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Road Salt Report – 2008-09
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<u>Overview</u>

Winter road maintenance is critical and the application of road salt is an important tool in the maintenance process. However, the use of road salt can negatively impact the environment. Salt use began in Madison in 1959; and by 1962 the Madison Common Council requested that the Madison Department of Public Health (MDPH) begin a study of the effects of road salt on surface waters in the Madison area. At that time, its effects were found to be minimal. In 1973, the Madison Common Council put forward a plan to reduce the use of road salt in the Lake Wingra watershed to 50% of the amount used in the winter of 1972-73. In the winter of 1977-78, the 50% salt use reduction objective was extended to include the entire City and MDPH was directed to submit an annual report to the Madison Common Council.

Despite implementing recommendations by the Salt Use Subcommittee, and other ongoing efforts by both the City of Madison and Dane County, the use of road salt continues to rise. Monitoring of surface and ground water continue to show increasing trends in chloride and sodium levels, although the levels are not yet a human health hazard. Storm water monitoring during snowmelt has identified surges of extremely high levels of chloride. These surges have the potential of harming fish and other aquatic organisms as they enter local lakes and rivers. Additional efforts to reduce road salt applications are needed if Madison is going to achieve the goals set in the 1970's. . This report contains a revised estimate of Dane County's road salt use in the Mendota and Monona watersheds.

<u>Discussion</u>

Salt Use in the Lake Mendota and Lake Monona Watersheds.

The term *watershed* describes an area of land that drains down slope to the lowest point. Every stream, lake, or river has an associated watershed, and small watersheds join to become larger watersheds. Because water moves downstream, any activity that affects the water quality at one location can affect locations downstream[1].

Road salt is used for winter road maintenance throughout the Mendota and Monona watersheds. It enters surface water, soil and groundwater after snowmelt. In the environment, the salt dissolves and dissociates into sodium (Na) and chloride (Cl) ions that are transported in melt water. Chloride ions are conservative, moving with water without being retarded or lost through biological or chemical processes. Accordingly, all the chloride ions that enter the soil and groundwater can be expected to reach surface or ground water.

Sodium is also relatively low in chemical and biological reactivity as it moves in the ecosystem. However, it can be adsorbed by the soil particles and may not reach surface or groundwater as readily as chloride ions.

[1]This description of a watershed was taken from the Watershed Stewardship Education Program Training Guide, Oregon State University and Sea Grant Extension: http://seagrant.orst.edu/wsep

