Chlorides Workgroup

Recommendations on a Statewide Chloride Strategy

Report to Water Initiatives Steering Committee (WISC)

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Executive Summary and Recommendations

The Water Initiatives Steering Committee (WISC) is comprised of Wisconsin Department of Natural Resources staff drawn from the Division of External Services (Watershed Management), the Division of Environmental Management (Drinking Water and Groundwater, Water Resources, Wastewater, Office of Great Waters), and Regional Staff from the Office of the Secretary. The Committee is responsible for evaluating and directing the integrated efforts of field and central office staff on key surface water and groundwater quality activities.

The WISC chartered the Chloride Workgroup in April of 2021 to gain a better understanding of the chloride pollution problem statewide, identify available data for chlorides in Wisconsin, and gather data that did not already exist, with an end goal of developing a statewide strategy for chloride reduction. The group met monthly beginning in July 2021 and heard presentations from a number of professionals working on chlorides issues to help formulate recommendations. After hearing from these individuals and reviewing the data, the group developed a set of recommendations Wisconsin could pursue to address areas where water quality criteria (WQC) are not being met and to slow the increase of chlorides across the state.

Summary of Recommendations

There are many pieces to the puzzle of reducing chloride pollution; a single recommendation will not work alone. The workgroup's recommendations to mitigate the increase of chloride contamination in the state's surface and drinking water **include various efforts relating to education and training, regulatory and policy, monitoring, and financial support among various DNR programs and other state partnerships**. The recommendations are broken into the following categories:

DNR program implementation and partnerships. DNR programs include urban runoff, wastewater, drinking water and groundwater, water resources, community financial assistance, and sustainability and business support programs.

Sustainability and Business Support

1. Support a smart salting certification program for communities and businesses through the DNR's Sustainability and Business Support Program.

Urban Runoff and Wastewater

2. Develop and support salt reduction education programs among permitted Municipal Separated Storm Sewer Systems (MS4s) and Publicly Owned Treatment Works (POTWs) with chloride variances via the DNR's Urban Runoff and Wastewater Permit Programs.
3. Require permitted MS4s to report salt discharges as an illicit discharge.
4. Continue implementation of chloride WQBELs and WQS variances in wastewater WPDES permits.

Water Resources

5. Develop a Total Maximum Daily Load (TMDL) for chloride.
6. Update the chloride surface water quality criteria for the state.

Drinking Water and Groundwater

7. Incorporate additional drinking water requirements for chloride and sodium.

Community Financial Assistance

8. Offer State Revolving Loan Funds (SRF) to cover the costs to acquire brining equipment and outreach programs.

Agency-wide/Multi-program

9. Rebate programs for communities that have high water softener use.
10. Develop a partnership with U.S. Environmental Protection Agency (EPA) in reversing the trends in chloride levels.

State facilities and maintenance management. State facilities includes operations at state-owned and operated facilities, which incorporates efforts to be facilitated by the Department of Administration and DNR facility and lands, and parks staff.

11. For state-owned properties, have contractors and individuals conducting winter property maintenance take winter maintenance training and implement salt reduction strategies.
12. Reduce water softening salt use at state owned and operated facilities.

Governor's office and legislative initiatives. Legal reform includes providing limited liability security to private businesses, and open up resource sharing among private-public partnerships.

13. Legislation to reduce slip and fall claim liability for businesses where salt applicators have completed smart salting certification.
14. Update statutes to allow private entities to take advantage of municipal resources for brining.
15. Promote opportunities for private contractors to unload salt and have it stored at a permitted facility (e.g., municipality, county, state) to prevent overuse in the spring.
16. Adopt the recommendations of the Upper Mississippi River Basin Association (UMRBA) resolution to reduce chlorides inputs into the basin.

1. Introduction

In Spring 2021, Laura Dietrich, Water Quality Standards Variance Coordinator, and Suzy (Limberg) Hasheider, Municipal Storm Water Program Coordinator, both DNR liaisons with the Wisconsin Salt Wise Organization, approached the Water Initiatives Steering Committee (WISC) in the interest of chartering a workgroup to better facilitate cross-program coordination on the topic of chlorides across the state of Wisconsin. WISC chartered the Chloride Workgroup in April of 2021. The group met monthly beginning in July 2021. At the first meeting, the group developed a set of action items that included gaining a better understanding of the chloride pollution problem statewide, identifying existing chloride data in Wisconsin, and gathering data that did not already exist, with an end goal of developing a statewide strategy for chloride reduction.

The group heard presentations from a number of professionals working on chloride issues including:

- Shawn Giblin, Office of Great Waters, Mississippi River and La Crosse County chloride study
- Laura Herrick, Southeast Wisconsin Regional Planning Commission's chloride study
- Jim Hughes, Wisconsin DOT, information on DOT efforts to reduce salt use
- Kevin Kirsch, Water Quality, Water Evaluation section, information from long term trend monitoring sites
- Allison Madison, Sustainability and Development Coordinator of Wisconsin Salt Wise, spearheads statewide collaboration around salt reduction
- Stephen McCracken, DuPage River Salt Creek (IL) Workgroup, chloride reduction efforts
- Lexi Passante, UW-Milwaukee School of Freshwater Sciences, research on salt-loving bacteria in southeastern Wisconsin tributaries as potential biological indicators of chloride pollution
- Sophie Hammond, University of Wisconsin-Wisconsin DNR work study, analysis of Municipal Separate Storm Sewer System (MS4) permittees' annual report data for winter maintenance product usage and rates

The 2022 303(d) Impairments list includes 50 rivers and one lake in Wisconsin that exceed the state's 395 mg/L chronic water quality criteria (WQC). To put the magnitude of this concentration into perspective, unimpacted waters of the state historically have been recorded to be less than 5 mg/L of chloride. With use of chloride-based products like road salts still on the rise in snowy climates (Pecher, et al. 2019), it is imperative for the state of Wisconsin to be at the forefront and help lead chloride reduction efforts to slow salinization and keep freshwaters safe for wildlife and human consumption.

Exhibiting a similar rising trend like chloride, elevated sodium concentrations in surface and groundwater is also becoming problematic. Most deicing salts are typically applied as sodium chloride, resulting in elevated sodium in addition to chloride. Unlike chloride, sodium can bind to soil and sediments in the environment. Because of this, sodium can also displace heavy metals that were once inert, threatening groundwater supply (Schuler and Relyea 2018). Present EPA guidance states that individuals on salt restricted diets should not drink water with sodium concentration >20 mg/L (US EPA 2003). Currently, many wells throughout the state are above this level with many more at risk of exceeding this level in the coming years.

The workgroup's objective is to foster cross program coordination of chloride reduction efforts, which include developing an efficient way to share resources across DNR programs, data baselines, and define an agency Chloride Reduction Strategy collectively.

2. Chloride in Wisconsin's Surface Waters

Natural background levels of chloride are driven by the weathering of rock and change slowly over a large timeframe in unimpacted freshwaters. Salinization occurs when mineral salts, dominated by chloride, are loaded to surface waters. The salinization of freshwater has become a major ecological problem in recent decades due to human activities that add salts to the environment.

Freshwater organisms can differ widely in the level of salinity they can tolerate. Many species of fish, invertebrates, plants and amphibians are highly sensitive to elevated chloride concentrations (Kefford, et al. 2016). Elevated chloride concentrations can lead to an overall reduction of ecological integrity and biodiversity in aquatic ecosystems (Canedo-Arguelles, et al. 2013). Currently, thousands of North American rivers and lakes are at significant risk for salinization over the long term (Dugan, et al. 2017; Kaushal, et al. 2018). More recently, it has been estimated about 1 million metric tons of chloride are entering Lake Michigan on an annual basis (Dugan, et al. 2021).

The pace of freshwater salinization has resulted in increased attention directed toward chloride in recent years. The term "freshwater salinization syndrome" has become common in scientific literature and is used to describe a suite of symptoms that range from ecosystem degradation to infrastructure corrosion (Kaushal, et al. 2018). Corrosion related to elevated chloride can result in corrosion of lead and copper drinking water lines creating contaminated drinking water (Stets, et al. 2018). Elevated chloride has also been shown to interfere with lake mixing and turnover processes (Novotny, et al. 2008). Very high chloride concentration has been shown to result in reduced zooplankton abundance, causing a trophic cascade that results in elevated phytoplankton abundance (Jones, et al. 2017). Furthermore, excessive use of salt has been linked to groundwater contamination (Kincaid and Findlay, 2009). Other work has pointed to the inadequacy of current regulations to protect freshwater ecosystems from salinization and its negative consequences (Schuler, et al. 2019).

Chloride in Wisconsin surface waters continues to increase on an annual basis. All 43 of the DNR's Long Term Trend (LTT) river monitoring sites are indicating increasing chloride concentrations. Most sites are indicating a 1-4% annual increase in chloride, with some sites increasing >10% annually. This is consistent with trends in the northern United States that have indicated a doubling of chloride concentration in recent decades (Corsi, et al. 2015).

Wisconsin has chloride surface water quality criteria (WQC) that are set to protect aquatic life from chronic (long-term) and acute (short-term) toxicity. The Wisconsin criteria for chronic toxicity is 395 mg/L and 757 mg/L for acute toxicity. Chloride accounts for 3% of impaired water pollutant listings in Wisconsin. More than half of the existing impaired waters listings for chloride were added in the 2016 and 2018 reporting cycles and are located in the Milwaukee area. A waterbody is considered impaired for chronic toxicity if a 4-day average of the daily maximum values taken from 4 consecutive days exceeds the 395 mg/l chronic WQC more than once in a 3-year period. For acute toxicity, a waterbody is considered impaired if the daily maximum exceeds the 757 mg/l acute WQC more than once in a three-year period. In southeastern Wisconsin, 11 different watersheds monitored were found to have 55% of

the sites exceeding the acute criteria and 100% exceeding the chronic criteria for chloride (Corsi, et al. 2010).

Chloride is a conservative contaminant, meaning it has a free-flowing ability to move between the water column and groundwater with no feasible option to remove it once exposed in the environment. Chloride budgets developed for states in the northern United States typically list winter de-icing salts as the major source of chloride, followed by potassium chloride fertilizer use and water softening equipment (Overbo, et al. 2019). Urban environments have been linked to increased chloride concentration due to the increase in impervious surfaces in urban settings and the use of deicing salts on those surfaces (Corsi, et al. 2015).

Chloride levels in surface water may be assessed at any time during the year because the aquatic community may be detrimentally impacted regardless of season; however, levels tend to be highest during and after snowmelt. It is becoming clear that the current pattern in road salt usage is unsustainable and there is a strong desire for communities in Wisconsin to act before more surface waters become impaired due to high chloride levels.

2.1 Data Trends in Western Wisconsin

The DNR's Shawn Giblin and Jeremy King recently conducted a study of the state of chlorides in La Crosse County, Wisconsin. Water samples were collected at 20 water sites within La Crosse County, which is situated on the banks of the Mississippi River. Samples were collected quarterly in July 2020, October 2020, January 2021 and April 2021. Two additional sampling events occurred during the winter months and were timed to coincide with days above freezing to document melt of accumulated snow. The February melt off sampling event occurred during a period of significant snowmelt while the early-March sampling event occurred during a period when snowpack prior to the thaw was minimal. All 6 sampling events were analyzed for chloride, while the July and January quarterly samples were also analyzed for sodium to develop a relationship between chloride and sodium (**Figure 1**).

Monthly data from the Wisconsin DNR LTT river monitoring site on the Mississippi River at Lock and Dam 9 (Lynxville, WI) were also analyzed. Data were analyzed using linear regression and Mann-Whitney Rank Sum tests to assess chloride seasonality and trends at this site from 1982-2020 (**Figures 2 and 3**).

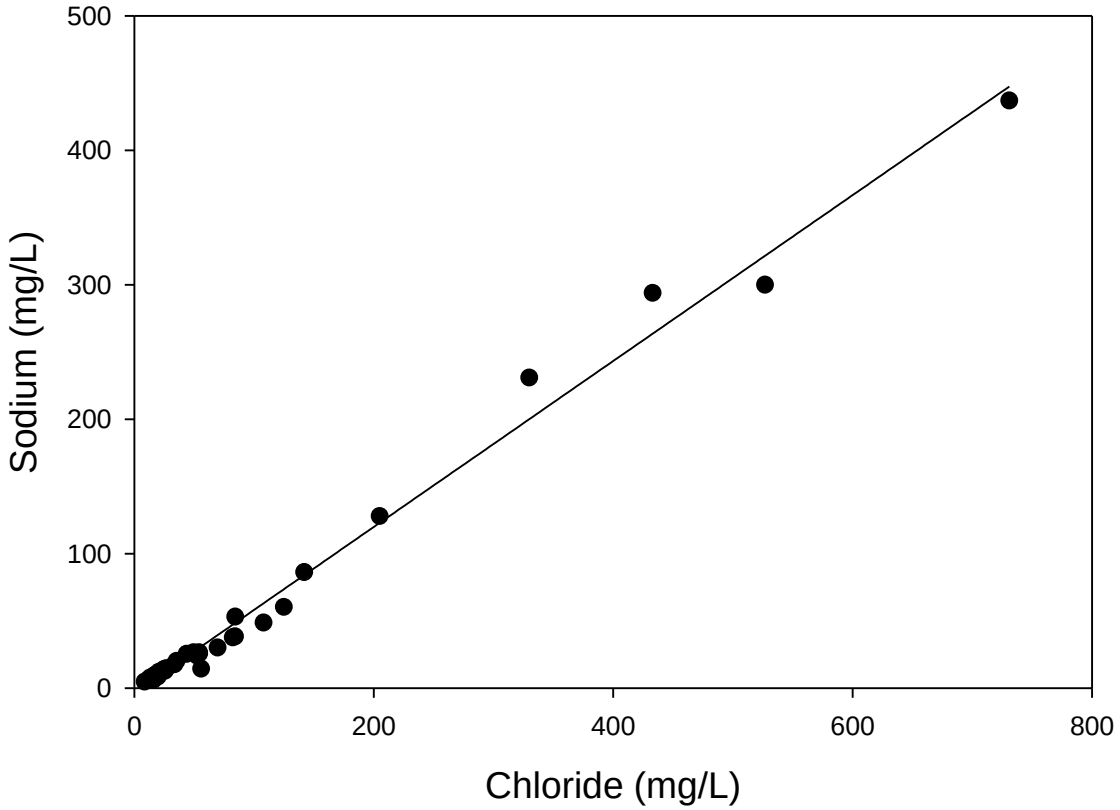


Figure 1. Relationship between chloride and sodium during the July 2020 and January 2021 sampling events (r^2= 0.9898)

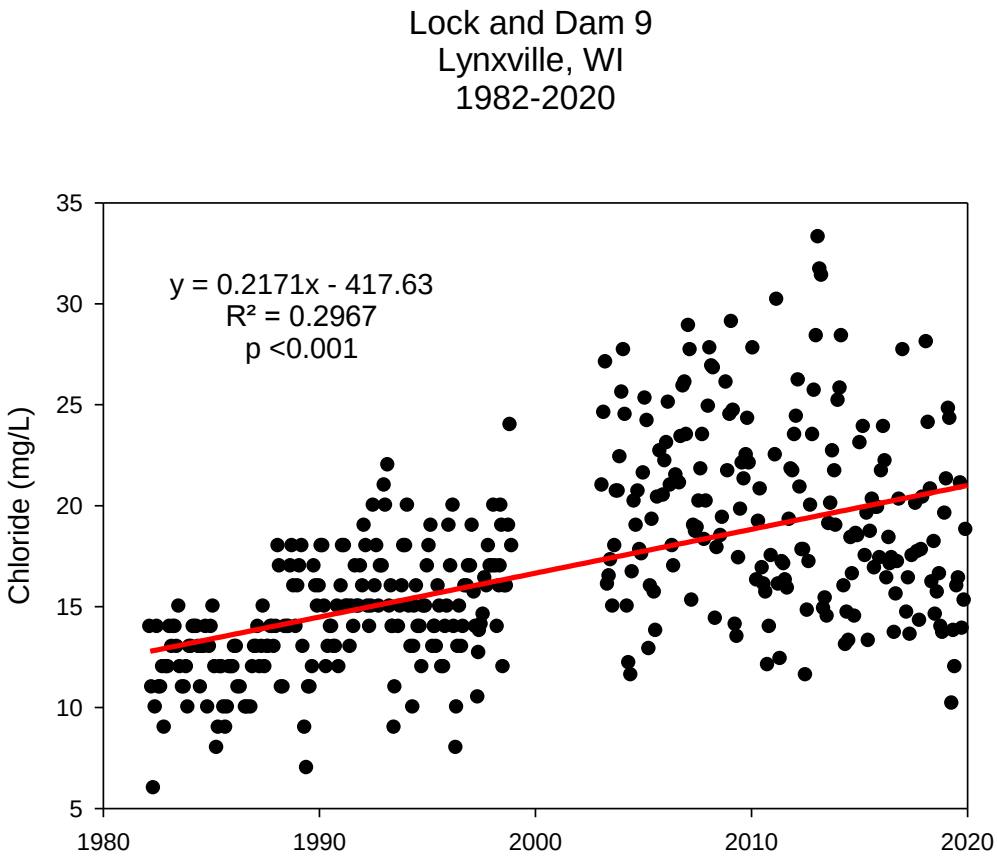


Figure 2. Chloride data from 1982-2020 collected at the Mississippi River Long Term River Monitoring site at Lynxville, WI. The red line is the linear regression result for the time period. Regression statistics and level of significance are presented.

