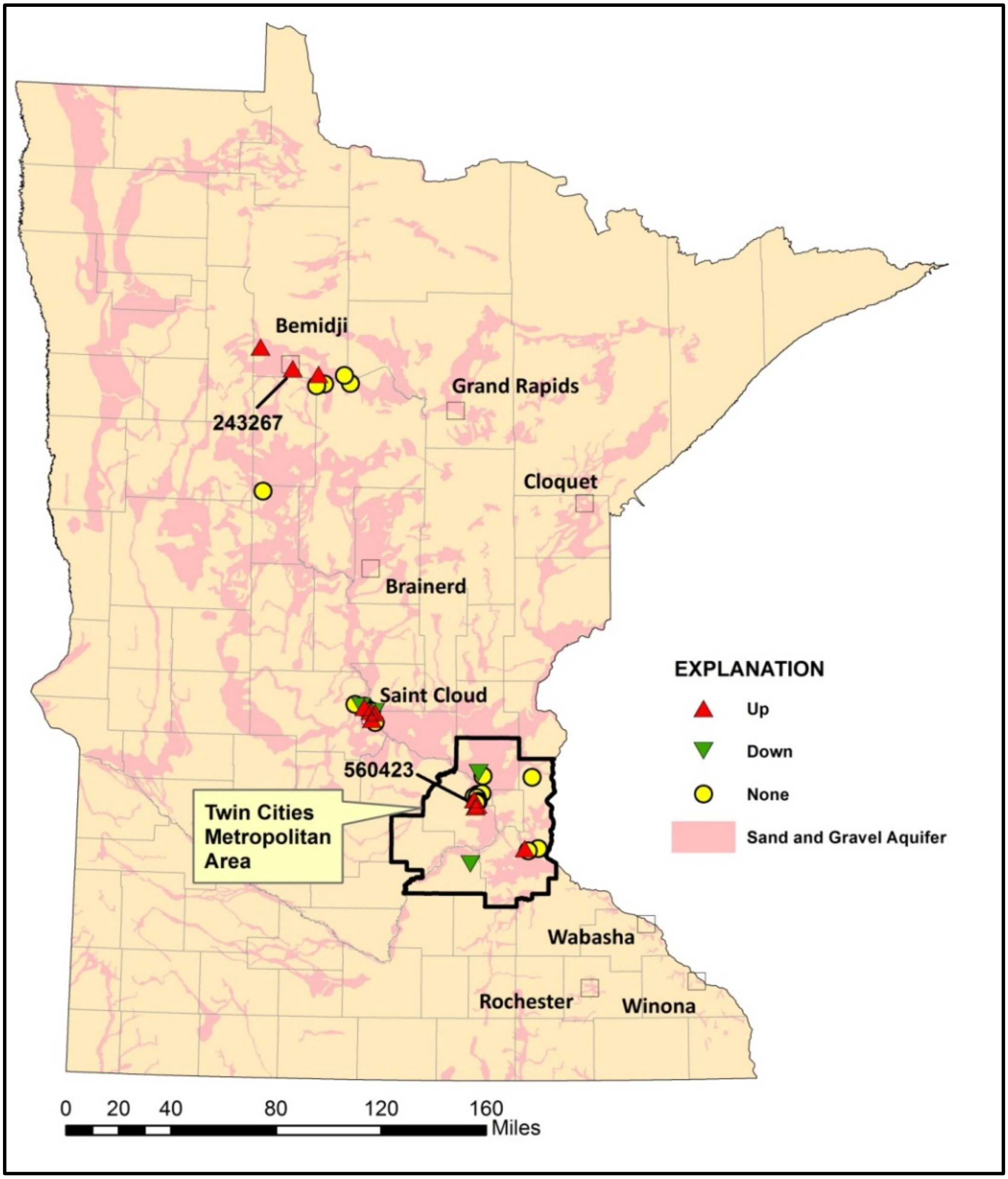


Figure 17. Chloride concentration trends in Minnesota's ambient groundwater

Data from 1987-2011; figure taken from the MPCAs Ambient Groundwater Monitoring Network and the US Geological Survey (MPCA 2013, p. 34).

Chloride Trends within Lakes

As chloride concentrations in water increase, the density of the water increases. Water that is denser will tend to collect at the bottom of a lake. As chloride concentrations increase, the differences between chloride concentrations in the bottom and top waters can become more pronounced. As these differences become greater, the normal mixing patterns of the lake can be inhibited and potentially stop all together (Novotny et al. 2008). Some lakes exhibit meromictic conditions or incomplete mixing and/or circulation, which can mean turn-over of the lake is limited, delayed, or non-existent. Mixing is an important process in a lake as it prevents reduced dissolved oxygen levels in the hypolimnion or lower level of the lake. Factors such as hydraulic residence time, fetch, groundwater inputs, colored fraction of dissolved organic carbon, and lake depth all influence the mixing conditions in a lake. Meromictic conditions are more likely to occur in lakes with higher depth to surface area ratios, as measured by the Osgood Index. High chloride concentrations in a lake may result in an increased risk of meromictic conditions. Brownie Lake and Spring Lake have been identified as being meromictic. The meromictic conditions in Brownie Lake may be due to alterations to the watershed and outlet that occurred prior to the practice of winter salt application.

A number of the monitored lakes had substantial differences in the chloride concentrations between the top and bottom of the water column. Brownie Lake exhibits this characteristic most dramatically, as shown in Figure 18. Peavey Lake, Powderhorn Lake, and Spring Lake also exhibit a clear pattern of higher chloride concentrations at depth as shown in Figure 19, Figure 20, and Figure 21 respectively.

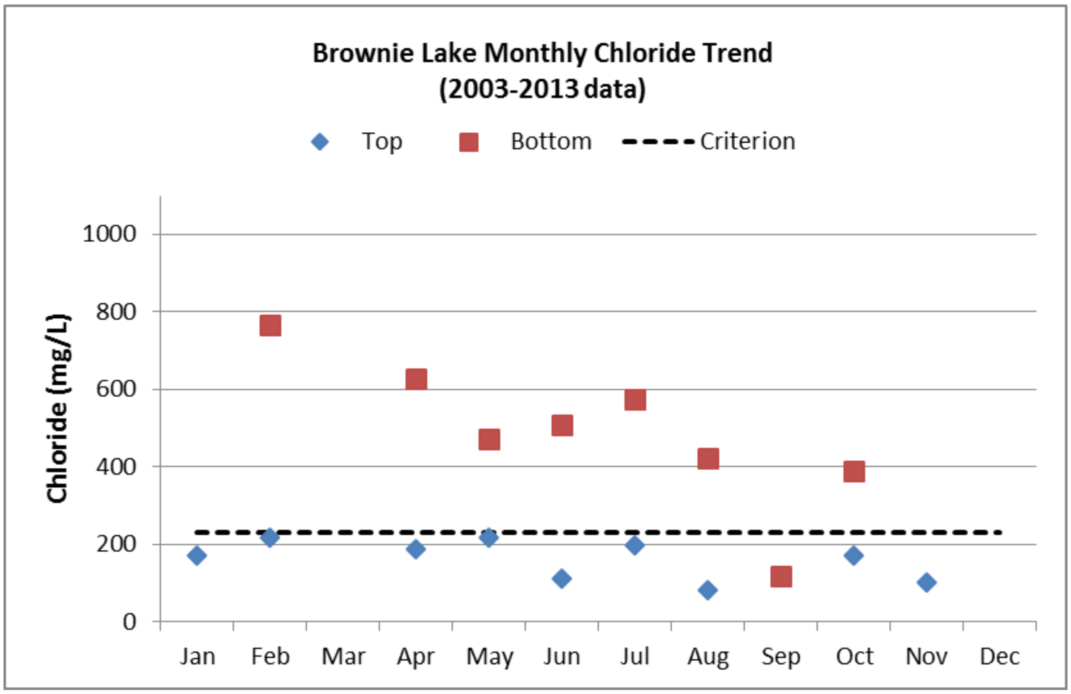


Figure 18. Average monthly chloride concentrations in top and bottom samples in Brownie Lake

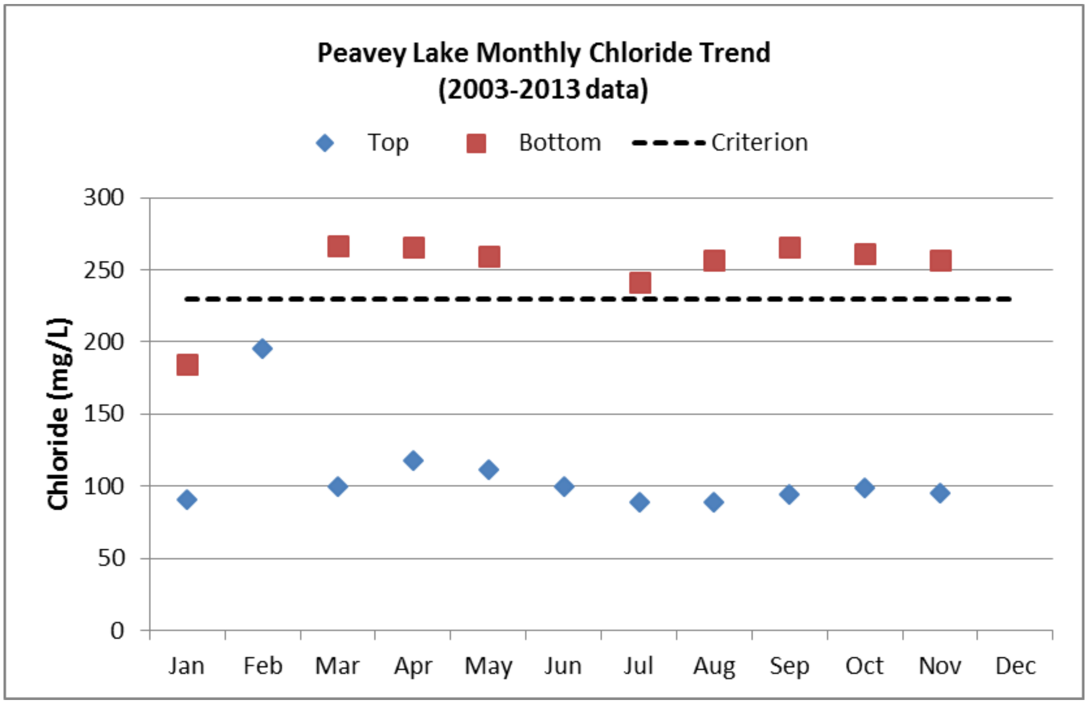


Figure 19. Average monthly chloride concentrations in top and bottom samples in Peavey Lake

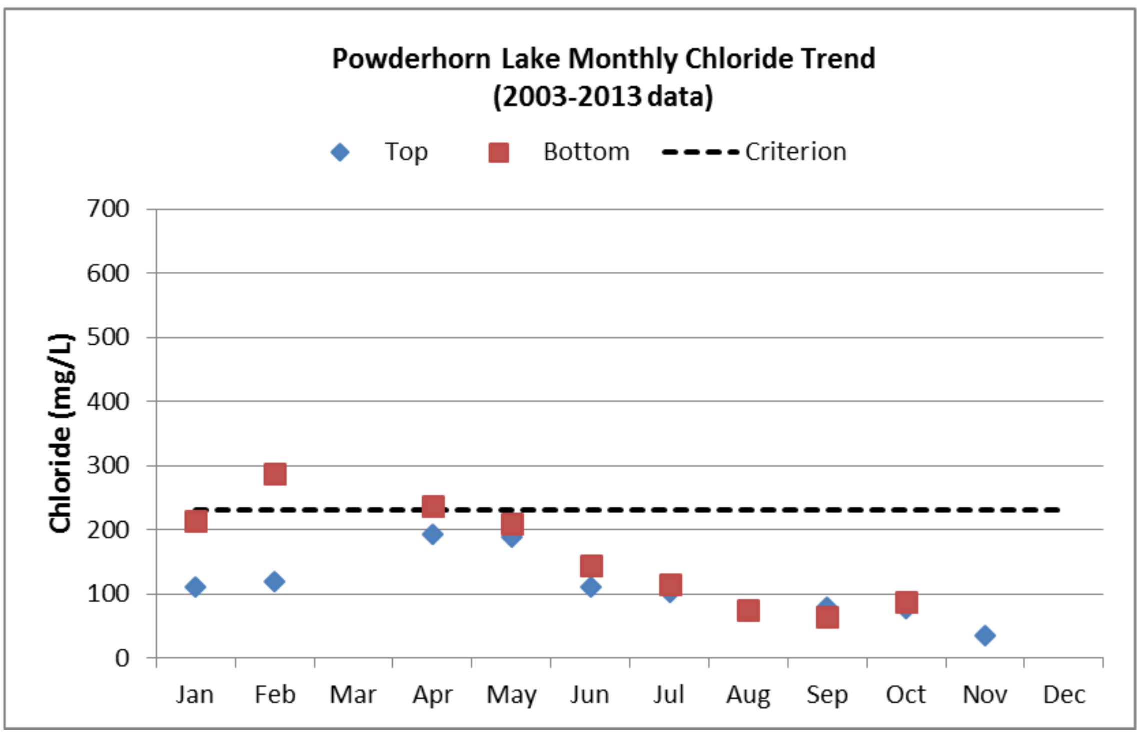


Figure 20. Average monthly chloride concentrations in top and bottom samples in Powderhorn Lake

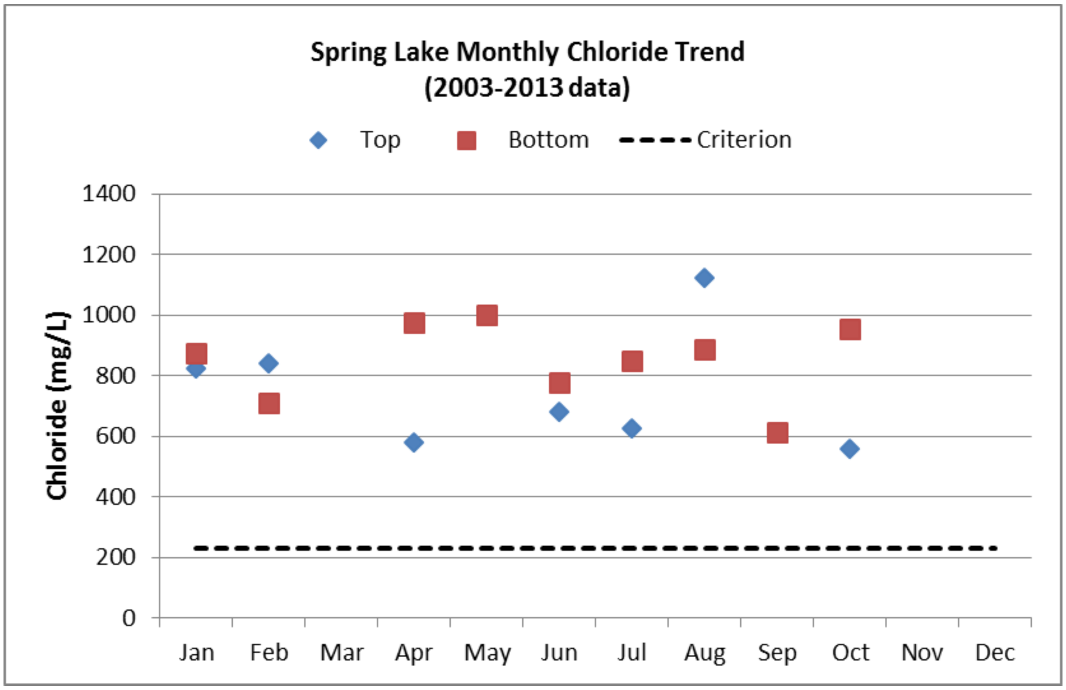


Figure 21. Average monthly chloride concentrations in top and bottom samples in Spring Lake

Chloride Relationships to Watershed and Waterbody Characteristics

Relationships were evaluated between the average winter chloride concentrations to watershed size, percent impervious surface, lake volume, and the lake Osgood Index. No strong relationships were identified with the exception of the Osgood Index and road density. The Osgood Index relates the mean depth of a lake to the surface area (Osgood Index = Mean Depth (m) ÷ Surface Area $(km^2)^{0.5}$). Lake chloride concentrations generally increase with increasing Osgood Index as shown in Figure 22. The Osgood Index may be used to prioritize monitoring efforts for lakes with no or limited data.

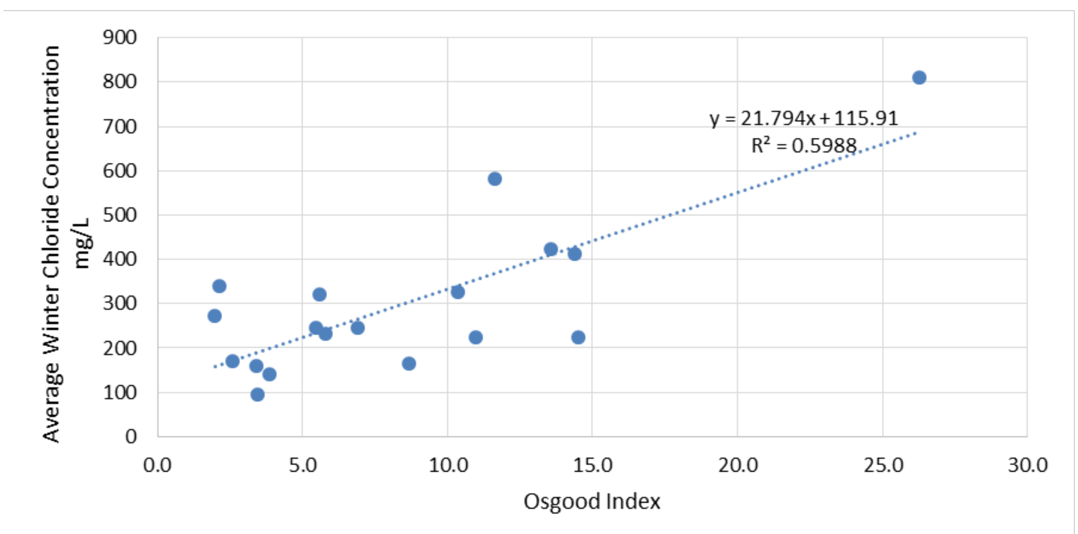


Figure 22. Winter chloride concentrations (November-March) in TCMA lakes versus Osgood Index

Salt applied to impervious surfaces as a deicer is considered a primary source of chloride to lakes and streams. Therefore, one might expect chloride concentrations to be correlated to the amount of impervious area in a watershed. Winter stream chloride concentrations were positively correlated with annual winter salt application (Figure 23). Watersheds with less than 15 tons per square mile of chloride varied in winter stream median chloride concentration ranging from 18 to 89 mg/L (Wenck 2009).

Road density was also positively correlated with median winter chloride concentrations. The deicing salt load was highly dependent on road density (Figure 24). Median winter chloride concentrations appear to increase with road densities greater than 25 lane miles per square mile (Wenck 2009). A road density map for the TCMA is presented in Figure 25.

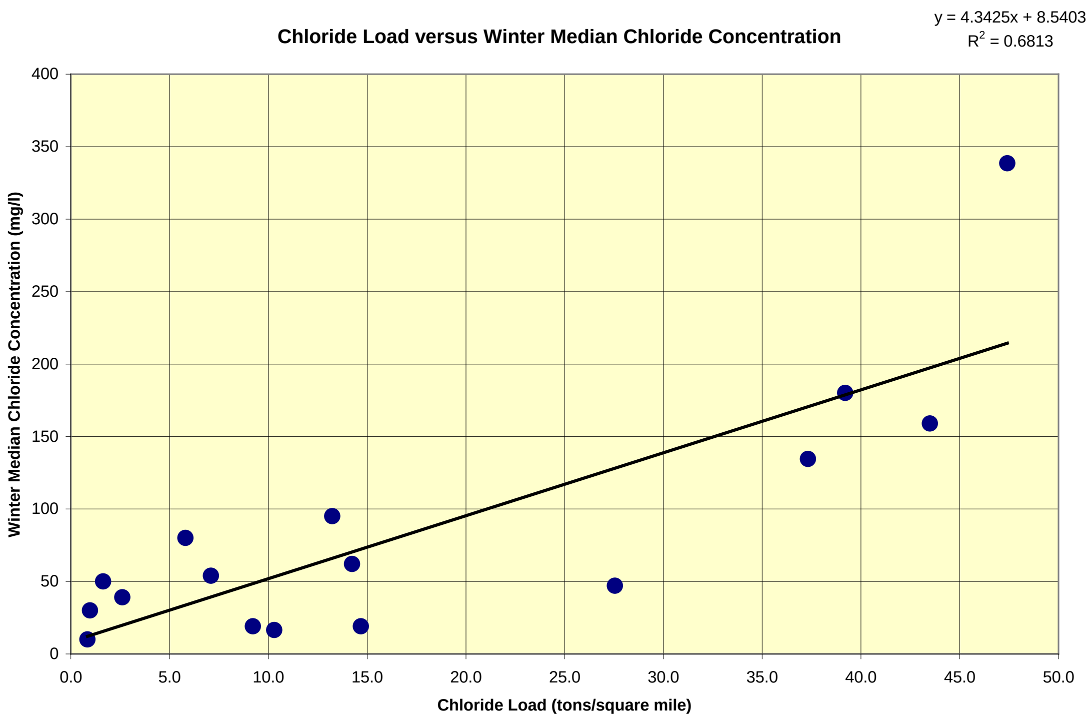


Figure 23. Relationship between road salt load and median winter stream chloride concentration
(Wenck 2009)

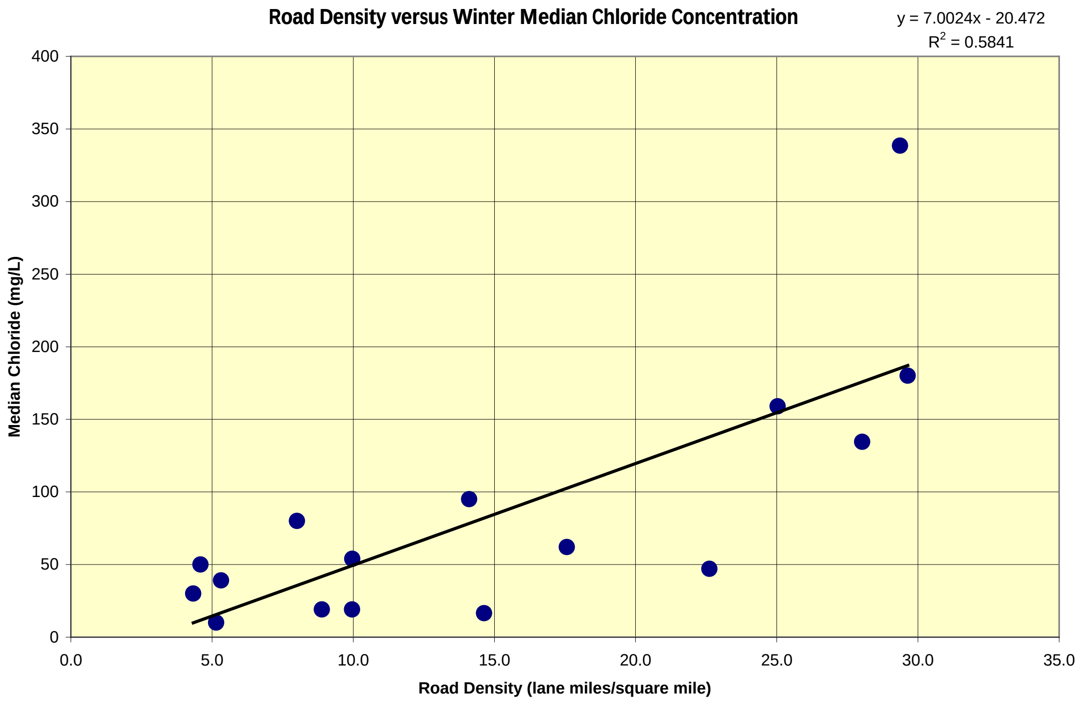


Figure 24. Relationship between road density and median winter chloride concentration

(Wenck, 2009)

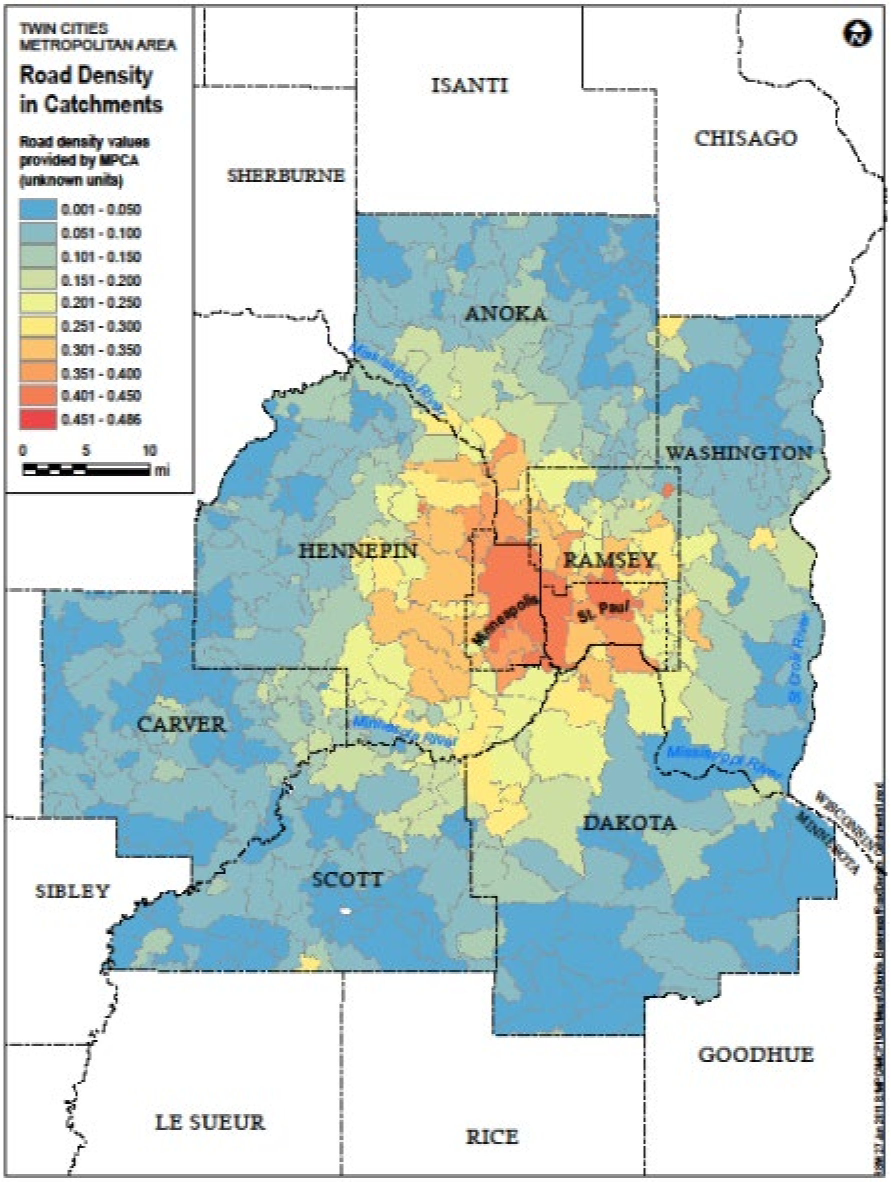


Figure 25. 2010 Road Density in the TCMA
(Road density from MPCA based on roads from MnDOT and catchment watersheds from DNR)

Chloride Concentrations in Stormwater

In comparison to chloride samples taken from lakes, wetlands, and streams, the area's stormwater runoff contains some of the highest chloride concentrations found in the TCMA. The data indicates a high degree of seasonal variability, which is a result of winter maintenance activities and the direct connection to impervious surfaces. Figure 26 shows storm sewer chloride data collected in the TCMA from 1980 through 2013. Sample set sizes ranged from 19 to 288 samples per month, for a total of 1,569 samples. The data indicate that high chloride concentrations are found during the winter maintenance season and increase as the winter season progresses with the peak occurring in February.

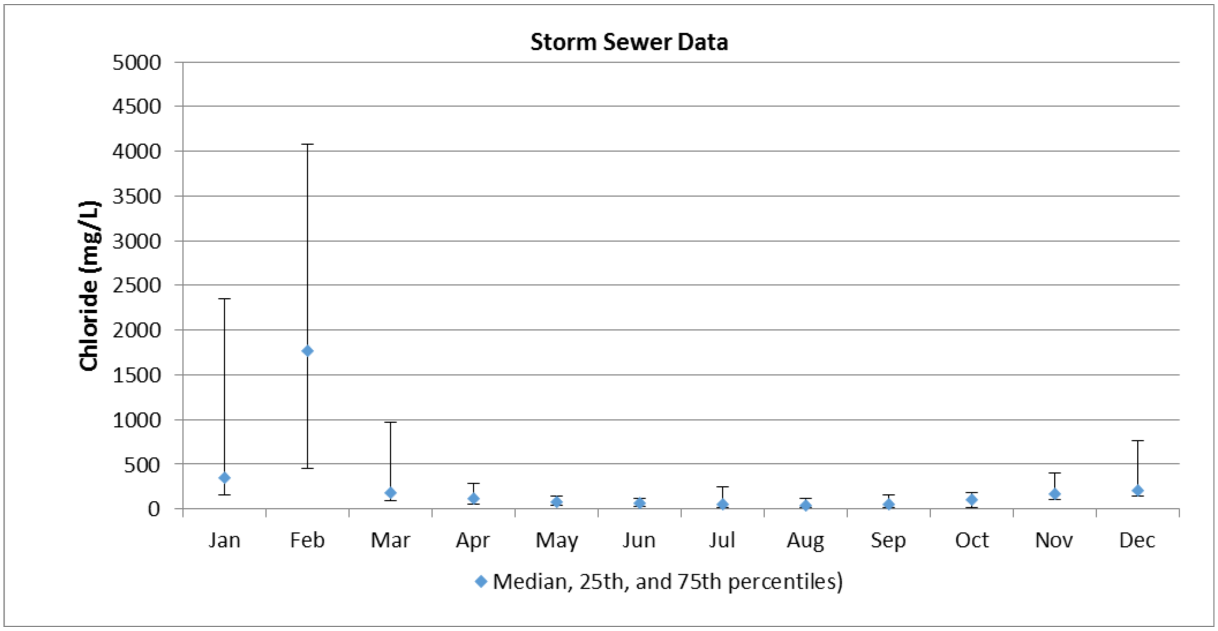


Figure 26. Storm sewer monthly chloride concentrations (*Data from TCMA between 1980-2013; median, 25th, and 75th percentiles*)

Chloride Relationships between Surface and Groundwater

Concentrations of chloride in shallow groundwater are increasing. Shallow groundwater contributes flow to lakes, wetlands, and streams. In the TCMA, average chloride concentrations in shallow monitoring wells located within watersheds that contain one or more impaired surface waters were higher (141 mg/L) compared to wells in watersheds without an impaired lake, stream, or wetland (48 mg/L) (Figure 27 and Figure 28).