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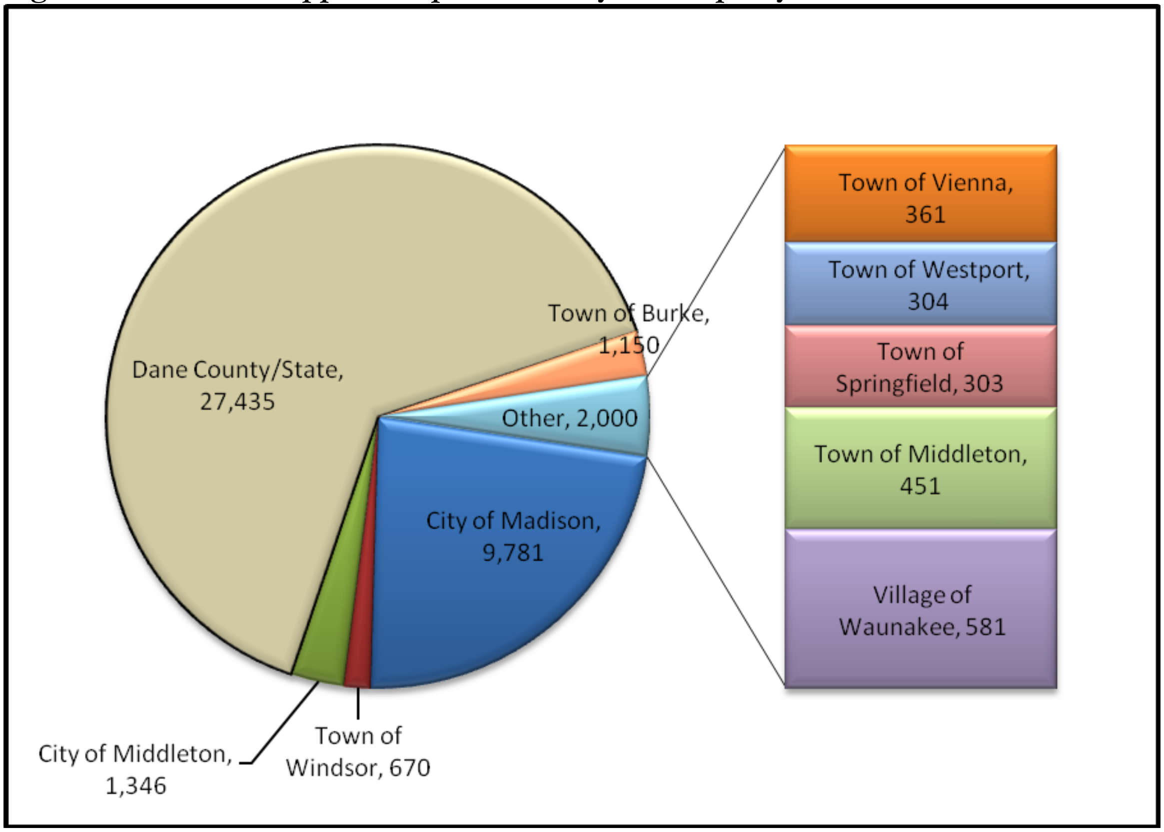
Because of road salt's mobility and potential toxicity, its use by all road maintenance entities within the Lake Mendota and Lake Monona watersheds needs to be examined. Eight townships, two villages, and three cities comprise most of the area within the watersheds for Lakes Mendota and Monona. Although all the street departments in the watersheds have unique salt application policies, most departments strive to minimize road salt application to reduce cost. Total salt application, by reporting municipality, for the winter of 2008-2009 is illustrated in Figure 1. The total for the Dane County Highway Department has been revised, from last year, to reflect the different application rates associated with the Wisconsin Department of Transportation's (DOT) maintenance categories for state highways. This adjustment attributes nearly two thirds of the road salt used in the watersheds to Dane County's maintenance of state highways.

Figure 1 Tons of salt applied or purchased by municipality winter of 2008-2009



It should be noted that this is a crude approximation obtained by estimating lane miles within each DOT plowing category with Google Earth aerial photographs. After conferring with Dane County staff, the following application rates were used for each category: 300 lbs/lane mile-category 1; 200 lbs/lane mile-category 2; 100 lbs/lane mile –categories 3 and 4; 25 lbs/lane mile-category 5 (see the DOT map on the following page). Lane mile estimates did not include entrance and exit ramps, so Dane County's contribution is underestimated.