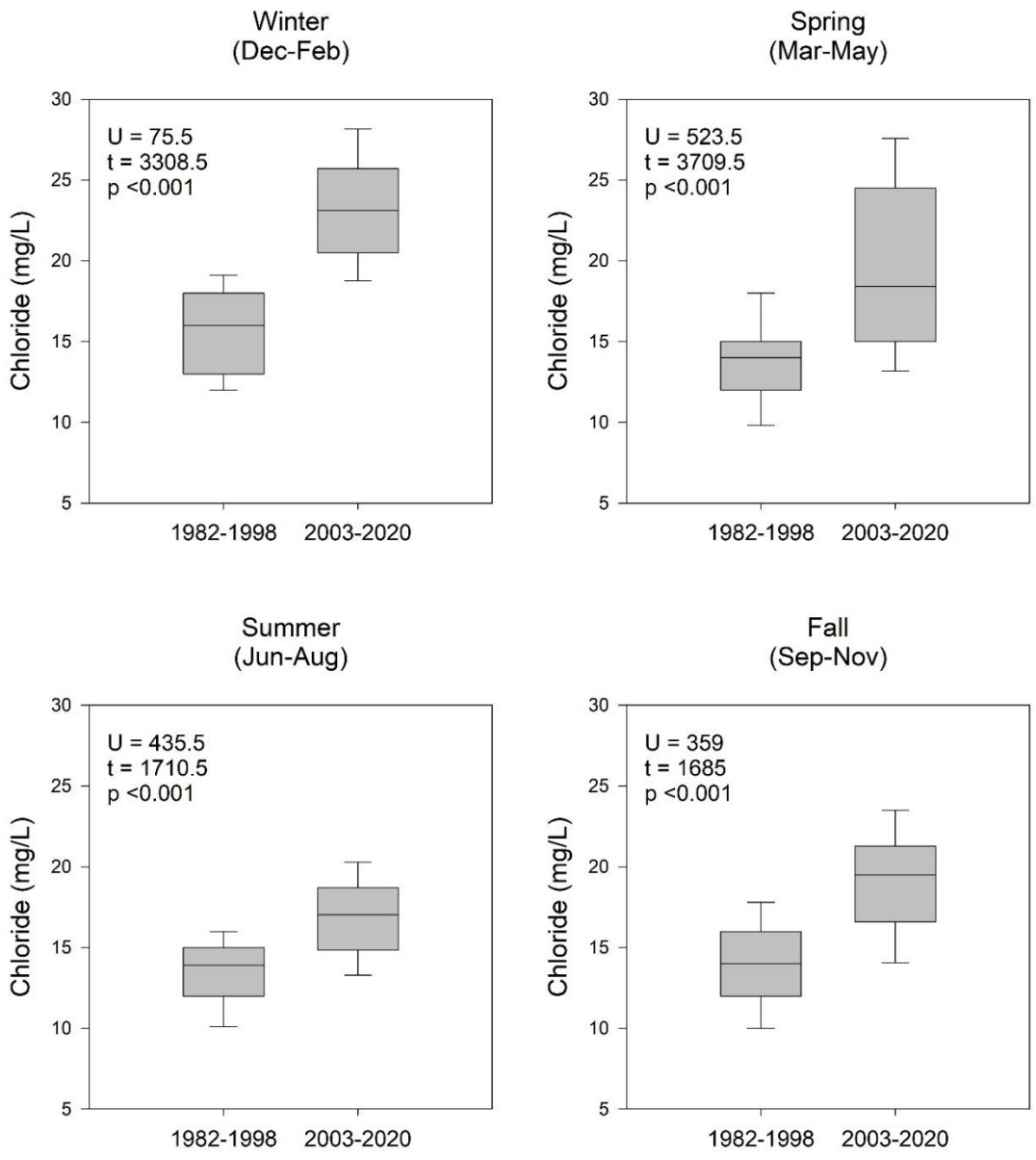


Figure 3. Chloride concentration by season at Lock and Dam 9 during the 1982-1998 and 2003-2020 time periods. The Mann-Whitney rank sum test statistics are presented for each season. Boxplots represent the 10th, 25th, 50th, 75th and 90th percentiles.

Chloride samples collected quarterly within La Crosse County indicated the highest concentrations during winter, followed by spring, fall and summer (**Figure 4**). Although EPA's chronic WQC (230 mg/L) does not apply to inland waters in the state of Wisconsin, chloride concentrations exceeding this chronic toxicity criteria were common during the winter months and to a lesser degree during spring. Sodium samples were higher during January than July with frequent exceedances of US EPA recommended drinking water recommendation for people on salt restricted diets (< 20 mg/L).

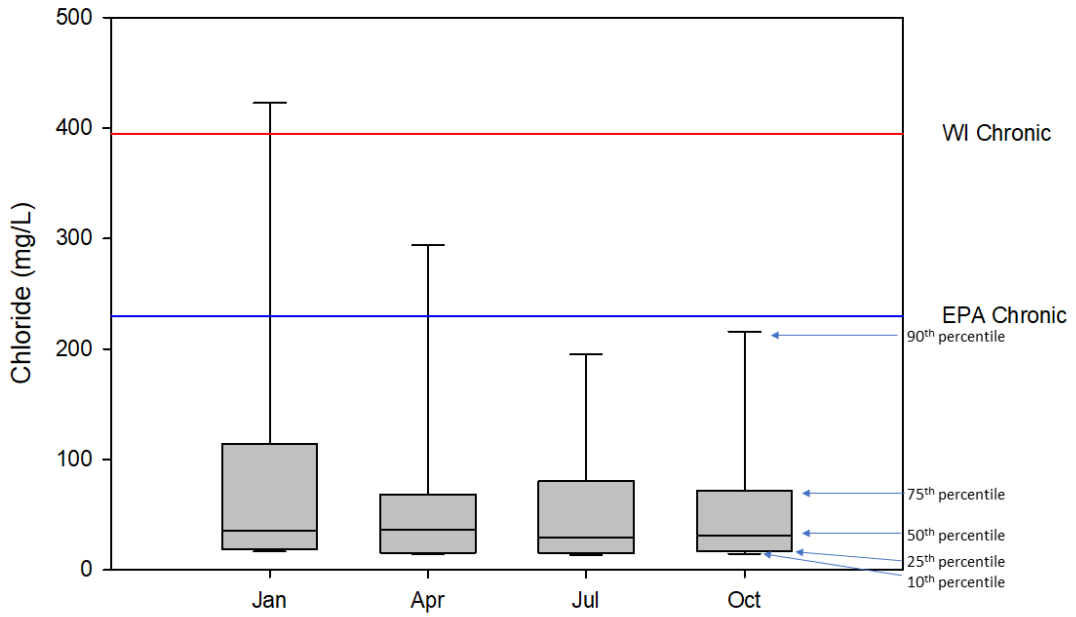


Figure 4. Quarterly La Crosse County chloride data from 2020-2021. Boxplots represent the 10th, 25th, 50th, 75th and 90th percentiles. The red and blue lines represent the Wisconsin (395 mg/l) and US EPA (230 mg/L) chronic toxicity values.

Analysis of the quarterly chloride data revealed a wide range of concentrations throughout the county with numerous exceedances of WI and USEPA chronic toxicity WQC. Quarterly sodium data revealed a similarly wide range of conditions throughout the county.

Winter chloride data also revealed a wide range of concentrations throughout the county with numerous exceedances of WI and USEPA chronic and acute toxicity WQC (**Figure 5**). Of these three winter sampling events, two were designed to capture melt off events resulting in values that are likely higher than typical winter conditions. Of the 120 total study samples from all six sampling events:

- 10.83% exceeded US EPA chronic toxicity criteria (> 230 mg/L)
- 7.5% exceeded Wisconsin chronic toxicity criteria (> 395 mg/L)
- 3.33% exceeded Wisconsin acute toxicity criteria (> 757 mg/L)
- 3.33% exceeded US EPA acute toxicity criteria (> 860 mg/L)

All four of the study samples greater than the WI acute toxicity criteria were collected during the winter months and were located near storm water outfalls.

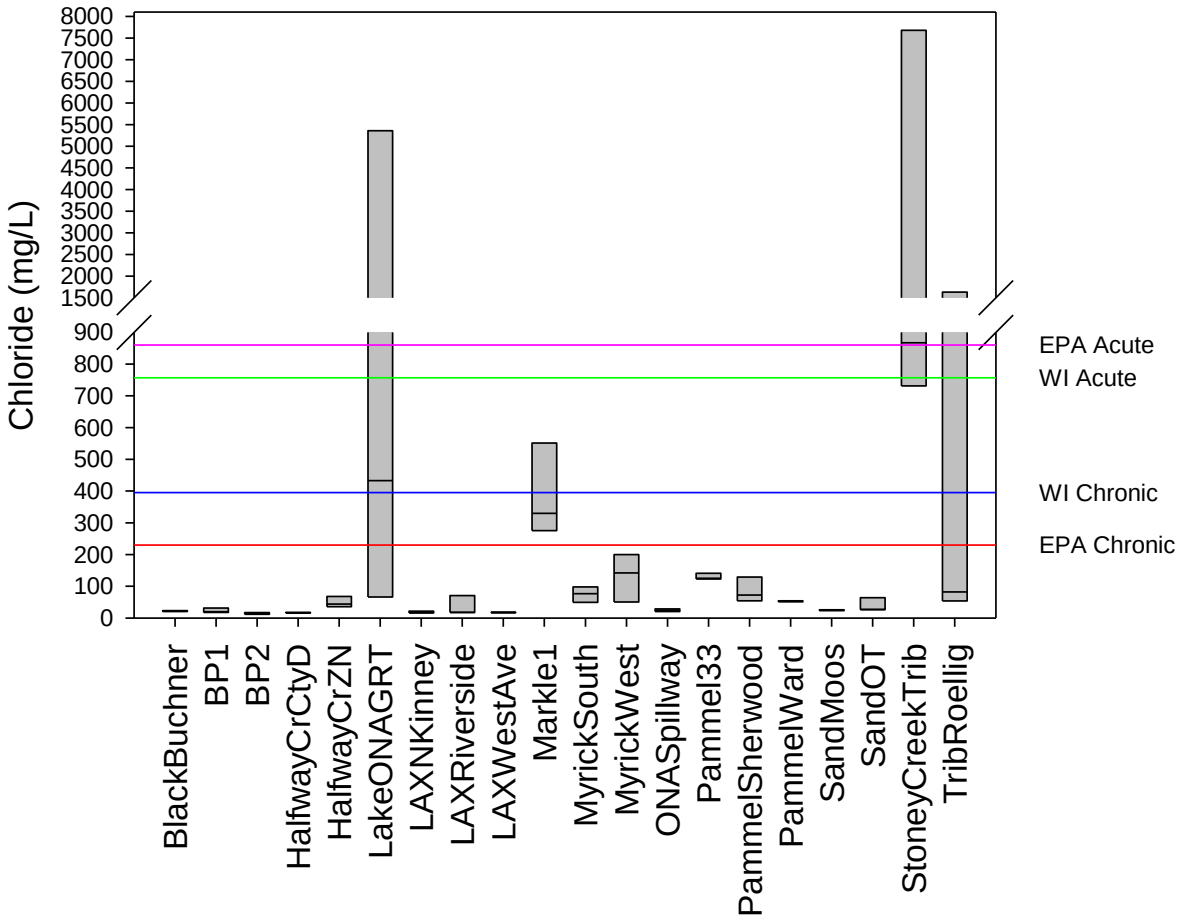


Figure 5. Winter La Crosse County chloride data from 2021. Boxplots represent the 25th, 50th and 75th percentiles. The lines represent the Wisconsin (395 and 757 mg/l) and US EPA (230 and 860 mg/L) chronic and acute toxicity values.

A statistically significant relationship between the total percentage of developed land and quarterly median chloride concentration was observed. A stronger relationship was observed between the total percentage of developed land and winter median chloride concentration. The strong winter relationship highlights winter deicing salt as a dominant source of chloride to surface waters within La Crosse County.

The data from this study highlight the degree to which La Crosse County, and Wisconsin in general, is on an unsustainable path regarding chloride use. Many sites routinely exceed water quality criteria put forth by Wisconsin and USEPA. This is notable when considering that La Crosse County is only a partially urban county, with the mid-sized city of La Crosse (pop. 52,000) as its main population center. It is also important to note that many of the watersheds from this study are tied into regional wastewater plants. Therefore, a sizeable fraction of human salt additions via water-softening equipment aren't fully captured in these results. Actions will need to be taken to reduce chloride concentration statewide and

within waters of the county to prevent the addition of waters to the DNR's Impaired Waters listing in the coming years.

2.2 Data Trends in Southeastern Wisconsin

The Department's Elexius (Lexi) Passante, a previous graduate student from University of Wisconsin Milwaukee – School of Freshwater Sciences, conducted chloride pollution research in southeastern Wisconsin (i.e., Passante, et al. 2022). A total of seven riverine study sites were selected in the Milwaukee River Basin using surface water chloride monitoring data from the Milwaukee Metropolitan Sewerage District (MMSD) (**Table 1**). Surface water grab samples and sediment were collected monthly during Feburary – September 2021 and January – Feburary 2022 and chloride was measured in surface water and sediment pore water. In addition to chloride measurements, real-time specific conductance monitors (Southeast Wisconsin Regional Planning Commission (SEWRPC) or MMSD) were present upstream of each sampling site where data could be obtained.