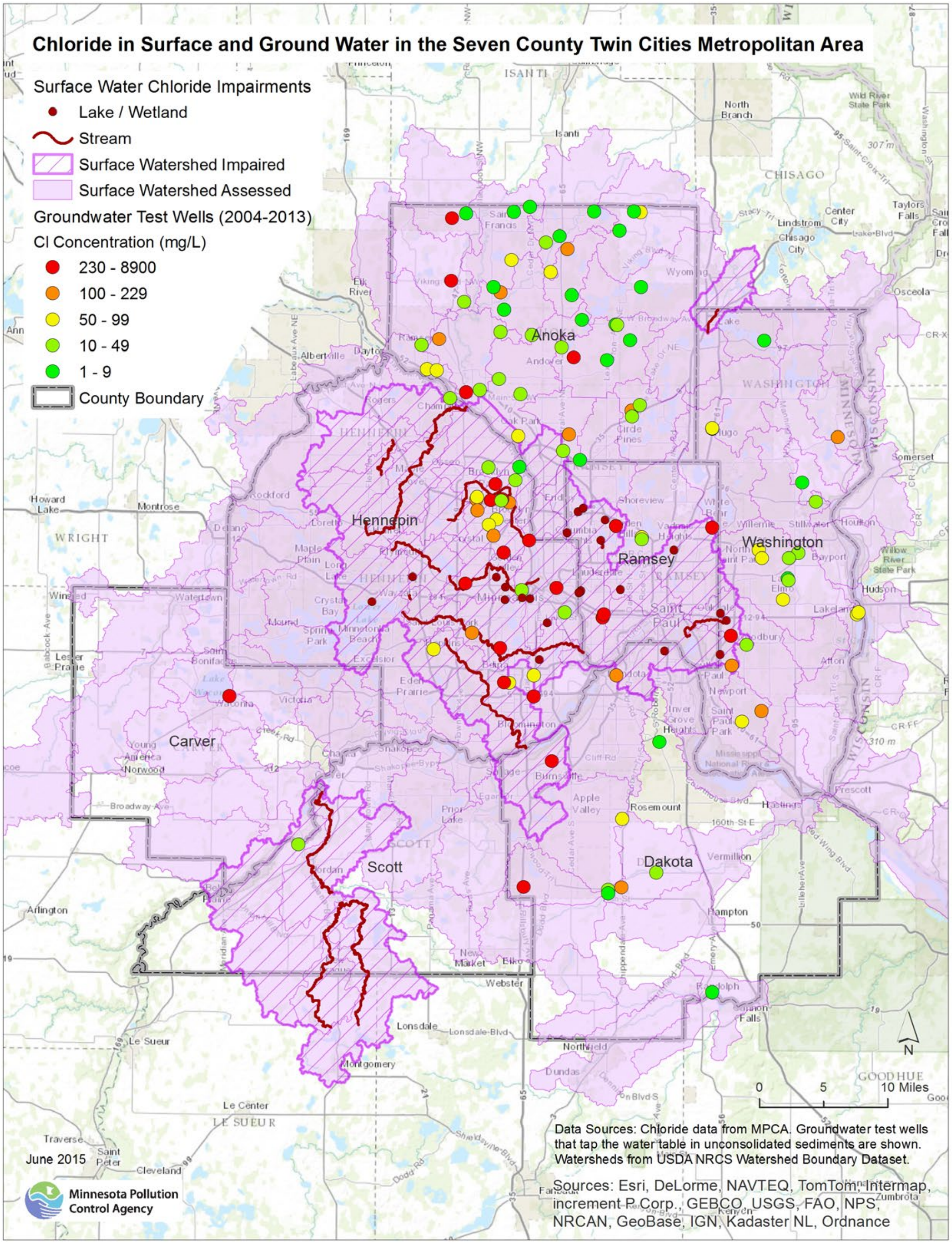


Figure 27. Chloride in Surface and Ground Water in the TCMA

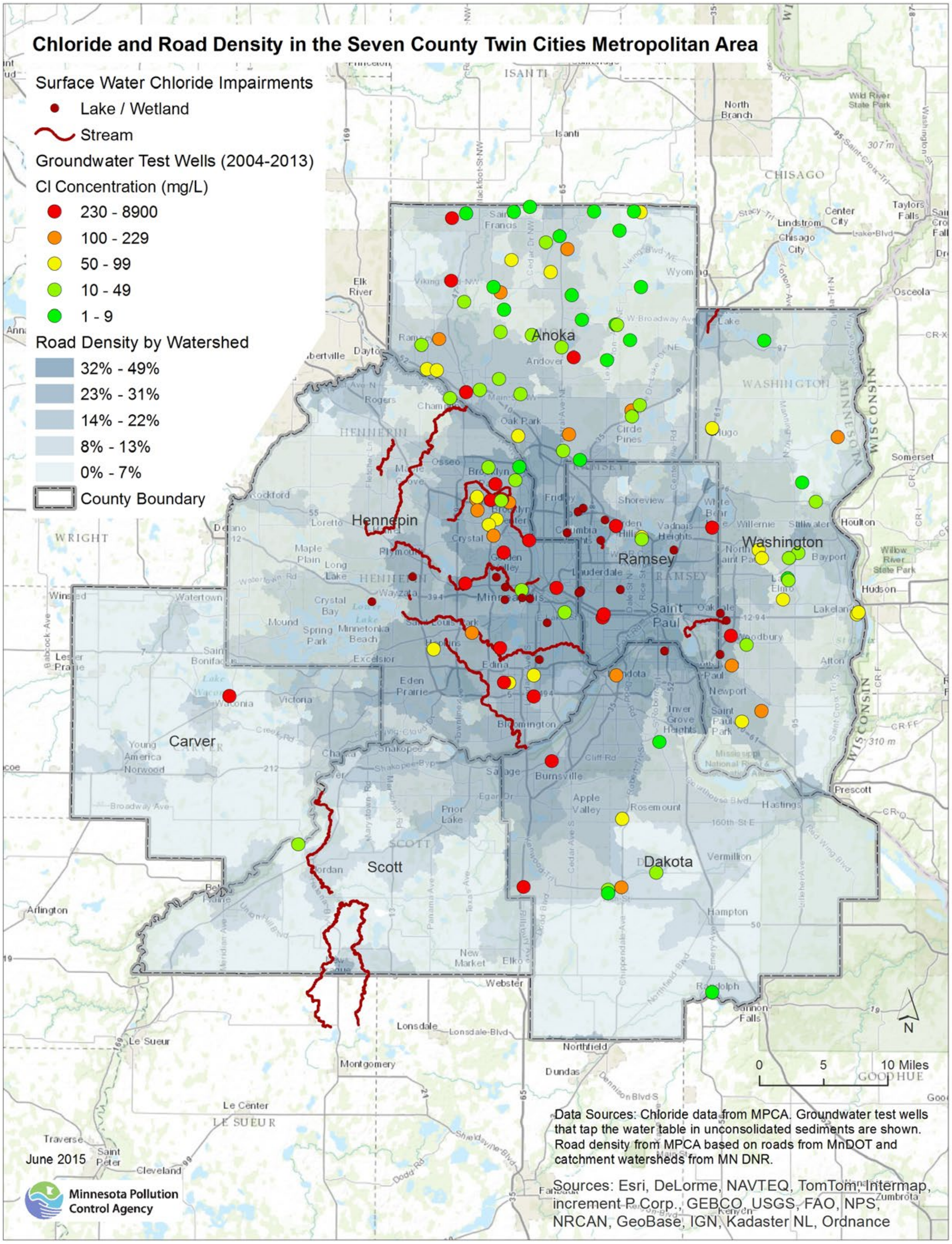


Figure 28. Chloride and Road Density in the TCMA

Several studies of streams in the Upper Midwest have found that higher chloride levels in shallow groundwater have, in part, contributed to an increase in concentration in streams during low flow conditions, when stream flow is dominated by groundwater inputs (Kelly 2008; Eyles et al. 2013; Corsi et al. 2015). This pattern of increased chloride concentrations during low flow conditions, typically during the summer months, is also evident in streams in the TCMA. Chloride concentrations exceeding the 230 mg/L standard have been observed in Bassett Creek in June and Shingle Creek in August. This issue is not isolated to the TCMA. For example, chloride levels in Miller Creek, a trout stream located in Duluth, have also consistently exceeded the 230 mg/L standard in July and August.

Eagle Creek is located in the city of Savage (Scott County) near the Highway 13/Highway 101 crossroads and is a Class 2A cold-water trout stream, meaning that it is a self-producing trout stream and is primarily fed by groundwater year round. Chloride concentrations have always been below the chronic chloride water quality standard of 230 mg/L; however, chloride concentrations have increased over time. The median chloride concentration in 2012 was 36 mg/L, which is more than twice the median concentration in 2001, 16 mg/L (Figure 29).

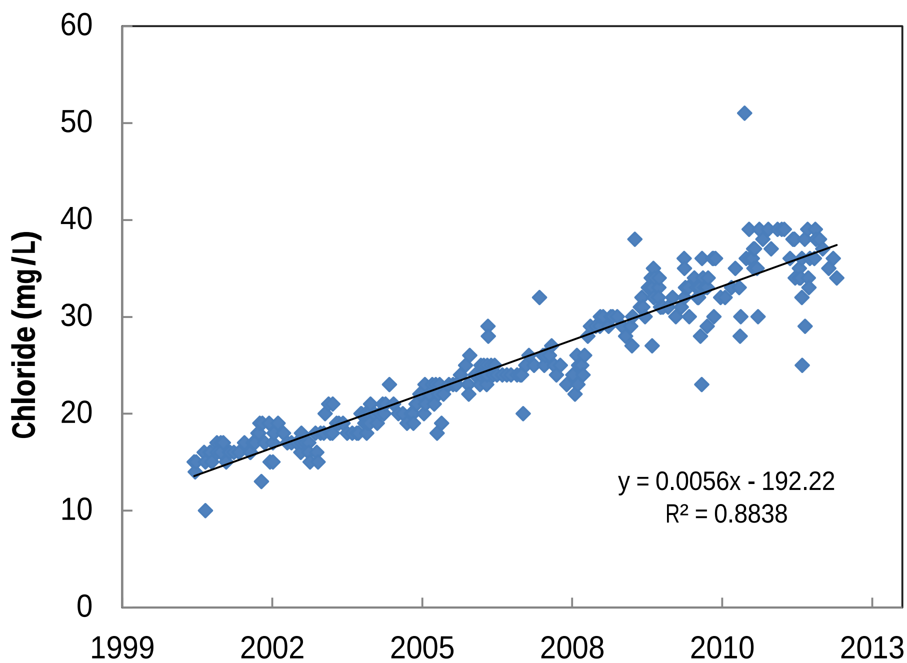


Figure 29. Increasing chloride concentrations in Eagle Creek from 2001-2012 (*Data collected by MCES)*

Shingle Creek, a tributary to the Mississippi River, is an urban stream that runs through Brooklyn Park, Brooklyn Center, and Minneapolis. The creek typically has numerous exceedances of the 230 mg/L standard each year, particularly during winter months. However, average chloride levels in the stream during summer months have also increased over time (Figure 28). The estimated increase in average summer (July through October) chloride concentration in Shingle Creek from 1996 to 2014 was 53 mg/L, based on a linear regression. The increased chloride concentrations in Eagle and Shingle Creek, and likely many other streams in the TCMA, suggest that chloride from deicing activities is infiltrating into shallow groundwater, resulting in elevated chloride concentrations in streams during summer baseflow conditions.

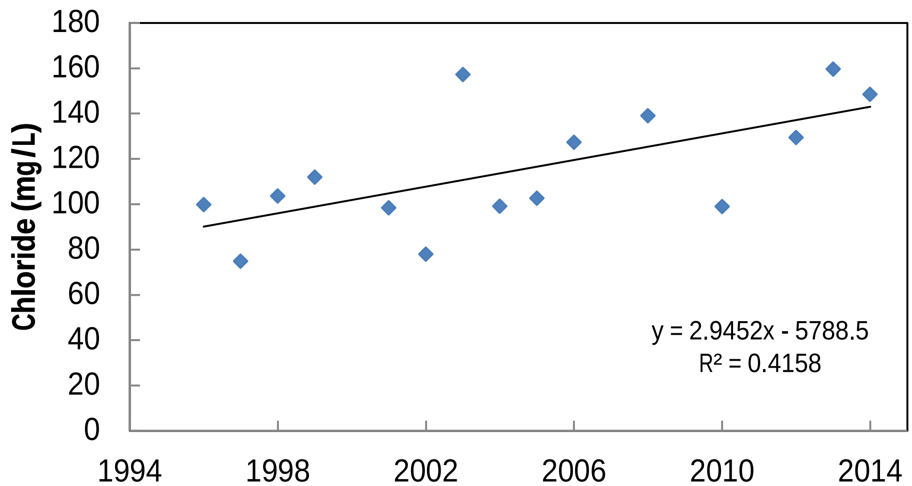


Figure 30. Average monthly chloride concentrations (July-October) in Shingle Creek from 1996-2014
(Data collected by the USGS at Queen Avenue in Minneapolis)

Similar to other studies (Kelly 2008; Eyles et al. 2013; Corsi et al. 2015), streams in the TCMA and greater Minnesota are experiencing high chloride concentrations during summer baseflow conditions. This trend is attributed to high chloride concentrations in shallow groundwater discharging to streams as baseflow.

Summary of Data Analysis

Based on the water quality data collected and the above data analyses, the following conclusions can be made:

1. Chloride use increased in the TCMA in the latter half of the 20th century, 1950-2000.
2. Levels of chloride are continuing to increase in both groundwater and surface waterbodies in the TCMA.
3. The highest chloride concentrations occur during snowmelt conditions during winter months and low flow periods in streams.
4. Chloride levels tend to be higher in the bottom of a lake versus the surface.
5. Chloride concentrations in TCMA waterbodies are positively correlated to road density in the contributing watersheds.
6. There are existing data gaps of chloride concentrations in TCMA waterbodies, as many have limited to no data and lack data that would represent critical conditions.
7. Winter maintenance activities in urban areas and WWTPs in rural areas tend to be the primary sources of chloride to TCMA waters.

2.4 TMDL Summary

The TMDLs were developed for each of the lakes, wetlands and streams in the TCMA impaired for chloride, with the exception of Shingle Creek and Nine Mile Creek which already have existing TMDLs. A TMDL quantifies the allowable pollutant loading to a lake, wetland, or stream that will result in water quality standards being attained. The water quality target for the TMDLs was set to the chronic water quality criterion for chloride of 230 mg/L. The total allowable load, or TMDL, is allocated to the various sources contributing chloride as well as consideration of a margin of safety and reserve capacity. Margin of safety is intended to account for uncertainty in the development of the TMDL. Reserve capacity is intended to set-aside a portion of the TMDL for future growth. For the TCMA chloride TMDLs, reserve capacity was set to zero assuming that any further development and additional impervious surfaces would be expected to have the same level of best management practices (BMPs) implemented for winter maintenance activities as for the remainder of the watershed. The complete details of the TMDL development are presented in the TCMA Chloride TMDL report (see Appendix A).

A total of 39 waterbodies are listed as impaired by chloride, and TMDLs for Shingle Creek and Nine Mile Creek have already been prepared under separate projects. A total of 37 TMDLs were completed as part of this project. Summaries of the TMDLs are presented in Table 4 for lakes and wetlands and Table 5 for streams.

Table 4: Summary of TMDL and Components for Impaired Lakes and Wetlands in the TCMA

Lake/Wetland	AUID	Watershed Area (ac)	TMDL and Components (all values in lbs/yr of chloride)					
			Loading Capacity (TMDL)	WLA		LA		Margin of Safety
				MS4 Categorical	Wastewater Sources[1]	Non-Permitted Aggregate	Natural Background	
Battle Creek Lake	82-0091-00	4,326	2,153,699	1,766,033	0	0	172,296	215,370
Brownie Lake	27-0038-00	452	341,418	279,963	0	0	27,313	34,142
Carver Lake	82-0166-00	2,242	1,071,123	878,321	0	0	85,690	107,112
Como Lake	62-0055-00	1,850	994,078	815,144	0	0	79,526	99,408
Diamond Lake	27-0022-00	744	486,017	398,534	0	0	38,881	48,602
Kasota Ponds North	62-0280-00	10	6,234	5,112	0	0	499	623
Kasota Ponds West	62-0281-00	6	5,742	4,708	0	0	459	574
Kohlman Lake	62-0006-00	7,533	4,839,183	3,106,733	1,050,484	0	303,096	378,870
Little Johanna Lake	62-0058-00	1,703	1,224,242	1,003,879	0	0	97,939	122,424
Loring Pond (South Bay)	27-0655-02	34	9,764	8,007	0	0	781	976
Mallard Marsh	62-0259-00	16	9,851	8,077	0	0	788	985
Parkers Lake	27-0107-00	1,064	1,431,262	528,161	787,163	0	51,528	64,410
Peavey Lake	27-0138-00	776	205,995	165,889	3,692	0	16,184	20,230
Pike Lake	62-0069-00	5,735	3,591,268	2,943,971	1,059	0	287,217	359,021
Powderhorn Lake	27-0014-00	332	218,588	179,242	0	0	17,487	21,859
Silver Lake	62-0083-00	655	370,011	303,409	0	0	29,601	37,001
South Long Lake	62-0067-02	114,785	26,334,624	21,534,261	4,030	0	2,106,448	2,633,059
Spring Lake	27-0654-00	39	15,600	12,792	0	0	1,248	1,560
Sweeney Lake	27-0035-01	2,439	1,456,271	1,194,142	0	0	116,502	145,627
Tanners Lake	82-0115-00	1,732	826,520	677,746	0	0	66,122	82,652
Thompson Lake	19-0048-00	178	134,340	110,159	0	0	10,747	13,434
Valentine Lake	62-0071-00	2,404	1,165,072	955,359	0	0	93,206	116,507
Wirth Lake	27-0037-00	426	1,095,000	897,900	0	0	87,600	109,500

[1] WLA=0 in the wastewater sources column means that there is no wastewater discharges in that watershed

Table 5. Summary of TMDL and Components for Impaired Streams in the TCMA

Stream	AUID	Watershed Area (ac)	TMDL and Components (all values in lbs/yr of chloride)						
			Loading Capacity (TMDL)	WLA		LA		Margin of Safety
				MS4 Categorical	Wastewater Sources[1]	Non-Permitted Aggregate	Natural Background	
Bass Creek	07010206-784	5,434	1,746,399	1,432,047	0	0	139,712	174,640
Bassett Creek	07010206-538	25,209	9,334,219	6,642,961	1,233,048	0	648,094	810,117
Battle Creek	07010206-592	7,246	2,328,721	1,909,551	0	0	186,298	232,872
Elm Creek	07010206-508	66,382	21,332,410	17,386,888	0	105,688	1,706,593	2,133,241
Judicial Ditch 2	07030005-525	1,587	510,115	418,294	0	0	40,809	51,011
Minnehaha Creek	07010206-539	109,151	35,997,083	28,679,140	1,004,128	0	2,806,140	3,507,675
Raven Stream	07020012-716	42,750	15,023,193	442,771	1,284,983	10,822,561	1,099,057	1,373,821
Raven Stream, East Branch	07020012-543	14,751	6,025,349	442,093	1,284,983	3,445,007	379,229	474,037
Rush Creek, South Fork	07010206-732	13,844	4,470,069	3,646,696	21,010	1,532	355,925	444,906
Sand Creek (South) - includes 07020012-662	07020012-513	175,578	59,480,179	4,402,547	3,056,425	41,864,932	4,513,900	5,642,375
Unnamed creek (Headwaters to Medicine Lk)	07010206-526	6,447	2,071,959	1,699,006	0	0	165,757	207,196
Unnamed creek (Unnamed ditch to wetland)	07010206-718	793	254,852	208,979	0	0	20,388	25,485
Unnamed Stream (Unnamed lk 62-0205-00 to Little Lk Johanna)	07010206-909	1,627	522,817	428,710	0	0	41,825	52,282

[1] WLA=0 in the wastewater sources column means that there is no wastewater discharges in that watershed

2.5 Protection of Surface and Groundwater

Protection is an opportunity to prevent waters from continued degradation which may result in impairment. Prevention or protection is often more easily accomplished than the restoration of an impaired waterbody. Protection efforts also may eliminate the need for additional permit and other regulatory requirements to reduce pollution. Successful protection efforts rely on understanding how current practices or conditions may be contributing to water quality conditions.

High Risk Surface Waters

Preventing a waterbody from being contaminated with chloride is easier and more cost effective than restoration. Chloride is a conservative ion and will not break down over time but rather it accumulates in waters. Therefore, efforts should be made to protect waters that show an increasing trend in chloride concentration or have been shown to have chloride concentrations approaching the water quality criteria. Lakes, wetlands, or streams with at least one sample within 10% of the chronic water quality standard within the last 10 years have been identified as a high risk waterbody (one exceedance of 207 mg/L chloride). Proactive actions to reduce chloride loads to these high risk waterbodies should be pursued. Proactive actions similar to actions listed for impaired waters should be explored to protect high risk waters. These waters are considered to be approaching the water quality standard and if no actions are taken, they will likely reach impairment status in the near future. The TCMA lakes and streams identified as being at high risk for potential chloride impairment are shown in Table 6 and Table 7, respectively.

It should be noted that there are potentially many more high risk waters in the TCMA that have not been identified because there is limited or no monitoring data available for those waters. For this reason, similar proactive approaches to chloride management should be taken to prevent chloride contamination.

All Surface Waters and Groundwater

In addition to the high risk waters listed above, protecting all surface waters and groundwater from further degradation due to chloride is important. By implementing salt reducing practices throughout the TCMA, both the need to restore those waters already impaired and also protect those waters not yet exceeding the standard are addressed. The practices necessary for protection of groundwater are the same as those for restoring and protecting surface waters. Through targeting and prioritization a starting point can be established. Management practices and BMPs used for impaired and high risk waters can be the same for all waterbodies and should provide the same level of protection and chloride reduction.

Table 6: High Risk Lakes in the TCMA

Lakes	AUID
Beaver Lake	62-0016-00
Bennett Lake	62-0048-00
Calhoun Lake	27-0031-00
Centerville Lake	02-0006-00
Crosby Lake	62-0047-00
Crystal Lake	27-0034-00
Fish Lake	19-0057-00
Gervais Lake	62-0007-00
Hiawatha Lake	27-0018-00
Johanna Lake	62-0078-00
Keller Lake (Main)	62-0010-02
Lake Of The Isles	27-0040-00
McCarron Lake	62-0054-00
Medicine Lake	27-0104-00
Ryan Lake	27-0058-00
Taft Lake	27-0683-00
Unnamed Lake	62-0278-00
Wabasso Lake	62-0082-00
Wakefield Lake	62-0011-00

Table 7: High Risk Streams in the TCMA

Streams	AUID
Bevens Creek	07020012-718
Bluff Creek	07020012-710
Classen Lake Creek	07010206-703
Clearwater Creek	07010206-519
County Ditch 17 (Spring Brook)	07010206-557
Credit River	07020012-517
Diamond Creek	07010206-525
Dutch Lake Outlet	07010206-678
Fish Creek	07010206-606
Painter Creek	07010206-700
Rush Creek	07010206-528
Unnamed Creek	07010206-704
Unnamed Creek	07010206-740
Unnamed Creek (Pleasure Ck)	07010206-594
Unnamed Stream (Perro Ck)	07030005-612
Unnamed Stream (Sand Ck)	07010206-744
Unnamed Stream (Trib To Long Lk) (Furgala Creek)	07030005-765
Unnamed Stream In Plymouth	07010206-738
Unnamed Stream Receiving Wtr From Medicine Lk	07010206-785

3. Prioritizing and Implementing Restoration and Protection

Reducing chloride at the source is needed throughout the entire TCMA, not only to restore already impacted waters but also to protect all water resources. There are multiple sources to consider, a variety of options to reduce chloride, and a large geographical area to address. This section is intended to provide guidance, resources, and information to assist in making the important decisions of the what, how and when for managing chloride. The available data indicates that surface waters and groundwater that exceed the state's chloride standards, as well as many lakes and streams that are considered to be at high risk for chloride impairment. Many lakes, streams, and wetlands have minimal or no data available, especially during critical times of the year, which makes it difficult to determine the current chloride status. Reductions in chloride loads not only benefit surface and groundwater quality, but may also reduce damage to infrastructure and vehicles due to corrosion, and reduce impacts to vegetation along roadways. Finally, improved winter maintenance practices that reduce salt usage also result in direct cost-savings to winter maintenance organizations and private applicators. Without making efforts to reduce chloride loads, the trend of increasing chloride concentrations in lakes, wetlands, streams, and groundwater is expected to continue and the cost-savings related to improved winter maintenance practices will be lost. Treating waters already contaminated by chloride through RO or distillation is impractical and cost-prohibitive.

Performance-Based Approach for Reducing Chloride

Deicing salt is currently the most common and preferred method for meeting the public's winter travel expectations. There is currently not an environmentally safe and cost-effective alternative that is effective at melting ice. Therefore, the continued use of salt as the predominant deicing agent for public safety in the TCMA is expected. Setting a specific chloride load reduction target for each individual winter maintenance chloride source is challenging, as is measuring actual chloride loads entering our surface and groundwater from deicing salt and other nonpoint sources in the TCMA. Therefore, priority should be put on improving winter maintenance practices to use only a minimal amount of salt, also referred to as Smart Salting, across the entire TCMA. With these considerations in mind, the implementation approach for achieving the TMDLs and protecting all waters in the TCMA is to focus on performance of improved winter maintenance practices as well as continuing to monitor trends in local waterbodies.

A standard approach to TMDL implementation is to translate the wasteload allocation (WLA) component of the TMDL directly to a numeric permit limit, which is typical for permitted facilities with monitoring requirements. In the case of urban stormwater regulated through a Municipal Separate Storm Sewer System (MS4) Permit, the WLA may be presented in the form of a percent reduction from a baseline condition. The specified percent reduction is then included in the MS4 Permit. With a performance-based approach, the numeric WLA is translated to a performance criterion. This can include the development and implementation of winter maintenance plan which identifies a desired level of the BMP implementation and a schedule for achieving specific implementation activities. Progress made towards those goals are documented and reported, along with annual estimates of salt usage and reductions achieved through BMPs implemented.

In cases where it is not feasible to calculate a numeric effluent limit, federal regulations allow for the use of the BMPs as effluent limits (40 CFR § 122.44(k)). Such a performance-based or BMP approach to compliance with WLAs is being taken by states to address the Chesapeake Bay TMDL for nutrients. The TMDL is being implemented through state Implementation Plans. Some states are taking a performance-based approach to addressing urban stormwater sources, requiring minimum levels of the BMP implementation rather than requiring specific levels of pollutant load reductions.

A performance-based approach will be tracked through documentation of existing winter maintenance practices, goals for implementing improved practices including schedules, and reporting on progress made. Entities may choose to use the Winter Maintenance Assessment tool (WMAt), which is a winter maintenance BMP tracking tool, to assess and document practices and set goals, or another approach of their choice. Entities should track progress and document efforts, including, to the extent possible, estimates of reduced salt usage as a result of improved practices. Entities that have achieved their goals for winter maintenance will have documented their practices in a winter maintenance plan. Entities that have already made significant progress in winter maintenance activities will be able to demonstrate this through their documentation of existing practices. This plan should be reviewed annually and evaluated against the latest knowledge and technologies available for winter maintenance.

The performance-based approach doesn't focus on specific numbers to meet, but rather on making progress through the use of BMPs. Progress is measured by degree of implementation and trends in ambient monitoring. In a traditional approach with numeric targets, progress would be measured by accounting for salt applied and comparing to the targets. The performance-based approach is intended to allow for flexibility in implementation and recognize the complexities involved with winter maintenance. Because the performance-based approach does not provide a specific numeric target, a limitation of the approach is that it is not definitive on when enough progress has been made. This can only be determined by continued ambient monitoring that demonstrates compliance with water quality standards.

3.1 Prioritization and Critical Areas

This plan has been developed for many different audiences. Organizations interested in reducing the amount of salt in waters should start with an effort to fully understand the problem and determine what role the organization plays in contributing, preventing, or remediating the growing trend of increased chloride in surface and groundwater.

Prioritization of efforts to reduce chloride may be based on current water quality conditions. Waters found to exceed the state standard and their contributing watersheds should be given top priority for chloride reduction efforts. Many waters are considered to be high risk, but do not exceed the standard at this time. These areas may be given second priority unless there are no known chloride impairments in the watershed, and then the high risk waters could be given highest priority.

Prioritization of reduction efforts may also be based on the relative size and impact of the source of chloride, such as prioritizing winter maintenance activities in areas with a high density of impervious surfaces, or putting emphasis on residential water softeners for those watersheds where wastewater treatment facilities are identified as a major contributor of chloride. There may also be other ways that are more appropriate for each organization to determine where to prioritize reduction efforts.

Critical areas have been identified where chloride reduction efforts are necessary to achieve water quality goals. Two strategies have been used based on the source of chloride to identify critical watershed. The first strategy identifies watersheds with road densities of 18% or greater to identify watershed where chloride concentrations are typically above water quality standards. Figure 31 depicts the critical watersheds statewide; Figure 32 highlights the critical watersheds in southern Minnesota; and Figure 33 shows the critical watershed in the norther part of Minnesota. An interactive map showing these critical areas is available on the MPCA Road Salt & Water Quality website. The second strategy used to identify critical areas for chloride reduction focuses on areas with drinking water supply wells with hard and very hard water. Figure 10 identifies areas across the state where the drinking water supply is considered hard or very hard therefore requiring softening treatment. Through these two strategies critical areas have been identified across the state where chloride loadings are to be expected high and therefore implementation efforts to reduce chloride should be focused. For the protection of surface and ground waters implementation is encouraged statewide.