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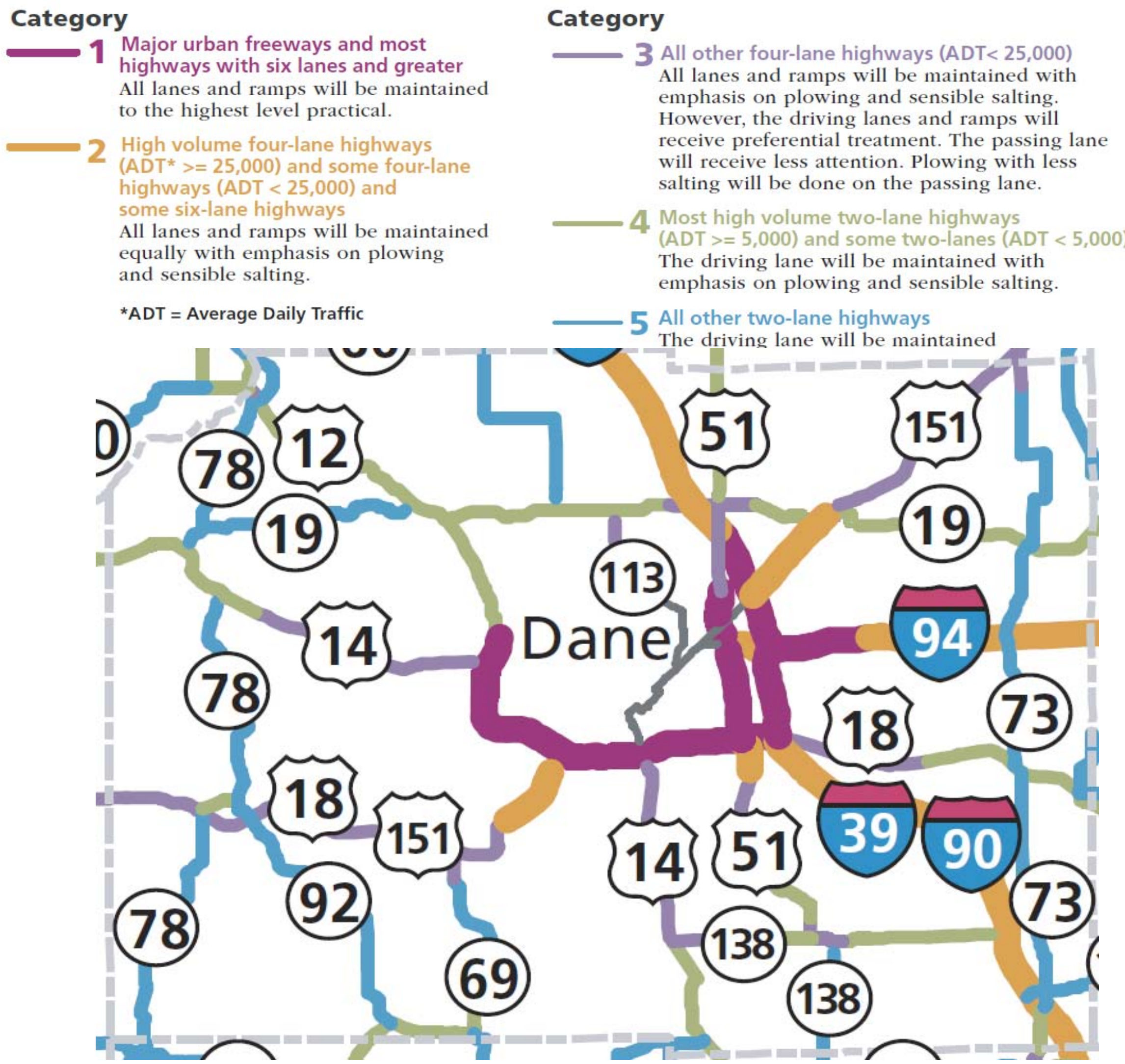
Wisconsin Department of Transportation Snowplowing and Ice Control Categories



Snowfall in Madison for the winter of 2008-2009 was again well above normal. The season total of 72 inches is almost 50% above the norm; however, this is still 25% less snow than last year. The reduction in salt application was considerably greater than the change in snowfall would suggest; the City used 45% less salt than the previous winter. However, the goal set in 1972-1973 was still exceeded by over 200% (see Figure 2). Throughout the two watersheds, salt use was generally down by 20-50%.