This research also investigated an unorthodox way of measuring chloride pollution through the use of bacteria to serve as a biological indicator. A biological indicator is different than the use of abiotic parameters (e.g., chloride or specific conductance) because it is an integrative response that could be used as a longer-term measurement to help understand the quickly changing environment in freshwater systems (Passante, et al. 2022). This study investigated two different methods, using the presence of salt-loving bacteria (i.e., halophiles) and salt-tolerant bacteria in the sediments. Two other notable studies have documented salt-loving bacteria in environmental samples located in snowy climates with speculations that their presence was due to chloride pollution (Pecher, et al. 2019; Tiquia, et al. 2007). Salt-loving bacteria are halophiles that are traditionally found in extreme saline conditions like the oceans or the Great Salt Lake in Utah, where they use the salt available for survival. Salt-loving bacteria utilize the salt present in the environment for cellular activities, whereas salt-tolerant bacteria do not necessarily thrive in salty conditions but can withstand high salt concentrations for long periods of time. A good example of the use of bacterial indicators in the environment is the analysis of *E. coli* to determine beach water quality from a public health standpoint.

In this particular southeastern Wisconsin study Passante, et al. (2022) were able to use a relatively inexpensive microbiology technique to count how many salt-loving and salt-tolerant bacteria were present in the study site sediment samples. Another alternative microbiology measure was developed to specifically quantify only salt-loving bacteria using molecular equipment.

Table 1. Study site information obtained and modified from Passante, et al. (2022). The maximum chloride concentration observed from MMSD's sampling 2018 – 2020 period to show previous concentrations that have been measured at these riverine sites.

Site	Site abbreviation	Type	Urban land coverage (%)[1]	Near MMSD monitoring site[2]	Maximum chloride concentration
Honey Creek	HC	Urban	84	HC-03	3/8/2018
					1500 mg/L
Kinnickinnic River	KK	Urban	80.5	RI-33	2/21/2019
					2700 mg/L
Root River	RR	Urban	92.5	RR-02	11/29/2018
					1100 mg/L
Underwood Creek	UC	Urban	100	UC-04	11/7/2019
					1800 mg/L
Underwood Creek downstream	UC2	Urban	100	UC-06	11/7/2019
					770 mg/L
Cedar Creek	CC	Rural	26	CC-01	8/6/2018
					110 mg/L
Menomonee River	MN	Rural	33.5	RI-16	8/6/2018
					190 mg/L

[1] In 1 km^2 radius around site

[2] Data obtained from the National Water Quality Monitoring Council, The Water Quality Portal (WQP)

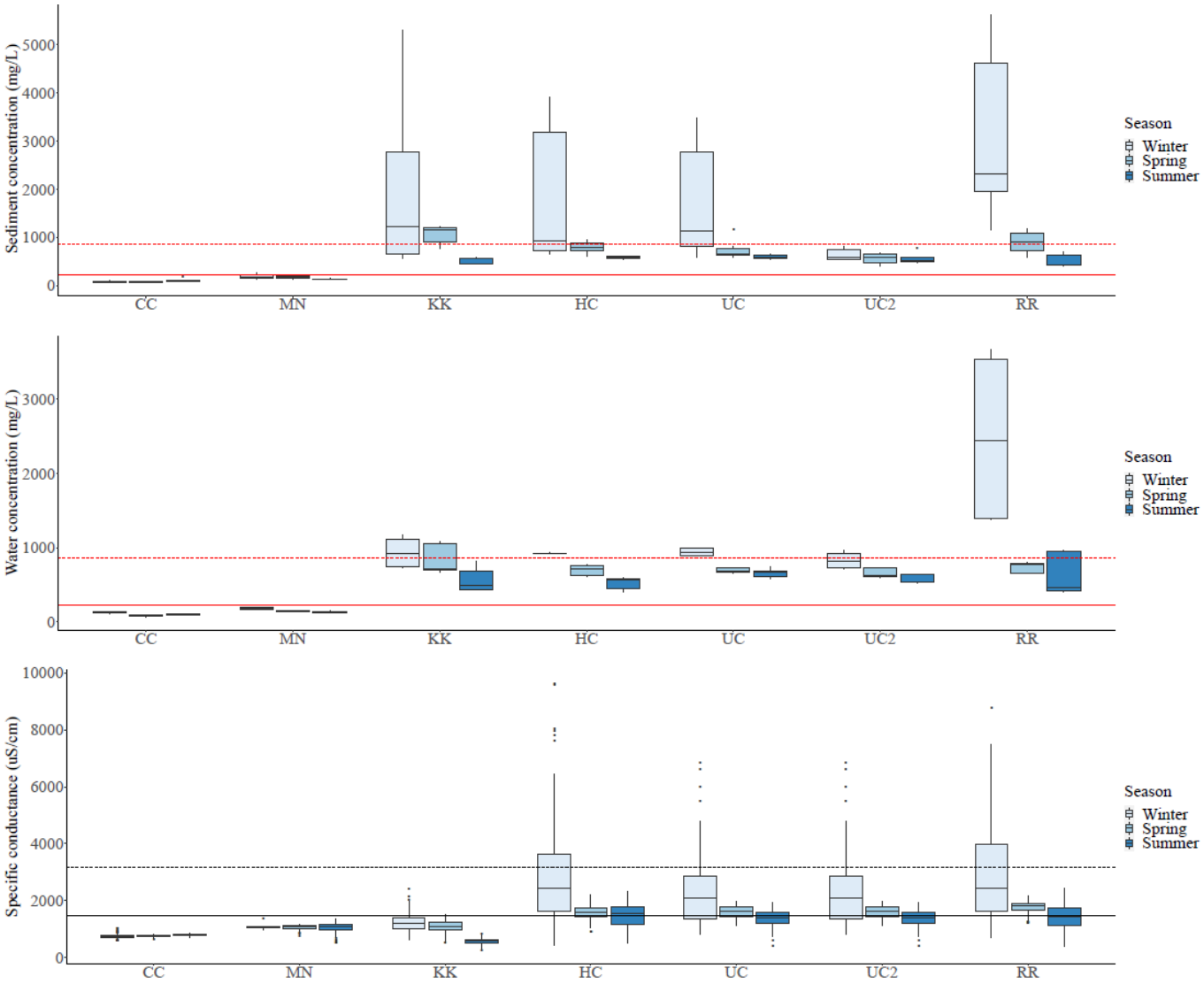


Figure 6. Obtained from Passante, el al. (2022). Sediment pore water chloride concentration (top), surface water chloride concentration (middle), and real-time specific conductance (bottom) at seven sampling sites in southeastern Wisconsin across seasons. Real-time specifc conductance was collected from MMSD and Southeastern Regional Planning Comission stations. Red solid and dashed line represent EPA's chronic and acute toxicity standards. Black solid and dashed lines are estimates of the toxicity standards using Corsi, et al. (2010) regression relationship.

Passante, et al. (2022) results show both sediment pore water and surface water chloride concentrations are much higher in the winter season at the urban sites (KK, HC, UC, UC2, and RR), and return to baseline conditions in spring and summer (**Figure 6**). High chloride concentrations during the winter are indicative of chloride pollution from road salts. Passante, et al. (2022) findings also show that the rural sites (CC and MN) are just below the EPA's chronic toxicity standard, and overall remain steady throughout seasons. The opposite observations are made at the urban sites, where they continue to exceed the chronic toxicity standard throughout the seasons, with some hovering above the acute toxicity standard in some instantances. In additon, this study found that sediment pore water chloride

concentrations were significantly higher than the surface water grab samples (p-value < 0.0001) (Passante, et al. 2022).

From a bacterial standpoint, this research found that there was a significant difference in salt-loving and salt-tolerant bacteria in urban site sediments compared to rural sites (p-value < 0.0001) (Passante, et al. 2022). More specifically, the urban sites were significantly higher in bacteria abundance during the winter (p-value = 0.024) and spring (p-value = 0.005) when chloride concentrations were also highest when compared to the rural sites sediment. Passante, et al. (2022) hypothesizes that urban sites had higher salt-loving and salt-tolerant bacteria populations due to the heavy influence of storm water outfalls that carry road salt runoff in winter and spring. This research is the first of its kind to document salt-loving bacteria in a Lake Michigan drainage basin and ulitimately lays the foundation to look at chloride pollution through a different lens with the use of a biological indicator rather than the single use of instanteaous measurements (e.g., surface water grab sample to measure chloride).

2.3 Statewide Data Trends

An overall statewide chloride trend for the time period of 1961 – 2020 appears to be increasing (**Figure 7**). However, there are some trends in specific areas of the state that suggest decreases between 2010 – 2020. These potential decreases could likely be linked to winter weather patterns in the last decade or the use of a smaller dataset when observing longer-term trends. Although there are apparent localized areas of decrease, most areas of the state have shown increasing chloride over the past decade.

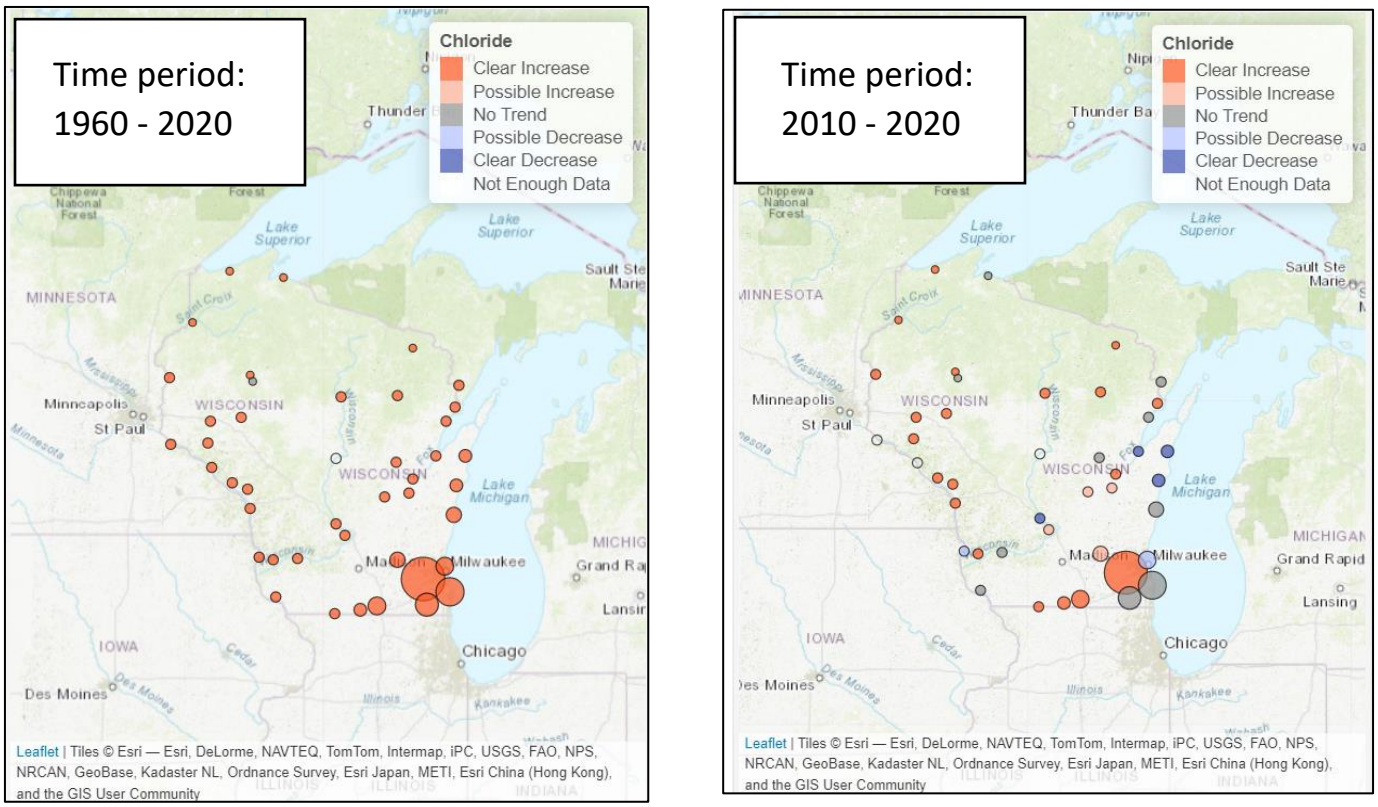


Figure 7. Statewide chloride trend at long-term trend river water quality sites of two time periods from 1961-2020 and 2010 - 2020. Images retrieved from shinyapps.io; [WI LTT Rivers (shinyapps.io).]

Also notable are the chloride hotspots that exist in southeastern Wisconsin (**Figure 8**). The United States Census Bureau's 2010 Wisconsin census demonstrates that the southeastern region contains the greatest population density of people per square mile. Larger population means more urbanization, resulting in more impervious surfaces where receiving streams, rivers and lakes are more prone to storm water pollution.

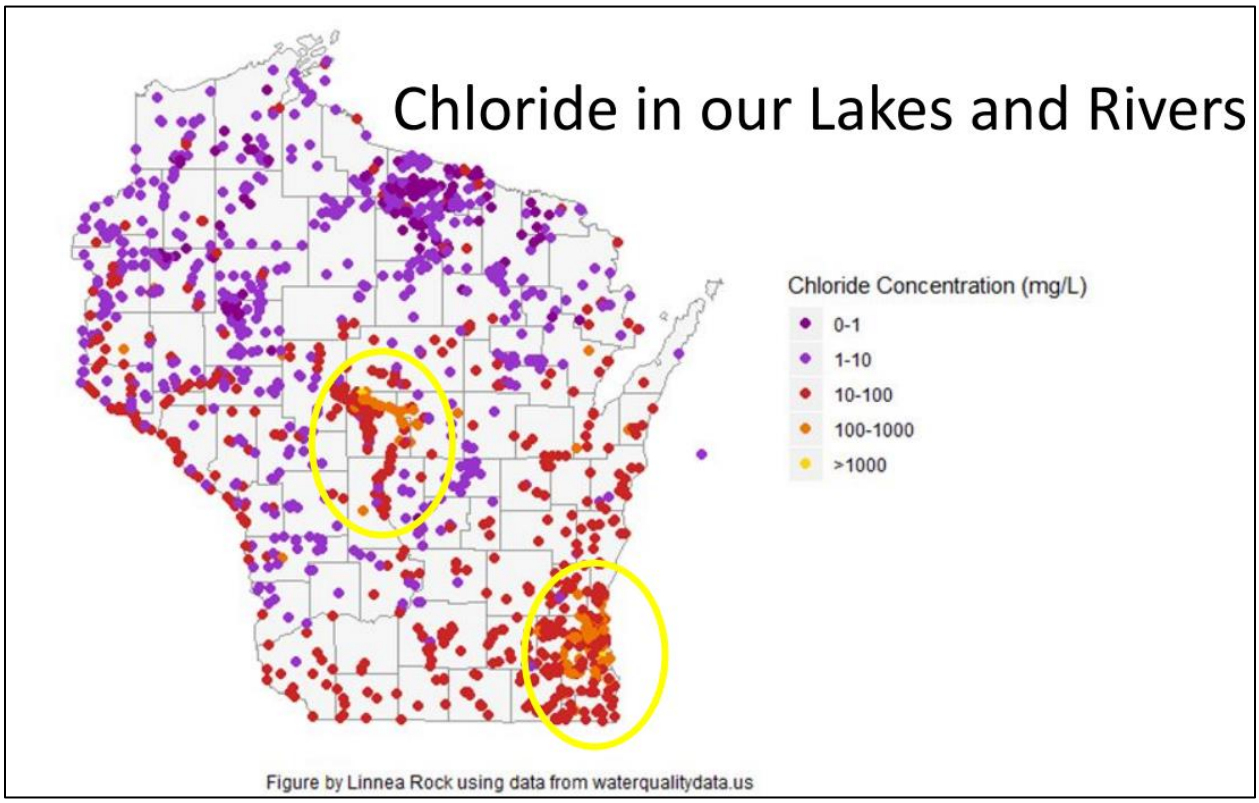


Figure 8. Surface water quality data showing the chloride concentration that was observed throughout the state of Wisconsin.