Figure 31. Watershed with road densities 18% and greater in Minnesota

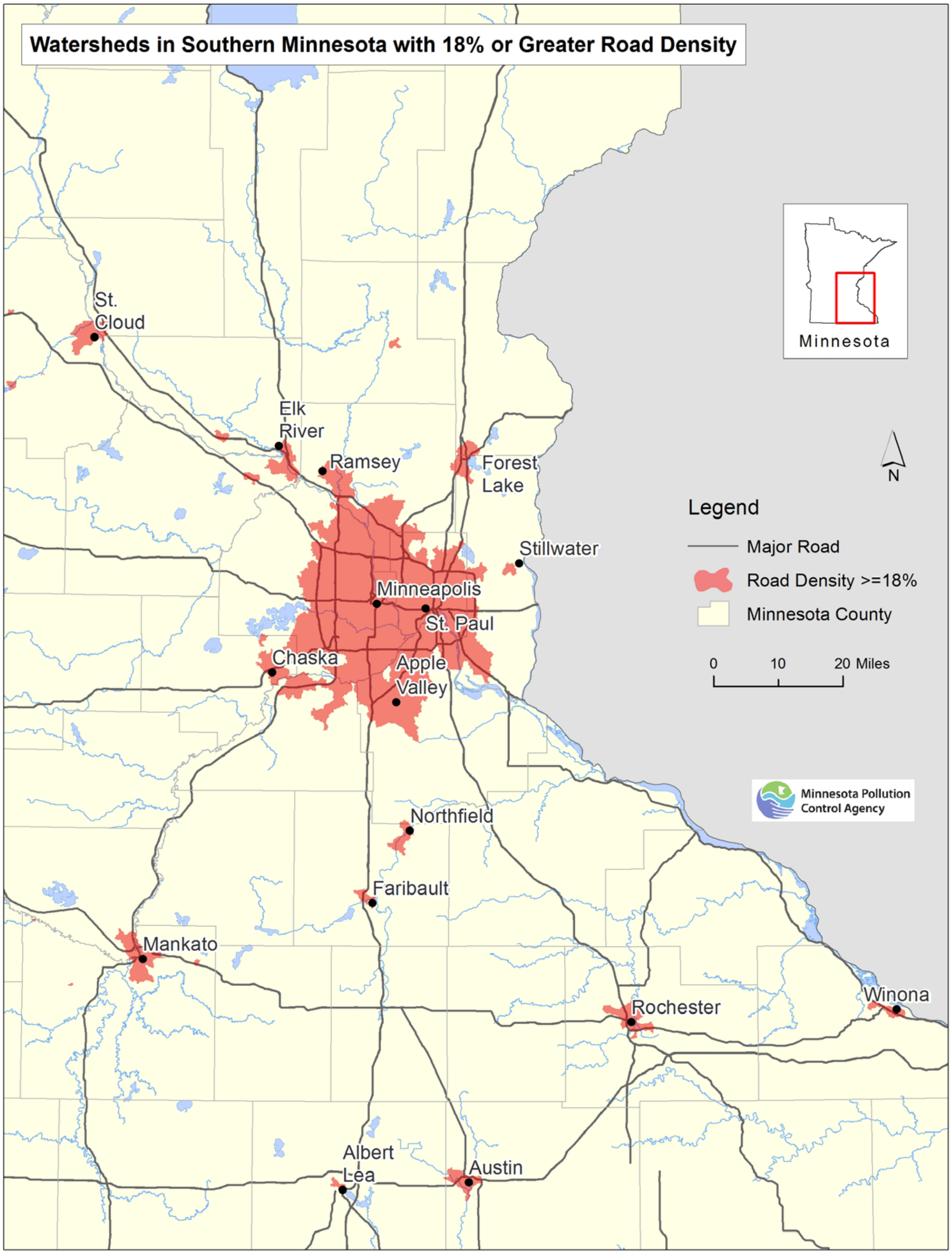


Figure 32. Watershed with road densities 18% and greater in southern Minnesota

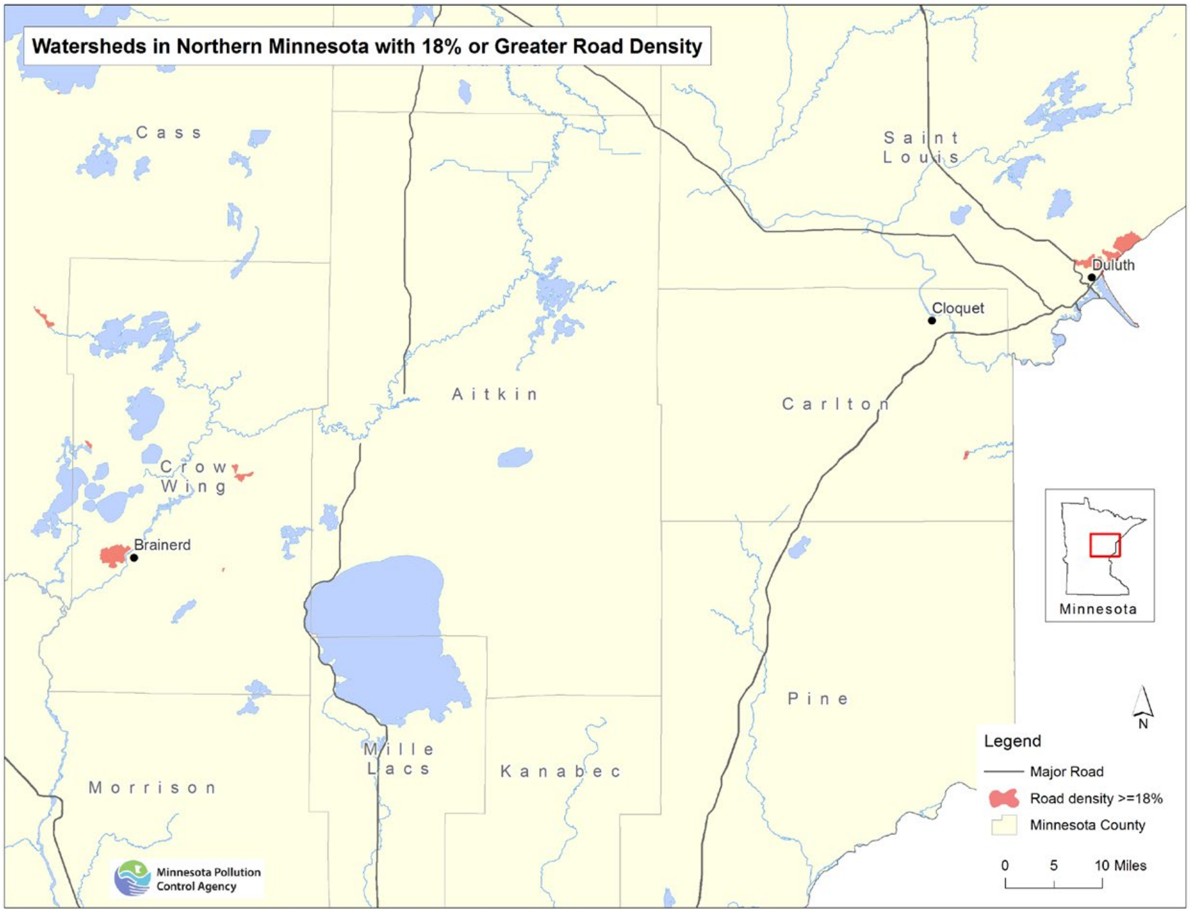


Figure 33. Watershed with road densities 18% and greater in northern Minnesota

3.2 Implementation Strategies

This section provides the overall framework for the implementation strategies that are necessary to protect and restore our water resources. These high-level strategies are intended for both protection and restoration and are described by audience. The next section will provide more detailed implementation activities for the various sources of chloride. The over-arching implementation strategy is a performance-based approach. This approach allows stakeholders and regulators flexibility in the type of BMPs and the timing of implementation, and allows individuals an opportunity to develop chloride management strategies that are practical for their individual situation. Success under the performance-based approach will be measured in terms of the BMPs implemented.

A tool called the WMAt has been developed by the MPCA and is available for use by winter maintenance professionals across the state. The WMAt can be used voluntarily to understand current practices, identify areas of improvement, and track progress. While optional, everyone involved in winter maintenance is highly encouraged to use the WMAt. The tool is intended to streamline and simplify implementation goals and strategies. The tool can also be used to compare practices with other entities and learn from each other in order to achieve the greatest chloride reductions while providing a high level of service. Utilization of this planning tool will allow the user to track their progress over time and show the results of their efforts. The tool can serve as both a reporting mechanism to understand the current practices and as a planning tool to understand future practices. The planning side of the tool will help understand the challenges and costs associated with improved practices.

The overall performance-based implementation strategy for the primary audiences and a suggested timeframe is presented in Table 8 with descriptive text following the figure. Secondary audiences are described at the end of this section and are not presented in a table.

Table 8. Performance-Based Chloride Reduction Strategies

TCMA CMP Performance-Based Implementation Audience	years 1-2	years 3-5	years 6-10	Beyond year 10
Winter Maintenance Leadership (state, county, city, schools, private): those not involved in day to day operations of maintenance crew.	- Review responsibilities - Develop policies - Assess the situation - Create goals - Set priorities - Implement changes - Use WMAt	- Follow plan - Share successes	- Re-assess operations - Revise goals - Continue to implement changes - Share successes	- Re-assess operations - Revise goals - Continue to implement changes - Share successes.
Winter Maintenance Professionals (state, county, city, schools, private): plow drivers, mechanics, supervisors of crew.	- Attend training - Keep an open mind towards change - Look for ways to make salt use more efficient - Use WMAt tool - Create list with the desired changes - Prioritize the action plan - Implement changes - Use less salt	- Follow plan - Eliminate poor practices - Share successes - Use less salt	- Re-assess operations - Adjust goals - Follow plan - Eliminate all poor practices - Share successes - Use less salt	- Re-assess operations - Revise goals - Continue to implement changes - Share successes - Use less salt
WMOs/WDs, Environmental Organizations and Institutions, and Educators	- Modify plan - Put salt education and outreach goals in the operating plans - Develop/modify grant program - Develop a cost share program - If there is an existing grant program, modify - Continue monitoring	- Implement plan - Educate	- Implement plan - Educate	- Review and revise the outreach plan - Continue to educate - Encourage testing of new technologies
Municipalities	- Create a plan - Start implementing the plan - Track progress - Use the WMAt - Prioritize actions - Continue monitoring	- Follow plan - Continue to improve practices - MS4s report progress to MPCA	- Review and revise plan - Continue to improve practices - MS4s report progress to MPCA	- Follow plan - Continue to improve practices - MS4s report progress to MPCA
Wastewater Treatment Plants and Industrial Dischargers	- Understand the sources - Create a plan to reduce and remove chloride - Monitor chloride in effluent	- Implement plan - Discharge less salt	- Continue implementing plan for lower salt discharge - Share successes - Discharge less salt	- Review and revise plan - Continue making progress - Discharge less salt
Water Treatment Facilities (water supply)	- Research to determine if centralized softening or individual softening would be a lower salt solution - Develop plan for minimal salt use in water distribution area.	- Implement plan	- Implement plan	- Continue to work towards lower salt solutions.
Citizens	- Follow recommendations - Use less salt - Encourage others to use less salt	- Reduce salt use - Encourage others to reduce salt use	- Reduce salt use - Encourage others to reduce salt use.	- Continue to reduce salt use.
MPCA	- Create and share the CMP for the TCMA - Create an internal plan to assist stakeholders - Continue monitoring chloride - Help various groups better understand the salt problem - Educate and promote lower salt solutions	- Support TCMA CMP - Follow internal chloride reduction plan	- Support TCMA CMP - Follow internal chloride reduction plan	- Determine if TCMA CMP was effective - Adjust as needed - Re-evaluate chloride reduction efforts
Policy Makers (city, county, state, other)	- Understand why we use salt - Understand what the options are for lower salt use	- Improve policy	- Improve policy	- Improve policy

Winter Maintenance Leadership (State, County, City, Schools & Private)

Winter maintenance leadership is the group responsible for hands-on efforts and operation management. This group includes the individuals in charge of the shop facilities, selling winter maintenance services, determining the type of pavement overlays, or organizing the "getting ready for winter" refresher training. This group does not include the plow drivers or their direct supervisors.

Winter maintenance leadership is a very diverse group that plays a variety of roles across many organizations. Their influence is significant and they have great potential to positively impact reductions in salt use. This group can advocate for change by understanding the economic benefits of salt reduction, including the direct cost savings as a result of using less salt.

Table 9 presents example activities and timelines for winter maintenance leadership to consider. Throughout implementation, goals and practices should be reviewed, assessed, and adaptively updated to reduce the use of chloride. Examples presented in this section include specific possible actions. However, these actions are intended to be examples and are not meant to put emphasis on the specific actions. Each entity will need to assess the most relevant and cost-effective actions to take in their situation to reduce salt loadings.

Table 9. Examples of Implementation Strategies for Winter Maintenance Leadership

Example Implementation Strategies Assessment Items	Goals	Actions
Does salt leave storage sites in ways not intended?	No salty runoff water from salt sheds.	Storage sheds 1, 2, 4 are ok. Re-grade floor of storage shed 3 so water that enters the shed stays in shed.
Do customers know that salt harms the environment and that improved practices are being implemented to reduce salt use yet provide great service?	Give all customers the opportunity to learn about efforts to reduce salt.	Meet or talk to all customers when bidding on work explaining approaches to winter maintenance and environmental protection (private contractors) or run cable TV infomercials about salt reduction reasons and strategies during November (municipal).
Do trucks contribute salt to the truck wash water?	Re-use 50% of winter truck wash water for brine making or have less salt on truck prior to entering the wash.	Install filter system to remove wash water oils and solids, install tank to capture wash water, integrate filtered wash water in brine making system or Install a truck cleaning station before the truck wash to encourage thorough truck emptying in an area where granular salt can be easily reclaimed.
Which organizations have been most successful in reducing salt and what are the lessons learned?	Identify outstanding success in areas of interest (i.e. storage buildings, contracts that don't bill by the ton, using non-traditional plow drivers to get 24 hour coverage).	Look at Clear Roads research, Snow and Ice Management Association (SIMA) research, APWA research, AASHTO research, attend the Freshwater Society's annual Road Salt Symposium and other winter maintenance conferences to identify the leaders. Talk to them directly.
Are lower salt use pavements being installed (permeable, heated, narrower)?	Find some sort of pavement surface that requires 20% less salt on it.	Install permeable asphalt in parking lot near "Smith" lake.
Is payment based on amount of salt applied?	Have a profitable contract without billing by the ton which encourages overuse of salt.	Look at SIMA website for example contracts that do not charge by volume.
Is concern over liability resulting in over applying salt?	See if other states have a law to reduce liability for private companies doing winter maintenance.	Encourage legislators to look at New Hampshire's law that limits liability of private contractors in winter maintenance.

EXAMPLE: YEARS 1-2

- Better understand the impacts of salt on the environment and how organization may contribute.
- Create a chart of items to investigate that may reduce salt use/waste. Consider creating a list of items to be assessed, including goals, actions, and priorities.
- Visit the Snow and Ice Management Association website for example contracts that do not charge by volume.
- Encourage legislators to look at New Hampshire's law that limits liability of private contractors in winter maintenance.

Watch a video: This video, produced by the MWMO and the UMN, is used to train seasonal and full-time property employees as well as business owners, front desk staff and anyone else who needs to control snow and ice in or near entrances and on sidewalks- https://www.youtube.com/watch?v=-xMt1kyzIcg

EXAMPLE: YEARS 3-5

- Install truck cleaning station before truck wash and provide training for proper use.
- Provide training for crew on how to monitor pavement temperatures, calibrate equipment, chose deicer's that will work best based on pavement temperatures.
- Revise contracts to avoid billing by the ton and stay profitable, meet with them for ideas.
- Educate customers about winter maintenance strategies.

EXAMPLE: YEARS 6-10

- Re-grade floor of storage shed #3.
- Install permeable asphalt in parking lot near "Smith" Lake.

Winter Maintenance Professionals (State, County, City, Schools, Parks, Private)

Winter maintenance professionals are responsible for performing outdoor, hands-on winter maintenance and those who supervise them. The primary duties include snow and ice removal from roads, sidewalks, parking lots, and trails, and applying a variety of deicers and abrasives. Some are part of emergency services and have exemption for laws that may cover weight restrictions on trucks or hours of consecutive work.

Winter maintenance professionals are employed by the public and private sectors, working for very small organizations to large organizations. Unusual hours and working in a variety of difficult winter weather conditions are typical in this industry. All of these professionals are under public scrutiny and receive comments about their work, because it directly and visibly impacts the public. There is a lot of pride within this sector as they are called on repeatedly, in the most difficult weather, to get the travelling public to their destinations safely.

The state, county, and city winter maintenance operations in the TCMA are under the extreme pressure of moving people safely on high volume, high speed roads, during all times of the day and night. Although their job is difficult, they often have the advantages of more sophisticated equipment, bigger support staff, less staff turn-over, and access to better and more frequent training than their private counterparts.

Private winter maintenance companies are very diverse and have a unique set of challenges. They often assume legal liability for "slip and falls" at their customer sites. They cannot bill clients when they attend training and have fewer incentives for training their crews. It can be difficult to locate this segment to invite them to Smart Salting trainings. The equipment used for small sites is less sophisticated and prone to over application of material. Their customers are spread out geographically, creating problems for proper and efficient storage and the transport of materials. Part-time seasonal workers fill many of the positions in these companies, which makes proper training an additional challenge for the employer.

The areas of maintenance vary greatly from seldom used sidewalks to the interstate. It ranges from concrete bridge decks to the marble steps of the capitol building. Each maintenance area has unique challenges that must be understood and mastered. The public generally does not understand or appreciate the difficulty of winter maintenance, and certainly does not understand the increasing challenges and changes coming to this industry as it moves towards conservative use of salt.

Maintenance professionals should become educated on the environmental impacts of salt and how their practices contribute to it. Maintenance professionals could attend training on lower salt use strategies, keep an open mind towards change, and look for ways to make salt use more efficient.

Operators could attend training and learn about changes that can be made on an individual basis. Many salt saving strategies do not need the cooperation of an entire agency; they can be incorporated into daily work. Other salt savings actions can be led by supervisors that will involve teamwork within the department, such as moving from manual controlled spreaders to computer controlled spreaders.

Supervisors may assess their current maintenance program using the WMAt, or other assessment techniques, to assess advanced, standard, and remedial practices. The remedial practices could be prioritized then followed by working towards improving good practices to make excellent practices.

Training opportunities, tools, and other resources for winter maintenance professionals can be found in Appendix D.

EXAMPLE: YEARS 1-2

- ÿ Clean out salt from truck thoroughly before washing truck.
- ÿ Reduce speed when applying salt.
- ÿ Avoid plowing off other's salt, communicate with other drivers.
- ÿ Bring extra salt back to the pile, do not use it up on the route if not needed.
- ÿ Add tanks to 5 trucks a year starting in 2017.
- ÿ Work out agreement to buy brine from neighboring agency.
- ÿ All supervisors will attend training.
- ÿ Speed up physical removal of snow by changing our call out policy to 2 inches of snow.
- ÿ Reduce speed of application on high speed roads to 30mph.
- ÿ Calibrate most equipment yearly.

EXAMPLE: YEARS 3-5

- ÿ Speed up physical removal of snow by changing call out policy to 1 inch of snow.
- ÿ Work out salt building agreement for salt storage with neighboring agency.
- ÿ Calibrate all equipment yearly.

EXAMPLE: YEARS 6-10

- ÿ Push snow across bridges and/or truck it away.
- ÿ Adjust to selecting the appropriate material for the pavement temperature all of the time.
- ÿ All personnel will attend training.

Watershed Management Organizations & Districts and Soil & Water Conservation Districts

The WMOs, WDs, and SWCDs play a significant role in the management of the TCMA waters and provide an opportunity to combine the goals and recommendations of the CMP into watershed plans. This important group, together with environmental organizations, agencies and educators are the key organizations to help increase awareness of the problem and encourage reduced salt use across the TCMA. Much of the changes in attitudes and environmental awareness has stemmed from this group of organizations. There are a wide range of possibilities for incorporating key elements of this CMP into watershed plans, as well as important roles that the WMO/WDs can take to help reduce salt use.

The WMOs/WDs/SWCDs play an important role in developing funding programs specifically for private entities, who may have limited funding options.

EXAMPLE: YEARS 1-2

ÿ Partner with the MPCA to offer the Smart Salting winter maintenance training for local private and public winter maintenance professionals each winter.
ÿ Educate 50% of constituents on the benefits of smart salt use.
ÿ Create awareness about the environmental impacts of chloride through education, outreach, and other activities to local residents, applicators, elected officials and businesses.
ÿ Monitor local surface waters for chloride concentrations to track trends, track progress and understand the movement of chloride through the watershed.
ÿ Develop incentive based program for chloride reduction strategies.
ÿ Host yearly workshops for local winter maintenance professionals to encourage the use of the WMAt and track progress of BMPs implemented.
ÿ Provide a measuring cup type salt scooper to homeowners and small businesses at the point of sale of salt in order to raise awareness of the amount of salt they are using.

EXAMPLE: YEARS 3-5

- Educate 75% of constituents on the benefits of smart salt use.
- Offer grants to private and public winter maintenance organizations for upgrading equipment or implementing innovating practices.
- Implement a rebate program to residents to install on-demand water softeners and remove old, inefficient water softeners.
- Provide "free" advertising to private applicators who meet "smart salting" criteria.
- Encourage local businesses and public buildings to reduce salt use through improved insurance benefits and liability protection.
- Partner with local stakeholder on innovative projects to reduce chloride at the source and alternatives for de-icing and water softening.

EXAMPLE: YEARS 6-10

- Educate 100% of constituents on the benefits of smart salt use.
- Create model ordinances, educational materials, or incentives for the organization or others to use and/or adopt. For example:
  - Restrict the application of salt within a city to trained winter maintenance professionals.
  - Citizens are asked to prove their knowledge of salt impacts on the environment and sign a pledge to use less salt, in return for a stormwater fee credit.
  - Create consumer awareness materials available at participating stores (promoting the sales of shovels and snow blowers instead of ice melt).
  - Encourage hazardous household waste centers to accept ice-melt products.

Municipalities

Expectations for all municipalities will begin with an assessment of the existing winter maintenance practices and designing a plan to improve practices. The MS4s will have an additional requirement to report progress on the use of improved winter maintenance practices to the MPCA.

The purpose of this assessment is to determine where opportunities exist to make reductions in salt use. The information in the CMP may be used by municipalities to assess existing practices, specifically the assessment criteria in Appendix B. For a quicker and more thorough assessment, the online WMAt, currently under development, could be used. The WMAt designed to be an easy-to-use web-based tool. This tool will allow municipalities to evaluate their current winter maintenance program at a very detailed level and create a customized plan for implementing salt savings. The tool will allow an individual to assess their current practices and speculate on potential future practices to understand how to reduce the use of chlorides while still providing an acceptable level of service.

This tool is developed for winter maintenance professionals with a broad and detailed understanding of the winter maintenance operations. These professionals should conduct the assessment, then set and share the goals so that the organization can work to meet the goals.

Municipalities can choose to assess existing practices using any means. Municipalities should identify practices to improve winter maintenance activities, with priority on eliminating remedial or unacceptable practices. The implementation goal for each MS4 will be specific to the MS4.

Each municipality will have a unique implementation goal. Some municipalities have already made substantial improvements in practices and require minor effort to improve practices. For leading edge operations it is worthwhile to note the technology and tools for further reductions of salt use are constantly evolving and changing. Organizations currently demonstrating the best practices will still have to dedicate time and resources to stay current with the industry. Leading edge operations could consider sharing their experiences with other organizations that are attempting to lower salt use. For organizations that are just beginning reductions, it may be worthwhile to observe the operations and equipment of those who have already made progress on reducing salt. Networking with other operators could be part of the organization's plan. Organizations outside of Minnesota may also have valuable insights. Many municipalities in the Midwest and Canada have developed expertise in different areas of winter maintenance and are recognized by their peers across the nations.

EXAMPLE: YEARS 1-2

- Educate civic leaders on the benefits to reducing chloride and its importance.
- Partner with the MPCA to offer the Smart Salting winter maintenance training for local private winter maintenance professionals in the area each winter.
- Educate 50% of constituents on the benefits of smart salt use.
- Create awareness about the environmental impacts of chloride through education, outreach, and other activities to local residents, applicators, elected officials, and businesses.
- Attend trainings, workshops, and events to learn about new technology and strategies for reduced salt use.

EXAMPLE: YEARS 3-5

- Educate 75% of constituents on the benefits of smart salt use.
- Recognize private winter maintenance organizations for upgrading equipment or implementing innovating practices.
- Implement a rebate program to residents to install on-demand water softeners and remove old, inefficient water softeners.
- Provide “free” advertising to private applicators who meet Smart Salting criteria.
- Encourage local businesses and public buildings to reduce salt use through improved insurance benefits and liability protection.
- Partner with state and local stakeholders on innovative projects to reduce chloride at the source.

EXAMPLE: YEARS 6-10

- Educate 100% of constituents on the benefits of smart salt use.
- Create model ordinances, educational materials, or incentives for the organization or others to use and/or adopt. For example:
  - Restrict the application of salt within a city to trained winter maintenance professionals.
  - Citizens are asked to prove their knowledge of salt problems in the water and sign a pledge to use less salt, in return for a stormwater fee credit.
  - Create consumer awareness materials available at participating stores (promoting the sales of shovels and snow blowers instead of ice melt).
  - Encourage hazardous household waste centers to accept ice-melt products.

Wastewater Treatment Facilities and Industrial Dischargers

This section addresses municipal and industrial WWTPs that either create saline water in their operations or receive saline water and discharge it. The concentration of chloride present in the waste stream will vary for every facility and is dependent on the source of chloride. The major source of chloride to municipal WWTP is from residential water softeners (>90% in some municipalities).

If WWTPs effluent chloride concentrations demonstrate a reasonable potential to exceed 230 mg/L, the MPCA will work with the permitted entity to include appropriate permit conditions, including monitoring requirements, compliance schedules, and possible effluent limits. If a permitted facility receives a chloride limit they will be required to identify sources of chloride.

For municipal wastewater facilities, technologies capable of removing chloride from wastewater are either cost-prohibitive, technologically infeasible, or a mix of the two. The RO and evaporation of the resulting brine is the most viable option for removal of chloride at the WWTP. The MPCA analyzed the cost and implementation concerns of using RO treatment and evaporation to remove chloride for WWTPs in 2012 (Henningsgaard 2012), which is also summarized in Section 3.6. Based on the assessment, RO treatment and evaporation are cost prohibitive and pose significant implementation concerns.

The most feasible option for reducing chloride loading to the WWTPs is upstream source reduction. The two primary sources of chloride to WWTPs are industrial users and residential water softeners. If a facility has a chloride limit or would like to voluntarily reduce chloride, WWTPs should work through their Industrial Pretreatment Program (IPP) to identify significant users who may be contributing chloride. The WWTPs can review existing data from industrial users or can require industrial users to collect chloride data. If industrial users are identified as a significant source of chloride, the WWTP can work with the industrial user through the IPP to develop and implement a plan to reduce chloride loads.

Water Softeners

One option for municipalities includes the potential of providing lime or membrane water softening at the water treatment plant (WTP) in an attempt to eliminate water softening at individual residences. This option assumes that all WTP users would be connected to city drinking water and would have taken their water softener offline. Water softening at the WTP has the potential to be more cost efficient than individual residential water softening for many users.

The MPCA supports any effort to reduce chloride loading to the WWTPs, including encouraging residential users to switch to high efficiency ion exchange softeners. However, the MPCA does not believe that switching residents to high efficiency softeners will automatically allow a WWTP to come into compliance with chloride permit limits. The MPCA is developing a guidance document that will provide WWTPs chloride source reduction methods, treatment alternatives, and permitting strategies that will help WWTPs to come into compliance with the chloride water quality standard. The following steps will help to reduce the amount of salt being discharged to a WWTP:

- Know the hardness level of local water supply.
- Consider whether a water softener is needed and avoid the ongoing expenses if it isn't. Test water for hardness. Typically water hardness greater than 120 mg/L $CaCO_3$ needs to be softened. See the University of Kentucky's Guidance: Hard Water- To Soften or Not to Soften for more information.
- Do not over soften. Program the water softener to obtain an optimal level of hardness.
- Uninstall an old timed softener and replace it with a new demand softener. A new demand softener could be optimized to minimize backwashing and the newer model would have a more efficient ion exchange resin.
- If using a timer-based softener, set to recharge at the lowest effective rate and turn it off when on vacation.
- Install a bypass so landscape irrigation water is not softened.
- Consider alternatives to salt-based water softeners.
- Move to centralized water softening using lime rather than salt

Homeowners with water softeners with an on-site septic system, salt reduction strategies should also be taken. Chlorides in on-site septic systems will infiltrate to groundwater and may result in elevated levels of chloride in groundwater which can impact water supplies as well as groundwater recharge of lakes, streams, and wetlands.

For direct dischargers of industrial wastewater, the individual permittee will need to work with the MPCA to develop and implement a plan to reduce chloride if effluent concentrations have reasonable potential to exceed 230 mg/L. Each industrial discharger will have unique circumstances and will need to consider whether source reduction, treatment, or another approach would be most effective in their specific situation.

EXAMPLE: YEARS 1-2

- Monitor chloride in effluent and review past monitoring reports for chloride concentrations.
- Evaluate chloride data and determine if reasonable potential to exceed 230 mg/L exist.
- If potential to exceed 230 mg/L work with MPCA permit staff and create a plan to reduce upstream chloride sources.

EXAMPLE: YEARS 3-5

- Identify goals for chloride reductions.
- Develop a compliance schedule if chloride limits are established through NPDES permit.
- Educate industrial dischargers on the importance of reducing chloride in waste streams.
- Educate residents in cities that pre-soften water that they do not need water softeners.

EXAMPLE: YEARS 6-10

- Work with water softening companies to offer a trade-in program to upgrade to high efficiency residential water softeners.
- Offer a credit to a city or industrial discharger for reducing chloride concentrations in wastewater.
- Work with municipality to install municipal lime softening at the WTP.

Water Treatment Facilities (Water Supply)

This sector draws water from groundwater or surface water sources and tests and treats it before distributing it to residents. Municipalities that soften the water before it is distributed to households or municipalities that are considering this, care should be taken to minimize salt use and salt waste. Assess the need for soft water in the area and look for non-salt approaches such as lime softening. Consider the mass balance of how much salt is used by individual water softeners versus centralized water softening. However, users may be unaware the water from the municipality is softened or may be accustomed to having a residential softener leading to double softening. Municipalities can also evaluate how high saline water is disposed of in the cleaning and flushing process.

EXAMPLE: YEARS 1-2

ÿ Assess hardness level of water and need for softening.
ÿ Determine if non-chloride source softening is a viable option.
ÿ Survey homeowners on the use of residential water softening.
ÿ Educate customers on water conservation and the benefits related to chloride reduction.

EXAMPLE: YEARS 3-5

ÿ Encourage residents to install high efficiency water softeners.
ÿ Encourage home by-pass of soft water for irrigation and drinking water. Create cost share program to encourage plumbing changes needed to accommodate this.
ÿ For those with RO systems, explore ways to capture RO waste water which is saline and route to water softener.

EXAMPLE: YEARS 6-10

- ÿ Reuse salt from cleaning municipal water softening equipment.
- ÿ Use non-chloride techniques for softening source water.

Citizens

This group includes everyone living or working in the TCMA. Each person contributes to the attitudes and practices that have created a high and steadily growing volume of salt to be used each year. In order to reverse this situation each person must contribute to changing attitudes and practices that are more sustainable and require less salt. The list of actions that this group can take is extensive. Citizens form public policy, set the expectations that our maintenance crews must live up to, and use salt on their own property such as water softening and salting their sidewalks in the winter. Engaging the citizenry in the TCMA offers the best chance to get salt use under control.

There are many ways to reduce salt use while maintaining high safety standards. Below are a few simple steps that residents can take to help reduce the amount of chloride entering waters. More ideas are listed on the MPCA's website.

Citizens can look for ways to reduce salt use. Every teaspoon of salt reduction prevents five gallons of water from being polluted. Small changes can have big results. Typically the biggest salt uses are sidewalk/driveway/steps (winter maintenance) salt and water softeners, with the outdoor use for winter maintenance being the largest use.

Winter Safety:

- Support local and state winter maintenance crews in their efforts to reduce their salt use.
- Work together with local government, businesses, schools, churches, and non-profits to find ways to reduce salt use in the community.
- Inform and educate local and state policy makers on the importance of this issue.
- Shovel. The more snow and ice removed manually, the less salt is needed and the more effective it can be. Whether through shoveling, blowing, plowing or scraping, getting out early and keep up with the storm. Salt may not be needed.
- Do not apply salt to areas that have not been shoveled.
- Generally speaking, sidewalk salts work better when it is warmer. Below 15°F is too cold for salt as most salts stop working at this pavement temperature. Use sand instead for traction, but remember that sand does not melt ice. If melting snow or ice look for opportunities when the sun is shining or the temperatures are warming, which will be more effective with less salt.
- Slow down. Drive for the conditions and make sure to give plow drivers plenty of space to do their work. Consider purchasing winter (snow) tires.

- Be patient. If the salt is not visible on the road doesn't mean it hasn't been applied. These products take time to work. Allow more time for trips to account for driving at a slower speed.
- More salt does not mean more melting. Use less than 4 pounds of salt per 1,000 square feet (an average parking space is about 150 square feet). One pound of salt is approximately a heaping 12-ounce coffee mug. Consider purchasing a hand-held spreader to apply a consistent amount.
- Sweep up extra salt and sand. If salt or sand is visible on dry pavement it is no longer doing any work and will be washed away. Reuse this salt or sand somewhere else.
- Research the products. Choose the right one for the conditions. Salts are used because they are able to decrease the freezing point of water. Whatever product selected, know the temperature it stops working.
- There are no labeling laws for bags of deicers. Therefore the information on the bag may be accurate or misleading; it may contain a list of all ingredients, a partial list, or no ingredient list. See the MPCA salt & water quality website for information on common deicers and the practical melting ranges.
- Watch a video. This video, produced by the MWMO, provides tips to homeowners about more environmentally friendly snow and ice removal: Improved Winter Maintenance: Good Choices for Clean Water.
- Read and pass along Nine Mile Creek Watershed District's (NMCWD) brochure about residential snow and ice care: Residential snow and ice care (NMCWD)

Water Softening:

- Use a high efficiency water softener.
- Avoid using softened water for irrigation or drinking water.
- Do not use a water softener if source water is already softened by the WWTP.