Waterbodies in different regions of Wisconsin were also selected from the long term trend sites to show long-term increasing trends of chloride. In the Fox River at Waukesha, there is an observable steady upward trend (**Figure 9**), with concentrations above the EPA's chronic toxicity standard beginning in the early 2000s. However, the Manitowoc River at Manitowoc is showing a downward trend starting around 2005 (**Figure 10**). To better understand this decreasing trend, it would be useful to know if communities within the Manitowoc River watershed have been implementing best management practices (BMPs) specifically to lower chlorides or if there are other changes within the watershed that are leading to a decline.

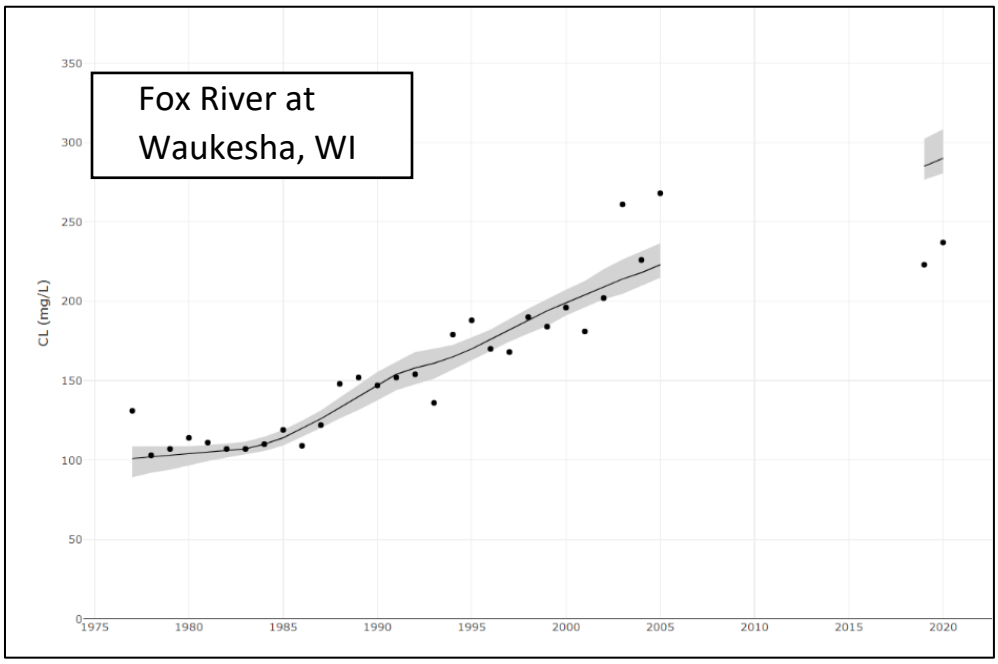


Figure 9. The Fox River located in southeastern Wisconsin long-term chloride trends. Image retrieved and modified from shinyapps.io.

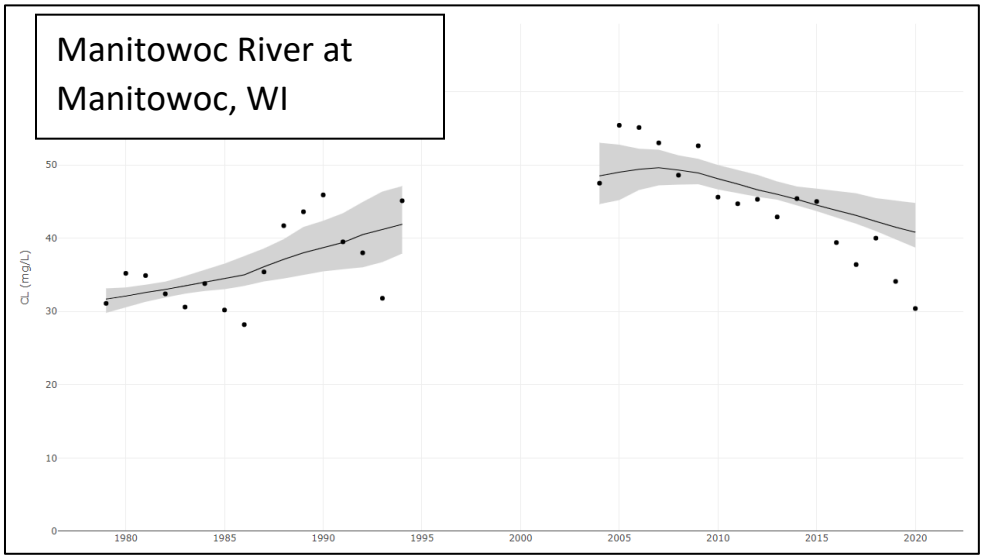


Figure 10. The Manitowoc River located in northeastern Wisconsin long-term chloride trends. Image retrieved and modified from shinyapps.io.

In western Wisconsin, the Chippewa River located in Durand, Wisconsin, follows an upward trend (**Figure 11**). An increasing trend is observed, but it should be noted that chloride concentrations are not nearly as high as the Fox River, located in the southeastern region.

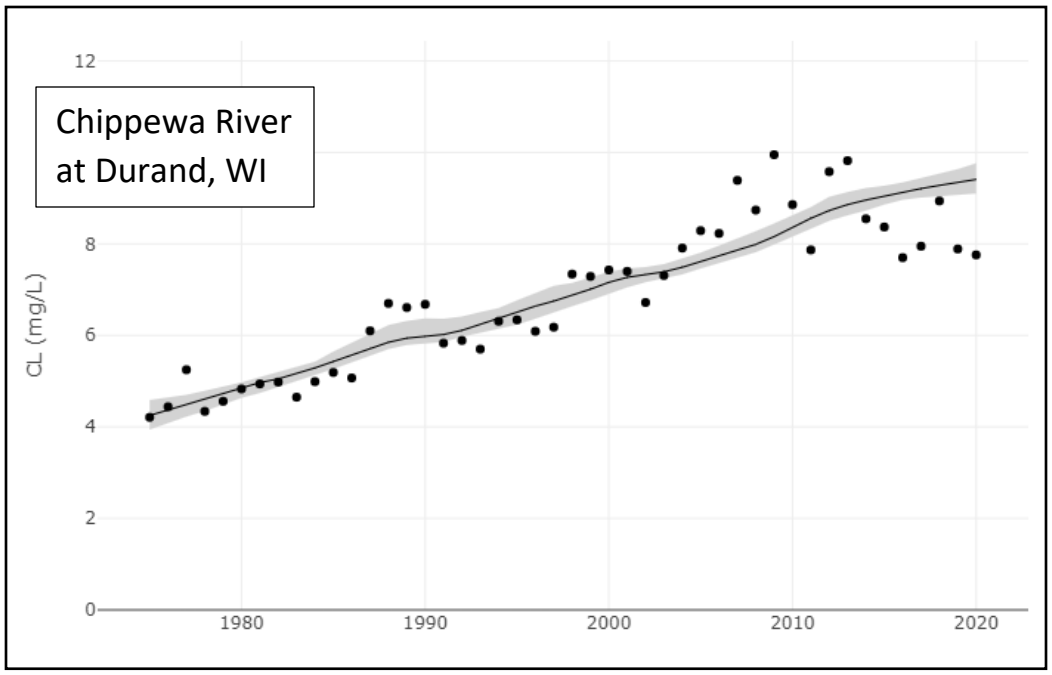


Figure 11. Chippewa River, located on the western side of the state long-term chloride trends. Image retrieved and modified from shinyapps.io

Overall, these site-by-site chloride trend comparisons demonstrate that chloride is steadily increasing in Wisconsin. More importantly, these long-term trends match up with the statistic that suggests the use of chloride products are still increasing, and the river sites with the highest concentrations are in the most densely populated areas of Wisconsin (i.e., southeast region).

2.4 Municipality Winter Maintenance Activities

Municipalities and the WisconsinDepartment of Transportation (DOT) can modify winter road maintenance routines or implement various roadside BMPs. In Wisconsin, recent technological advancements such as brining equipment have made it possible to cut salt material usage while still maintaining road maintenance objectives (WI DOT, 2020). The use of brine, often as a partial substitute for road salt under certain road conditions, has proven to reduce chloride runoff entering freshwater systems (Haake and Knouft, 2019) and, in some instances, to be more cost-effective than only using dry road salt (Fay, et al. 2015). Brine can be applied through different methods called anti-icing, pre-wetting, and deicing application.

Anti-icing is the application of brine solution before the winter storm, whereas deicing applications of brine solutions occur during and after the storm (Dane County Winter Maintenance Application Rate Guidelines, Fortin Consulting 2017). Pre-wetting is a technique where dry salt application can be wetted to speed up the melting process and adhere more effectively to the road surface (Minnesota Local Road Research Board, 2012). Other alternative strategies like structural BMPs, retention ponds and riparian buffer zones can also help mitigate chloride loading from snowmelt runoff (Fay and Shi 2012).

Although there are benefits of safer roads during the winter, winter road maintenance is also costly. In Wisconsin, the WI DOT reported $84,639,241 of total costs from the 2019-2020 winter season. One

contributor of this total cost was salt materials, with equipment costs ranking second, and labor costs as the third major cost (WI DOT, 2020). In addition, rock salt prices have increased in the last decade, according to the state's expenditures. It was calculated that Milwaukee County cities from the 2007-2008 winter season compared to the 2018-2019 season were paying an extra $30.55 per ton for rock salt (5.7% increase) (City of Cudahy Public Works Department, n.d.). Much research has supported that brining is an excellent alternative to cut salt usage while not compromising road safety (Ye, et al. 2013). For example, in southeastern Wisconsin, the City of Cudahy's Public Works Department in Milwaukee County found that prior to the 2016-2017 winter season, they were using approximately 17.8 tons of salt for each winter event. However, the city began implementing brining techniques and were able to decrease salt usage by 13.8 tons for each winter event with a total savings of $40,602 according to 2018 data (City of Cudahy Public Works Department, n.d.).

Each year, municipalities covered by a Wisconsin Pollutant Detection and Elimination System (WPDES) Municipal Separate Storm Sewer System (MS4) permit are required to report their winter road maintenance activities, including the type of approach used (e.g., brine, rock salt, pre-wetting, etc.) as well as the number of lane miles receiving applications. It had been previously discovered that the lane miles reported in the annual reports did not always match lane miles communities reported to the DOT each year. The workgroup hired a student from the University of Wisconsin, Sophie Hammond, who compiled annual report data during her appointment with the DNR. In addition to Hammond's ongoing work with statewide data, the DNR's Lexi Passante investigated product usage of permitted MS4 communities grouped by county in Wisconsin's southeast region from 2019 annual report data. This region was selected due to the numerous chloride hotspots that exist in surface waters (**refer to Figure 8**). Despite the recent studies that have shown a clear, cost-effective outcome with brining technologies, most southeastern counties are only using dry salt applications with a small percentage using brine (**Figure 12**).

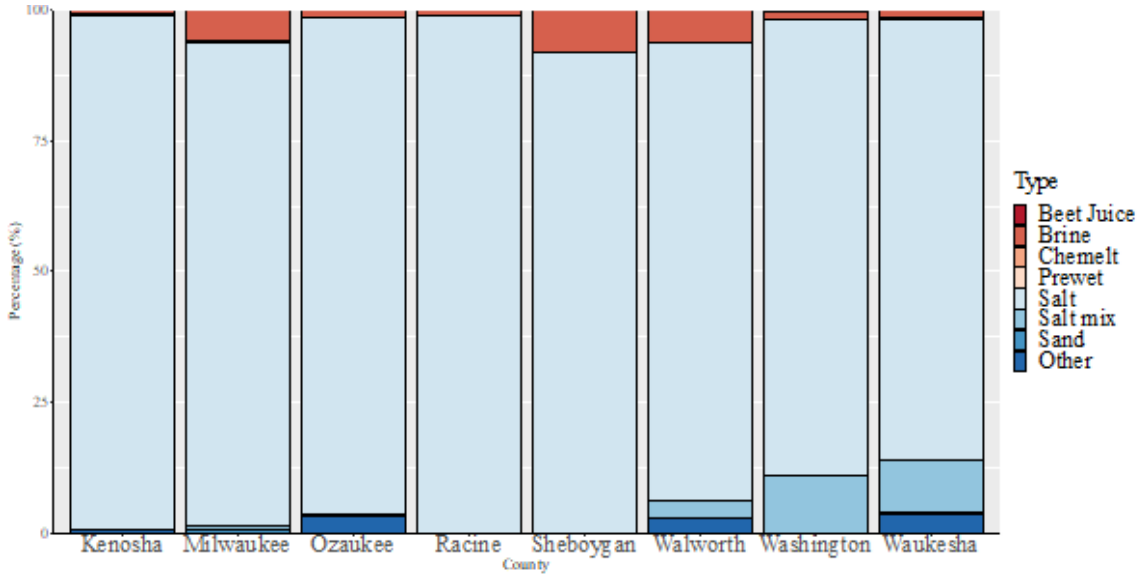


Figure 12. Southeastern Wisconsin MS4 communities grouped by county from 2019 winter maintenance data. Data is expressed in percentage to demonstrate how much of each product is used by the county.

2.5 Wastewater Discharges to Surface Water

The DNR has been addressing point source discharges of chloride from wastewater treatment plants for more than 20 years. Industries and municipalities with wastewater discharges to surface water are assigned water quality based effluent limits (WQBEL) for chloride when data suggests a reasonable potential to cause or contribute to an exceedance of the acute or chronic water quality criteria, according to ch. NR 106, Wis. Adm. Code. During the initial implementation of the chloride rule, there were a total of 93 facilities that were granted a water quality standards (WQS) variance based on the substantial and widespread economic hardship that would be incurred by the installation of treatment technologies. A WQS variance allows a facility to temporarily discharge chloride at levels greater than their calculated WQBEL and requires the permittee to complete chloride source reduction activities throughout the permit term, with an end goal of eventually meeting the WQBEL. Over half of the original 93 facilities with chloride variances have been able to reduce their discharge amounts enough to meet their WQBELs, either via source reduction activities or due to new or updated information that became available regarding characteristics of the receiving water. Through the implementation of source reduction measures, average discharge concentrations of permitted variance facilities have decreased by approximately 32%. As of July 1, 2022, there are 46 municipal dischargers covered under a variance (**Table 2**). These permittees continue to implement source reduction and other activities to work towards meeting their WQBELs.

Table 2. Wastewater Dischargers with Chloride Variances as of July 1, 2022.

POTW Permittee	County	POTW Permittee	County	POTW Permittee	County
Algoma	Kewaunee	Eden	Fond du Lac	Paddock Lake	Kenosha
Arlington	Columbia	Fairwater	Fond du Lac	Potter	Calumet
Blue Mounds	Dane	Fennimore	Grant	Ripon	Fond du Lac
Brillion	Calumet	Fontana Walworth	Walworth	Rockland	Manitowoc
Brookfield	Waukesha	Hartford	Washington	Rosendale	Fond du Lac
Brownsville	Dodge	Holland SD	Brown	Slinger	Washington
Cedar Grove	Sheboygan	Ixonia SD	Jefferson	St. Nazianz	Manitowoc
Chilton	Calumet	Larsen Winchester	Winnebago	Sullivan	Jefferson
Clyman	Dodge	*Madison MSD	Dane	Sussex	Waukesha
Cuba City	Grant	Maple Grove Estates	LaCrosse	Twin Lakes	Kenosha
Dale	Outagamie	Mount Calvary	Fond du Lac	Union Grove	Racine
Deerfield	Dane	Mount Horeb	Calumet	Waukesha	Waukesha
Denmark	Brown	New Holstein	Calumet	West Bend	Washington
Dickeyville	Grant	Norway SD	Racine	Yorkville	Racine
Dodgeville	Iowa	Oconomowoc	Waukesha		
East Troy	Walworth	Oostburg	Sheboygan		

*Madison MSD's variance is based on a factor 3 justification – it would cause more environmental damage to correct than to leave in place.

3. Chlorides in Wisconsin's Groundwater

All natural waters contain some chloride from contact with soils, rocks, and other natural materials. Too much chloride can impair water use - unpleasant taste, high water-treatment costs, mineral accumulation in plumbing, staining, corrosion, and restricted use for irrigation are among the problems associated with elevated concentrations of chloride in groundwater.

As noted in Hem (Study and Interpretation of the Chemical Characteristics of Natural Water, John Hem, USGS, 1985), chloride is the most abundant of the halogen elements, and compounds containing chloride bound with common metallic elements, alkali metals, and alkaline earth metals are readily soluble in water. The oxidation state of chloride is the only one of major significance in water exposed to the atmosphere, and more than ¾ of the total amount of chloride in the Earth's outer crust, atmosphere, and hydrosphere is in solution in the ocean as chloride ions. Chloride is present in various rock types, particularly in evaporitic sedimentary rocks.

Evaporitic sedimentary rocks, such as halite and gypsum, are not present in Wisconsin, and naturally occurring chloride levels in Wisconsin groundwater aquifers are generally low. A 1981 assessment of groundwater quality in Wisconsin aquifers (Groundwater Quality Atlas of Wisconsin, Phil Kammerer, USGS, 1981) showed mean chloride concentrations in the "sand and gravel" aquifer at 8.6 mg/L, mean chloride concentrations in the Silurian dolomite aquifer, in eastern Wisconsin, at 17 mg/L, and mean chloride concentrations in the Sandstone aquifer at 13 mg/L.

Human activities can add dissolved solids to recharging groundwater. Detergents, water softeners, fertilizers, road salt, urban runoff, and animal and human waste can contain chlorides that are delivered to groundwater by stormwater infiltration, wastewater disposal, septic systems, or direct application to the land surface. As a result, concentrations are more likely to be high in shallow, recently recharged groundwater near the water table beneath urban, suburban, or agricultural areas than in shallow groundwater beneath undeveloped areas or in deeper groundwater.

Chapter NR 140, Wis. Adm. Code, establishes groundwater quality standards to protect public health and welfare or prevent a significant damaging effect on groundwater quality for present or future consumptive or non-consumptive uses. Section NR 140.12, Wis. Adm. Code, sets a groundwater preventive action limit (PAL) at 125 mg/L and an enforcement standard (ES) of 250 mg/L for chloride.

The groundwater quality standards in ch. NR 140 apply to all facilities, practices, and activities which may affect groundwater quality and which are regulated under state statutes. State regulatory agencies establish rules that assure that regulated facilities and activities will not cause substances in groundwater to exceed groundwater standards. Regulatory agencies may require response actions at regulated facility or activity sites if groundwater standards are attained or exceeded.

Under the Safe Drinking Water Act, the US Environmental Protection Agency (EPA) establishes maximum contaminant levels (MCLs) for pollutants in drinking water that may present a health risk, and secondary maximum contaminant level (SMCL) guidance values for substances in drinking water that might present an aesthetic concern (such as taste, color, odor). States adopt EPA drinking water standards in their regulation of public water supply systems.

Wisconsin ch. NR 809, Wis. Adm. Code, establishes minimum standards and procedures for public water systems for the protection of the public health, safety and welfare in the obtaining of safe drinking water. A secondary maximum contaminant level (SMCL) is set at 250 mg/L in ch. NR 809 for chloride.

There are no state or federal standards for sodium in drinking water, however, the Wisconsin Department of Health Services (DHS) recommends a threshold of 20 mg/L for people that are on a low sodium or “no salt" diet. In cases where sodium in a water supply exceeds 20 mg/L, DHS recommends that people on a low sodium or “no salt" diet use bottled water for drinking.

In accordance with ch. 85, Wis. Stats., the WI DOT regulates the storage of highway salt, and liquid calcium chloride, to protect the waters of the state from harm due to contamination by dissolved chloride. Chapter Trans 277, Wis. Adm. Code, contains design and management standards applicable to any person who stores highway salt in the course of its manufacture, distribution or use. The rule does not apply to the application of salt on highways. Under ch. Trans 277, a person who stores highway salt within the boundaries or jurisdiction of the state, or who manufactures, distributes or uses highway salt, must exercise all reasonable precautions to prevent the entry of highway salt from a storage facility into the waters of the state. The rule contains specific requirements related to the design, construction and maintenance of highway salt storge facilities. The rule also contains specific response actions, to be required by DOT, in the event that a highway salt storage facility causes an exceedance of state groundwater quality standards or adversely impacts surface water.

LOCAL EXAMPLE: ONALASKA AND LA CROSSE

In recent decades, wells in the cities of Onalaska and La Crosse have begun to exceed 20 mg/L sodium (WI DNR Sanitary Survey Reports- La Crosse and Onalaska 2017). One well site in La Crosse with elevated sodium (>70 mg/L) is associated with a former deicing salt pile that wasn’t covered in a timely enough fashion in the past. The elevated chloride associated with this well resulted in the La Crosse Brewery having to install an interceptor well to ensure low sodium source water.

3.1 Trends in Groundwater Used as Public Drinking Water

Data from the Groundwater Retrieval Network (GRN) were obtained to understand potential chloride trends in ground water. Sampling data from the last 20 years was obtained (2002-2021) from this database. The original data set included 8950 well samples with a chloride detection. For this time period, the following results were noted:

- 33% of samples exceeded 20 mg/L
- 3.3% of samples exceeded 125 mg/L
- 1.5% of samples exceeded 250 mg/L

Samples from the last ten years showed the following results:

- 33% of samples exceeded 20 mg/L
- 5.0% of samples exceeded 125 mg/L
- 1.7% of samples exceeded 250 mg/L

This quick overview of samples did not account for drilling a new well that may result in lower chloride levels.

Samples reporting chloride levels less than 120 mg/L were removed from the data set. Duplicate samples for the same well were also removed. Removing these data points left 208 data points for samples exceeding 120 mg/L for chloride. The lowest detection was 126 mg/L. Six wells exceeded 1000 mg/L and the highest detection was 1100 mg/L. The spatial distribution of these wells and POTWs receiving a variance to their chloride discharges are depicted on the maps below (**Figures 13-15**).

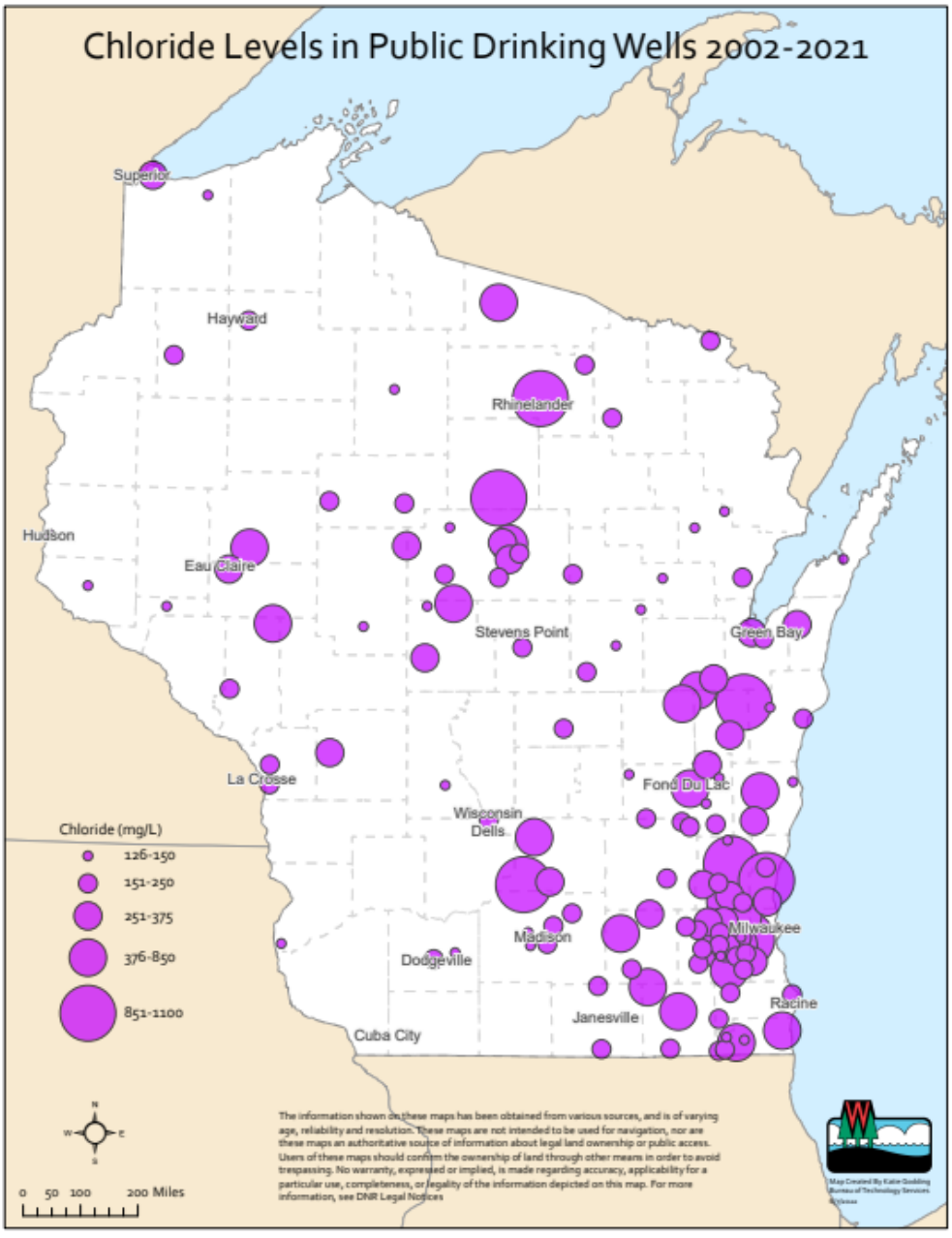


Figure 13. Wisconsin public drinking wells with chloride >120 mg/L (2002-2021).

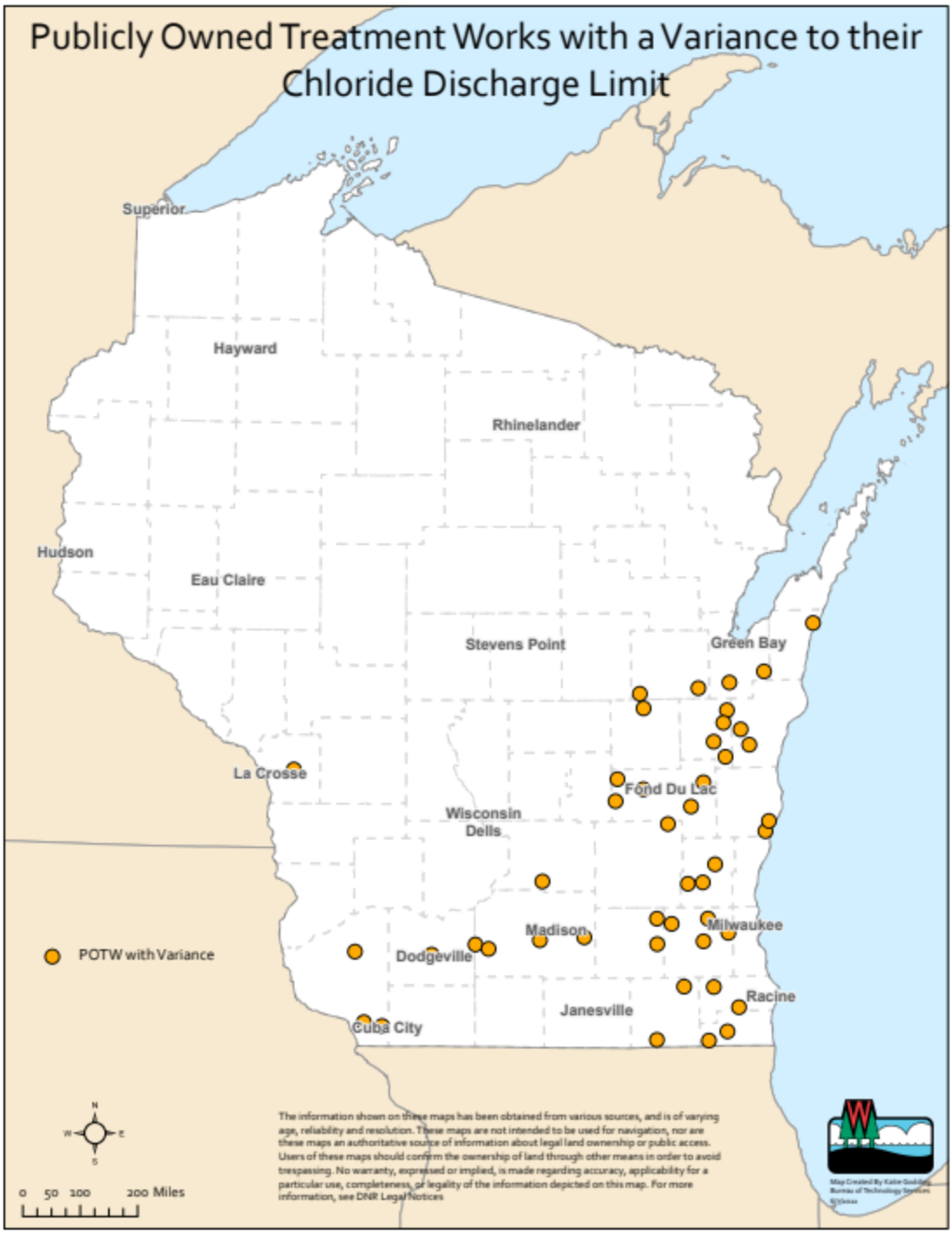


Figure 14. Publicly owned treatment works (POTW) with a chloride variance.