Minnesota Pollution Control Agency

The MPCA will continue to provide support to stakeholders to address chloride impacts on surface water and groundwater resources, as resources allow. The MPCA will continue to monitor lakes, streams, and groundwater for chloride, in cooperation with the TCMA partners, to track progress and better understand water quality trends. The MPCA recognizes the importance of the MPCA Smart Salting (S2) training program and will continue to support and improve the training as new technologies and resources are available. The MPCA will also continue providing necessary technical assistance, resources, tools including supporting and hosting the WMAt, to its permitees, stakeholders and local partners, and to facilitate forums discussing progress of implementation of the CMP and adaptive management strategies in the TCMA as resources are available.

EXAMPLE: YEARS 1-2

ÿ Explore ways to support a sustainable MPCA Smart Salting Program.
ÿ Host, support and update the WMAt on the MPCA website.
ÿ Continue to monitor lakes, rivers, and groundwater for chloride.
ÿ Solicit assistance in statewide chloride monitoring through partnerships and grant programs.
ÿ Participate in the Freshwater Society’s annual Road Salt Symposium.
ÿ Update website with educational information on lower salt use for citizens.
ÿ Support and provide access to the “Salt Dilemma” display at various events and venues.
ÿ Provide technical assistance to permitee for reducing chloride.

EXAMPLE: YEARS 3-5

ÿ Continue to monitor lakes, rivers, and groundwater for chloride.
ÿ Continue to update impaired waters list with waterbodies exceeding the state’s chloride standard.
ÿ Participate in the Freshwater Society’s annual Road Salt Symposium.
ÿ Support and provide access to the “Salt Dilemma” display at various events and venues.
ÿ Continue to provide technical assistance to permittees for reducing chloride and fulfilling permit requirements for Chloride TMDLs.
ÿ Integrate chloride reduction opportunities into other MPCA programs.
ÿ Include chloride reduction as a priority at the MPCA where possible.

EXAMPLE: YEARS 6-10

- Continue to monitor lakes, rivers, and groundwater for chloride.
- Continue to update impaired waters list with waterbodies exceeding the state's chloride standard.
- Continue to support the implementation of the TCMA CMP.
- Support and provide access to the "Salt Dilemma" display at various events and venues.
- Continue to provide technical assistance to permittees for reducing chloride.

Policy Makers

State, county, city policy makers, and those that make policy to govern other entities have an important role to play in chloride management. Policy is the tool that helps speed up behavior change in areas where behavior change is not progressing or progressing fast enough. One of the challenges facing policy makers is that they may not fully understand the environmental impacts of salt. In order to enable policy makers to be more active in this area, information about the environmental impacts of salt and awareness of the existing voluntarily efforts to improve salt reductions is necessary. There are many policies and actions that can be considered to assist with reducing salt use.

EXAMPLE: YEARS 1-2

- Better understand environmental impacts of salt use and ways the constituents contribute.
- Understand options for reducing chloride use.
- Support the implementation of the CMP.
- Develop a limited liability law to protect private contractors from being sued if they are following BMPs under the Smart Salting (S2) training, similar to New Hampshire. Fear of law-suits often drives over application of salt.
- Create an ordinance for city that all salt and salt/sand piles must be stored indoors and on an impermeable surface.

EXAMPLE: YEARS 3-5

- Require statewide certification of salt applicators similar to the Department of Agriculture's pesticide applicator certification program.
- Require all new construction to have irrigation water and drinking water plumbed so as to not pass through the water softening.
- Require water softeners that recharge by the time of day and not by the salinity of water be banned from sale.
- Provide funding to various state agencies to support local implementation of salt reduction practices.
- Discuss lower levels of service with constituents.

EXAMPLE: YEARS 6-10

- Develop labeling laws for deicers sold in MN so ingredients are listed along with practical. melting range. Also should include warning about the environmental impacts of using the material.
- Policies should be reviewed to determine effectiveness in chloride reductions.
- Work with other policy makers to understand the most effective policies.

Secondary Audiences

This group includes those that have a smaller, but important, role in reducing the amount of salt entering surface and ground water.

Those awarding maintenance contracts

The property manager or contracts department for any organization hiring winter maintenance services should consider requiring those bidding on work to have successfully completed the MPCA Smart Salting training. When crews are on-site conducting maintenance work a high percentage (to be determined by contracts department) should have successfully completed the training within the past five years. Here are things to consider when negotiating a contract for winter maintenance services:

- Have all contracted and landlord winter maintenance workers applying salt attend the MPCA Smart Salting training.

- Charge for level of service (i.e., hourly, event-based or seasonally), not per pound of product.
- Develop a Snow and Ice Policy and set clear expectations (see Smart Salting training website for example policies).
- Clean up accidentally spilled piles of salt.
- Use mechanical methods of snow and ice removal (plow, shovel, brush, blow) prior to using any chemical control – capabilities needed.
- If using sand, conduct year-around sweeping to remove any excess product applied in winter.
- Record what and how much product is applied for each event.
- Calibrate all equipment at least annually and document the results.
- Use salt (NaCl) only if pavement temperature is above 15 degrees Fahrenheit.
- Find ways to wet salt – 30% less material can be used, it works faster and stays in place Show progress towards lower application rates based on the MPCA's training program.

Some example language to consider:

> *Snow plowing and deicing of parking lots will be done in a manner similar to guidelines provided under both the Minnesota Pollution Control Agency and the Minnesota Department of Transportation "Winter Parking Lot and Sidewalk Maintenance" manual provided to LESSOR.*
>
> *LESSOR shall request LESSOR'S vendor to attend Smart Salting training offered by the Minnesota Pollution Control Agency. The following link provides information about the Minnesota Pollution Control Agency's Road Salt Education Program:* http://stormwater.pca.state.mn.us/index.php/Smart_Salting_(S2)_training_information

Grant-giving organizations

Ensure that grant opportunities are available for protection and restoration of surface and ground waters for chloride. Consider ways to ensure a simple application process and equal access to funds for non-traditional source reduction (pollution prevention) projects addressing chloride. Possible areas include:

- Research or implementation of reduced-salt strategies to winter maintenance.
- Research or implementation of lower or no salt pavement strategies.
- Citizen involvement on environmental impacts and solutions.
- Research or implementation of changing winter driver behavior and expectations.
- Research high efficiency residential water softening and non-chloride options.
- Re-using waste stream products for deicing.
- Research or implementation of urban design solutions that reduce salt use. (Examples: parking ramps/covered parking as an alternative to vast parking lots. Skyways or covered walkways. Transit-oriented development so people have alternatives to driving.)

Driver Education Programs and Department of Driver and Vehicle Services

For all new drivers, those getting additional licenses such as commercial or motorcycle licenses, and those moving into Minnesota, consider educating about winter tires, appropriate winter driving, and the environmental impacts of salt. Include training on winter driving, the temperature range at which salt does not work, how bridge decks and ramps freeze before the roads, and other tips for safe winter driving. Teach drivers to respect the plowing operations and take pressure off of public works departments for instantly cleared surfaces. Send information with driver license renewals to current drivers on tips for winter driving.

Pavement designers, researchers, engineers

Become educated on the issues with high-salt-use surfaces and the impacts to water resources. Look for opportunities to invent, test, and implement lower-salt-use pavement surfaces. This includes sidewalks, parking lots, roads, bridges, ramps, trails, parking ramps, steps or other highly salted surfaces in the winter months. Possible areas include, but are not limited to:

- Permeable surfaces
- Flexible surfaces
- Heated surfaces
- Different color or texture of surfaces
- Smaller surfaces
- Pavement overlays

Water experts in most any field including limnologists, hydrologists, biologists, chemists

Understand the impacts of chloride to water resources and the pathways it takes to get there. Look for opportunities to invent, test, and implement techniques to prevent salt from entering water resources after application or for strategies to mitigate for it. Problem areas to consider include:

- Recovering salt after application to paved surfaces
- Options for treating chloride in stormwater ponds
- Research the impacts of infiltration into ground water versus surface flow to surface waters
- Options for mitigating chloride already present in surface waters
- Capturing and reusing salt water (truck wash, runoff, waste water discharge)

Agriculture

The primary source of chloride from agricultural lands in the TCMA is from fertilizers and land application of food processing waste and biosolids from municipal sewage treatment. Excessive chloride concentrations on agricultural lands can be harmful to crop growth in addition to contributing to elevated levels of chloride in surface runoff and groundwater infiltration. Conservation practices and nutrient management not only protect water resources, but can save farmers money. Development and implementation of nutrient management plans could potentially be conducted for agricultural lands. Conservation practices and nutrient management planning information and guidance can be found at the Minnesota Department of Agriculture website.

Other State Organizations

The Minnesota Department of Health (MDH) should continue to monitor chloride in drinking water, as resources allow. The Metropolitan Council may continue to monitor chloride in lakes, wetlands, streams, and groundwater, as well as chloride in wastewater discharges in the TCMA. The Minnesota Department of Natural Resources (DNR) could continue to monitor chloride impacts on aquatic life, plants, and animals. The Board of Water and Soil Resources (BWSR) will continue to administer grant programs to protect, enhance, and restore water quality in lakes, rivers, and streams in addition to protecting groundwater and drinking water sources from degradation, as resources allow.

The MnDOT should continue to provide in-house training and leadership throughout the state in an effort to enable the implementation of effective chloride reducing BMPs. This includes research on innovative technology and passing the knowledge on to others.

The Minnesota Department of Agriculture could potentially work with farmers to develop nutrient management plans, which include methods to reduce chloride-based fertilizers.

3.3 Chloride Reduction Strategy

Implementation Strategies: Traditional Framework

Chloride management is a challenging issue in Minnesota and requires a balance between public safety and the environment. In addition to the balance, chloride management is complex since every winter event is different. The different events can be a result of the type of precipitation, temperature, longevity of the event, timing of the event, etc. In addition to variations in each event, winter seasons can be highly variable from year to year.

Snow and ice maintenance practices vary between road authorities and private applicators. Training, equipment, available resources, client expectations, and political pressure all factor into the amount of deicer being applied.

There is no single BMP that can cost-effectively remove snow and ice and maintain an appropriate level of service for all of the various situations. Chloride management can only be achieved through implementation of an array of different BMPs. The BMPs vary by effectiveness in reducing chloride application and cost of implementing the BMP.

The CMP includes an arsenal of BMPs, which give chloride applicators multiple ways to reduce chloride. This provides BMPs that can be used by high-use/high-experience entities all the way down to low-use/low-experience entities. A wide range of BMPs also allows greater flexibility in the timing and extent of implementation of BMPs.

Traditional BMP strategies can be implemented by chloride applicators. The primary recommended strategies include, but are not limited to:

1. Shift from granular products to liquid products
2. Improved physical snow and ice removal
3. Snow and ice pavement bond prevention
4. Training for maintenance professionals
5. Education for the public and elected officials

These strategies are centered on the continued use of chloride containing products in the most efficient and effective manner possible. This approach assumes maintaining the same level of service. There are several industry shifts that are needed to reduce salt waste. These changes are applicable to all winter maintenance areas in which a high level of service is expected: roads, parking lots, and sidewalks.

Implementing the strategies above will lower salt use, but it may not be reduced enough to protect or restore all water resources.

As part of the stakeholder process to develop the CMP, a TechEx was developed and consists of hands-on salt applicators and suppliers. The TechEx was engaged to better understand the state of the practice and the BMPs available to the winter maintenance industry. The TechEx provided valuable information on specific BMPs that are currently being used by various entities and the benefits of implementing these salt reducing BMPs. This team has been instrumental in the development of the WMAt that will assist winter maintenance organizations in developing their own customized salt reduction plan. Their knowledge, experience, and dedication to using smart salting techniques has been utilized to create this first ever comprehensive evaluation of all available chloride BMPs. Utilization of this planning tool will allow the user to track progress over time and show the results of the efforts.

The tool can serve as both a reporting mechanism to understand the current practices and as a planning tool to understand future practices. The planning part of the tool will help the user understand the challenges and costs associated with improved practices. The WMAt provides a more detailed and comprehensive list of the BMPs available to winter maintenance professionals.

A few salt saving BMPs for winter maintenance programs

While the preferred and most effective approach for developing a chloride reduction plan for individual winter maintenance programs is to utilize the WMAt, here are a few BMPs that have been proven to reduce salt use.

1. Calibrate all equipment regularly (both liquid and granular systems).
2. Integrate liquids (avoid applying dry material).
3. Develop a Winter Maintenance Policy/Plan and share it with supervisors, crew, and customers.
4. Provide state-of-the-art Smart Salting training, education, and professional development for all who work in the industry.
5. Store salt indoors and on an impermeable pad.
6. Anti-icing before events to reduce bonding of snow to pavement.
7. Use ground speed controllers.
8. Upgrade to equipment that can deliver low application rates.
9. Select products that will work well given the pavement temperatures and conditions.
10. Select application rates based on road temperatures and trends, the product used cycle time and other factors.
11. Start mechanical removal as soon as possible and keep at it throughout the storm.
12. Use a variety of methods to reduce bounce and scatter of salt
    - Reduce speed
    - Higher liquid to granular ratio
    - Lower spinner elevation
    - Chutes or skirts
    - Reduced spinner speed
    - Target center of road.
13. Refine application rates charts and continually test lower rates.

These BMPs may not be practical for all winter maintenance programs and should not be considered the best or only options for salt reducing activities, but rather a list of BMPs that many programs have already begun implementing and are seeing reduced salt use as a result. To determine the activities appropriate for each organization please visit the MPCA's Stormwater Manual to utilize the WMAt.

The MnDOT is a leader in winter maintenance related research in the state. Research reports and technical summaries on the latest research can be found on the MnDOT Research Services website.

Implementation Strategies: Non-Traditional Framework

The continued use of chloride containing deicing materials to provide safe winter conditions may not be a sustainable long-term solution. Therefore, considering practices that fall outside the current and common methods for winter maintenance are worth evaluating. When evaluating non-traditional methods, it is important to consider the environmental impacts of the methods.

Non-traditional approaches require public acceptance in terms of costs, expectations, and changes in behavior. Implementation of these practices will require a combination of messaging to the public which includes discussion of the potentially significant costs to individuals and government. Five of the main areas where change may be considered include:

1) Adopt a lower level of service for roadways, parking lots, and/or sidewalks during snow and ice conditions.

In this scenario, the public would be given a lower level of service on the roadways, parking lots, and/or sidewalks. Physical removal of snow would likely remain the same but the salting would diminish. There are many ways in which winter maintenance professionals could change their level of service. For example, roads could be salted less frequently or perhaps less of the road could be salted. Instead of roads free of ice and snow from shoulder to shoulder, the melted zone could be reduced, perhaps to the middle of the drive lane. Salting could be restricted to critical areas such as intersections, ramps, hills, and high speed roads. Road salt would still be used, but to a lesser extent.

Winter speed limits – alter the speed limits to match the driving conditions during winter storm events or super cold weather times when black ice is present. The MnDOT currently uses a managed traffic lane approach for dealing with high traffic volumes and congestion on the interstate system within the TCMA. It provides a way for the MnDOT to suggest a speed that will reduce braking and further congestion. This same approach could be utilized to manage the expectations of drivers in terms of speed during snow and ice conditions. The temporary winter speed limit approach has been taken in several states including Illinois, Pennsylvania, Colorado, Maine, and Oregon.

- *Primary challenges:* Changing the public's behavior and would require acceptance from the public. The cost of longer commute times and less safe travel conditions in winter months are unknown with this approach however. This would affect non-motorized commuters as well (i.e. pedestrians and bicyclists).
- *Benefits:* Potential to immediately reduce the amount of chloride entering our waters and would save money in salt purchases. This strategy would be easy to implement from a technical perspective but challenging to implement without political and public support.

2) Alternative pavement types and urban design

In this scenario, government transportation agencies and private industry would adopt different forms of pavement that can be kept clear with less or without the use of salt. This could include various forms of heated roadways, new types of improved traction surfaces, surfaces constructed with internal anti-icing features, solar roadways which could generate heat as well as electricity, permeable pavements, and flexible pavements. Narrower roadways may also allow for less application of deicing material.

Urban design methods such as parking ramps and covered parking, skyways or covered walkways, porous paving, public transit, transit-oriented development, and higher density development may also help to reduce impervious surfaces, reduce impervious surfaces requiring deicing, and reduce the overall chloride use.

- *Primary challenges:* would require large-scale public funding, and substantial rework of existing roadways. May result in much higher direct costs making its adoption less desirable and practical. This would be difficult to implement on a large scale due to funds, but may be feasible at a smaller, watershed scale. This approach may take a significant amount of time to convert traditional roads to high performance roads. It will be important to educate entities on permeable pavements and the importance in reducing chloride application since the runoff from permeable pavement surfaces will enter the groundwater.
- *Benefits:* No drastic change in the public expectations for winter travel conditions. Could implement as infrastructure is redeveloped. Would allow for treatment of other pollutants as well.

3) Driver behavior changes

Use of winter tires or other types of tires with improved traction could be required. This might possibly reduce the expectations for a high level of service, and any salt savings would need to be linked to this secondary step of diminished road melting. There remain concerns that driver behavior would not change enough to allow less salt use. Some types of tires have been associated with increased road wear and subsequent pollution, and Minn. Stat. 169.72, prohibits studded tires. The challenge with this approach lies again with public acceptance and driver education on how to safely use winter tires. There would also be a direct cost to consumers and the enforcement of such a requirement. Increased maintenance to roads would likely be an indirect cost associated with this approach, which the resulting salt savings would be modest at best.

Work with large employers to establish a work from home policy during snow events for employees who have suitable jobs. Possibly this will reduce traffic enough during critical times to allow maintenance to be more effective with less salt.

- *Primary challenge:* need for widespread changes from the public. Likely indirect cost passed onto consumers. Safety concerns. Increase damage to roads.
- *Benefits:* would allow for easier continued reduction in salt use.

4) Non-chloride deicers

There is a fairly wide variety of other chemicals that can be used for anti-icing and/or deicing, chemicals which do not contain chloride. However, there are significant environmental concerns with most of the existing alterative products. In general the toxicity of non-chloride based deicers is often more severe to surface water organisms in the short term as the chemicals breakdown. There are fewer long-term concerns with non-chloride deicers, which should be evaluated against the long-term permanency with chloride. Of the four strategies, this may be the easiest to implement, but the environmental impacts of these alternatives are the highest of the options listed and needs to be better understood.

- *Primary challenge:* in general, the costs of alternative products that work as well at melting ice are more expensive than chloride containing products. The environmental consequences of alternative products are relatively unknown.
- *Benefits:* no requirement for public acceptance or changes in behavior. Easy to begin implementing and only requires minor adaptations from maintenance professionals to understand how to effectively and appropriately use these new chemicals.

See MnDOT's Transportation Research Synthesis Report: Chloride Free Snow and Ice Control Material for further information on non-chloride deicers and other non-traditional strategies such as permeable pavement, reducing road widths, solar, and others.

5) Snow melting equipment

Snow melting equipment may be a viable solution in some cases. However, the costs, practicalities, and other environmental consequences of snow melting equipment should be explored further before implementing this method.

Training and Professional Development Opportunities

- MPCA Level I Smart Salting Training – Snow and Ice Control Best Practices
  - This training program is aimed at high level BMPs for private applicators and for city, county and state winter maintenance professionals. There are two classes offered:
    - Winter Parking Lot and Sidewalk Maintenance with reduced environmental impacts. The parking lot and sidewalk training manual is given to each participant.
    - Winter Road maintenance with reduced environmental impacts. The Field Handbook for snowplow operators is given to each participant.
    - The training schedule for the MPCA Smart Salting trainings can be found at http://stormwater.pca.state.mn.us/index.php/Smart_Salting_(S2)_training_information
- MPCA Level II Smart Salting Training
  - This program is currently being developed and is intended to provide a higher level of training for more experienced winter maintenance professionals.
  - The training will provide winter maintenance professionals an opportunity to learn how to utilize the WMAt.
- Minnesota Local Technical Assistance Program (LTAP)
  - Snow and Ice Control Material Application
    - This training is aimed at determining proper application rates during various conditions in order to use salt and sand effectively and efficiently.
  - Snowplow Salt and Sander Controller Calibration Hands-on Workshop

        - This workshop is aimed at calibrating salt and sander controllers. Attendees receive hands-on calibration instruction.
- Freshwater Society's Annual Road Salt Symposium
  - The symposium brings together environmental and transportation professionals to learn about the latest research on the environmental impacts of road salt and innovations that are helping overcome the problems. Environmental leadership awards are presented to local organizations that are making progress in reducing salt.
- American Public Works Association (APWA)
  - Offer training at APWA meetings and conferences: http://www.apwa.net/topics/education-and-training
    - List of those certified by the MPCA Smart Salting trainings can be found at: http://stormwater.pca.state.mn.us/index.php/Smart_Salting_(S2)_training_certificate_holders
- Small site Smart Salting training video and homeowner Smart Salting training video can be found at https://www.pca.state.mn.us/water/educational-resources .

More training and professional development opportunities can be found in Appendix D.

MS4 Permit Implications/Strategies/Reporting

One of the challenges for public road authorities is the variability in road types, conditions, and meeting driver expectations. Each municipality is faced with unique challenges and circumstances that will play a role in determining the specific BMPs implemented. Development of winter maintenance policies/plans that are proactive and aim to minimize salt use is a critical first step for all winter maintenance programs to begin implementing the BMPs in an effective and strategic way. Training and regular professional development for all applicators is another key strategy to allow winter maintenance programs to reduce overall chloride use while providing an appropriate level of service.

Municipalities in the TCMA make up the most significant portion of salt applicators and would be expected to take on the majority of the BMP activities for reducing chloride. Those municipalities with a National Pollutant Discharge Elimination System (NPDES) Permit with the MPCA in a chloride impaired watershed will be required to report progress on the implementation of the salt reducing BMPs beginning after issuance of the next Phase 2 MS4 permit, which is expected to occur in 2019. The Phase 1 MS4s, (St. Paul and Minneapolis) will be asked to report their progress in 2016.

The WMAt is a valuable resource to MS4s in terms of prioritizing and implementing the BMPs. Use of the WMAt is not a requirement but will allow each MS4 to determine their own priorities that may be based on cost, location, ease of acceptance, or other important factors unique to the MS4's particular situation. The WMAt provides the specific BMPs related to all areas of winter maintenance to aid in the development in a detailed plan that meets the unique conditions of each individual program and can be prioritized and implemented according specific needs and constraints.

Another valuable resource for public road authorities is their peer group. Several public road authorities have improved practices, significantly reduced chloride use, and have recognized cost savings by implementing BMPs. These success stories, when shared between entities can be a great way to demonstrate specifically how chloride reductions have been successfully achieved. Case studies describing some of these local success stories and specific areas of improvement are discussed below in Section 3.5.

The MS4 reporting will consist of discussion of the BMPs that have already been implemented and the BMPs that are planned, including a timeline for implementation. Further information on reporting requirements can be found on the MPCA MS4 program website.

Private (Commercial, Industrial, Residential)

A major challenge in the overall reduction of chloride use in the TCMA is getting private applicators to reduce chloride usage. There are five primary hurdles related to this effort:

1. Liability concerns for applicators and property owners
2. Education and training for applicators, including cost
3. Contracting practices and incentives for applicators
4. Diversity in personnel experience
5. Private companies often are excluded from grant opportunities

Two potential approaches to educating/training private applicators include a required training approach and a voluntary training approach, both discussed further below. A required training assumes that an ordinance or other regulatory mechanism is adopted by a governing body that requires training. A voluntary approach assumes that there is no ordinance or regulatory mechanism in place.

<u>Potential Required Training Approach</u>: for watersheds with chloride impairments (or suggested reductions)

1. Implement a state-wide Smart Salting certification program.
2. Watersheds to require the MPCA Smart Salting training for anyone performing professional level winter maintenance in the watershed.
3. Cities within those watersheds create an ordinance requiring Smart Salting training certification to work in their cities.
4. Cities ask commercial property owners in their city to become trained. They award contracts only to certified applicators.
5. All government organizations (state/counties/parks/schools/cities) to hire only Smart Salting certified contractors to maintain government properties.
6. The MPCA, watersheds, and cities all help advertise the training.

<u>Voluntary Training Approach:</u>

1. The MPCA to continue offering Smart Salting training.
    a. Increase the number of classes
    b. Expand locations of classes
    c. Incorporate alternative methods for certification (e.g., Webinars)
    d. Increase advertising about the availability and importance of being "certified" winter maintenance professionals
2. Watershed organizations and cities host and advertise classes in their area.
3. Ask cities/watersheds to host and advertise Smart Salting training classes in their area.

4. Improve communications with contractors by advertising training and following the research recommendations:
   a. Email
   b. Mail
   c. Websites (the MPCA, watersheds, cities)
   d. In-person at trainings, seminars, and conferences (both winter and summer maintenance)
   e. Via other professional organizations (MNLA was commonly referenced)
   f. Posting in newsletters of other professional organizations
   g. Telephone

The winter maintenance industry has changed since the MPCA Smart Salting training program started in 2006. The training itself has also changed. By making the training valid for a fixed number of years, this will encourage on-going awareness of the winter maintenance BMPs, keep the industry current with regulations, and strengthen communication between maintenance organizations and strengthen communication between the environment and maintenance. For optimal success these considerations should be made:

- Have training valid for a fixed number of years.
- Notify training participants when certification expires.
- Inform training participants that names/companies will be removed from the MPCA Smart. Salting certification list when expiration occurs.
- Provide a schedule for upcoming trainings.

In addition to education, legislation that limits liability for private applicators that are certified under the Smart Salting training program would enable them to use less deicer without fear of litigation. An important aspect to a statute like this is requiring training in order to maintain an appropriate level of service. The State of New Hampshire passed a new law, RSA 489-C effective November 1, 2013, which limits the liability of business owners who contract for snowplowing and deicing as long as the applicator is certified through the New Hampshire Green SnowPro Program. The entire law can be found at: www.gencourt.state.nh.us/rsa/html/NHTOC/NHTOC-L-489-C.htm.

Feedback from stakeholders in Minnesota has indicated that many of the private applicators over-apply salt because of concerns about litigation. A law similar to New Hampshire's RSA 489-C could change salt application behaviors of private applicators by limiting their liability.

In some cases, compensation for winter maintenance is based on the amount of salt used, which can incentivize over-application of salt. In this case, a boilerplate should be developed and performance based contract for private entities to use when contracting for winter maintenance services. Performance based contracting methods and the boilerplate contract could be part of the education and training programs for private applicators.

Homeowners and Small Business Owners

A clear message on why reducing chloride is important for the environment, important for saving money, and how to effectively apply chloride will be the key to changing salt application behaviors by homeowners and small businesses. This messaging should be carried out by various state and local governmental entities in order to reach a broad range of people in the TCMA.

Nine Mile Creek approached this by providing a measuring cup type salt scooper to homeowners and small businesses in order to raise awareness of the amount of salt they are using. Homeowners currently not using salt should be encouraged to continue without salt. See detailed survey results in Appendix C and Section 3.4 for additional information on public education.

3.4 Citizen Attitudes and Practices

The average Minnesotan values having clean, healthy water resources. The same Minnesotans value safe driving conditions on roads and bridges. These two public goods are in direct conflict and create a serious dilemma for local government and businesses. Driving in difficult winter road conditions is a problem that directly impacts daily life for nearly all members of the public. It is immediately recognized and felt. Conversely, the problem of chloride pollution causing permanent damage to local waters is something that must be imagined and may not be felt until much later. Extreme public pressure is often brought to bear on local officials to address the immediate problem of icy roads, in spite of the long-term consequences of permanent damage to water resources that will have severe and wide impacts.

When confronted with this dilemma, most citizens will acknowledge this challenge needs to be resolved. However, the expectation is this is government's problem to solve. This dynamic – the government must solve this problem, while the public simply observes – is at the root of this challenge. Changing this expectation is needed to change the over use of chloride to manage winter roads, parking lots, and sidewalks.

The question is how?

Traditional information and education campaigns are important tools in raising awareness about chloride impairments in lakes, rivers, and groundwater. However, if the goal is to create long-term, sustainable change in the practices surrounding the use of salt and other chloride products (e.g., sidewalk deicers, water softening agents) additional strategies will be needed. Research shows that education may be effective in altering some citizens' behaviors for the short-term, but these changes are not likely to be widespread or sustained unless they are coupled with organizing strategies that provide supportive structures for citizen collaboration and public action (Dietz and Stern 2002).

In order to ensure that a new mindset and social norm are achieved around winter road expectations and the use of chloride, a long-term approach to organizing stakeholders will be needed. Changing attitudes will require significant, long-term, and small-scale organizing of homeowners to work in partnership with WDs, WMOs, lake associations, and neighborhood organizations. These community-based organizations are best poised to deliver outreach and programs.

Outreach and education programs remove the barrier of lack of information and encourage people to make changes in their day-to-day practices. However, research has found that there are often other barriers that keep people from changing their existing practices. One effective strategy for overcoming these barriers is to couple information with relationship-building and collaboration support systems in small-scale settings. Community associations, civic groups, and lake associations that already organize neighbors around the issue of water quality can expand their learning and strategies to include addressing chloride pollution. The trusting relationships that develop in these contexts and citizens openness to learn and act, increases the possibility they will consider new information and assistance.

Trusted local leaders delivering information will likely have greater impact than blanket media campaigns, fact sheets, or other educational materials. This approach can be especially effective when coupled with an effort to develop a sense of citizenship and common good while addressing water quality as part of an overall outreach and organizing strategy. Inspiring citizenship and caring for the common good and community, is showing promise in sparking interest in participation.

Development and implementation of public education and involvement is critical and necessary to the success of chloride management in the TCMA. Based on feedback from stakeholders, a multi-agency approach to public education and involvement is needed to reach a large and diverse group of salt applicators with a range of motivations related to salt application. Public education and involvement can be accomplished through multiple venues such as mainstream news media, social media, permanent and variable message signs, elementary and high school education, and other resources aimed at reaching the general public. The MPCA road salt and water quality website maintains a list of available educational resources: https://www.pca.state.mn.us/water/educational-resources. Educational resources for educators and citizens are also available in Appendix D.

Changes in personal practices and attitudes can be the most challenging and time consuming and require short- and long-term strategies. Current winter driving expectations is a result of decades of increasing road salt use and improvements to the level of service. The improved level of service has allowed the traveling public to drive faster with greater confidence during snow and ice events. A long-term strategy is needed to reverse this expectation. Education of young drivers could be an important starting point in changing driver behaviors to expect a lower level of service during snow and ice events.

As part of the TCMA Chloride Project, an education committee was created to identify the principal audiences for winter maintenance education and discuss potential opportunities and strategies to increase awareness about salt use and associated water quality issues. The EOC included state and local education specialists from the MPCA, counties, the UMN, The Freshwater Society, WDs, WMOs, conservation districts, and MnDOT which met four times over the duration of the TCMA Chloride Project.

The following is a summary of recommendations provided by the EOC and other stakeholders. These recommendations should be considered by professionals in relevant organizations and roles. In addition to the great information and recommendations gathered from local education specialists, there is a need for government and citizens to collaborate to make effective policy choices for reducing salt use.

Strategies for Education and Outreach

- Share winter maintenance success stories that reflect people who have made positive and measurable changes. Create a recognition award program to acknowledge organizations that have made efforts to improve winter maintenance practices.
- Share Smart Salting training for Small Sites, and Improved Winter Maintenance: Good Choices for Clean Water videos.
- Provide information on hiring certified winter maintenance contractors to condominium associations, townhouse developments, etc. The NMCWD (ninemilecreek.org) created "Hiring a Snow Removal Service" brochure.
- Develop seasonal salt messages for radio public service announcements.