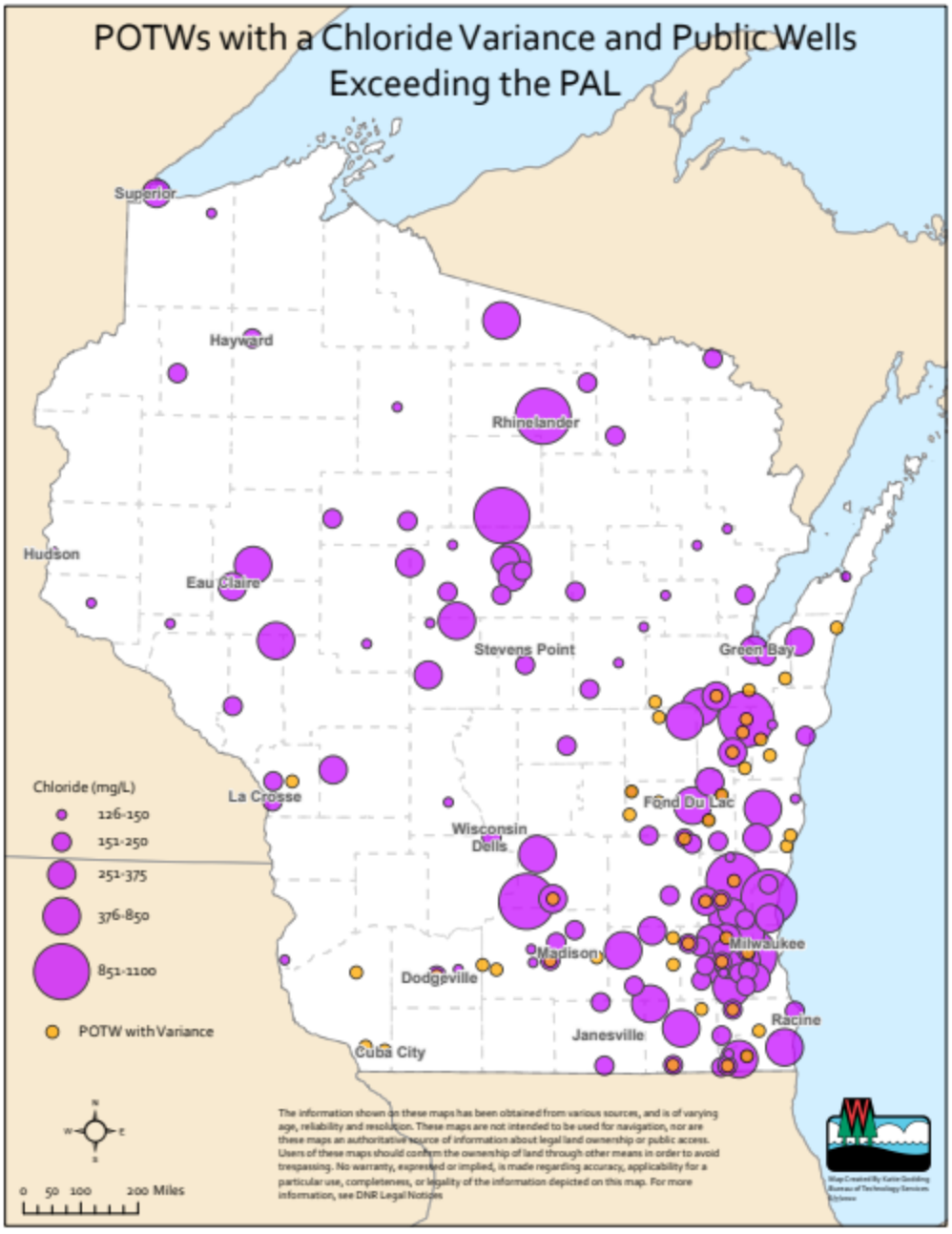


Figure 15. Publicly owned treatment works (POTW) with a chloride variance and public wells exceeding the preventative action limit (PAL).

In addition, the University of Wisconsin - Stevens Point has a robust well data viewer. This map, from the viewer, shows chloride levels found in ground water throughout the state (**Figure 16**)

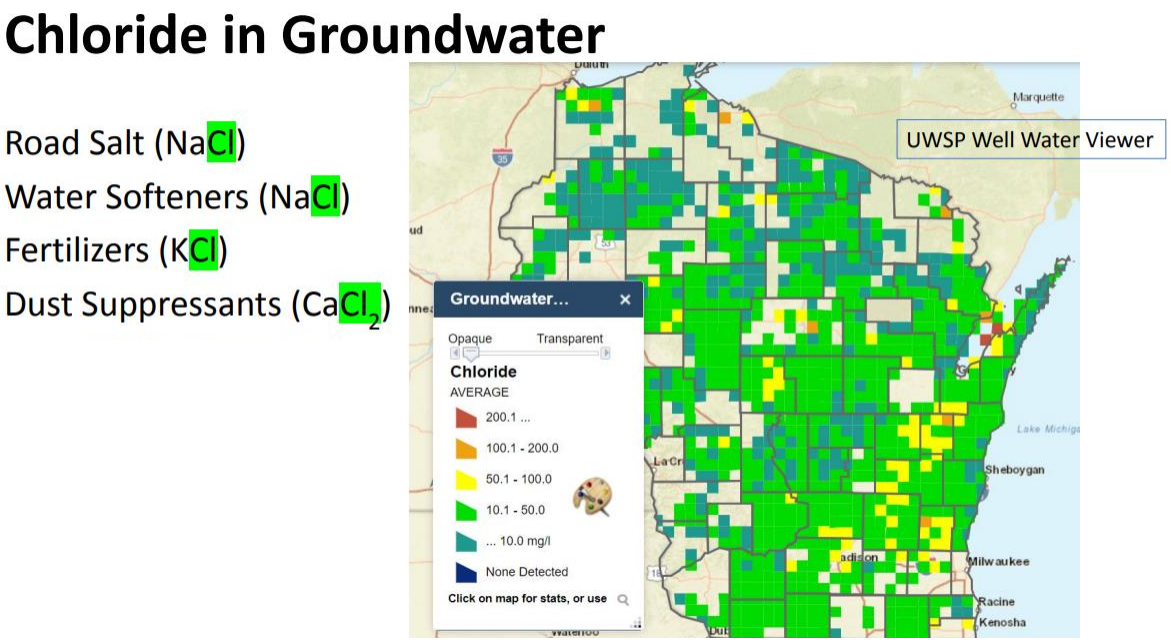


Figure 16. Results from UW Stevens Point Well Water Viewer (WI Well Water Quality Viewer (uwsp.edu)).

3.2 Wastewater Discharges to Groundwater

Wastewater discharges to groundwater are regulated to ensure that they will not cause the concentration of chloride in groundwater to exceed enforcement standards and preventive action limits set in ch. NR 140, Wis. Adm. Code, at a point of standards application.

4. Federal and State Authority

Under the Clean Water Act, the EPA must adopt water quality criteria to protect, maintain and improve the quality of the nation's surface waters. States with delegated programs must then adopt numeric or narrative WQC that are consistent with EPA's criteria or process for criteria derivation. EPA last updated their recommended chloride WQC for the protection of aquatic life in 1988. Wisconsin's current chloride WQC of 395 mg/L (chronic) and 757 mg/L (acute) are based on protection of aquatic life and are consistent with EPA's existing criteria for chloride.

4.1 Federal Authority

Federal regulations establish the authority of states and tribes to promulgate water quality standards, including criteria. Relevant portions of 40 CFR include:

40 CFR 131 Subparts A-C: Requirements for establishing state water quality standards.

40 CFR 131.4: States are responsible for establishing and revising water quality standards. U.S. EPA approves or disapproves standards under 40 CFR s. 131.5.

40 CFR 131.6: Water quality standards consist of designated uses and criteria to protect the designated uses.

40 CFR 131.11: States must adopt water quality criteria that protect designated uses. For waters with multiple uses, the criteria must protect the most sensitive use.

40 CFR 131.20: Revision of state water quality standards is subject to public participation procedures and U.S. EPA review and approval under 40 CFR 131.20.

40 CFR 122.44(d): Provides that water quality based effluent limits (WQBELs) must be derived from and comply with water quality standards and designated uses.

4.2 State Authority

Additionally, Wisconsin statutes and administrative codes provide authority at the state level for the department to promulgate water quality standards. Programs that are currently regulating chloride pollution include: urban runoff management (NR 216), wastewater (surface water NR 105 and 106, groundwater NR 140), and drinking water and groundwater (NR 809).

5. Other States' Chloride Programs

The Chlorides Workgroup met with individuals from the states of Illinois, Maryland, Minnesota and New Hampshire to learn about their chloride programs.

5.1 Illinois

Regulatory Framework

The workgroup heard from Stephen McCracken from the DuPage River Salt Creek Workgroup. Illinois had a number of individual variances to chloride effluent limits. Eventually, one of the approved variances was denied by U.S. EPA. It was determined that the existing state variance requirements were not entirely compatible with USEPA's variance requirements. In 2015, U.S. EPA published new rules on variances to water quality standards. In response, Illinois updated its variance rules to make them more compatible with those established by U.S. EPA. In 2015, the state passed new legislation creating time-limited water quality standards (TLWQS). The Illinois Environmental Protection Agency (IEPA)agency is working through the rule-making process to implement these standards.

The TLWQS allows for:

- Individual TLWQS
- Multi-discharger TLWQS
- Stream Segment TLWQS
- Watershed TLWQS

The TLWQS is consistent with USEPA variance requirements. The Standard allows for greater than a 5-year timeframe to come into compliance with a pollutant that is not achieving the standard.
The Illinois Pollution Control Agency adopted a variety of TLWQS for waterways in the DuPage Salt Creek River based on the water bodies designation. Effective July 1, 2015, until July 1, 2018, there were different standards based on the time of year. From May 1 – November 30, a chloride standard of 500 mg/L applied and from December 1 to April 30, a Total Dissolved Solids standard of 1,500 mg/L applied. After July 1, 2018, the Chloride standard became 500 mg/L. Illinois only has an acute criterion and does not have a chronic criterion for chlorides.

Chloride Reduction Efforts by the DuPage Salt Creek Watershed Workgroup

The workgroup was set up primarily by POTWs. The group consists of 22 POTWs, as well as MS4 permittees and transportation agencies such as IDOT, Illinois Tollway, and DuPage and Cook County Divisions of Transportation.

Timeline for the workgroup's efforts:

- 2004- TMDL approved DuPage River and Salt Creek.
- 2009- Additional TMDLs were created.
- 2012- O'Hare Western Access permit was scrutinized for chlorides.
- 2015- Water quality permits for construction projects were scrutinized for chlorides. A time-limited water quality standard was implemented for the DesPlains River Watershed.
- 2016- New ILR40/MS4 permit was issued with references to chlorides.
- 2019- TMDLs started in 2009 were officially published.
- 2021- Time-limited water quality standard for DesPlains River was approved.

Using data gathered by the workgroup and local agencies, a comparison was conducted to see the difference between actual chloride loading and required reductions to meet the TMDL. Data showed much more salt was used than originally thought. (For example, in the Salt Creek watershed, the TMDL required a 14% reduction in chlorides to meet the standard, but based on actual loading, a 59% reduction was needed to meet the standard). Based on these findings, a new chloride requirement has been set for MS4s within the DuPage River Watershed.

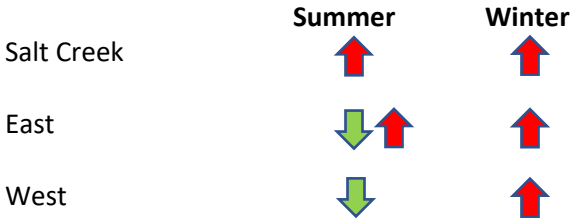
	Actual	TMDL
Salt Creek	59%	14%
East Branch	69%	33%
West Branch	35%	35%

The workgroup conducted surveys of stakeholders from 2007-2012. The surveys showed an increase in brine use, but no real decrease in dry salt use. A more recent survey shows more communities are using no dry salt at all. From 2007-2014, DuPage County reported a 40% reduction in salt use.

The workgroup conducts in-stream monitoring for annual winter concentrations. The workgroup always sets the data review time frame between 12/2 to 12/4 for consistency. The workgroup has found that loading is slightly up, but the general trend is downward. Weather is a major factor as they are getting higher flows with more rainfall. Salt Creek winter load was generally relatively stable between 2012-2020. Summer load between 2012-2020 is going up slightly, but the trend has remained below the water quality standards.

Chloride Concentration	**Summer**	**Winter**
Salt Creek		
East		
West		

Chloride Load



Lessons Learned

- Achieving the reduction the workgroup aspired to is a long term process. Work in the watershed spanned over 30 years. It took 10 years to replace equipment for effective salt application reduction.
- Engaging the public sector was more successful than the private sector.
- The workgroup is interested in understanding more about the summer/winter dichotomy. The workgroup would like to explore why they are seeing chlorides persist into the summer.

5.3 Maryland

Regulatory Framework

Maryland has 28 waterbodies identified as impaired of chloride. The state of Maryland had developed a TMDL for chloride, however, the TMDL was not formally adopted. Instead, the state was hoping to implement the draft TMDL on a voluntary basis. In response, the state chose to develop an alternative plan to avoid having to create a TMDL. Ultimately, they were able to convince USEPA R3 to allow them to develop a "Category 4b" (Other required control measures are expected to result in the attainment of applicable water quality standard in a reasonable period of time." Supplemental Module: Listing Impaired Waters and Developing TMDLs | US EPA) plan to address chloride impairments. This plan laid out the rationale for why a TMDL may not have the same result as a reduction plan.

The draft TMDL that was created will act as an implementation tool to manage and measure chloride use. In the spring of 2022, there were two bills pending in the Maryland legislature that would require the implementation of the TMDL that did not ultimately get approved by the legislature.

At the time of the discussion in the spring of 2022, staff hoped they could sell the idea that the TMDL is a tool and that they can address chloride impairments through voluntary actions versus mandating implementation of the TMDL.

In 2011, the state highway administration was required to reduce salt use. As a result, they require all contractors and employees to take "Salt University" training. This course focuses on accounting for salt use and managing application rates.

It was noted that nearly ½ of the land area in the state of Maryland is covered by an MS4 permit. Maryland includes specific language requiring a salt management plan as part of the MS4 permit. The permit also requires everyone in their jurisdiction to apply salt appropriately. The state is developing a new training that incorporates a variety of approaches.

The state of Maryland does not have any POTWs that have a variance for their chloride discharge. It was noted that that they do have some communities water softening due to radon. It was also noted that their two largest POTWs discharge to brackish water and do not have a chloride limit for their discharges.

During the conversation with Maryland's staff, it was mentioned that chloride has both a chronic and acute limit and that Wisconsin has not developed a TMDL for a pollutant in this manner. Maryland reported that they are still working with the U.S. EPA, but they included the chronic standard as the endpoint in their TMDL.

Chloride Reduction Efforts

To address chloride issues, Maryland said that they are looking at things such as variable speed limits during winter storms, changing the level of service strategy for de-icing, and finding ways to reduce traffic in winter. Maryland had decided not to go the limited liability route that New Hampshire has due to the level of effort with paperwork required. New Hampshire reported they have four full time staff managing documentation for training and application reporting.

Maryland has communities that have initiated a "buy back" program for unused salt to eliminate situations where landscapers overuse salt in the spring so as not to have to store it through summer.

The Muddy Branch River Alliance is working with its local state representative and the MD Department of the Environment to propose legislation for smart salt distribution by private organizations. The Alliance is working to address slip and fall liability concerns on private property. Similar to other state programs such as New Hampshire and Minnesota, if a private contractor becomes trained in Smart Salt Techniques (via the MD Dept of the Environment) and distributes salt appropriately, then the organization hiring the contractor could be shielded from slip and fall liability. More information can be found at the Salt – Muddy Branch Alliance.