- Create targeted messaging such as information wheels or videos for gas stations, home improvement stores, hardware stores, and other stores that sell deicers; create winter maintenance tips for products, like shovels.
- Create a system for the public to report excessive salt use. The system could be used to notify users of excessive use reports.
- Incorporate education on chloride into pre-existing community events (e.g., National Night Out) as much as possible, rather than expecting the public to attend a separate event about road salt.

Winter Maintenance Training

- Provide Smart Salting training for school maintenance and grounds directors. The NMCWD developed Winter Maintenance on School Grounds Workshop to train building and grounds directors on proper winter maintenance techniques for entrances, sidewalks, and parking lots.
- Provide training for private applicators and offer it at events such as the Northern Green Expo.
- Develop and implement a train-the-trainer and/or mentorship program. Provide opportunities for winter maintenance professionals to share changed practices and lessons learned at expos, trainings, etc.
- Create and implement a program similar to the Canadian program "Smart about Salt": www.smartaboutsalt.com. A similar program would allow schools, apartment complexes, condominiums, government, commercial properties, etc. to become certified. Benefits are cited as quality for insurance premium discounts and stormwater credits offered to certified sites within certain municipalities.

Strategies for Recruiting for Training

- Include a letter or a link to a short online video with the training brochure explaining the importance of the training and include a list of example BMPs.
- Prioritize recruiting individuals who perform winter maintenance activities on large parking lots, such as malls, hospitals, universities, etc. that drain to waterbodies.
- Promote trainings at events such as the Northern Green Expo, and at non-environmental events to target different audiences. Adjust emphasis and message (e.g., cost savings, habitat, etc.) depending on event and audience.
- Recruit individuals who have received funding for past projects (e.g., rain gardens) and/or individuals that have applied for permits for construction activities.

Legislative Strategies

- Create an ordinance for the city's legislative and administrative code that addresses certification of winter maintenance applicators, similar to the Lawn Fertilizer and Pesticide Application code.
- Introduce legislation that provides protection for slip and fall lawsuits for private applicators that are certified through the Smart Salting training program.
- Require all commercial applicators to receive the MPCA's Smart Salting training. Provide training remotely through webinars for applicators outside the TCMA.
- Apply a salt tax to annual vehicle registrations that could be used to implement salt reduction strategies.

Demonstration Projects

Demonstration projects can be used to test the organizing approaches for building partnerships between citizens and government or property owners to work together to solve the challenge of chloride use and water resource impairments. The demonstrations will likely be most successful where community capacity around environmental issues exists. Local leaders should be supported to experiment with building partnerships across sectors to co-develop strategies for chloride reductions by municipalities, businesses, and households. The demonstrations can employ pre- and post-evaluation to determine whether the approach achieves meaningful outcomes over time. The outcomes will determine whether the efforts should expand past the pilot stage. If defined outcomes are significant, the plan should be developed to scale to metro-wide and beyond application.

3.5 Success Stories

Reductions in the use of deicing salt are possible through smart salt use and adoption of winter maintenance BMPs. Many winter maintenance organizations have already begun implementing salt reduction practices across the state. Examples of local efforts to implement smart salting strategies are included in this section to provide ideas that may work for other winter maintenance programs and to highlight the great work already being done.

Maintenance Decision Support System and Automatic Vehicle Location -- MNDOT

Curt Pape presented this information at the 2012 Road Salt Symposium.

The Automated Vehicle Location (AVL) uses GPS equipment to track where and how much salt is applied. The Maintenance Decision Support System (MDSS) is used in conjunction with the AVL will use multiple factors to decide when, where, and how the salt should be applied. The average savings achieved through the use of the MDSS and AVL is 53%.

Example

Over 11 ice and snow events, a total of 71,745 tons of salt was applied at a total cost of $4,356.351. Using the projected average savings from implementing MDSS and AVL of 53%, the total savings would be approximately $2,308,866, which would also prevent over 38,000 tons of salt from entering lakes, streams, wetlands, and groundwater.

Dakota County

This information was taken from the *Dakota County Smart Salting training KAP Study Report* (Eckman et al. 2011).

The snowplow drivers in Dakota County, Minnesota, attended the MPCA sponsored Smart Salting training course presented by Fortin Consulting and the Minnesota LTAP in 2008. To test the effectiveness and impact of the course, a knowledge, attitudes and practices (KAP) was administered to these drivers before the course to establish how the snowplow drivers approached the job. After two winter seasons, approximately 14 months after the initial training, the same KAP test was administered again to measure any change. Steps were taken to maintain confidentiality of the respondent and to insure the same people were compared. Seasonal and temporary employees were not used in the comparison.

Results

In September 2008, the results of the survey showed that Dakota County plow drivers had good general knowledge and good practices, but they were in need of some improvement. While the drivers were aware of the county's winter maintenance policy, the independent judgement factor was a little more difficult. For example, only 60% agreed they "minimize the use of deicers during a snow storm." Although this type of information is useful, the goal was to evaluate how effective the training was to actually make a difference in all three facets of knowledge, attitudes, and practice.

The follow up survey in November 2010 showed mixed results. Most importantly, some of the significant improvements were under knowledge and practices.

Question	2008 Response (Yes)	2010 Response (Yes)	+/- percentage change
I minimize the use of deicers during a snow storm	60%	96%	+36%
During calibration I have set the computer speedometer to match my trucks speedometer.	40%	73%	+33%
I use an application rate chart to determine the amount of salt/sand to apply	35%	76%	+41%
I avoid using road salt when pavement temperature is below 15 degrees F	27%	88%	+60%
I document my winter maintenance actions	73%	69%	-4%
The policy encourages plowing before two inches of snow accumulation	92%	84%	-8%
Equipment is calibrated for each type of deicing material used	92%	88%	-4%
I have ground-speed controlled sanders-the auger is installed and working	84%	77%	-7%
I plow before applying deicers to minimize the dilution of the chemical	96%	92%	-4%
I avoid salt/sand mixes	72%	68%	-4%

The areas that showed declines were areas that either additional training or clearer policies could produce better outcomes. The majority of the questions indicate there has been a positive shift in knowledge, attitudes, and practices since attending training. In addition to the KAP survey, the amount of actual salt has been reduced to further underscore the success of the training. The county used an average of 405 tons of salt per snow event in 2007, the winter season before attending the training. Post training, the county reduced their usage by about 50 tons per event to 355 tons of salt per snow event. This reduction correlates to about 40 million gallons of freshwater protected from chloride contamination per snow event.

Scott County

This information was supplied by Scott County.

The past practice of Scott County was to use a mixture of 1:1 sand and salt that was applied with uncalibrated spreaders. No policy or guidelines were in place for mixture ratios or spread rates.

The county started a training program for the supervisors and operators to familiarize them with the effectiveness of salt depending on pavement and air temperatures. After attending the training, treated salt was added to the county's material options. Each plow truck was supplied with information about the route, how many lane miles, and tables for each material and its spread rate based on the temperature.

It took several events to convince the members of the team of the effectiveness. There was not an instant buy-in from the drivers, but after several events, most of the drivers were impressed with the results using the treated salt. During the course of 8 to 10 events, the usage of the sand and salt declined. The winter maintenance teams stopped using the sand/salt mixture, although small cities and townships continued to purchase the sand/salt mixture from Scott County.

Results

By implementing the new practices and policies, the drivers found a single load, or less, was enough to treat the route. Anecdotally, the drivers reported the usual practice would be to apply three or four truckloads of the sand/salt mixture in a single event. The County estimates that 1,500 to 2,000 pounds of the sand/salt mixture was applied per mile lane each event. After the change, the usage dropped to about 424 pounds per lane mile per event. The savings of over 1,000 pounds per lane mile paid for the increased costs of the treated salt. This correlates to a 25-30% reduction of chloride entering lakes, streams, wetlands, and groundwater. Scott County maintenance believes this is the most economical and environmentally sound approach available.

St. Louis County Public Works Department

St. Louis County began working on reducing salt contamination by erecting dome buildings and coverall type buildings where they store their salt and sand. This has been accomplished by the county alone and through partnerships with Net Lake Indian Reservations, Hibbing, Ely, and the state. They now have all of their salt and sand supplies covered. Hibbing, Pike Lake, and Ely have built-in storm water drainage ponds to stop runoff into lakes and streams.

In 2008, trucks with calibration technologies were purchased to make the application of materials more precise. They will continue to purchase trucks with this technology. In addition to this technology, the newest trucks in the fleet have pre-wetting equipment and GPS/AVL technology. Forty-six trucks purchased prior to 2008 have been retrofitted with the calibrated controls and pre-wetting equipment. Plans to add the GPS/AVL have been made, depending on available funds. St. Louis County has expanded their salt brine making capabilities to five additional facilities by partnering with MnDOT to share capabilities in Hibbing and Pike Lake.

Expectations

St. Louis County currently uses approximately 19,265 tons of salt each year and 67,440 cubic yards of sand, at a cost of around $1,207,338 and $202,320 respectively. Through the addition of new equipment and implementation of better practices, St. Louis County projects they will reduce their salt use by as much as 45%. The projected monetary savings is $634,346 per year. The environmental savings is the prevention of 8,669 tons of salt from entering the environment, and saving 7 billion gallons of freshwater. By reducing the application of the less effective sand/salt mixture, St. Louis County will be responsible for reducing 30,348 cubic yards of sand from entering the rivers and streams.

City of Cottage Grove

Cottage Grove saw a significant decline in salt usage after attending training. Their usages for the past few years, per event have declined steadily.

- 2009/2010 = 1,987 tons of salt used (71 tons/event)
- 2010/2011 = 2,083 tons of salt used (75.9 tons/event)
- 2011/2012 = 1,320 tons of salt used (57 tons/event)
- 2012/2013 = 3,019 tons of salt used (67.1 tons/event)

Results

The City realized a savings of 694 tons of salt for the 2011-2012 winter season. This translates into a savings of $40,000 in one season.

City of Eagan

This information was gathered from Tom Struve's presentation notes, 2011.

The city of Eagan discontinued mixing sand and salt in the 2005-2006 winter season. Without dropping the level of service to residents, the city was able to eliminate a five year average purchase of safety grit. The elimination of the 3,249 tons of grit led to a 65% reduction in spring street sweeping hours. This elimination saved Eagan $70,000 per year.

In 2008, Eagan began using EPOKE winter chemical application technology. This enabled the city to use a precise chemical application of up to 90 gallons of brine per one ton of salt and realize immediate improvements. Also, the addition of AVL allows snowplow drivers to inform the police of the location of cars remaining on the streets during snow emergencies. The police receive a map by 8:00AM showing the exact location of the cars, which makes the mechanical removal of snow much more efficient and effective for the snowplow drivers.

The city of Eagan implemented additional practices including: pre-wetting material at the spinner; using salt brine to 10-15 degrees and substituting magnesium chloride when the temperature falls below 10 degrees; limited uses of Clear Lane for severely cold temperatures; and, managers directing the lane mile calibrated application rates. Eagan still has a stockpile of sand, which they rarely apply. Most importantly, Eagan has the buy-in of the operations staff, which has been very important for their success.

Despite the new practices, the level of service that Eagan provides for residents remains high. The residents have high expectations for winter road maintenance and Eagan has been able to make changes to reduce salt use, while also meeting the expectations of the community.

City of Minnetonka

The winter maintenance operators and managers for the city of Minnetonka are committed to the need to reduce salt to protect the environment. This city delivers high service and the residents expect excellent service. Minnetonka Public Works maintains 254 centerline miles of streets which includes 562 cul-de-sacs. During full scale snow events of 2 inches or greater, 20 plow trucks, 2 loaders, and 7 pickups are mobilized to perform snow removal.

Prior to the 2010-2011 winter season, Minnetonka installed a Cargill Accubrine automated brine production system. The system can blend up to two other products with the brine produced to aid in temperature suppression of the brine when needed. There are five 6,500 - gallon tanks to store the finished products or purchased additives. The City currently uses a corrosion inhibited 32% calcium chloride to pre-wet salt when temperatures are below 15 degrees F. Outside agencies, including Hennepin County and neighboring cities, purchase brine for use. The brine is used to pre-wet the salt before it is applied to the road and for anti-icing prior to a snow event.

Prior to snow events, Minnetonka uses a 2,000 gallon tanker truck and a truck with a 900 gallon tank that are used to pretreat the highest volume streets with brine at a rate of 30-35 gallons per lane mile. The fleet is currently being retrofitted with new technology: pre-wetting equipment, on spot chains, Force America data, and AVL.

All 20 plow trucks and 1 spare truck in the snow fleet are equipped with ground speed controllers to accurately apply and track salt used. The trucks are also equipped with brine tanks so that the salt that is discharged from the trucks is treated with brine at a rate of 10 gallons per ton of salt.

The City subscribes to a web-based weather service that provides a 48-hour weather forecast which is updated every hour. Information provided includes air and pavement temperature, wind speed, dew point, snow and ice accumulation totals and rates/hour, when the precipitation will start and stop, and also provides recommendations for salt and liquid application rates. This information supports decisions for properly staffed crews for the event, application of anti-icing liquid, and the application of the correct liquid for pre-wetting the salt. City staff can compare information from around the state with regards to road temperatures, wind speed, and radar to see how an approaching storm will affect Minnetonka operations.

The AVL is used on all mobile snow equipment to track vehicle location and salt application. A real-time, citywide map shows progress of snow removal operations and allows movement of plows around the City to address any missed areas or areas that are running behind schedule. The system will also send an email notification if an error occurs with a salt controller on a truck. Depending on the status of the plowing and storm, staff determines whether to bring the truck in for repair. Even if in an error state, the controller is able to track salt application provided the spreader is functioning. Four trucks are equipped with air and road temperature sensors which are monitored through the AVL system.

Results

The city of Minnetonka has achieved its goal set by the Nine Mile Creek Watershed during the 2010-2011 season. They reduced application of salt to 4.2 tons per mile from 7.022 tons per mile. This was a reduction of 180% during a normal season.

Minnetonka is focused on improving the use of liquids. For the 2012-2013 winter season, the trucks averaged 3.5 gallons/ton of brine for pre-wet and the city realized that the nozzles were not calibrated for the gravity application system. The nozzles are now calibrated along with the salt controllers before winter and the average for 2014-2015 increased to 6.2 gallons/ton. This is still below the 10 gallons/ton rate the trucks are calibrated for but it is improving.

Norwood Young America

This information was provided by Freshwater Society, 2014 Environmental Leadership Award on February 6, 2014.

In 2009, Norwood Young America city employee's attended an ice and snow workshop where they learned the importance of calibrating equipment. In 2010 staff attended another workshop on snow and ice control practices. After training, the city purchased tanks for pre-wetting salt. Through the implementation of recommended practices and attending the Smart Salting training, the city was able to reduce their salt usage by almost half in 2010. On average, the city had been using about 600 tons of salt per year.
After training, the city averaged 350 tons per year, saving $17,500. This success has encouraged the city to continue to improve their operations and practices.

City of Plymouth

The city of Plymouth began implementing salt reduction practices in 1996 by implementing the use of brine. At first, brine was used on a limited basis, but expanded through 2004. The city began implementing anti-icing and expanded its application by purchasing a 1,300 gallon tank in 2007. The AVL technology was added to the vehicles in 2009 to track the routes and salt application. The city continues to improve, and in 2014 purchased its most recent 1,300 gallon brine tank for anti-icing.

Results

As with many municipalities, it is difficult to track the reductions with absolute certainty. The City has experienced growth in excess of 30% since the mid-nineties. Granular salt use has been decreased by 40% despite this growth. Despite the 40% reduction in granular salt, it should be noted that there is still salt applied in the form of brine for anti-icing. The City estimates that the overall reduction, since the mid-1990s, is approximately 25%

City of Prior Lake

The information provided below is based on information provided by the city of Prior Lake for the 2010 American Public Works Association Excellence in Snow and Ice Control awards ceremony. The city of Prior Lake maintains approximately 100 center lane miles of street with 10 maintenance personnel and one supervisor.

Starting in 2003, Prior Lake implemented a winter maintenance program which includes:

- Staff education and development
- Anti-icing before events to reduce removal time
- Pre-wetting to deliver salt more efficiently at lower concentrations
- Upgraded controllers and sanders that allow flexibility for precise applications Pre-mixed chemical storage that allows on-site storage of three ready- to-use mixes and bulk storage of critical ingredients
- Liquid mixing and transfer equipment

Education

The staff buy-in and support was critical to the success of this program. Education was important for this; they started with supervisor training and researched other programs. Various training programs were attended or used including: LTAP, CTAP, Manual of Practice for an Effective Anti-icing Program, APWA Anti-icing/RWIS CD, AASHTO Clear Roads CD Series, and attending an APWA Snow Conference.

Since 2003 to 2011, the City invested about $250,000 in the program, including a $50,000 building addition. They recognized that the right equipment is the key to providing the flexibility to apply the right chemicals, in the appropriate amounts by the most efficient method.

Chemicals and Storage

Depending on conditions, Prior Lake keeps pre-mixed chemicals ready for use and bulk materials on hand. This allows the City to pre-mix and modify operations depending on weather conditions. Using the best available weather data for preparation and monitoring actual ground temperatures during operations is critical.

- Bulk materials include brine, beet juice, magnesium or calcium chloride, and molasses
- Pre-mixes include liquids for anti-icing and pre-wetting above and below 15 degrees

Application Equipment

Equipment upgrades can be phased in over time. Prior Lake took seven years to fully upgrade the fleet. The new 5100/6100 controllers and new sanders can apply pre-wet material at rates down to 85 pounds per lane mile. Liquid application units can also apply at below 100 pounds per lane mile rates. Upgraded equipment includes:

- Controllers
- Salt Sanders
- Evaluate plow configuration to further optimize
- On-board liquids

Liquid anti-icing operations increased removal efficiency. The City found that applications are effective for 7-14 days after application, depending on the type of mixture and conditions. Equipment was also used for a liquid-only route with deicing application rates of less than 100 pounds per lane mile.

Efficient truck design and equipment including Elliptical Box, 200 gallons of Liquid Storage, Falls Salt Special Material Applicator, Force America 6100 Controller, and bed tarp allows for more efficiency with application rates of pre-wet salt as low as 85 pounds per lane mile.

Results

Prior Lake had a reduction of average application rates from 500 pounds per lane mile of salt in 2005 lane to 200-250 pounds per lane mile using pre-wet salt in 2010.

- Added an all liquid route with application rates equivalent to 100 pounds per lane mile or less.
- Observed chloride level reduction in controlled watershed of 20 – 40 mg/l with all liquid program
- Reduced staff time for snow removal and maintenance
- Overall salt use reduced 42% since 2005 even with an additional 7% increase in mileage maintained.
- Minimum estimated savings per snow removal event $2,000 (salt, labor, equipment).
- Maintained safety and increased level of service.

Future Plans

- No chemical application routes, blade cutting edge technology advances
- Pre-wet application rates of 100 pounds per lane mile
- Expand liquid only routes
- High Priority Chloride Reduction Zones designations

Rice Creek Watershed Cities

This information was taken from the Six Cities Chloride Reduction Project. (http://www.ricecreek.org/vertical/sites/%7BF68A5205-A996-4208-96B5-2C7263C03AA9%7D/uploads/Road_Salt_Reduction_5-17-13.pdf)

The city of Centerville, after attending a winter maintenance workshop, collaborated with Lino Lakes, Hugo, Circle Pines, Lexington, and Columbus to purchase shared anti-icing equipment and to train the staff to use BMPs. The coalition was able to successfully apply for a Rice Creek County Watershed grant of $65,000 to offset the costs. The new anti-icing equipment was used to apply liquid salt brine to 245 miles of paved roadways before the winter storms to reduce the need to apply salt during and after the storm. The training provided to the operators, reinforced the need to apply enough salt for public safety, but to avoid applying unnecessary amounts to pollute. The coalition plans on using the savings on materials to continue to fund the operational costs and program maintenance.

Results

In the 2012-2013 winter season, the six participating cities reduced their salt use by 528 tons, or a 32% reduction based on the previous monitoring data. The six cities saved a combined total of $26,400 in a single winter, based on a conservative cost estimate of $50/ton of salt.

City of Richfield

The information provided below is based on information presented at the awards ceremony at the 2013 Road Salt Symposium (Freshwater Society 2013).

In 2009, the NMCWD began a TMDL Analysis and Report process for the chloride impairment identified for the Nine Mile Creek. By 2010, they had prepared a draft TMDL report that called for a 62% reduction of salt application by the NMCWD MS4 cities, including Richfield. Along with other agencies, Richfield's reaction to the reduction was the requirement was not only unreasonable, but impossible. They believed that public safety would be compromised and that the goal was too far to take seriously. However, the City eventually came to accept that they had to make efforts toward reducing salt usage.

The City Engineer learned that the NMCWD was working with Fortin Consulting and the LTAP to offer the free MPCA Winter Maintenance Certification Training. After attending the training the City Engineer found the training to be excellent. The entire snowplow operations staff was immediately enrolled in the next available training and all of the snowplow operators that plow parking lots have attended the MPCA Winter Parking Lot and Sidewalk Maintenance Training.

Despite the pride and effort that Richfield's winter maintenance staff has in their work, the training showed them many ways to improve their operations. The education, along with the dedication of the staff, created a sense of urgency to change their practices and make the needed improvements. The changes needed were relatively small and simple to implement quickly

Richfield's salt application process changes were:

- Calibrating all sanders every year
- Applying salt to the crown of the road only
- Determining application rates by road temperatures/weather conditions
- Using alternative materials for low road temperatures
- Adjusting policies for minor arterial roads

These small changes reduced the amount of salt applied to roads by over 50%. It is projected this will improve over time, bringing the city closer to the TMDL of 62%. The Richfield operators have traditionally taken great pride in their work; the additional training provided them with the understanding of the importance of reducing salt for the environment and not just cost savings shown below.

- 2010-2011--$30,000* in salt because of the trained crew, calibrated equipment, and correct application rates
- 2011-2012--$70,000* saved in salt; new addition was adding the pre-wet product, "Ice Slicer"
- 2012-2013—no savings (many more ice events than the previous years)
- 2013-2014—no savings (many more ice events than the previous years)
- 2015-2016—the operations superintendent expects to see savings compared to previous practices

*The cost savings were based on the 2009-2010 price of salt.

City of Shoreview

This information was supplied from the city of Shoreview in 2015.

In 2006, the city of Shoreview stopped using a mixture of sand and salt and began using straight salt. This was the beginning of a continuous effort to reduce chloride.

Shoreview's applicators and their supervisors each attend the annual "Snow and Ice Control Best Practices" training and are certified through the MPCA. The crew attends an annual meeting to discuss and review procedures and conservation methods. The operators are trained and allowed to make adjustments based on conditions and the pavement temperatures. The MPCA materials, guidelines, and BMPs have been successfully used throughout this effort.

A snow event begins with the city's crew monitoring the surface temperature and road conditions. This information is critical to following their BMPs and application guidelines. This practice allows for preparation for the storm and the application of anti-icing to reduce the ice that requires treatment during and after the storm.

The goal of the anti-icing procedure is to apply calcium chloride to at least 28 lane miles of roadway before the storm to reduce the buildup of ice and allow for cleaner plowing. All of the city's trucks are equipped with state-of-the-art spreading controls, pre-wetting tanks, and pavement sensors to ensure that each truck is calibrated and efficient. The use of the pre-wetting calcium chloride reduces the need for rock salt and minimizes the loss of salt from bounce or vehicle distribution. Pre-wetting allows the salt to be effective at lower temperatures.

Results

The three-year average salt use for 2006-2008 was 786 tons and in the period of 2009-2011 the average amount of salt used dropped to 437 tons. The reduction continued during 2012-2014 to 444 tons. Although the tons of salt appear to increase, there were more snow and ice events during the 2012-2014 period. The total reduction of salt since 2006 is approximately 44%. The cost savings for 2014 is estimated at approximately $24,468.

City of St. Paul

This information was provided by Freshwater Society, 2014 Environmental Leadership Award on February 6, 2014.

St. Paul Street Maintenance has changed and updated its snow maintenance practices and equipment to reduce salt, increase driver safety and improve the service level. The city created its first Snow Plan in 2011 through the collaboration of the maintenance staff.

The following equipment has been upgraded:

- In 2011, the decision was made to make salt reduction a priority when selecting equipment
- The salting equipment was upgraded with electronic controls—95% of the city's trucks were equipped with electronic spreader controls (90% increase)
- Trucks were upgraded with pre-wetting systems over two years (50% increase)
- All trucks with electronic controls were equipped with AVL to monitor and correct salt usage
- All trucks are calibrated before the season

Between 2012-2013, the following training was completed:

- By 2012, 95%, and by 2013, 99% of the staff and leadership had successfully completed the MPCA Winter Maintenance Certification training
- In 2012, six supervisors successfully completed the APWA Winter Maintenance Supervisor Certification training. Three more were certified in 2013.
- The vendor performed small group training for 92 workers and supervisors
- In 2013, 170 employees attended a two-day snow operations training program

Results

The city has had an average salt reduction of 30% per event over the past five years. The purchase of salt was reduced over the five years from 24,000 tons to 16,000 tons.

City of Waconia

The information provided below is based on information presented at the awards ceremony at the 2013 Road Salt Symposium (Freshwater Society 2013). The city of Waconia Public Services Department completes winter maintenance activities on 56 street center lane miles, portions of 14 miles of concrete sidewalk and 13 miles of bituminous trails.
Prior to the winter season, City staff attends an annual winter preparations meeting. They review the Winter Maintenance Policy, route assignments; discuss material use, and the service level expectations. All spreaders are calibrated for liquid and solid material applications. Calibration charts are prepared and placed in each vehicle for user review.

In 2010, the staff updated their 1999 "Snow and Ice Policy" to a "Winter Maintenance Policy." The document title expresses a different, proactive approach to events. In the past, the city had a reactive approach to storms. The City changed from a 1:1 sand/salt mixture to straight salt and liquid anti-icing practices. Additional items reflected in the policy included:

- Service level expectations for streets, sidewalks, trails, parking lots, and downtown snow removal
- Additional ordinances reflecting policy guidelines
- Right-of-Way uses, including mailbox placements
- Description of operation commencement, use of air and pavement temperatures, and anti-icing practices
- Tips on resident snow storage, or maintaining a "snow pocket," for driveway cleaning

By implementing calibration and equipment changes, the staff has been able to reduce materials rates of salt per-pound by 70%. Using pre-wetting practices and saving material by application rates based on weather and pavement conditions have saved $1.80 per-lane-mile and a yearly savings of $8,600.

As part of the winter maintenance practices for sidewalks and trails, the staff took the initiative to switch from hand-applied and truck-applied chloride products to liquid applications only. The staff conducts anti-icing and deicing activities as needed on sidewalks and trails leading to substantial savings. The staff obtained a "Local Operational Research Assistance Program" grant for $5,000. The research found a savings of 70% for activities related to recreational critical areas through the use of liquids for trails and sidewalks

University of Minnesota, Twin Cities

The information provided below is based on information presented at the awards ceremony at the 2007 Road Salt Symposium (Freshwater Society 2007) and updated by Doug Lauer, a Landcare Supervisor with the University. The UMN Twin Cities Campus made changes to their winter maintenance program starting the winter of 2006. They began making their own salt brine and anti-icing and adopted several other salt reduction BMPs. The resulting reductions for each winter maintenance material are listed below in Table 10.

Table 10: UMN – Twin Cities Campus – Winter Maintenance Improvements

Material	Tons/Year Used (1997-2005)	Tons/Year Used (2006-2008)	Tons/Year Used (2008-2014)	Reduction	Notes
Rock Salt	775	262		40%	
Ice Melt ($MgCl_2$)	131	64		51%	Changed from $MgCl_2$ to $CaCl_2$ in 2008
Ice Melt ($CaCl_2$)	131 ($MgCl_2$)		59	55%	
Sand	1965	20		99%	

In addition to salt reductions, they invested about $10,000 in new and saved $55,000 the first year the BMPs were implemented. The UMN used an average of 1,965 tons of sand from 1997-2005; in 2006 to 2008, it was reduced to 18 tons. This is a 99% reduction. Between 2009 and 2014, the UMN used an average of 21 tons of sand in this five year period, showing a continuing decline.

The UMN continues to use brine to treat before the storm, as indicated in Table 10. The staff is aggressive with mechanical removal using blades and brooms. A change was made from magnesium chloride to calcium chloride because it mixes better with sodium and doesn't clog their equipment when changing products. The product contains less corrosive beet juice.

Joe's Lawn & Snow

Joe's Lawn and Snow is a small lawn and winter maintenance company located in the TCMA. The following information was provided by Joe Mather, owner.

Joe's Lawn and Snow plows and treats both sidewalks and parking lots. Prior to attending the MPCA Winter Maintenance Certification class, the staff relied on manufacturer recommended application rates and best judgment for application rates. Joe Mather attended the certification class in the winter of 2013-2014 and sent four employees. Joe and his staff were able to implement the practices learned in the first year.

Practices implemented included:

- Purchased new spreader
- Calibrated equipment
- Made a bowl to catch any excess salt at spinner and reuse
- Adjusted the spreader to even the spread and prevent salt piles
- Reduced application rates
- Tested the results of application rates and continued to refine
- Purchased hand-held and truck mounted temperature sensors
- Used temperature to help determine rates and materials
- Identified drainage patterns and appropriate snow storage areas before the season
- Used sediment traps to contain solids in runoff and subsequently cleaned out manholes
- Experimented with anti-icing using liquids and plans to continue experimenting

Results

These changes, implemented for the last half of the 2013-2014 season, resulted in a reduction of salt by about 50% and did not reduce the level of service. Based on the 2014 cost of salt per ton, this saved Joe's Lawn and Snow $770 in material costs.

3.6 Cost Considerations and Funding Opportunities

The potential costs of reducing chloride loads and potential funding opportunities s are discussed.

Winter Salt (applied to Roads, Parking Lots, and Sidewalks)

The assessment of costs and economic benefits associated with chloride uses and its impacts is complex. One thing is certain, removing chloride from impaired lakes, wetlands, and streams through RO or distillation is impractical and cost-prohibitive; therefore, prevention or source control is the logical approach.

Application of salt in winter months is currently the most commonly used method of maintaining safe roads, parking lots, and sidewalks. The economic benefit of safe travel is hard to measure. Economic benefits also from reduced work-loss time. The various economic impacts and benefits are shown in Figure 34 and discussed briefly below. Though salt is one means of reducing accidents and work-loss time resulting from winter weather other means are available. Slower speed limits during snow events are one such option.

The economic impact of salt use goes beyond the environmental and includes costs associated with damage to transportation infrastructure, vehicle corrosion, and vegetation damage (Fortin 2014).

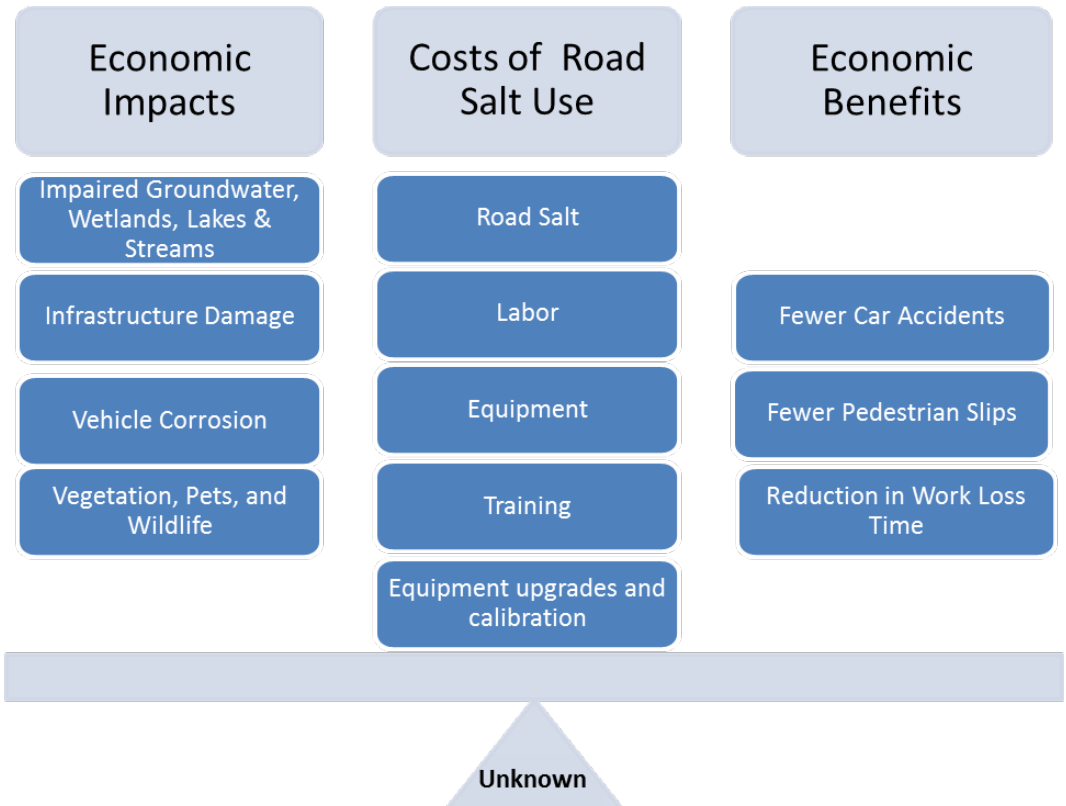


Figure 34. Cost Considerations Related to Salt Use

Efficient winter maintenance practices can reduce salt use without lowering the level of service. The improved practices are intended to maintain a consistent level of service in terms of safe roads, parking lots, and sidewalks with lower salt use. Implementation of improved winter maintenance activities may come with an initial investment cost to address training, new equipment, and public outreach. However, as a result of reduced salt usage, a cost savings is expected based on information provided by several local winter maintenance organizations. A net cost-savings has been shown by many organizations who have tracked cost before and after the implementation of winter maintenance BMPs. Table 9 provides examples of tracked cost savings associated with the implementation of various salt reducing BMPs by local winter maintenance organizations. Detailed descriptions of these cost savings examples can be found in section 3.5 of the CMP. The cost estimates provided in Table 11 reflect implementation of a variety of BMPs with multiple activities applied simultaneously. The information provided in Table 9 is not intended to be a reflection of cost for any one practice but rather an overall estimate. Each organization will implement practices that are most appropriate for their individual operations and there is not a one-size-fits-all approach when it comes to winter maintenance; therefore, the costs will vary greatly across organizations.

Table 11. Examples of Municipal and Private Cost Savings

Entity	Implementation Period	Main Actions Implemented	Salt Reduction	Cost Savings
University of Minnesota, Twin Cities	Start 2006	Began making salt brine and anti-icing and adopted several other salt reduction BMPs.	48%	New equipment cost $10,000 $55,000 cost savings first year
City of Waconia	Start 2010	Switch from 1:1 sand:salt to straight salt & liquid anti-icing; calibration; equipment changes; use of air and pavement temperatures.	70%	$8,600 yearly cost savings ($1.80 per lane-mile)
City of Prior Lake	2003-2010	Upgrade to precision controllers & sanders; anti-icing & pre-wetting; use of ground temperatures, best available weather data; on-site pre-mix liquid & bulk-ingredient storage, mixing & transfer equipment; staff education.	42%	$2,000 per event estimated cost savings; 20 – 40 mg/L decrease in receiving-water chloride (liquid app-only watershed)
City of Richfield	Start 2010	All-staff Training*; yearly sander calibration; use of low-pavement-temp de-icers; road crown-only application; minor-arterial-road policy adjustments.	> 50%	$30,000: 2010-2011 $70,000: 2011-2012
Rice Creek Watershed District Cities	2012-2013	Staff training; purchased shared anti-icing equipment	32%	$26,400 in one winter
City of Cottage Grove	2011-2012	Staff training	Not available	$40,000 in one winter
City of Shoreview	Start 2006	Stopped using a salt/sand mixture and moved on with straight salt; set up all its large plow trucks with state of the art salt spreading controls, pre-wetting tanks and controls and pavement sensors; use of calcium chloride in the pre-wetting tanks reduced the amount of rock salt as well; all applicators and supervisors annually attend *Training; crews attend an annual snowplow meeting to review procedures and talk about salt use and conservation methods; trucks set up for anti-icing main roads with calcium chloride.	44% since 2006	$24,468 in 2014

City of Eagan	Start 2005	Moved from a 50/50 salt/sand mix to straight salt; eliminated purchase of safety grit; EPOKE winter chemical application technology; use AVL; pre-wet at spinner.	Not availab le	$70,000 annual savings
Joe's Lawn & Snow, Minneapolis	Start 2013-2014	Owner & staff Training*; purchase of new spreader, temperature sensors; equipment calibration; use of temperature data; on-going experimentation.	50%	$770 estimated cost savings in 2014 Expected to use 20 tons, only use 9 tons

* Training - MPCA Smart Salting Training (All entities described above have attending the MPCA Smart Salting Training.)

Municipal Waste Water (primarily from Water Softening)

The cost for point source dischargers to remove chloride from their wastestream is very high and is cost prohibitive for most facilities. Below is an estimate of the cost to treat effluent from a WWTP (Henningsgaard 2012):

An estimate for the total cost is $4-$5.25 million:

- Fine filtration - $1.5 million per million gallons treated
- RO - $1-$2.25 million per million gallons treated
- Evaporation technology prior to landfill – $1.5 million per million gallons treated

Annualized cost for construction (assuming 20 year term at a market rate of 2.25%) is between $250,568 and $328,871 per year.

Annual Operation and Maintenance costs:

- Fine filtration – $0.01 to $0.15 per 1,000 gallons treatment
- RO - $2,200 per million gallons treatment
- Evaporator fuel - $10,000 to $12,000 per month

Based on specifics from each community, this cost could be considered to have "substantial and widespread economic and social impact" (40 CFR 131.10 (g) (6)) and could be justification for a variance that would not require this type of expensive treatment. There is no reasonable (environmental and economic) way to dispose of the highly concentrated sludge produced by RO treatment.

The high cost of end-of-pipe treatment for chloride and the high cost and difficulty of final disposal of the brine makes source reduction is a critical element to wastewater treatment of chloride-containing waste streams. In most municipal situations, a major source of chloride is water softeners. The NaCl or KCl is commonly used in the softening process at the WTP and in residential or commercial softeners.

Funding Opportunities

There are available sources of money to offset some of the costs of implementing practices that reduce chloride from entering surface and groundwater. Several programs, listed below, have web links to the programs and contacts for each entity. The contacts for each grant program can assist in the determination of eligibility for each program and funding requirements.

On November 4, 2008, Minnesota voters approved the Clean Water, Land & Legacy Amendment to the constitution to:

- *protect drinking water sources;*
- *protect, enhance, and restore wetlands, prairies, forests, and fish, game, and wildlife habitat;*
- *preserve arts and cultural heritage;*
- *support parks and trails;*
- *and protect, enhance, and restore lakes, rivers, streams, and groundwater.*

The Clean Water, Land, and Legacy Fund has several grant and loan programs that can be used for implementation of the BMPs, education and outreach, and WWTP modifications. The various programs and sponsoring agencies related to clean water funding and others are:

- Agriculture BMP Loan Program (Minnesota Department of Agriculture)
- Clean Water Fund Grants (BWSR)
- Clean Water Partnership (MPCA)
- Environment and Natural Resources Trust Fund (Legislative-Citizen Commission on Minnesota Resources)
- Environmental Assistance Grants Program (MPCA)
- Phosphorus Reduction Grant Program (Minnesota Public Facilities Authority)
- Section 319 Grant Program (MPCA)
- Small Community Wastewater Treatment Construction Loans & Grants (Minnesota Public Facilities Authority)
- Source Water Protection Grant Program (Minnesota Department of Health)
- Surface Water Assessment Grants (MPCA)
- TMDL Grant Program (Minnesota Public Facilities Authority)
- Wastewater and storm water financial assistance (MPCA)

The WDs and WMOs may have individual grant opportunities for implementation of the BMPs and education and outreach activities.

The Minnesota Local Road Research Board's Local Operational Research Assistance (OPERA) Program helps develop innovations in the construction and maintenance operations of local government transportation organizations and share those ideas statewide. The OPERA program encourages maintenance employees from all cities and counties to get involved in operational or hands-on research. The program funds projects up to $10,000 through an annual request-for-proposal process. (www.mnltap.umn.edu/about/programs/opera/).

Implementation of the BMPs for this project can sometimes require purchasing and/or upgrading equipment, which does not necessarily fit nicely into the conventional grant and loan programs. Some work will need to be done with the funding agencies in order to make grants and loans available for equipment purchase and/or upgrades.

The Water Environment Research Foundation (WERF) funds water quality research that is funded through a competitive process. Apply for grants for research related projects at: www.werf.org.

There are several grant and loan programs through the federal government for education and outreach and purchasing equipment and implementation of the BMPs. A list of federal grant programs can be found at: water.epa.gov/grants_funding/.

4. Monitoring, Tracking, Reporting, and Adaptive Management

Addressing the issue of the environmental impacts of chloride in the TCMA is a long-term endeavor. Water quality improvements may take time to observe, due to historical loadings, groundwater inputs, variable residence times, and other complicating factors. Continued monitoring of the TCMA lakes, wetlands, and streams for chloride is critical, along with documenting changes in winter maintenance activities, point source discharges, and water softener usage. Continued water quality monitoring along with improved source tracking will allow adaptive management and inform the future steps to restore and protect the TCMA waters. This CMP is intended to be revisited and revised within 10 years based on improved understanding. The update of the CMP will also include new waterbodies that are identified as impaired by chloride.

4.1 Water Quality Monitoring

Addressing the issue of chloride impacts on the environment in the TCMA is a long-term endeavor and it may take some time before water quality improvements are seen due to historical loadings, groundwater inputs, variable residence times and other complicating factors. Therefore, continued monitoring of the TCMA lakes, wetlands, and streams for chloride is critical as well as the need to document changes in winter maintenance activities, wastewater source discharges, and water softener usage. Continued water quality monitoring, along with improved understanding of the sources of chloride will allow adaptive management to take place and inform future steps needed to restore and protect TCMA waters. The CMP is intended to be revisited within 10 years and revised based on improved understanding.

There are a number of organizations across the TCMA that monitor water quality or partner with others to conduct monitoring. In addition the MPCA, Metropolitan Council and the USGS also collect data throughout the TCMA. Incorporating the recommendations below into existing local water monitoring programs will provide valuable data to assist with tracking progress and meeting water quality goals. Monitoring should take place at the existing sites for consistency and comparison purposes. However, since monitoring activities are lead at the local level it will be dependent on available resources and local priorities. We encourage local monitoring data be shared with MPCA by routinely submitting data to the MPCA's water quality database, EQuIS. The monitoring that MPCA conducts across the state follows the 10-year monitoring strategy as described in Minnesota's Water Quality Monitoring Strategy report.

The MPCA has worked with the MSG to develop monitoring guidelines for lakes, streams, wetlands and storm sewers. Monitoring guidance documents are available on the MPCA TCMA chloride project website. The key components of continued monitoring to support the implementation of the CMP include:

- Collect samples during the critical periods for elevated chloride concentrations: January through May for lakes and December through April for streams. However, always put safety first when assessing conditions for collection of samples through the ice.
- Analysis of chloride should also be included in typical summer season sampling. Analysis for chloride is relatively inexpensive and should be included if the effort is being made to collect samples for analysis of other parameters.

- In lakes with potential for stratification collect a bottom sample and surface sample.
- Maintain consistency in sampling. Chloride concentrations may vary from year-to-year depending on the winter conditions. Assessment of long-term trends will have greater confidence with consistent, yearly datasets.
- Collect a matching conductivity reading with each sample taken for chloride analysis.
- Expand the sampling program to additional lakes, streams, and wetlands as resources allow. Many waterbodies in the TCMA have not been sampled sufficiently to make a reliable assessment of potential impairment by chloride.

High Risk Monitoring Recommendations

The MPCA has developed specific guidance for monitoring of the TCMA waters not currently impaired but showing a high risk of impairment. The chronic standard of 230 mg/L for chloride concentration applies as a four-day time average. In practice, impairment is often judged from monthly sampling results when these show a clear pattern of prolonged concentrations exceeding the standard. Weekly or twice-weekly sampling would provide the basis for a clear determination. Long-term sampling at such high frequencies is unreasonably expensive in most cases. Therefore, the MPCA suggests the following guidance for additional monitoring of high risk waters:

1. Identify dates or periods of past chloride concentrations that were either:
    a. Exceedances (exceeded the chronic chloride standard), and
    b. High occurrences, defining high as less than, but within, 10% of the chronic standard (thus >207 mg/L)
2. Select a four-week period centered on each such date or period, and for each:
    a. Sample for chloride weekly, always on the same day of the week
    b. Sample at the same depth or depths as in past sampling
3. If an electrical conductivity meter is available, take and record a matching conductivity reading with each lab sample taken:
    a. matching = from the same primary sample that provides the lab subsample, if the primary sample is a sufficiently larger volume than the laboratory bottle used; or otherwise
    b. matching = same location and depth as the lab sample
4. Possible expanded effort:
    a. Monitor twice weekly rather than once, always on the same days of the week (e.g., Mon and Thu) including, as resources permit:
        i. Chloride sample and conductivity measurement if possible
        ii. Chloride sample only if lacking conductivity meter
        iii. Conductivity measurement only on the increased frequency if laboratory costs limit sampling but a meter is available

To clarify, sampling for chloride at least weekly during the selected four-week period(s) is the necessary minimum effort for ensuring the value of this additional monitoring; conductivity measurements alone will not suffice at present. This could change in the future if a reliable and accurate relationship between chloride and conductivity is developed for an individual waterbody or for an area including the waterbody.

Impaired Monitoring Recommendations (Tracking Progress)

In order to assess high risk waters and waters without data, the MPCA recommends monitoring waters already identified as impaired for chloride less frequently. It is recommended that efforts focus on collecting samples during critical periods. For instance, if the impairment is a result of winter maintenance activities, chloride sampling should be conducted during January through May for lakes and wetlands, and December through April for streams. If the impairment is caused by effluent with high chloride concentrations from WWTPs, monitoring during low-flow periods in the streams should be targeted. If long-term monitoring data has already been collected, less frequent monitoring during critical conditions (monthly or twice monthly) is recommended. If monitoring efforts are limited by costs and a site-specific chloride-conductivity relationship has been established, the MPCA recommends collecting conductivity measurements during the critical period to track progress.

General Monitoring Recommendations for Waters without Data

At a minimum, collect monthly chloride and conductivity data for waters without data during the critical period. If possible, expand the effort to weekly sampling during the critical period, and include chloride in typical summer season sampling efforts. For lakes with a potential for stratification, collect a bottom and a surface chloride sample. If it is determined that these waters meet the high risk criteria, the MPCA recommends following the monitoring guidelines for high risk waters.

4.2 Tracking and Reporting Implementation Efforts

Measuring water quality in the TCMA and monitoring chloride loads in the lakes, wetlands, and streams is critical to understanding progress toward the ultimate goal of restored and protected lakes, wetlands, and streams. However, these types of measurements alone will not be sufficient to demonstrate the progress made in implementing individual salt reduction efforts and accomplishments taking place throughout the TCMA to reduce chloride. Tracking of implementation activities is needed to assess the related benefits to water quality, take credit for making progress, and identify areas where additional effort is needed.

The approach to tracking implementation efforts will vary by the source type. The WMAt will be an option available to any winter maintenance group and will support a consistent approach to tracking and reporting winter maintenance activities.

Treatment facilities holding an NPDES Permit will be required by permit to monitor for chloride for an initial term. If the effluent shows no reasonable potential to contribute to or cause violations of the chloride criteria, monitoring requirements may be dropped. For facilities where monitoring shows elevated chloride concentrations, the MPCA will work with the individual facility to determine a course for reducing chloride loads. Where residential water softeners are a major contributor to elevated chloride concentrations, educational and outreach efforts and implementation of water softener buy-back programs should be documented.

4.3 Adaptive Management

Implementation of a TCMA CMP, which includes 186 cities and townships and seven counties as well as colleges, universities, private industries, commercial property owners, school districts, private homeowners, and others, can only be accomplished by maintaining flexibility and adaptability within the overall approach. It should be understood that the water quality goals and chloride loads presented in this plan are estimates based on the best available science.

Adaptive management is an approach that allows implementation to proceed in the face of potentially large uncertainties. Adaption allows the implementation plan to be adjusted in response to information gained from future monitoring data and new or improved understanding of related issues. The adaptive implementation process begins with initial actions that have a relatively high degree of certainty associated with their water quality outcome. Future actions are then based on continued monitoring of the TCMA water resources and an assessment of the response to the actions taken.

The TCMA CMP is a prime candidate for an adaptive implementation process for a number of reasons. First, the scale, complexity, and variability of chloride sources within the area make a traditional implementation plan (i.e., one that identifies the specific implementation activities required to attain the TMDL) impractical. Second, there will likely be a time lag between reduction of external loads and the response of the system, and there will be year-to-year variability in the monitoring results. Finally, the TMDLs focused on the problem of high chloride loads and its current sources. However, restoration and protection of the TCMA water resources will require a planning framework that recognizes potential future threats such as changing deicing products, driver expectations, climate change, and population increases. For these reasons, implementation of the TCMA CMP will be conducted within an adaptive framework. The primary steps in the adaptive management framework are presented in Figure 30. Measurement and evaluation of progress in early years of implementation will be critical to success.

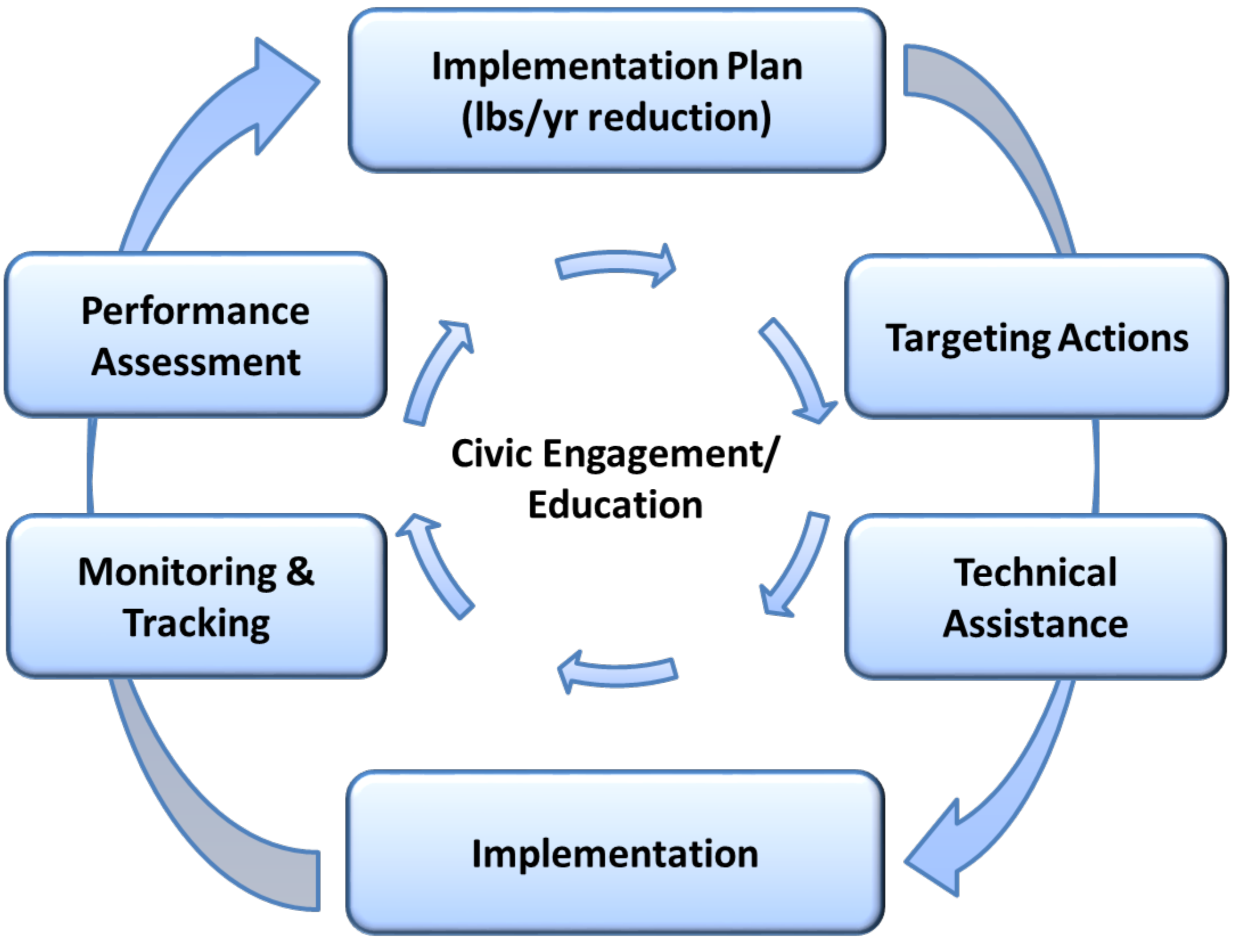


Figure 35. Adaptive Management Framework
Adapted from Washington County Conservation District

5. Research Needs

There are still many areas related to chloride where additional research and information may help to inform management decisions. There are 12 main areas that would benefit from additional information.

1. **Chloride reductions when implementing the BMPs.** The WMAt is the first ever, exhaustive resource of all known salt saving BMPs. The reduction potential for each BMP is largely unknown. The WMAt is limited by available research, in how much of a reduction that can be attained by improving each individual practice. More research is needed on many BMPs to understand how much salt can be saved when the BMP is implemented. The tool contains a list of over 200 BMPs, most of which would benefit from reduction potential research.
    a. For example, an estimated 17% of salt is lost by storing salt/sand pile uncovered over the winter. By implementing the recommended BMP of storing salt/sand pile indoor, there is an estimated 17% reduction potential for that pile
    b. For example, no information is available on the percent salt savings attained from increasing liquid to granular ratio from 8 gallons per ton to 50 gallons per ton. This information may help decision makers select those BMPs that achieve the greatest chloride reduction.

2. **Water softening options.** More information is needed on the effectiveness of various water softening systems at reducing chloride and the relative cost for each. The current available options for possibly reducing chloride from this source includes: converting old home water softening to on-demand softeners; eliminating home softeners with a centralized lime softening; and converting to non-chloride water conditioning in home systems. Developing a better understanding of the cost associated with such conversions would also aid in proper decision-making. Information on potential chloride reductions resulting from a more informed public would be beneficial. This would include a public that knows untreated hardness level, understands reasonably acceptable hardness levels for home use, and sets the water softeners appropriately.
3. **Environmental impacts of non-chloride deicers.** There are many alternative deicers that do not contain chloride; however, all have negative environmental impacts. A thorough review of all practical alternatives that exist with detailed information on the short-term and long-term environmental impacts and how it compares to chloride containing deicers in effectiveness and environmental impacts would allow more informed. Currently research about short term environmental impacts has been done on a variety of chloride and non-chloride deicers by the Clear Roads research consortium.
4. **Citizen attitudes and practices around the use of chloride.** Demonstration projects can be used to test the organizing approaches for building partnerships between citizens and government or property owners to work together to solve the challenge of chloride use and water resource impairments. The demonstrations will likely be most successful where community capacity around environmental issues exists. Local leaders should be supported to experiment with building partnerships across sectors to co-develop strategies for chloride reductions by municipalities, businesses, and households. The demonstrations can employ pre- and post-evaluation to determine whether the approach achieves meaningful outcomes over time. The outcomes will determine whether the efforts should expand past the pilot stage. If defined outcomes are significant, the plan should be developed to scale to metro-wide and beyond application.
5. **Effectively educate the public about environmental impacts of salt use and how they can help reduce it.** Research is needed for the most effective way to educate the public to make changes. A multi-agency approach is needed to reach the greatest public audience.
6. **Will the traditional salt savings steps recommended in this plan be enough**? If all the TCMA maintenance organization use the WMAt and show their practices are dominated by excellent practices, the information will show if these traditional BMPs will reduce salt enough to make the practices sustainable. It is difficult to project when, or if, this will occur. It is important to monitor the progress of the industry and compare to the water monitoring results. If there is a high compliance with traditional BMPs it will illustrate the effectiveness and demonstrate whether there can be a sustainable ecosystem and the use of salt for winter maintenance. This answer would be of high importance for all dealing with the same situation.
7. **Pavement alternatives.** Additional research should be done to understand pavement types and emerging pavement technologies that could reduce chloride usage while providing an adequate level of service.

8. **Water experts.** Research is needed to better understand how to capture chloride before it enters the water and how to remove it once it enters our surface water or ground water. Special attention should be directed toward preserving the food chain living in surface water systems when considering filtration methods for removing chloride from lakes, rivers, and wetlands.

9. **Reuse.** An evaluation of the feasibility of re-using wastewater with chloride for winter maintenance should be conducted, including brine from RO processes. As part of this evaluation, an understanding of the other chemicals present in the wastewater will be important in determining the feasibility of re-using wastewater.

10. **Non-chloride and reduced chloride.** The MnDOT has evaluated many different options for deicing, but some may need additional research into the effectiveness. Information can be found at "Chloride Free Snow and Ice Control Material."

11. **Septic Systems**. More research into septic systems and the amount of chloride loading to the groundwater needs to be better understood as well as other contributors of chloride to groundwater.

12. **Climate Change.** Additional research is needed to understand how climate change will affect precipitation patterns and temperatures and their effects on chloride. Precipitation and temperature could cause increases or decreases in chloride application. However, increased or decreased precipitation could also affect the amount of runoff available for dilution and flushing of chloride.

6. Stakeholder and Public Involvement Process

A robust stakeholder involvement process was undertaken to develop partnerships and gain insight into winter maintenance activities and municipal wastewater plants as a source of chloride. This process began in early 2010, and has continued throughout the project allowing the stakeholders to assist in the development of the TCMA CMP and the TMDL and has generated the support of local partners and created a common understanding of the challenges with balancing water quality and public safety. This effort consisted of over 115 participating stakeholders on seven teams over five years; an IAT, a TAC, a MSG, an IPC, an EOC, and Technical Experts (TechEx). Meeting information and stakeholder team membership lists are available at: http://www.pca.state.mn.us/programs/roadsalt.html.

The IAT members included water resources experts from the MPCA, MnDOT, BWSR, MDH, USGS, MCES, and the DNR. This team provided high-level oversight, support, and guidance for the project and became involved in the project during the initial feasibility study in 2009. The Committee met three times from 2010 through 2014.

The TAC members included representatives from the MPCA, MnDOT, St. Paul, Minneapolis, Shoreview, Burnsville, Plymouth, Capitol Region WD, Ramsey-Washington WD, Bassett Creek WMC, Mississippi WMO, Nine Mile Creek WD, Scott County WMO, Minnehaha Creek WD, Rice Creek WD and the APWA. This team was responsible for providing review, guidance, and support for the technical aspects of the project. Committee meetings were held seven times from 2010 through 2014. In addition to the in-person meetings, regular updates, and gathering of input and feedback on draft documents occurred over email.

The MSG was created to provide detailed technical guidance and support regarding the water quality monitoring aspects of the project. The team not only developed monitoring guidance for chloride but also partnered with MPCA to collect additional chloride data across the TCMA to inform the TCMA CMP and TMDL. This team consisted of local and state water quality experts from the MPCA, DNR, USGS, MCES, Minneapolis Park and Recreation Board, Three Rivers Park District, Ramsey County, Capitol Region WD, Ramsey-Washington WD, Rice Creek WD, Minnehaha Creek WD, and Mississippi WMO. The Committee met four times from 2010 through 2013.

The EOC included local education specialist throughout the TCMA representing WDs, WMOs, counties, Freshwater Society, UMN Extension, East Metro Water Resource Education Program, and the MnDOT. This team was created to provide insight, direction, and to share information and resources to develop the strategies and needs of educating and engaging the public and stakeholders. The team met four times from 2011 through 2014.

A TechEx was formed to assist in the development of the WMAt. The team included hands on leaders in the winter maintenance industry from the MnDOT, cities, counties, and private companies. This team was instrumental in developing the vision and technical details of the WMAt. This group met several times; however, much of the review, feedback, and expertise were shared electronically.

The IPC consisted of representatives from all other teams and other interested stakeholders. This team's primary responsibility was to provide oversight and guidance on the development of the TCMA CMP. This group also received updates on the development of the TMDL and other project information. Meetings were held three times from 2012 through 2014.

In addition to the involvement of the stakeholders on the seven project teams, there were many other meetings, events, and conferences over the five-year span of the project to share progress and results. This included:

- annual presentations at the Freshwater Society's Road Salt Symposium since 2010
- presentations at the Minnesota Water Resources conference in 2010 and 2014
- participation in the EPA's Stormwater Pollution Prevention Webinar in 2013
- presenting at the Minnesota Street Superintendent's Association meeting in 2014
- participation in the Mississippi River Forum in 2015
- attendance at numerous local meetings and events to discuss project

Two special outreach meetings were held specifically for the TCMA Chloride project. The first one was the Sand Creek Community Meeting, which was held in Jordan, Minnesota on July 30, 2014, to discuss the draft TMDL results. City, township, county representatives, and WWTP operators within the Sand and Raven Creek watersheds were invited to the meeting. Fourteen stakeholders attended the meeting. The second meeting was the Chloride Extravaganza held in St. Paul, Minnesota on April 28, 2015. Over 250 permitted and key stakeholders in the TCMA were invited to hear presentations from the various MPCA staff regarding the water quality conditions of chloride in the TCMA, results of the draft TMDL, and have discussion regarding implementation of the TMCA CMP and TMDL. About 100 stakeholders participated in the event.

Aside from collaborating, engaging, and informing local stakeholders about the TCMA Chloride project, additional efforts were made to increase the public's awareness about the environmental impacts of chloride. The primary and most effective efforts included the development of a new MPCA webpage with information and tips for the public to reduce salt use and protect water quality. A short YouTube video was created discussing the environmental concerns about deicing salt and the effort underway to develop a plan for a collaborative and effective chloride reduction strategy. A large interactive display was designed, built, and shared with the public at the Minnesota State Fair since 2012, and is available to local partners for local educational events. Finally, in 2010, the MPCA began generating press releases at the start of every winter that discusses the impacts of deicing salt on water resources and highlights new information, reports, or data available.

The official public comment period for the CMP and TMDL was held from August 3, 2015, through September 3, 2015. Eleven letters were received during the public comment period.

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Appendix A – TCMA Chloride Total Maximum Daily Loads (TMDLs)

[see TMDL report]

Appendix B – Winter Maintenance Assessment tool (WMAt)

There are thousands of miles of streets and highways in Minnesota, along with parking lots and sidewalks that must be maintained to provide safe conditions throughout the winter. Winter maintenance of these surfaces currently relies heavily on the use of salt, primarily NaCl, to prevent ice build-up and remove ice where it has formed.

In response to the increase in chloride concentrations from winter maintenance activities in area lakes, streams, wetlands, and groundwater, Minnesota state agencies, local municipalities, and experts across the TCMA have partnered to create a CMP to effectively manage salt use to protect our water resources in a responsible and strategic approach.

As part of the TCMA CMP development, the first of its kind, WMAt has been developed as a resource of all known salt saving BMPs. The WMAt is a web-based tool that can be used to assist public and private winter maintenance organizations in determining where opportunities exist to improve practices, make reductions in salt use and track progress.