5.2 Minnesota

Regulatory Framework and Chloride Strategy

Minnesota has 50 listed impairments for chloride, for which there are 40 TMDLs. Today, Minnesota has a chloride reduction strategy and one full-time employee implementing the state's strategy. The strategy was primarily driven by the need to implement the chloride TMDLs and USEPA 319 money that needed to be spent in areas with a TMDL for chloride impairments. The state first developed the Twin Cities Metropolitan Area plan for chlorides in 2016 and converted it to a statewide plan and formally adopted the statewide chloride management plan in May 2021.

On January 31, 2022, HF No 2908 was introduced in the state of Minnesota House of Representatives and was later passed by the full legislature. Previous attempts to pass the bill had failed. This bill establishes a salt applicator certification program, limit liability, and require reporting of salt use. It is believed that smart salt training can reduce salt use by 30-70%.

The state used momentum from the discussion of the original legislation to educate people on the importance of good winter maintenance practices. The state added language to its MS4 permits about chloride use and storage, as well as winter maintenance that led the MS4 permittees to request more training on the topic. The Minnesota Pollution Control Agency (MPCA) is adding a requirement to its

MS4 permits requiring proper storage of salt supplies. Permittees must also incorporate salt as a pollutant to control through Illicit Discharge Detection and Elimination (IDDE) or adopt an ordinance managing chloride use.

The MPCA developed a model ordinance around chloride use that was developed with the assistance of an attorney. The model ordinance has four parts.

1) The ordinance requires anyone applying salt to be trained.
2) Anyone who stores salt must store it properly.
3) Any new or reconstruction of commercial property must have a salt management plan and a person to act as a point of contact if there is an overapplication.
4) There is a sweeping requirement if salt is overapplied or spilled.

At the time this report was written, no one had adopted the ordinance. However, MS4 permittees were incorporating parts of the ordinance into their policies.

Winter Maintenance and Chloride Reduction Efforts

According to the Roadway Safety Foundation, salt use for winter maintenance is beneficial for public safety but comes at a cost. According to the Foundation, effective snow fighting on roads cuts injury accidents by 88.3% and decreases crash costs by 10%.

Additionally:

- During the first 4 hours after salt is applied, the direct road users' benefits are $6.50 for every $1.00 spent on direct maintenance costs for the operation.
- The economic impact of snow-related closures far exceeds the cost of timely snow removal. · Among all economic classes, snow-related shutdowns harm hourly workers the most, accounting for almost two-thirds of direct economic losses.
- A 1-day major snowstorm can cost a state $300-$700 million in both direct and indirect costs.

(Roadway Safety Foundation, undated)

A 2014 study conducted by Fortin Consulting on behalf of the MPCA estimated the following costs for salt, labor and equipment and damage from salt use within the seven-county urbanized Twin Cities Metro Area (TCMA) (**Table 3**).

Table 3. Costs of salt use in the TCMA, Minnesota.

Cost Component	Low Overall Damages Basis		High Overall Damages Basis	
	Rate per Ton of Salt	**Cost (millions) * per year**	**Rate per Ton of Salt**	**Cost (millions) * per year**
Material (salt)	$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

** Damage includes damage to transportation infrastructure, plants, vehicle corrosion, groundwater and surface water. Does not include unknown costs such as those to human health, aquatic life, wildlife and soil.

The study further estimated the cost savings associated with reducing salt used (**Table 4**).

Table 4. Cost savings estimates for reducing salt use.

Reduction in Salt Use*	**Operations (Materials, labor and equipment) Potential Savings**		**Combined Operations-Plus Damages Potential Cost Savings (millions) per year†**	
Percentage	Thousands of Tons/yr	Direct Cost (millions)/yr**	Low Damages Basis	High Damages Basis
10%	35	$8	$36	$124
20%	70	$16	$72	$249
30%	105	$23	$107	$373
40%	140	$31	$143	$622
50%	174	$39	$179	$746
60%	209	$47	$215	$746
70$	244	$54	$251	$870

*TCMA baseline salt use is approximately 349 thousand tons/yr (Sander 2007)

** Estimated based on $73/ton material cost (Schaefer 2012, MNDOT ca 2012, US Salt 2012), and $150/ton labor and equipment cost (Stefen et. Al 2008)

†TCMA estimated baseline combined cost is $358 million/yr on low overall damages basis and $1,243 million/yr on high overall damages basis (see previous table)

5.4 New Hampshire

Liability Limitation Program

New Hampshire has implemented a liability limitation program. The state was required by USEPA to reduce chlorides associated with the construction of 8 miles of a new highway. As a result of this consent decree, the New Hampshire DOT was required to pay into a mitigation account. A state legislator in the landscaping industry sponsored the liability limitation bill.

The law was implemented between 2013 and 2014. The state used the liability waivers from the ski industry as the basis of their program. The state implemented the "Green Snow Pro" training program. Individuals conducting winter property maintenance activities take the training and an exam, which are funded through fees paid by program participants. Once they are certified, they are also required to complete continuing education to maintain their certification status. Since the program started, 2000 people have been certified with 600 currently holding active certifications. The majority of program participants conduct maintenance on commercial property. New Hampshire staff noted that the program is getting "mixed reviews."

Slip and fall claims against the insurance company where the fall happens are still being made (e.g., claims against Walmart's insurance). Usually, these claims are settled before they go to court to avoid the legal costs for the company. For this reason, the state has not yet seen a case go all the way through the court and therefore, it is unknown if the law would be upheld. Under the law, judges should dismiss cases where the applicator is certified, but the courts are often willing to take on a case to make sure the victim has all the remedies afforded to them as a victim. But, as noted, these cases so far have been settled before trial.

New Hampshire staff shared a few lessons they have learned. First, they suggest states make sure the program is built before they implement it. New Hampshire built their program as they went. The program is very administratively intensive. The state is required to provide the training and then maintain records documenting certifications. Applicators have to keep very detailed records and submit them to the state. When there are claims, the state needs to provide all of the documentation to court. Staff also noted that it does not change behavior; the public still feels that facilities are not properly maintained if they do not see salt on the ground.

Other notable takeaways from New Hampshire:

- Staff noted that for their MS4 permittees, it is much easier to count BMPs and document calibration than it is to count salt use.
- New Hampshire DOT pays into municipal TMDL and implementation plans.
- With climate change, New Hampshire is seeing more ice events than snow events, leading to more drought and less baseflow. This results in more salt use and higher chloride concentrations in surface waters.

More information can be found on the Section 508 web page.

6. Other Chloride Programs in Wisconsin

Upper Mississippi River Basin Association (UMRBA)

UMRBA is an interstate water resources planning and management forum that includes the states of Illinois, Iowa, Minnesota, Missouri, and Wisconsin. The association facilitates dialog and action relating to the complex nature of the Mississippi River and its water and related land resources. Among their many focus areas, the group is facilitating cooperative action among state and federal water quality and transportation agencies, local governments, and private salt applicators to reduce rising chloride contamination in the basin and to improve understanding of chloride impacts in the basin. In 2022, UMRBA adopted a formal resolution describing long term trends, impacts, and current management

efforts and calls for a robust set of strategies to accelerate efforts to reduce chloride loading, improve our understanding of chloride impacts, and communicate the issues and management challenges and opportunities.

Wisconsin Salt Wise

Wisconsin Salt Wise is a coalition of organizations in Wisconsin working together to reduce salt pollution in Wisconsin's waterways and drinking water. The organization's primary efforts include educating residents, community leaders, and winter maintenance professionals on salt pollution, and providing teacher resources. The organization supports chloride monitoring efforts, smart salting training for roads, sidewalks, and parking lots, certifying individuals and organizations who have completed training, education on home water softeners, resources for teachers; and general outreach tools.

Current Research Programs in Wisconsin

Southeast Wisconsin Regional Planning Commission (SEWRPC): Chloride Study

In fall 2018, a region-wide chloride effort (i.e., southeastern Wisconsin) conducted by SEWRPC installed real-time continuous monitoring systems measuring specific conductance at approximately 40 stream locations. Data collection at these sites lasted for 2 years (2018 – 2020), and are now in the process of reporting SWERPC's findings in a final report. Specific conductance was chosen as research has shown it can be a good predictor of chloride concentrations (i.e., strong linear relationship).

University of Wisconsin – Madison

The Dugan research lab (Hilary Dugan, Assistant Professor, Center for Limnology) is well known for the chloride research done throughout the state of Wisconsin. More specifically, the lab investigates the impact of chloride loading in aquatic ecosystems and has published many scholarly articles on this research. More information on the Dugan lab.

University of Wisconsin – Milwaukee

The Paradis research lab (Charles Paradis, Assistant Professor, Dept. of Geosciences) has begun investigating the issues of chloride contamination in groundwater funded as a Sea Grant project. The lab has hypothesized that chloride stored in the groundwater (for unknown periods of time) on the Root River can contribute to high levels of chloride that have been measured in the water column during the summer. More information at the Paradis lab.

Wisconsin Department of Transportation

Jim Hughes, Chief State Highway Maintenance Engineer Wisconsin DOT, provided the workgroup an overview of the approach that Wisconsin DOT has implemented to reduce their salt use. Jim explained that Wisconsin DOT brought experts studying the issue of chlorides directly to the snowplow drivers. Dr. Koefod, Dr. Hillary Dugan and Dr. Wilf Nixon talked to the drivers about their studies and their findings. Jim added that upon hearing the information, the truck drivers expressed that they really cared; they did not want the work they were doing to pollute the waters that many of them fished in. However, the snowplow drivers also cared about safety.

The Wisconsin DOT looked at the difference between granular salt versus liquid salt (brine). Ultimately, they decided to switch over more of their maintenance to pre-wetting and brine versus granular salt. The agency reviewed a Michigan study that looked at "bounce" from granular salt. This study reported that more than 30% of all salt is lost from the road due to bounce (**Figure 17**). And in many instances, the salt is subsequently plowed off the roadway and more susceptible to entering surface waters.

In addition, the Wisconsin DOT uses a winter severity index that was developed in the 1980s. This index uses an algorithm to predict the severity of winter conditions and they adjust treatment accordingly. The Wisconsin DOT has road/weather sensors that help them make decisions in real-time, and planned to deploy more sensors statewide in 2021 and 2022.

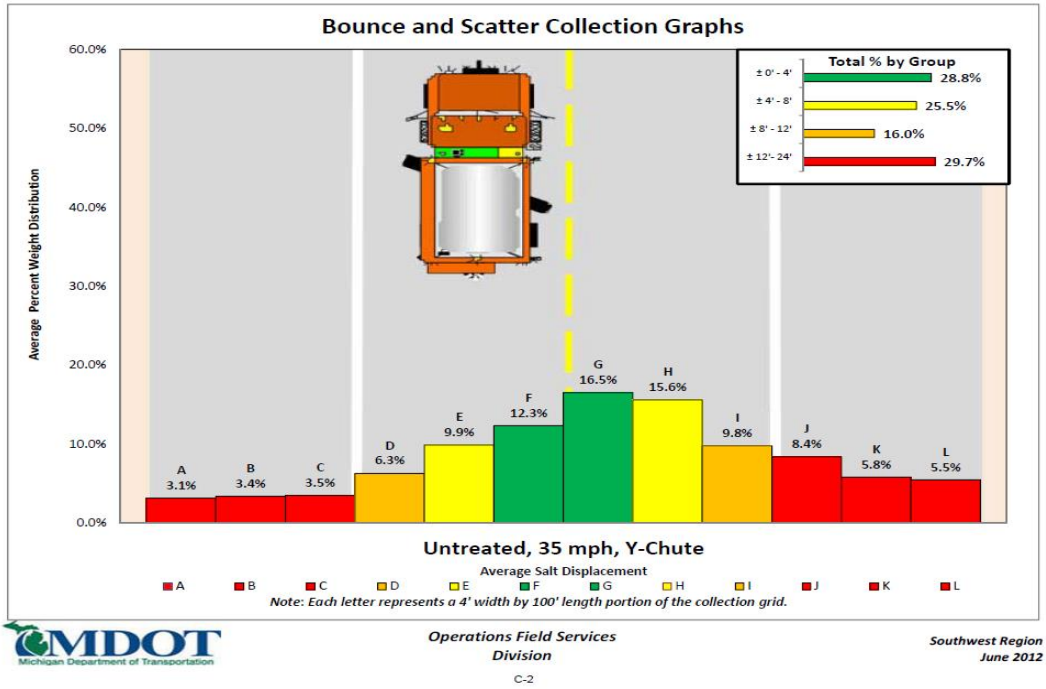


Figure 17. Michigan Department of Transportation (DOT) road salt scatter study.

The Wisconsin DOT is a member of the national consortium of states and communities that provide winter road maintenance called "Clear Roads". The group gets together to share best practices, initiatives and trade information. Jim shared data from Clear Roads comparing Wisconsin's winter road maintenance to adjacent states (**Figure 18).** As shown by the data reported by Clear Roads, the state of Wisconsin is doing well in making reductions; however, there is still much work to be done (**Table 5**).

"Final" Wisconsin 2017-2018 Winter Report					
	Wisconsin	Minnesota	Iowa	Michigan	Illinios
Lane Miles	34,678	30,585	24,482	32,045	n/a
Salt use (Tons)	568K	439K	175K	619K	n/a
Brine/Liquid Use	5.7M	4.3M	32.4M	2.4M	n/a
Material Costs	$41.8M	$34.7M	$15.1M	n/a	n/a
Equipment Costs	$29.2M	$47.1M	$6.0M	n/a	n/a
Labor Costs	$26.8M	$42.2M	$13.5M	n/a	n/a
Total Costs	$97.8M	$124.0 M	$34.6M	n/a	n/a
COST/LANE MILE	$2,821	$4,054	$1,413	n/a	n/a

"Final" Wisconsin 2018-2019 Winter Report					
	Wisconsin	Minnesota	Iowa	Michigan	Illinios
Lane Miles	34,774	30,456	24,525	31,958	44,768
Salt use (Tons)	553K	247K	222K	528K	600K
Brine/Liquid Use	9.4M	4.6M	39.3M	2.2M	1.9M
Material Costs	$44.1M	$30.4M	$19.8M	N/A	$35.2M
Equipment Costs	$36.3M	56.2M	$8.8M	N/A	$21.9M
Labor Costs	$31.3M	$17.1M	$17.1M	N/A	$31.8M
Total Costs	$111.7M	$132.7M	$45.8M	N/A	$88.9M
COST/LANE MILE	$3,212	$4,357	$1,867	N/A	$1,986

"Final" Wisconsin 2019-2020 Winter Report					
	Wisconsin	Minnesota	Iowa	Michigan	Illinios
Lane Miles	*34,859*	*30,341*	*25,767*	*31,958*	*45,304*
Salt use (Tons)	*426K*	*210K*	*185K*	*444 K*	*428 K*
Brine/Liquid Use (Gallons)	*11.4 M*	*6.5 M*	*31.5 M*	*1.7 M*	*3.0 M*
Material Costs	*$35.3 M*	*34.3 M*	*20.0 M*	*N/A*	*35.1 M*
Equipment Costs	*$26.3 M*	*52.5 M*	*9.5 M*	*N/A*	*15.5 M*
Labor Costs	*$23.0 M*	*40.2 M*	*17.6 M*	*N/A*	*20.1 M*
Total Costs	*$84.6 M*	*127.0 M*	*47.1 M*	*N/A*	*70.7 M*
COST/LANE MILE	$2,428	$4,188	$1,828	N/A	$1,562

"Final" Wisconsin 2020-2021 Winter Report					
	Wisconsin	Minnesota	Iowa	Michigan	Illinios
Lane Miles	*35,177*				
Salt use (Tons)	*324 K*				
Brine/Liquid Use (Gallons)	*11.5 M*				
Material Costs	*$22.7 M*	*20/21 Winter Data from other states is not published yet*			
Equipment Costs	*$23.0 M*				
Labor Costs	*$28.4 M*				
Total Costs	*$74.1 M*				
COST/LANE MILE	$2,107	N/A	N/A	N/A	N/A

Figure 18. Salt use and costs across five midwestern states produced by Clear Roads.