The WMAt contains a list of roughly 180 BMPs that allows agencies and companies to complete an assessment of their current winter maintenance practices and speculate on potential future practices to understand how to reduce the use of chlorides, while still providing an acceptable level of service. Utilization of this planning tool will allow the user to track their progress over time and show the results of their efforts. It also can predict salt savings and associated cost savings (with a low degree of accuracy at this point) based on the industry's current salt savings research.

Finally, once an assessment has been completed, a report can be generated summarizing current practices as "remedial", "best" and "advanced" identifying areas for future improvement. The report is an excellent and convenient tool for winter maintenance managers to use to communicate winter maintenance operations to residents, clients or elected officials.

For those users who prefer not to do an online assessment, Appendix B offers a snapshot of the Best Practices contained in the tool at the given time (when this management plan was finalized). This appendix will soon be out-of-sync with the WMAt tool as the WMAt tool will be refined during testing and implementation to reflect the current and best practices in the industry. It is not our intent to keep Appendix B up-to-date with the WMAt. For the latest recommendations, please use the online tool.

Questions are generally grouped to address practices in the following six categories:

1. Before winter activities
2. Before the storm activities
3. Accuracy
4. Efficiency
5. Reduce waste
6. After winter activities

The WMAt assessment questions and general scoring of responses, from "remedial" or "unacceptable" to "advanced" or "best" are included in the following pages.

Before Winter Activities

Do you have a written winter maintenance policy?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable **Best**

- No
- Yes

Does the crew understand the winter maintenance policy?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable **Best**

- No
- Some of them
- Yes
- Not applicable

Do you try to communicate your winter maintenance policy to your customers?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable **Best**

- No
- Some of them
- Yes
- Not applicable

Do supervisors compare crew actions to salt application guidelines?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable **Best**

- No
- Yes

How often is your policy reviewed and updated?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable **Best**

- Less than once a year
- Each year
- Not applicable

Does the crew document their actions?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable **Best**

- No
- Sometimes
- Yes, on paper or through an automatic tracking system

Do most buildings you maintain drain onto salted surfaces?
Applies to: Parking Lots, Sidewalks

Unacceptable → **Best**

- Yes
- No

Are appropriate people notified of drainage problems?
Applies to: Parking Lots, Sidewalks

Unacceptable → **Best**

- No
- Yes
- We are the property managers

Are culverts, storm drains, curb cuts inspected and cleared of debris/obstacles prior to first snow event?
Applies to: Low Speed Roads, Parking Lots

Unacceptable → **Best**

- No
- Some of them
- Meets MPCA MS4 stormwater permit (at least 20%)
- All of them
- Not applicable

Is anti-icing equipment ready for use before first salting event?
Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Yes
- Not applicable

Are pre-wet systems ready for use before first salting event?
Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable → **Best**

- No
- Yes
- Not applicable

Is your liquid deicer ready for use before first salting event?
Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Yes
- Not applicable

Are spill shields installed prior to first storm?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable → **Best**

- No, never use spill shields; salt leaks out of truck
- No, most spill shields installed after first snow event
- Yes
- No, don't need spill shields; salt does not leak out of truck

Do you use snow fences?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Yes
- Have used them in the past and are increasing our amount

Do you use weather prediction systems better than the TV news?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Yes
- Yes, and including pavement temperature

Do you test each batch of your liquids?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Sometimes
- Do not use liquids
- Always

How often are crew and supervisors trained on conservative use of salt?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Crew is trained occasionally
- Most of the crew is trained each year
- Entire crew is trained each year

Do crew and supervisors understand the long-term impacts of salt on our waters?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Yes, most of the crew
- Yes, everyone

Do supervisors participate in or attend training with crew?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Sometimes
- Yes

How do you rate your operators' willingness to change?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable **Best**

- Low
- Medium
- High

How do you rate your managers or supervisors willingness to change?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable **Best**

- Low
- Medium
- High

Do you educate your customers about salt, the environment and what you are doing to be pro-active?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable **Best**

- No
- Some
- Yes

Are lakes, rivers, wetlands, well-heads marked on route maps?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable **Best**

- No
- Yes

Are trouble areas documented on each route?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable **Best**

- No
- Yes

How well do operators work together within your organization?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable **Best**

- Poorly
- Ok
- Excellent

How well do you communicate with neighboring organizations?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable **Best**

- Poorly
- Ok
- Excellent

Do you use the optimal equipment for the route?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable **Best**

- No
- Most of the time
- Yes

Do most plow operators have regular routes?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable **Best**

- No
- Yes

Do you actively promote lower speed, safer customer behavior during winter?
Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Sometimes
- Always
- We reduce speed limits when necessary

Do you actively promote proper storage in your community? (beyond your operations i.e. private contractors)
Applies to: High Speed Roads, Low Speed Roads

Unacceptable → **Best**

- No
- Yes

Are you changing any salted maintenance areas to non-salted areas?
Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Yes

Are you changing any salted maintenance areas to reduce salt areas? (textured for traction, dark colored, crowned, sloped, covered, sub base influence for warmth, chip seal, pavement overlay, etc.)
Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Yes

What percentage of your salted parking lots/sidewalks are designed for reduced salt use? (textured for traction, dark colored, crowned, covered, sub base influence for warmth, chip seal, pavement overlay, ...)
Data entry question
Applies to: Parking Lots, Sidewalks

Unacceptable → **Best**

- Enter %

What percentage of your salted roads are designed for reduced salt use? (textured for traction, dark colored, crowned, covered, sub base influence for warmth, chip seal, pavement overlay, ...)
Data entry question
Applies to: High Speed Roads, Low Speed Roads

Unacceptable → **Best**

- Enter %

How fast do you need melted surfaces?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Faster than in the past, using more salt
- Same as in the past using more salt
- Slower than in the past, using more salt

- Faster than in the past, using the same amount of salt
- Same as in the past using the same amount of salt
- Slower than in the past, using the same amount of salt

- Faster than in the past, using less salt
- Same as in the past using less salt
- Slower than in the past, using less salt

What % of your salted roads must be snow/ice free?

Data entry question

Applies to: High Speed Roads, Low Speed Roads

Unacceptable → **Best**

- Enter %

What % of your salted parking lot/sidewalks must be snow/ice free?

Data entry question

Applies to: Parking Lots, Sidewalks

Unacceptable → **Best**

- Enter %

Is there a change in your service area?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Lane miles/acres increasing
- No change
- Line miles/acres decreasing

Do you provide different levels of service?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Same level of service for everything
- Different levels of service for different areas

Does most of your crew meet their level of service targets?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Exceed level of service
- Below level of service
- Meet level of service

Does your crew know the level of service required for their maintenance areas?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Some of them
- Yes

Before the Storm Activities

Where do you anti-ice?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable		Best
· None of the areas we salt	· Some of the areas where we salt	· All areas where we salt

When do you anti-ice? (i.e. apply liquids before the storm)

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable		Best
· On a regular schedule no matter how much residual salt · Never	· On a regular schedule, if not adequate salt on surface	· Before predicted frost or snow

How do you treat frost?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable		Best
· Apply granular salt after frost is formed	· Apply liquids after frost is formed	· Anti-ice to prevent frost · Do nothing

Our anti-icing systems are primarily:

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable		Best
· Anti-ice with granular products	· Gravity glow, open loop system, flow rate depends on your speed · By pump, open loop system, flow depends on your speed and how much pressure is in your tank · Not applicable	· Electronic controls, closed loop system, ground speed system

Do you have any automated anti-icing systems built into your pavement surfaces?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable		Best
	· No	· Yes

Have you made changes to reduce loss of anti-icing liquids from airflow?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable | **Best**

- No
- Yes some of our fleet has modifications
- Yes all of our anti-icing fleet has modifications such as: spray skirts, spray flaps, long tubes to lower discharge point, and/or lower boom
- Not applicable

What is the first step you take with slush that will refreeze?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable | **Best**

- Ignore it
- Salt it
- Remove it (shovel, plow, etc.)

For roads, what do you do with a light snow (> 1" for event)?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable | **Best**

- Without plowing, salt or sand it if needed
- Remove it and salt
- Nothing
- Remove it (salt only if needed)
- Anti-icing takes care of it

What do you do with a 2 inch snow?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable | **Best**

- Without plowing, salt or sand it if needed
- Nothing
- Remove it and salt
- Remove it (salt only if needed)

For parking lots, what do you do with a light snow (> 1" for event)?

Applies to: Parking Lots

Unacceptable | **Best**

- Without plowing, salt or sand it if needed
- Remove it and salt
- Nothing
- Remove it (salt only if needed)
- Anti-icing takes care of it

When we have compaction, our "primary tool" is to:
Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable		Best
· Salt/sand mix	· Salt it · Sand it · Liquid salt to get underneath bond · Other	· Scrape it · Leave it

Are you optimizing mechanical removal to reduce use of chemical?
Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable		Best
· No	· Sometimes	· Yes, never put salt on unplowed, unshoveled surfaces

Do you have good equipment for effective snow removal?
Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable		Best
· No	· More good than bad equipment	· Yes

How do you plow and apply salt?
Applies to: High Speed Roads, Low Speed Roads

Unacceptable		Best
· Plow and apply on each lane as you go		· Clear entire road, then have separate salting pass · Plow 2 lanes then apply salt to middle

How do you salt when plowing in tandem?
Applies to: High Speed Roads, Low Speed Roads

Unacceptable		Best
· Most plow tricks salt; nothing done to prevent loss of salt from plowing	· Most plow trucks salt; reduce salt loss by using spreaders on the left, turning spinners off, or using chutes. Two pass operation · Not applicable	· Plow in tandem salting is done later · Most plow trucks salt; reduce salt loss by using spreaders on the left, turning spinners off, or using chutes. One pass operation

How do you manage routes that overlap?
Applies to: High Speed Roads, Low Speed Roads

Unacceptable → **Best**

- Plow or salt on other peoples routes without being asked
- Avoid plowing or salting on other peoples routes unless there is communication

For sidewalks, are you clearing before salting?
Applies to: Sidewalks

Unacceptable → **Best**

- No
- Yes, if there is more than 1 inch of snow
- Yes, unless there is compaction
- Yes

Do you have the ability to plow continuously throughout the storm?
Applies to: High Speed Roads, Low Speed Roads

Unacceptable → **Best**

- No
- Snow removal is only at end of storm
- Sometimes
- Yes

Is your response to snow events the same during weekday hours and weekend/evening hours?
Applies to: High Speed Roads, Low Speed Roads

Unacceptable → **Best**

- No
- Yes

Accuracy

How often do you calibrate spreaders?
Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → ***Best***

- New equipment only
- Most equipment every other year
- Never
- Most equipment early
- All equipment yearly
- All equipment yearly, plus if equipment changes or something looks wrong

How many anti-icing systems (liquid only spreaders) do you calibrate?
Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable → ***Best***

- Less than half
- Don’t have any
- More than half
- All

How many liquid pre-wet systems do you calibrate? (Pre-wet refers to a system that discharges liquids onto granular products)

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable → ***Best***

- Less than half
- Don't have any
- More than half
- All

How many granular salting trucks do you calibrate? (including trucks from your active fleet that deliver sand/salt mix)

Data entry question

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable → ***Best***

- No
- Some, enter #
- Yes (for all)

Do you calibrate your "gator" or small vehicle granular spreaders?

Data entry question

Applies to: Sidewalks

Unacceptable → ***Best***

- No
- Some, enter values
- Yes (for all)
- Not applicable

Do you calibrate your push granular spreaders?

Data entry question

Applies to: Sidewalks

Unacceptable → ***Best***

- No
- Some, specify #
- Yes
- Not applicable

What percent of your fleet is set up for liquids (of the trucks that apply salt)?

Applies to: Sidewalks

Unacceptable → ***Best***

- 0 – 49%
- 50 – 79%
- 80 – 100%

Where are your manual spreader control calibration charts? (Manual spreader controls are controls that you adjust like a knob or gate opening and do not automatically change the discharge rate to match the speed at which you are applying)

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → ***Best***

- Not with the equipment
- Often with the equipment
- Always with the equipment and a back-up copy in the office
- No manual spreader controls

For manual spreader controls, do your operators know how to read the calibration card?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → ***Best***

- No
- Yes
- Have all electronic controls, so don't need cards

Do your operators know how to read your salt application rate charts?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → ***Best***

- Don't have charts
- No, supervisors read the charts and assign rates
- Don't have charts, use strictly MDSS for guidance
- Yes

What materials do you calibrate for?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → ***Best***

- Don't calibrate
- For most commonly used product(s)
- For every product used

What guidance do you give to your crew for hand spreading?

Applies to: Sidewalks

Unacceptable → ***Best***

- Have a scoop in bucket with no instructions
- Chicken feed with no instructions
- Have a line on spreader indicating fill line for each site
- Have a hand spreader in bucket of salt instead of scoop
- Crew has a picture of ideal spread pattern
- Amount of deicer is calculated each time based on square footage and pavement temp

For roads, what is your most common anti-icing rate for straight salt brine? (Straight salt brine is water and rock salt. No other ingredients)

Applies to: High Speed Roads, Low Speed Roads

Unacceptable ***Best***

- Don't use liquids
- More than 50 gallons per lane mile
- 50 gallons or less per lane mile
- Don't use straight salt brine

For parking lots/sidewalks, what is your most common anti-icing rate for straight salt brine?

Applies to: Parking Lots, Sidewalks

Unacceptable ***Best***

- Don't use liquids
- More than 0.8 gallons per 1000 square feet
- 0.8 gallons or less per 1000 square feet
- Don't use straight salt bine

Do you have more than one type of liquid to choose from (for anti-icing or deicing)?

Applies to: Parking Lots, Sidewalks

Unacceptable ***Best***

- No
- Don't use liquids
- Yes

For parking lots/sidewalks, what is your most common anti-icing rate for straight magnesium or calcium chloride liquid?

Applies to: Parking Lots, Sidewalks

Unacceptable ***Best***

- Don't use liquids
- More than 0.4 gallons per 1000 square feet (18 gal. per acre)
- Less than 0.4 gallons per 1000 square feet (28 gal. per acre)
- Don't use straight magnesium or calcium chloride

For roads, what is your most common anti-icing rate for straight magnesium or calcium chloride liquid?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable ***Best***

- Don't use liquids
- More than 25 gallons per mile
- 25 gallons or less per mile
- Don't use straight magnesium or calcium chloride

Who determines (granular and/or liquid) application rates?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → ***Best***

Unacceptable		Best
· We make our own application rate chart. Rates are higher than MN field handbook for snowplow operators · Application rate charts are not used	· We make our own application rate chart. The rates are higher than MN field handbook for snowplow operators or the MN parking lot and sidewalk manual but much less than we used to use · MDSS preprogrammed system with rates higher than MN field handbook for snowplow operators	· MDSS preprogramed system with rates similar to MN field handbook for snowplow operators. Truck suggests the rates · We use MN field handbook for snowplow operators · We use MN parking lot and sidewalk manual application rate chart · We make our own application rate chart comparable to the MN field handbook for snowplow operators or the MN parking lot and sidewalk manual

Are your application rates based on pavement temps?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → ***Best***

Unacceptable	Best
· No · Don't have application rate charts	· Yes

Do most of your operators follow application rate recommendations? (MDSS, supervisor, or chart)

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → ***Best***

Unacceptable		Best
· No · Don't know	· Half of the time	· Yes

How do you select your application rate?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → ***Best***

- Operator in charge: generally disregards charts and makes own decisions
- Supervisor in charge: generally disregards charts and makes own decisions
- Application rate charts are used but not based on pavement temperatures

- MDSS in charge: MDSS information is for general conditions not specific to operators route, operator follows MDSS advice
- Operator in charge: has application rate chart, pavement temperatures are from a remote source
- Supervisor in charge: dictate to the crew appropriate application rates based on general pavement temperatures

- MDSS in charge: MDSS uses information from individual truck sensors to suggest rates based on conditions specific to operators' route, operator follows MDSS advice
- Operator in charge: application rate charts and pavement sensor with operator, operator selects appropriate rates from supervisors chart

How many of each type of spreader controls do you have? (active fleet only)

Data entry question

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → ***Best***

- Manual, enter #

- Electronic controls (closed loop), enter #

- Electronic controls (MDSS), enter #

For manual controllers, when salting at different speeds how often does your crew change spreader settings?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable → ***Best***

- Rarely

- Half of the time

- Most of the time
- Have all computer controls

Where do you get your Maintenance Decision Support System (MDSS) advice?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable → ***Best***

- From remote site sending general guidance to the trucks

- From each truck's sensors that monitors the real-time situation as the truck is being driven

- Not applicable

How is the blast button set?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable → ***Best***

- 600 lbs
- 700 lbs
- 800 lbs
- 900 lbs
- 1000 lbs
- 1100 lbs
- 1200 lbs
- 1300 lbs
- 1400 lbs

- 400 lbs
- 500 lbs

- 300 lbs

- Don't have it

How accurate are your salt use numbers?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → ***Best***

- Low: estimate at end of year
- Not applicable: we don't keep track

- Medium: estimate and record after each shift

- High: AVL, scale in and out, PreCise MRM, etc.

- None: we don't use salt

Efficiency

Do you use a sand/salt mix as your primary deicer?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Yes

- No

How much salt is mixed into your winter sand?

Data entry question

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Salt in mix greater than 10%

- Salt in mix equal or less than 10%

- Not applicable

Pre-wet is mixing salt and liquid at the truck, when you increase the amount of liquid, do you change your granular application rate?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable → **Best**

- No, use same application rate
- Yes, increase application rate
- Don't pre-wet
- Yes, decrease application rate

Are you working to increase liquid and decrease granular use across your entire operations?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Yes

For parking lots and sidewalks, what % of the time do you use the below methods?

Data entry question

Applies to: Parking Lots and Sidewalks

Unacceptable → **Best**

- Dry salt
- Sand/salt mix
- 7 – 15 gal/ton
- 4 – 6 gal/ton (i.e. pretreated stockpile)
- Other
- Straight liquid
- Slurry >30 gal/ton
- 16 – 30 gal/ton

For roads, what % of the time do you use the below methods?

Data entry question

Applies to: High Speed Roads, Low Speed Roads

Unacceptable → **Best**

- Dry salt
- Sand/salt mix
- 7 – 15 gal/ton
- 4 – 6 gal/ton (i.e. pretreated stockpile)
- Other
- Straight liquid
- Slurry >30 gal/ton
- 16 – 30 gal/ton

Are you using liquids for deicing (during or after the storm)?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Yes

Do you stir your storage tanks to insure proper mix?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Don't use liquids
- Don't have storage tanks
- Yes

Do you understand the practical pavement temperature range of your deicers?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Yes

We select the appropriate material for the pavement temperature:

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Don't adjust our product selection based on pavement temps
- Don't know
- Most of the time
- Always

When pavement temps are below 15 degrees how often do you use dry rock salt?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- All of the time
- Don't know
- Half of the time
- Rarely or never

For extremely cold, below zero pavement temperatures

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- We use the best we have, but it's not very effective below 0 ^{o} F
- We use products that work better than salt or brine (e.g. potassium acetate, super slurry)
- We use nothing
- We use sand

If ice/snow isn't melting after plowing and salting:

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- We use more of the same deicer
- We wait to allow more time for the salt to work before reapplying
- We switch deicers to a product that will work faster or work at colder temps
- If pavement temps are no longer appropriate for our deicer to work, we switch to sand

We buy:

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- One deicer and use it for everything (e.g., rock salt)
- A selection of deicers so we have options

Reduce waste

What is the most common way you store your salt in the winter?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Pile tarped but not strictly maintained
- Salt pile uncovered
- Salt is purchased in small packages stored outdoors without additional protections
- Pile tarped and strictly maintained
- Salt is purchased in small packages stored outdoors on tarped floor and covered
- Salt pile located indoors or in container
- Salt is purchased in small packages store indoors

Do you prevent moisture from entering your salt shed(s)?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Poor quality buildings
- Ok quality buildings or a mix of good and bad
- All good quality buildings with doors
- All good quality buildings with no doors and salt protected from the opening
- Don't have sheds

Do your snow piles melt into your salt or salt/sand piles?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Sometimes
- No
- We don't have bulk salt or salt/sand piles

Any leaching out of your storage area? (one way to tell if you have leaching from your storage areas is if there are dried rivers of salt leading away from your shed)

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable → **Best**

- Sometimes
- No

What is under your salt pile?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Salt stored on absorbent surface (grass, gravel, cracked asphalt, etc.)
- Salt stored on hard surface (concrete, asphalt, storage containers, etc.)
- Salt stored on hard waterproof surface with concave base "birdbath shaped floor" and with a waterproof membrane, slope toward containment tank
- Don't have a bulk salt pile

Do you overfill your salt sheds?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Yes
- Rarely
- No
- Don't have sheds

How do you cover your salt/sand blended pile in the summer?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Summer salt/sand pile uncovered or poorly tarped
- Summer salt/sand pile tarped and properly secured
- Summer salt/sand pile indoors
- No sand/salt pile in the summer

How do you cover your salt/sand blended pile in the winter?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Winter salt/sand pile uncovered or poorly tarped
- Winter salt/sand pile tarped and properly secured
- Winter salt/sand pile indoors
- No sand/salt pile in the winter

What is your supporting surface for storing bagged salt?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Bagged salt stored on grass/gravel
- Bagged salt stored on tarp
- Bagged salt stored on concrete/asphalt
- Don't use bagged salt

What is under your salt/sand mix storage pile?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Sand/salt stored on absorbent surface (grass, gravel, cracked asphalt, etc.)
- Sand/salt stored on hard surface (concrete, asphalt, storage containers, etc.)
- Sand/salt stored on hard waterproof surface with concave base "birdbath shaped floor" and with a waterproof membrane, slope toward containment tank
- Don't have a bulk sand/salt pile

Do you prevent moisture from getting into your bags or buckets of deicers?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Sometimes
- Yes
- Don't use bagged salt

Do you receive salt shipments indoors or outdoors? (Can they drive into your building to unload?)

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Receive shipments outdoors, leave outdoors
- Receive shipments outdoors, but move material indoors with poor cleanup
- Receive shipments outdoors, but move material indoors with good clean up
- Receive shipments indoors
- Don't have salt pile

Do you restrict delivery of deicers while it is raining or snowing?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- No, we may receive shipments in the rain/snow, but only allow tarped loads

Yes

How do you store your salt pile in the summer?

Applies to: Universal Parking Lots, Sidewalks

Unacceptable → **Best**

- Use up salt so none is left at the end of the season
- Summer salt pile outdoor and uncovered or poorly tarped
- Summer salt pile outdoor, tarped and properly secured

- Don't have a salt pile, buy bags
- Give away or sell leftover salt at the end of the season
- Store inside

How do you store your liquids?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable → **Best**

- Single wall tank
- Do not use liquids

- Single wall tank with a secondary container with a volume smaller than tank capacity

- Single wall tank with a secondary container with a volume equal or greater than tank capacity
- Double wall tank
- Double wall tank and secondary containment area

Are your spreaders covered during sidewalk/trail application?

Applies to: Sidewalks

Unacceptable → **Best**

- Spreaders uncovered

- Spreaders covered

Are your trucks tarped during application?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable → **Best**

- No

- Half of the time

- Yes

How is salt transferred to and from storage facilities?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Transfer truck with uncovered loads

- Transfer truck with covered loads

- Not applicable – we don't move our salt around

Where is the bulk salt loading area for the trucks?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Outdoors

- Indoors

- Don't use bulk salt

Do you overfill trucks?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable		Best
• Yes	• Sometimes	• No

Do you overfill spreaders?

Applies to: Sidewalks

Unacceptable		Best
• Yes	• Sometimes	• No

What sort of bucket is used to load trucks?

Applies to: Parking Lots

Unacceptable		Best
• Loader bucket bigger than truck bed • Clam shell bucket		• Regular loader bucket smaller than truck bucket

Are my trucks easy to unload?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable		Best
	• No	• Yes

What is done with left over material at the end of shifts?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable		Best
• Used at the end of the shift if not needed	• Kept in the truck at the end of the shift	• Brought back to the pile at end of the shift

What do you do with leftover opened bags of salt?

Applies to: Sidewalks

Unacceptable		Best
• Use it up	• Not applicable	• Bring it back

What is done with leftover liquids?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable		Best
• Use it all during the shift, leftovers are rare • Don’t use liquids	• Left in truck/spreader	• Brought back to the main tank

Is there enough time to unload at the end of storm?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable — **Best**

Unacceptable:
- Not enough time for thorough unloading of trucks

Best:
- Allow ample time for unloading of trucks

Which tools/equipment do you use to unload (when you are done with your route)?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable — **Best**

Unacceptable:
- None

Best:
- Shakers, vibrators, raise the box, clean the auger or corners with a tool, elliptical boxes, run auger/conveyor

When salting low speed roads, the spinner is usually…

Applies to: Low Speed Roads

Unacceptable — **Best**

Unacceptable:
- On high

Middle:
- On medium

Best:
- On low
- Off

When salting high speed roads, the spinner is usually…

Applies to: Low Speed Roads

Unacceptable — **Best**

Unacceptable:
- On medium or high

Middle:
- On low

Best:
- Off

How do you apply granular salt to sidewalks?

Applies to: Sidewalks

Unacceptable — **Best**

Unacceptable:
- Broadcast spreader without shield
- Broadcast spreader with shield on one side

Middle:
- Broadcast spreader with shields on two sides

Best:
- Drop spreader

Do you restrict the output of your push spreaders?
Applies to: Sidewalks

Unacceptable → **Best**

- No
- Do not use push spreader
- Yes, by restricting the amount of salt you give to the person applying
- Yes, by blocking the spreader from delivering at high rates
- Yes, by following our policy to only use low settings

Where on the road do you place the salt?
Applies to: High Speed Roads, Low Speed Roads

Unacceptable → **Best**

- Entire drive lane
- Spread pattern in center (of 24-foot pavement)
- Narrow windrow on center line or super-elevation of road

What granular spread pattern is used on parking lots?
Applies to: Parking Lots

Unacceptable → **Best**

- Entire parking lot
- Drive lanes
- Areas of high use
- Strategic plan with customer to minimize salt use

How do you salt intersections?
Applies to: High Speed Roads, Low Speed Roads

Unacceptable → **Best**

- Blast button
- Much higher rate than you were using on the road (may change spinner speed to spread wider)
- Slightly higher rate than you were using on the road (may change spinner speed to spread wider)
- Same rate you were using on the road (may change spinner speed to spread wider)

What anti-icing liquid spread patterns are used on roads and parking lots?
Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable → **Best**

- Fan
- Don't use liquids
- Streamer

What anti-icing liquid spread patterns are used on sidewalks?
Applies to: Sidewalks

Unacceptable → **Best**

- Fan
- Fan spray at super low rates
- Don't use liquids
- Streamer

What areas do you salt on sidewalks, parking lots, and low-speed roads?
Applies to: Low Speed Roads, Parking Lots, Sidewalks

Unacceptable → **Best**

- All surfaces
- Strategic spots

What areas do you salt on high-speed roads?
Applies to: High Speed Roads

Unacceptable → **Best**

- All surfaces
- Strategic spots

What method is most frequently used to open frozen drains/culverts?
Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Leave them blocked
- Salt
- Not applicable
- Mechanical
- High pressure water or stream

How often is the outdoor loading area swept back into the pile?
Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Rarely
- After each storm
- Continuous during winter operations
- Not applicable
- All indoor loading areas

How often do you wash your trucks?
Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable → **Best**

- After each salting shift
- After the storm
- Less frequently than after each storm

How much salt is left in the truck when it goes into the wash?
Applies to: High Speed Roads, Low Speed Roads

Unacceptable → **Best**

- 100 lbs of salt washed out of box and sander
- 50 lbs of salt washed out of box and sander
- 25 lbs of salt washed out of sander
- Reuse wash water for brine system
- Do not wash trucks

What equipment is most commonly used to help keep salt on the road (not on shoulder/ ditch)?

Applies to: High Speed Roads

Unacceptable		Best
• Standard spinner	• Spinner with holes • Skirt	• Chute • Zero velocity • Lower spinner

Does salt commonly leave the truck through cracks, gaps, or when forget to turn off auger/conveyor (not salt lost over the top)?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable		Best
• Yes		• No

Where is the discharge of the truck located?

Applies to: High Speed Roads

Unacceptable		Best
• On right side of truck	• On left side of truck • In the center	• Chute on the left, spinner on the right side of the truck • Dual spinner

How man V-boxes and dump trucks do you have in your fleet?

Data entry question

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable		Best
	• Dump truck, enter #	• V-box, enter #

How do your trucks dispense salt?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable		Best
	• Auger • Conveyer without speed control • Other	• Conveyer • Slurry auger

What is the lowest application rate you can deliver with an even spread pattern?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable		Best
• Don't know • More than 200 lbs per mile (500 lbs per acre)	• 100 to 200 lbs per mile (300 to 500 lbs per acre)	• Less than 100 lbs per mile (300 lbs per acre)

Are most sidewalk spreaders able to deliver 10 pounds per 1000 square feet with an even spread pattern?

Applies to: Sidewalks

Unacceptable → **Best**

- Don't know
- No
- Yes

When you hand spread granular salt what is your most common method?

Applies to: Sidewalks

Unacceptable → **Best**

- Scoop delivery
- Pour from bag
- Shaker
- Scoop with fill mark and square footage guidance
- Hand spreader
- Other
- Not applicable

When salting parking lots, where are the spreader controls located?

Applies to: Parking Lots

Unacceptable → **Best**

- Controls not near operator while spreading
- Most controls near operator while spreading
- All controls near operator while spreading

When salting sidewalks/trails, where are the spreader controls located?

Applies to: Sidewalks

Unacceptable → **Best**

- Controls not near operator while spreading
- Most controls near operator while spreading
- All controls near operator while spreading

The discharge of deicing liquids (not anti-icing) are mostly:

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- Don't use deicing liquids
- Gravity or pump controlled without flow meter
- Pump controlled, closed loop

For parking lot deicing: Are the salt spreader settings marked? (so you know how much salt will be used at each setting)

Applies to: Parking Lots

Unacceptable → **Best**

- Gate opening with no setting on dial, hash marks on number to select
- Some settings marked and selected
- All settings marked and selectable

For sidewalk deicing, are the salt spreader settings marked? (so you know how much salt will be used at each setting)

Applies to: Sidewalks

Unacceptable → **Best**

Unacceptable		Best
• No settings selectable	• Some settings marked and selected	• All settings marked and selectable

At what speed do you spread salt on roads?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable		Best
• 40 – 50 mph	• 30 – 39 mph	• 23 – 29 mph • 22 mph or less

How much salt do you apply on roads while it is snowing?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable		Best
• Salt continuously during the event, applying roughly the same amount of salt on each pass	• Salt continuously during event, apply half the amount of salt during each pass as we do on the pass after the event	• Salt continuously during event, apply 1/4 the amount of salt during each pass as we do on the pass after the event

How much salt do you apply on parking lots while it is snowing?

Applies to: Parking Lots

Unacceptable		Best
• Salt continuously during the event, applying roughly the same amount of salt on each pass	• Salt continuously during event, apply half the amount of salt during each pass as we do on the pass after the event	• Salt continuously during event, apply 1/4 the amount of salt during each pass as we do on the pass after the event • No salt applied during the storm; salting occurs after the storm

How long after the storm until you apply salt?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable		Best
• Apply deicer immediately regardless of surface temperatures	• Apply deicer immediately if we have a deicer that works for the pavement temperature • Apply sand immediately if we do not have a deicer that works for the pavement temperature	• Wait for improved surface temperatures where less salt is needed

After the storm, do you apply salt to areas that are both clear and icy?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable	Best
• Yes	• No

Who salts the overlap stretches of routes?

Applies to: High Speed Roads, Low Speed Roads

Unacceptable	Best
• Anyone driving over another's routes	• Only one route can apply to overlap stretch, unless communication between drivers

Does the last pass of the day get more salt?

Applies to: High Speed Roads, Low Speed Roads, Parking Lots

Unacceptable	Best
• Yes • It depends on if I have salt left in my truck	• No

After winter activities

How do you dispose of truck wash water?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable		Best
• Dispose of wash water in storm sewer (goes to lake, river, pond) • Dispose of wash water on landscape	• Dispose of wash water in sanitary sewer (does to treatment plant)	• Remove salt from truck wash water, keep salt water, discharge clean water • Remove salt from truck wash water, keep salt water, reuse water

Where does most of your storage runoff water go?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable		Best
• Allow runoff into storm sewer • Allow runoff onto landscape • Allow runoff into pond with connections to either surface or ground water systems	• Allow runoff into pond with no connections to other surface or ground water systems • Collect runoff and bring to sanitary sewer • Direct runoff into sanitary sewer	• Collect runoff from storage area and reuse in brine system

Do you encourage research and development: to catch/filter salt before it enters our water, surfaces that do not need salt, ways to melt without chemicals?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Yes

Do you desalinize (remove salt) from any ponds, lakes, or rivers?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Encouraging others to remove salt from river, stream, creek
- Yes

Do you desalinize (remove salt) from ground water sources?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Encouraging others to remove salt from ground water
- Yes

Do you require private contractors or businesses applying salt in your city to be certified by MPCA training program (or other training/certification programs that encourage low salt use)?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Yes
- Not applicable

Do you host low impact Smart Salting training for others? (people not in your organization)

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

Unacceptable → **Best**

- No
- Yes
- Not applicable

Do you feel you have the necessary equipment, materials, and knowledge to use less salt?

Applies to: Universal (High Speed Roads, Low Speed Roads, Parking Lots, Sidewalks)

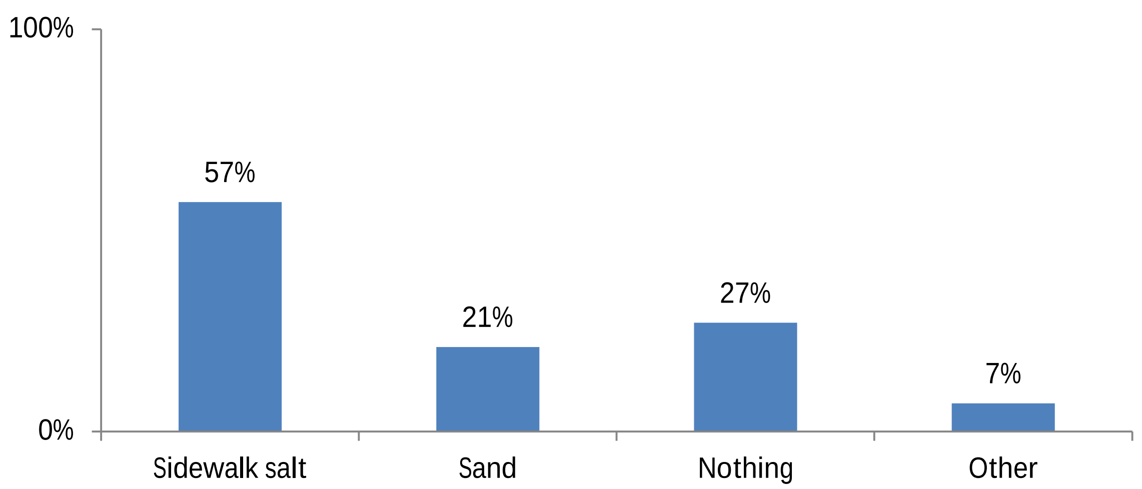
Unacceptable → **Best**

- No
- Some of the above
- Yes

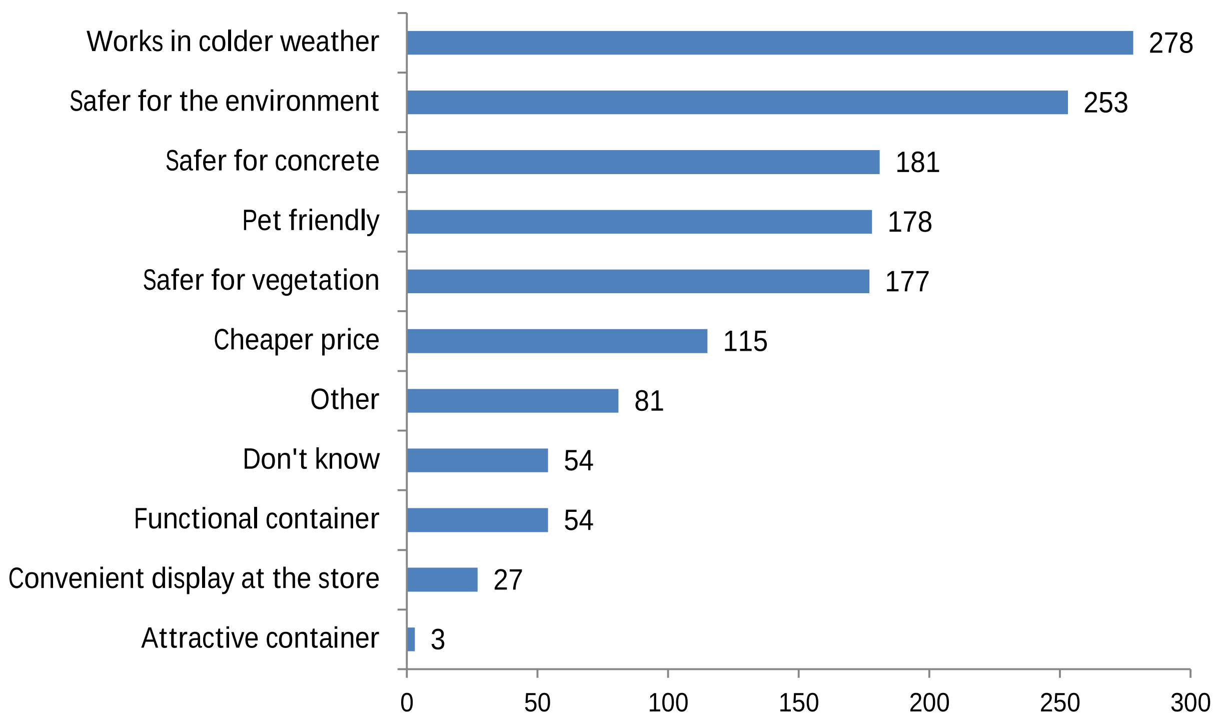
Appendix C – Sidewalk Survey Results

Below is a summary of results of the Sidewalk Survey that was completed by 754 residents in the TCMA from November 2011 through March 2012.

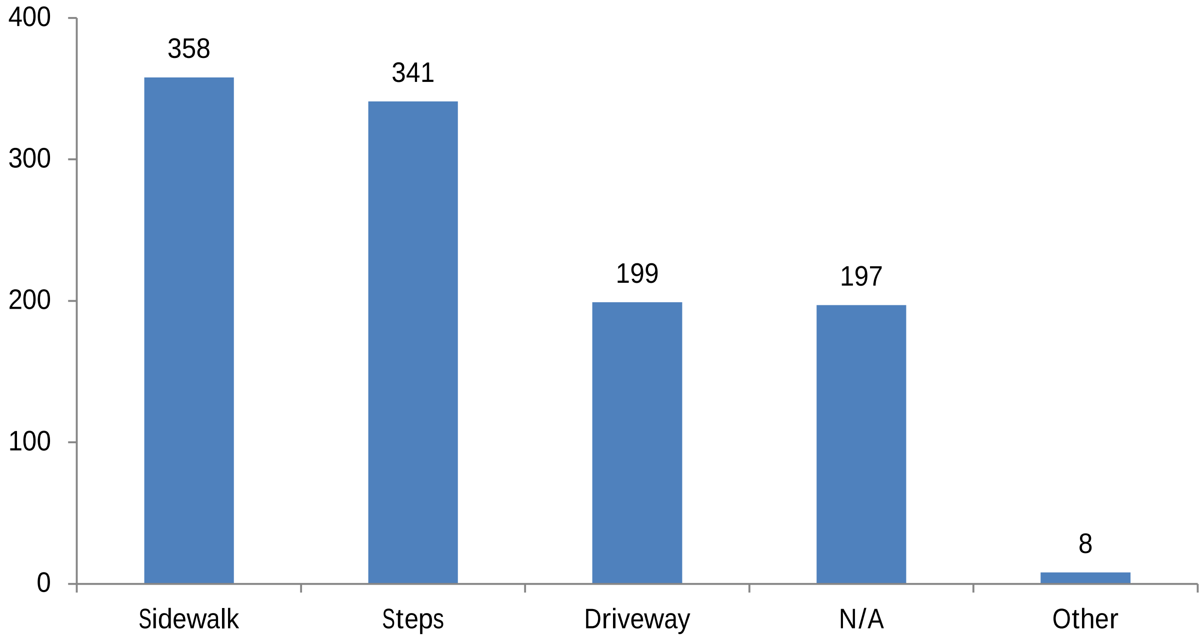
Question 1. What product do you most commonly apply to your icy areas?



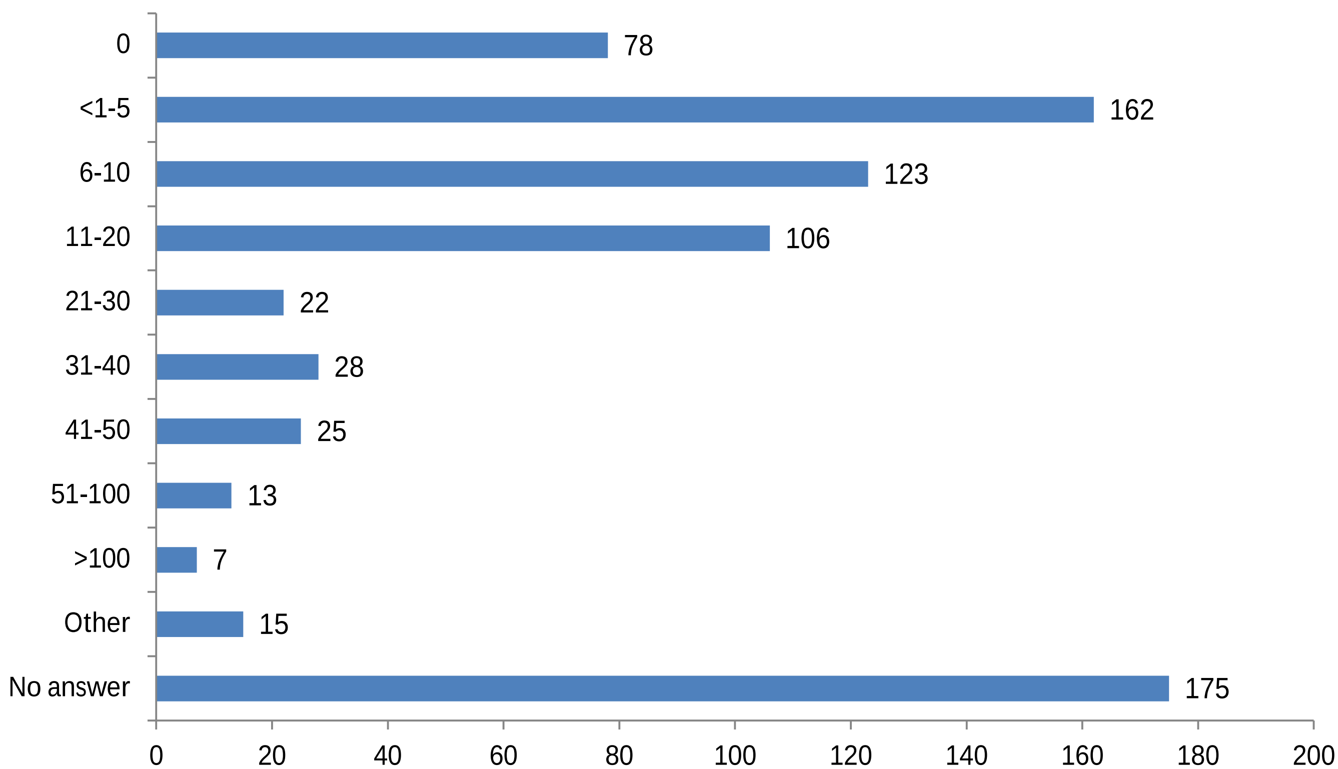
Question 2. Why did you choose that product?



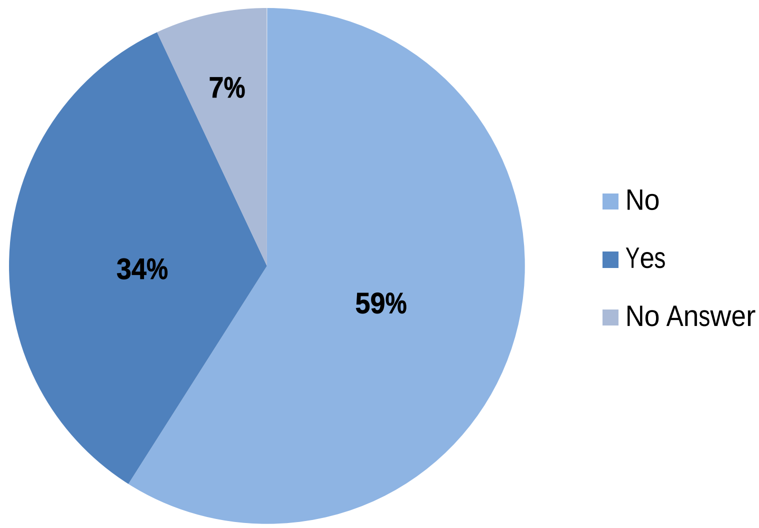
Question 3. Where do you most often apply sidewalk salt?



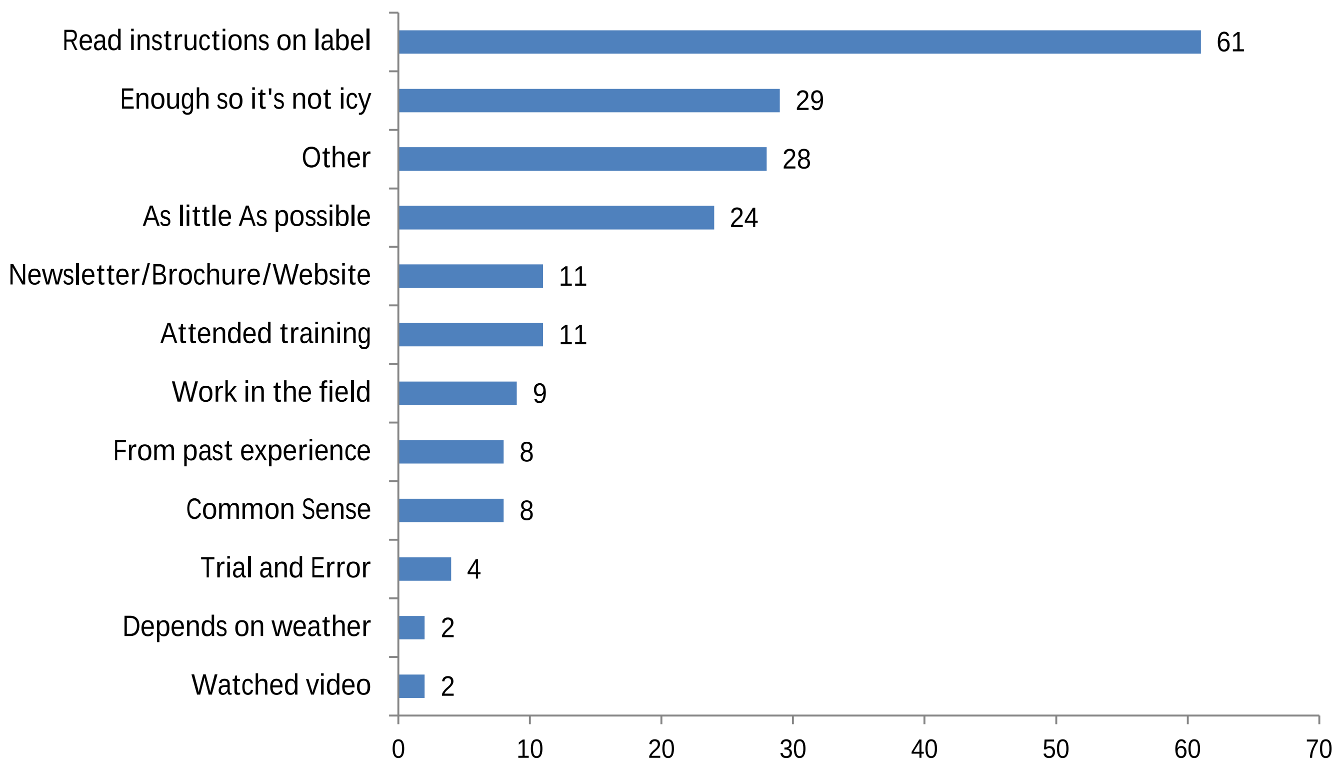
Question 4. How much sidewalk salt (lbs.) do you use in an average winter?



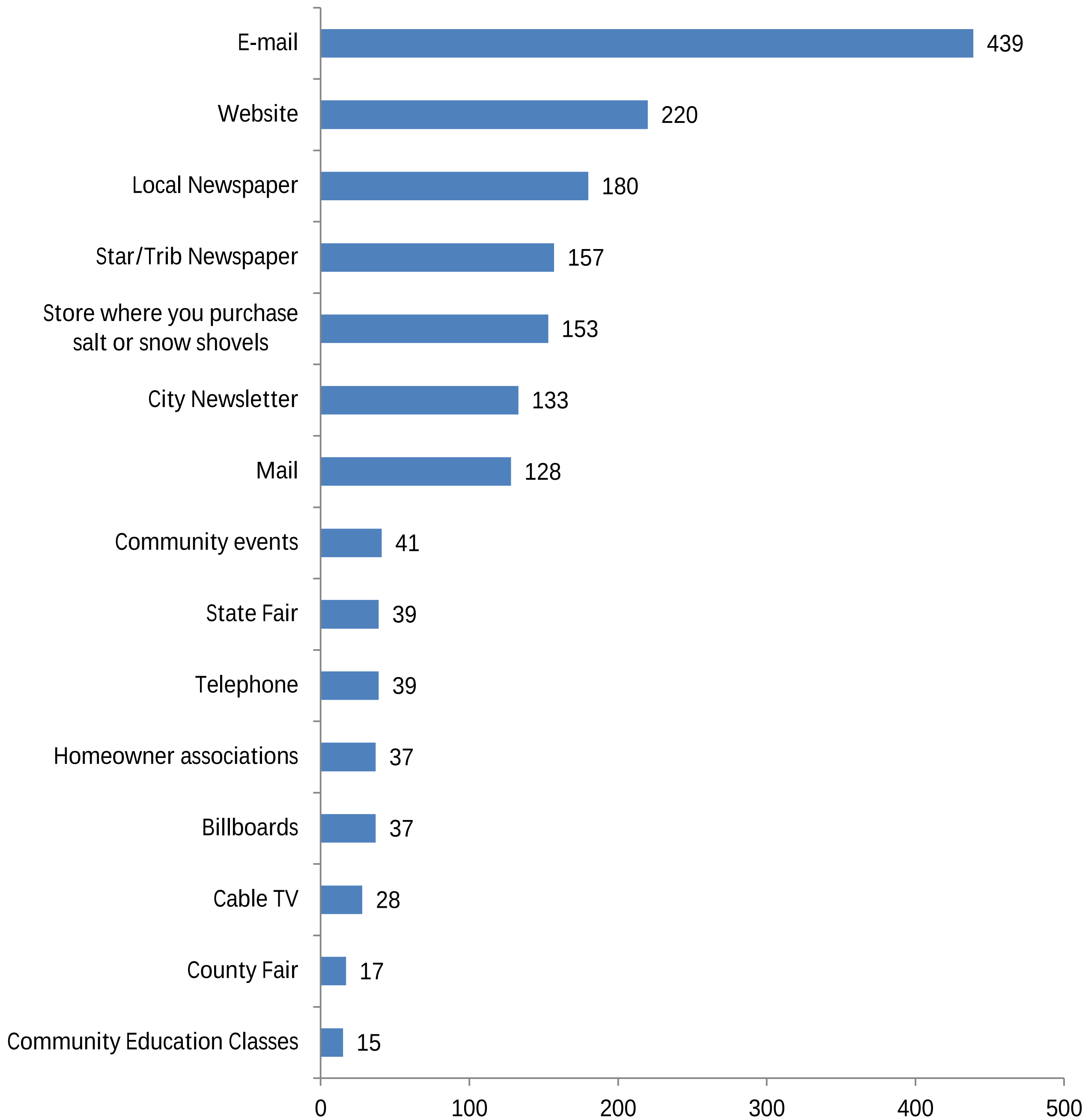
Question 5. Do you know how much sidewalk salt you should apply? (n = 754)



If yes, how do you know? (n=197)



Question 6. What are the best ways to get information to you?



Appendix D – Educational Resources

Table 1. Resources for Cities, Townships, Counties, and WMOs/WDs

Type of Resource	Title	Subject	Source
Brochure	Finding a balance: winter operations program	Winter performance goals, responsibilities, chemical information	MnDOT
Brochure	Snow happens	Snow ordinance operations and instructions for residents	City of Ankeny, IA www.ankenyiowa.gov
Brochure	The good, the bad, and the ugly	Advises public on proper winter and yard maintenance	MnDOT
Brochure	Don't pass the salt brochure	Includes information on salt in wastewater, and tips for homeowners	City of Farmington, MN fmtn.org/DocumentCenter/View/1190
Event	Freshwater Society's Annual Road Salt Symposium	Discussion on environmental impacts of road salt and innovations in transportation to reduce impacts	Freshwater Society freshwater.org/annual-road-salt-symposium-fights-chloride-pollution
Fact Sheet	Salt Affects our Water	How to prevent storm water pollution - for the public	City of Minneapolis www.minneapolismn.gov/publicworks/stormwater/
Fact Sheet	Chloride Usage Education and Reduction Program	Includes information on environmental concerns and alternatives to conventional road salting	Lower DuPage River Watershed Coalition www.dupagerivers.org/Chlorides.htm
Flier	More Salt: not always the cure for slippery roads	Includes information on temperatures where salt is most effective	Michigan DOT www.mi.gov/documents/mdot/MDOT_Salt_Cure_258508_7.pdf
Postcard	Get a Grip Postcard	Advises public to protect themselves from slips and falls	Smart About Salt www.smartaboutsalt.com/

Type of Resource	Title	Subject	Source
Postcard	Salt Pollutes Postcard	Includes winter maintenance tips for homeowners	MPCA www.pca.state.mn.us/programs/roadsalt.html
Resources: reports, manuals, videos	Various	Various	Local Road Research Board (LRRB) www.lrrb.org/
Resources: reports and technical summaries	Various	Various	MnDOT Research Services www.dot.state.mn.us/research/
Website	Reducing Road Salts Use	Comprehensive and integrated approach to road salt use	Riversides www.riversides.org/
Website	Road salt and water quality	Includes tips for homeowners, environmental concerns, educational resources, and training opportunities	MPCA www.pca.state.mn.us/r0pgb86
Website	Working to Advance Road Weather Information Systems Technology	Reports on winter maintenance projects	Aurora www.aurora-program.org/

Table 2. Resources for Winter Maintenance Professionals

Type of Resource	Title	Subject	Source
Clip Board Pages	Parking lot/sidewalk winter maintenance. Stickers for clipboards	Easy to reference highlights from Winter Maintenance for Parking Lots and Sidewalks training	MPCA www.pca.state.mn.us/programs/roadsalt.html
Event	Minnesota Fall Maintenance Expo	Exhibits, competitions, classes	Minnesota Fall Maintenance Expo mnfallexpo.com
Event	Minnesota Nursery and Landscape Association (MNLA) Snow Day	Tradeshow, seminars	MNLA www.mnla.biz
Event	Freshwater Society's Annual Road Salt Symposium	Discussion on environmental impacts of road salt and innovations in transportation to reduce impacts	Freshwater Society freshwater.org/annual-road-salt-symposium-fights-chloride-pollution
Event	Snow and Ice Symposium	Tradeshow, educational sessions on winter maintenance issues	Snow and Ice Management Association (SIMA) www.sima.org/show/schedule
Fact Sheet	Chloride Usage Education and Reduction Program	Includes information on environmental concerns and alternatives to conventional road salting	Lower DuPage River Watershed Coalition http://www.dupagerivers.org/Chlorides.htm
Handbook	Minnesota Snow and Ice Control Field Handbook for Snowplow Operators	Winter maintenance best practices for professionals	MPCA www.pca.state.mn.us/programs/roadsalt.html
Information Tools	City of Eagan Snow and Ice Control Policy for City Streets	Example city snow and ice control policy	City of Eagan www.pca.state.mn.us/index.php/view-document.html?gid=5501
Information Tools	Calibrating Manual Sanders	Instructions for calibrating manual sanders	MPCA www.pca.state.mn.us/index.php/view-document.html?gid=5495
Information Tools	Control Point Calibration	Instructions for control point calibration	MPCA www.pca.state.mn.us/index.php/view-document.html?gid=5493

Type of Resource	Title	Subject	Source
Information Tools	Field Guide for Testing Deicing Chemicals	Instructions for testing deicing chemicals	MnDOT www.dot.state.mn.us/maintenance/pdf/research/field-testing-deicers.pdf
Information Tools	Goodhue County Snow Removal Policy	Example snow removal policy	Goodhue County www.pca.state.mn.us/index.php/view-document.html?gid=5498
Information Tools	MnDOT Snowplow Salt and Sander Controller Calibration guide	Instructions for controller calibration	MnDOT www.dot.state.mn.us/maintenance/pdf/research/SaltSanderCalibrationGuide.pdf
Information Tools	Olmsted County Snow and Ice Removal Policy	Example snow and ice control policy	Olmsted County www.pca.state.mn.us/index.php/view-document.html?gid=5499
Information Tools	Open Loop Calibration	Instructions for open loop calibration	MPCA www.pca.state.mn.us/index.php/view-document.html?gid=5494
Information Tools	Scott County Snow Plow Route Book	Example snow plow route book	Scott County www.pca.state.mn.us/index.php/view-document.html?gid=5497
Manual	MnDOT Anti-icing Guide	What is anti-icing, why anti-ice, when to anti-ice, where to anti-ice, how to anti-ice	MnDOT www.dot.state.mn.us/maintenance/pdf/research/AntiIcingGuide8Full.pdf
Manual	Winter Parking Lot and Sidewalk Manual - Reducing Environmental Impacts of Chlorides	Winter maintenance best practices for professionals	MN LTAP www.mnltap.umn.edu/publications/handbooks/documents/snowice.pdf
Newsletter	Clear Roads newsletter	Winter maintenance news	Clear Roads clearroads.org

Type of Resource	Title	Subject	Source
Report	Salt Brine Blending to Optimize Deicing and Anti-Icing Performance	Evaluation of ice melt capacity and performance factors of deicers	MnDOT www.dot.state.mn.us/research/documents/201220.pdf
Resources: reports, manuals, videos	Various	Various	Local Road Research Board (LRRB) http://www.lrrb.org/
Resources: reports and technical summaries	Various	Various	MnDOT Research Services www.dot.state.mn.us/research/
Tools	Calibration Data Record	Template for calibration records	MPCA www.pca.state.mn.us/index.php/view-document.html?gid=5496
Tools	Local Government Snowplow Salt and Sander Controller Calibration Guide	Easy-to-use steps for calibrating snowplow sander controls	LRRB http://www.lrrb.org/pdf/2009RIC08.pdf
Training	Minnesota Circuit Training and Assistance Program (CTAP)	Training on deicers and anti-icing, application rates, costs, and storage	MN LTAP www.mnltap.umn.edu/about/programs/ctap
Training	Salt Solutions Program Maintenance Training	Winter maintenance training	MNDOT http://www.dot.state.mn.us/maintenance/training.html
Training	Snow and Ice Control Application (CTAP)	Deicing material choices, application rates, effectiveness	MN LTAP www.mnltap.umn.edu/about/programs/ctap/

Type of Resource	Title	Subject	Source
Training	Snowplow Salt and Sander Controller Calibration Hands-on Workshop (CTAP)	In person calibration assistance	MN LTAP www.mnltap.umn.edu/about/programs/ctap/
Training	Winter Parking Lot and Sidewalk Maintenance	Winter maintenance best practices for professionals	MPCA www.pca.state.mn.us/programs/roadsalt.html
Training	Winter Road Maintenance	Winter maintenance best practices for professionals	MPCA www.pca.state.mn.us/programs/roadsalt.html
Video	Small Site Winter Maintenance	Winter maintenance best practices for areas that are too small for motorized equipment	MWMO and UMN www.pca.state.mn.us/programs/roadsalt.html
Website	Minnesota Local Technical Assistance Program (LTAP)	Programs, training events, publications, design tools, technical topics	MN LTAP http://www.mnltap.umn.edu/
Website	MPCA Road salt education program	Training schedule, training materials, manuals, technical information, list of those certified	MPCA www.pca.state.mn.us/programs/roadsalt.html
Website	Reducing Salt Use While Keeping Streets Safe	Describes the winter maintenance practices of the city of Minnetonka	City of Minnetonka www.eminnetonka.com/snowplowing
Website	Reducing Road Salts Use	Comprehensive and integrated approach to road salt use	RiverSides www.riversides.org
Website	Snow and Ice Management Association (SIMA)	Includes winter maintenance resource, educational resources, and events	SIMA sima.org

Table 3. Resources for Educators and Citizens

Type of Resource	Title	Subject	Source
Brochure	Residential Snow and Ice Care	Brochure about smart snow removal practices for homeowners	Nine Mile Creek www.ninemilecreek.org
Brochure	Don't pass the salt brochure	Includes information on salt in wastewater, and tips for homeowners	City of Farmington, NM http://fmtn.org/DocumentCenter/View/1190
Brochure	Winter Maintenance: Choosing a deicer	Brochure about choosing a deicer	Nine Mile Creek www.ninemilecreek.org
Brochure	Winter Maintenance: Hiring a Snow Removal Service	Brochure about hiring a certified snow removal contractor	Nine Mile Creek www.ninemilecreek.org
Fact Sheet	Salt Affects our Water	How to prevent storm water pollution - for the public	City of Minneapolis www.minneapolismn.gov
Fact sheet	Winter maintenance for homeowners	Tips for homeowners on winter maintenance	MWMO www.mwmo.org/wintertrainings.html
Fact Sheet	Chloride Usage Education and Reduction Program	Factsheets for different audiences: mayors/managers, public works staff, commercial operators, homeowners	Lower DuPage River Watershed Coalition www.dupagerivers.org/Chlorides.htm
Flier	More Salt: not always the cure for slippery roads	Includes information on temperatures where salt is most effective	Michigan DOT www.mi.gov/documents/mdot/MDOT_Salt_Cure_258508_7.pdf
Information-Hiring a Certified Contractor	List of Certified Contractors	Road Salt Applicators Training Certificate Holders	MPCA http://www.pca.state.mn.us/index.php/view-document.html?gid=5489
Video	Training video for residents	Winter maintenance best practices for residents	MWMO and UMN www.pca.state.mn.us/r0pgb86

Type of Resource	Title	Subject	Source
Website	Road Salt: Can we have safe roads and healthy streams?	Information on road salt, alternatives, and environmental concerns	Lake Superior Duluth Streams www.lakesuperiorstreams.org/understanding/impact_salt.html
Website	Reducing Salt Use While Keeping Streets Safe	Describes the winter maintenance practices of the city of Minnetonka	www.eminnetonka.com/snowplowing
Website	Road salt and water quality	Includes tips for homeowners, environmental concerns, educational resources, and training opportunities	MPCA www.pca.state.mn.us/r0pgb86
Website	Smart About Salt: Winter Salt Management Program	Winter maintenance tips and information for homeowners	www.smartaboutsalt.com