Table 5. Summarized Wisconsin salt use per lane mile 2017-2021 from Clear Roads data.

Reporting year:	2017-2018	2018-2019	2019-2020	2020-2021
Lane Miles	34,678	34,774	34,859	35,177
Salt (tons)	568,000	553,000	426,000	324,000
Tons/Lane Mile	15	16	12	9
Brine/Liquid	5.7M	9.4M	11.4M	11.5M

On February 14, 2001, an Attorney General's opinion memo was issued regarding the permissibility of the practice, by county highway departments, of selling certain winter road maintenance supplies at cost to local municipalities or to private parties. DOT believes this opinion and the statutes referenced by the opinion are a barrier to getting more brining equipment to local municipalities and private

business. More information on the current legislative barriers that would need to change to allow for more opportunities for sharing equipment can be found on the Wisconsin State Legislature's website.

Throughout the state, 46 of the 72 counties have reduced their salt use since the state switched to more use of brine. Jim also reported that they spend a lot less money on maintenance of equipment. Jim shared that it is often difficult to change the perception of using brine after a failure occurs. Failure to properly mix brine will result in the creation of ice on the roadway. Jim reported that some counties are beginning to re-try brine. The Department prepares an annual winter maintenance report that details how the DOT is using salt.

Overall, the Wisconsin DOT is using less rock salt and more brine, which is less likely to enter surface waters and has less cost of equipment maintenance. The Wisconsin DOT reported that the primary drivers of this decision were safety, the environment, and cost. Lastly, the Wisconsin DOT will continue to work with Wisconsin Salt Wise for trainings and provide statewide data to the organization.

7. Recommendations

After reviewing the data and trends, speaking to other states, and group discussion, the workgroup has developed a number of recommendations the state could implement to mitigate the increase of chloride contamination in the state's surface and drinking water. The recommendations include education and training, regulatory and policy, monitoring and financial support efforts, and are broken into the following categories:

- DNR programs implementation and partnerships
- State facilities and maintenance management
- Governor's office and legislative initiatives

7.1 DNR Programs Implementation and Partnerships:

Sustainability and Business Support

1. **Support a smart salting certification program for communities and businesses through the DNR's Sustainability and Business Support program.** This recommendation supports "smart salting" certification programs, such as those promoted by Wisconsin Salt Wise or the city of Madison, which include training municipal and private salt applicators on techniques to lower salt use. The certification programs educate communities and businesses on the impacts of chloride pollution, what they can do to reduce their chloride use during winter, including the proper installation and calibration of deicing equipment. Another certification program could relate to upgrading and calibrating water softening devices among communities and businesses. **Work with the DNR Sustainability and Business Support program to include chloride reduction efforts in their Green Tier program.**

Urban Runoff and Wastewater

2. **Develop and support salt reduction education programs among permitted MS4s, industrial storm water permittees and POTWs with chloride variances via the DNR's urban runoff and wastewater permit programs.** The DNR's urban runoff and wastewater programs should implement permit language in Wisconsin Pollutant Discharge Elimination System (WPDES) permits for the permittee to engage the general public to increase the awareness of chloride

impacts on the waters of the state and encourage changes in public behavior to reduce such impacts. The Department can also work with partners such as storm water consortiums (e.g., Fox-Wolf Watershed Alliance, Sweet Water (Milwaukee River Watershed) and the Madison Area Municipal Storm Water Partnership (MAMSWAP)) and Wisconsin Salt Wise to develop and disseminate informational materials that can be replicated and reused statewide. The DNR could act as a central clearinghouse for materials developed as part of these partnerships.

3. **Require permitted MS4s to report salt discharges as an illicit discharge.** Examples of discharges that MS4 permittees should be reporting include, but are not limited to, overuse of salt on parking lots, and discharge of salt leaching from storage piles. The storm water program should ensure language is included in its general and individual permits and provide education to permittees on this requirement.

4. **Continue implementation of chloride WQBELs and WQS variances in wastewater WPDES permits.** The DNR has been addressing wastewater discharges of chloride for more than 20 years, and significant reductions in effluent chloride levels have been realized. The program has also developed a guidance document as part of the variance process. In this document, there is specific information regarding potential source reduction measures a wastewater treatment facility can take to reduce the amount of chlorides entering the treatment plant. This information can be found in Chapter 4 of the Development and Implementation of Water Quality Standards Variances guidance document. Implementation of these efforts should continue to further reduce chloride levels in wastewater effluents.

Water Resources

5. **Develop a Total Maximum Daily Load (TMDL) for chloride.** The DNR's water quality program should develop chloride TMDLs as a framework for addressing chloride impaired waters. States such as Minnesota reported that implementation of TMDLs for chloride was the impetus for getting communities to change their practices.

6. **Update the chloride surface water quality criteria for the state.** Updating chloride water quality criteria (WQC) has been of both national and statewide interest for several years, but recently, there has been increased recognition that aquatic organisms are commonly exposed to mixtures of ions, like chloride and sulfate. Mixtures of ions at varying concentrations and in different combinations may affect their toxicity to aquatic organisms to different degrees. Thus, the EPA is developing models that will predict the toxicity of ion mixtures to aquatic life.

   In order to appropriately apply the forthcoming EPA models and develop WQC for ions, the DNR's water quality program has recommended that staff begin to monitor the concentrations and prevalence of major ions (Na^+, K^+, Ca^{2+}, Cl^-, SO_4^{2-}), in conjunction with hardness and alkalinity, in Wisconsin's surface waters beginning in 2022. This will produce a dataset containing ion concentrations in waters throughout the state by the time the EPA models are fully developed, which can be used to protect aquatic life from ion toxicity. Once EPA models are established, the DNR should update their WQC for chlorides.

Drinking Water and Groundwater

7. **Incorporate additional drinking water requirements for chloride and sodium.** Beginning in 2022, the Drinking Water and Groundwater program required community water systems to include chloride concentrations in their annual Consumer Confidence Report. The program also added sodium to the data application used by externals to create their Consumer Confidence report. Adding sodium to the reports will begin in the 2023 calendar year.

   Additionally, in partnership with the Department of Health Services, the program will determine if any health effects language or recommendations for sodium concentrations that exceed a certain level should also be included in the report.

   Furthermore, the Public Water Supply guidance will also be updated to include a note that describes actions the program staff should take if a contaminant in a drinking water supply is thought to be the result of road salt applications.

Community Financial Assistance

8. **Offer State Revolving Loan Funds (SRF) to cover the costs to acquire brining equipment and outreach programs.** The state of Minnesota allows SRF funds to be used for brining equipment, and the development of an education, outreach and training program to help their community, work force, and/or private contractors reduce salt use. The environmental loans program is exploring this as an option. Wisconsin Salt Wise is currently anecdotally gauging interest, and a DNR survey sent to municipalities in August 2022 showed 46% of the 327 respondents expressed interest in the program.

Agency-wide/Multi-program

These recommendations would require agency-wide effort and may need individual programs designated to work on these initiatives:

9. **Rebate programs for communities that have high water softener use.** Several communities have implemented rebate programs with various levels of success, however their experiences provide 'lessons learned,' which can assist other communities in developing successful programs. Madison Metropolitan Sewerage District piloted a program providing rebates for replacements and optimization with limited success. This program was a lot of work for staff with very little impact resulting in about 100 homes taking advantage of the program. Paddock Lake had more success with its program, which may be attributed to the smaller size of the community. The city of Lake Geneva and the Village of East Troy both have rebate programs.

   Barriers to implementing this program include implementation and costs. Most treatment plant operators are not set up to do outreach programs. There are real dollar costs to communities and/or utilities to offer rebates to customers.

   It is recommended that a state program assist with providing a template for this type of program if communities are interested in implementing this effort.

10. **Develop a partnership with the Environmental Protection Agency (EPA) in reversing the trends in chloride levels.** Specifically, this includes assisting the states by:

- Improving the scientific understanding of chloride-related impacts to designated uses in surface and groundwater.
- Partnering in the development of a communications strategy for the purposes of informing government officials, decision makers, and applicators about chloride trends, negative effects of excessive use, and best management practices to minimize runoff.
- Prioritizing EPA resources on chloride-related monitoring and research, as well as implementing best management practices to reduce salt usage and address policy needs.

7.2 State Facilities and Maintenance Management

11. **For state-owned properties, have contractors and individuals conducting winter property maintenance take winter maintenance training and implement salt reduction strategies.** Work with the Department of Administration to identify state-owned and operated properties to recommend contractors and winter maintenance staff take regular salt reduction trainings and implement those strategies. Ensure this is specified in the contractor's contracts. (For example, this could be a focus for DNR facilities and lands, and parks staff.)

12. **Reduce water softening salt use at state-owned and operated facilities.** Identify state-owned and operated facilities that use water softening equipment. Work with state facilities managers to install high-efficiency demand-based softening equipment when replacements are warranted, and work to ensure proper calibration and installation to minimize salt use.

7.3 Governor's Office and Legislative Initiatives

13. **Adopt Legislation to reduce slip and fall claim liability for businesses where salt applicators have completed smart salting certification.** Liability concerns for slip and fall claims are repeatedly reported by those responsible for clearing snow and ice off roads, parking lots and sidewalks in the winter as a reason for excessive salt use. Research conducted in states such as Minnesota tells us that most property managers are over-using salt. This research also tells us that the public often perceives that more salt equates to safer facilities. Legislation to limit liability for entities that are trained and apply salt in appropriate amounts, similar to those adopted in Minnesota and New Hampshire, could substantially reduce salt use in winter.

14. **Update Wis. Stat. § 83.035 and Wis. Stat. § 83.018 to allow private entities to take advantage of municipal resources for brining**. If government entities can become a supplier of brine, the technique might be more accessible and affordable for private entities to use brine.

15. **Promote opportunities for private contractors to unload salt and have it stored at a permitted facility (e.g., municipality, county, state) to prevent overuse in the spring.** There have been anecdotal reports of private contractors over-applying in spring to avoid storing salt over the summer months. During this time, contractors often have other summer landscaping materials and equipment that require storage space.

16. **Adopt the recommendations of the Upper Mississippi River Basin Association (UMRBA) resolution to reduce chloride inputs into the basin.** The resolution was drafted on behalf of the governors from the states of Illinois, Iowa, Minnesota, Missouri and Wisconsin, all working together to address chloride concerns in the Upper Mississippi River Basin. The resolution cites

concerns about rising chloride levels in the basin, with data going back to 1961. The resolution also cites concerns about the interaction of chloride and the mobilization of metals in nutrients and soils creating negative secondary effects. The resolution calls for a number of actions to be undertaken, including:

- Calling for USEPA to update the acute and chronic standards for chloride that have not been updated since 1988, citing new data that show negative effects on biodiversity in the aquatic environment at levels below those currently required**.**
- Collaboration to make chloride-reduction strategies and equipment more affordable.
- Partnerships to promote training, citing Minnesota's Smart Salting program as responsible for the reduction of salt use by 30-70% in the Twin Cities Metropolitan Area.
- Legislation to protect from potential liability related to slip and fall litigation that with the intent of reducing salt overuse as a perceived measure of safety.
- Better communication to the public about the negative impacts of chlorides on the environment, as well as the upward trend of chloride contamination throughout the Upper Mississippi River Basin.

It is recommended that both the governor and the agency approve this resolution.

Potential actions considered but not forwarded for recommendation:

1. **Analyze the pros and cons of community-wide softening.** Communities can provide community-wide softening right at the water plant. This gives the community more control over the chloride inputs into their system. However, one downfall is that all water is softened, not just hot water as is the case with in-home water softening units. Water used in outdoor landscaping would also include chloride. We need to determine if this is causing "over-softening" or additional chloride inputs, or if it is creating efficiencies in salt reduction efforts. The city of Little Chute is doing community-wide softening and is using the waste brine in their road maintenance. A study of the risks and benefits of community-wide softening was conducted in Minnesota. This study found that centrally softening water at drinking water plants is an environmentally- and cost-effective solution to reduce chlorides in the water resources. (Bakshi B, et. al, (2021)) Centralized softening as a solution to chloride pollution: An empirical analysis based on Minnesota cities | PLOS ONE

8. Priorities

After the workgroup developed recommendations, it further prioritized the recommendations. To do this, a smaller workgroup met to develop a rating process. The smaller group developed a rating process for the larger team. The group used the following criteria to develop the priority ranking.

Priority. Each recommendation received a priority score of 1-5 with 1 being the lowest priority and 5 the highest.

- 5 pts: Very High
- 4 pts: High
- 3 pts: Medium
- 2 pts: Low

- 1 pt: Very Low

Environmental Benefit. A score of 1-3, with 3 being the greatest benefit to the environment and 1 the lowest.

- 3 pts: Significant environmental benefit
- 2 pts: Moderate environmental benefit
- 1 pt: Minor environmental benefit

Opportunity. An "opportunity score" was defined and assigned to each recommendation. This score is intended to weigh the degree of difficulty to implement the recommendation.

- 3 pts: Likelihood to implement in the near term 1-2 years
- 2 pts: Likelihood to implement in next 2-5 years
- 1 pt: Timeframe to implement is unknown

Barriers. A barrier score was assigned to weigh the significance of barriers to implement the recommendation. Barriers that were identified included funding, staffing, level of control over the recommendation, if opportunities already existed to implement the recommendation and the potential partners that might need to be involved.

- 3 pts: No barriers
- 2 pts: Some barriers
- 1 pt: Many barriers

Using the process described above, the workgroup has ranked the recommendations in the following priority order:

1. Continue implementation of chloride WQBELs and WQS variances in wastewater WPDES permits.
2. Offer State Revolving Loan Funds (SRF) to cover the costs to acquire brining equipment and outreach programs.
3. Develop a Total Maximum Daily Load (TMDL) for chloride.
4. Support a smart salting certification program for communities and businesses through the DNR's Sustainability and Business Support program.
5. Update the chloride surface water quality criteria for the state.
6. Adopt the recommendations of the Upper Mississippi River Basin Association (UMRBA) resolution to reduce chloride inputs into the basin.
7. Legislation to reduce slip and fall claim liability for businesses where salt applicators have completed smart salting certification.
8. Incorporate additional drinking water requirements for chloride and sodium.
9. Require permitted MS4s to report salt discharges as an illicit discharge.
10. For state-owned properties, have contractors and individuals conducting winter property maintenance take winter maintenance training and implement salt reduction strategies.
11. Update statutes to allow private entities to take advantage of municipal resources for brining.
12. Develop a partnership with U.S. Environmental Protection Agency (EPA) in reversing the trends in chloride levels.

13. Reduce water softening salt use at state-owned and operated facilities.
14. Develop and support salt reduction education programs among permitted MS4s and POTWs with chloride variances via the DNR's urban runoff and wastewater permit programs.
15. Promote opportunities for private contractors to unload salt and have it stored at a permitted facility (e.g., municipality, county, state) to prevent overuse in the spring.
16. Implement rebate programs for communities that have high water softener use.

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