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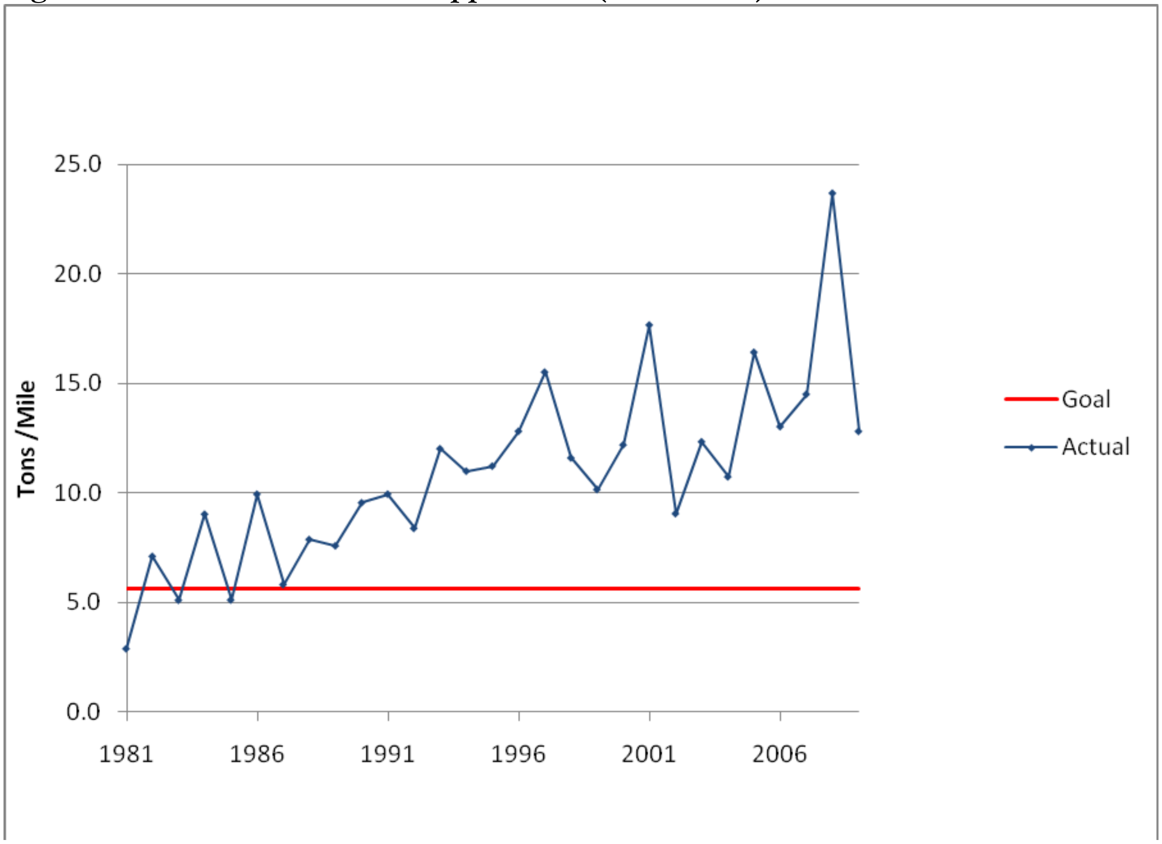
Figure 2. Annual Madison Salt Application (Tons/Mile).



Prior to the salt reduction goal initiated by the Common Council, there was no official policy. The operators just applied salt until the streets were clear. After the Common Council's directive, Madison snowplows were set to apply at a rate of 50 pounds per lane mile. Also, segmented salting on sections of salt routes was initiated. Segmented salting was a procedure of applying salt for several blocks, then leaving the next several blocks unsalted. It was hoped that the salt would be distributed to the unsalted sections by traffic.

This policy has changed over time. Segmented salting was discontinued circa 1980. The City now salts only main arterials, main thoroughfares, main neighborhood connectors, major hills and curves, Madison Metro bus routes, and areas around schools and hospitals. Salt is applied with the first plowing to prevent the snow from bonding to the street, but then the streets are plowed without salting until the storm is nearly over. Salting is resumed with the final plowing. The salt application rate has gradually increased to the current level mainly because of public demand for a quick return to bare pavement (see Table 1).

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Table 1. Tons of Road Salt Applied

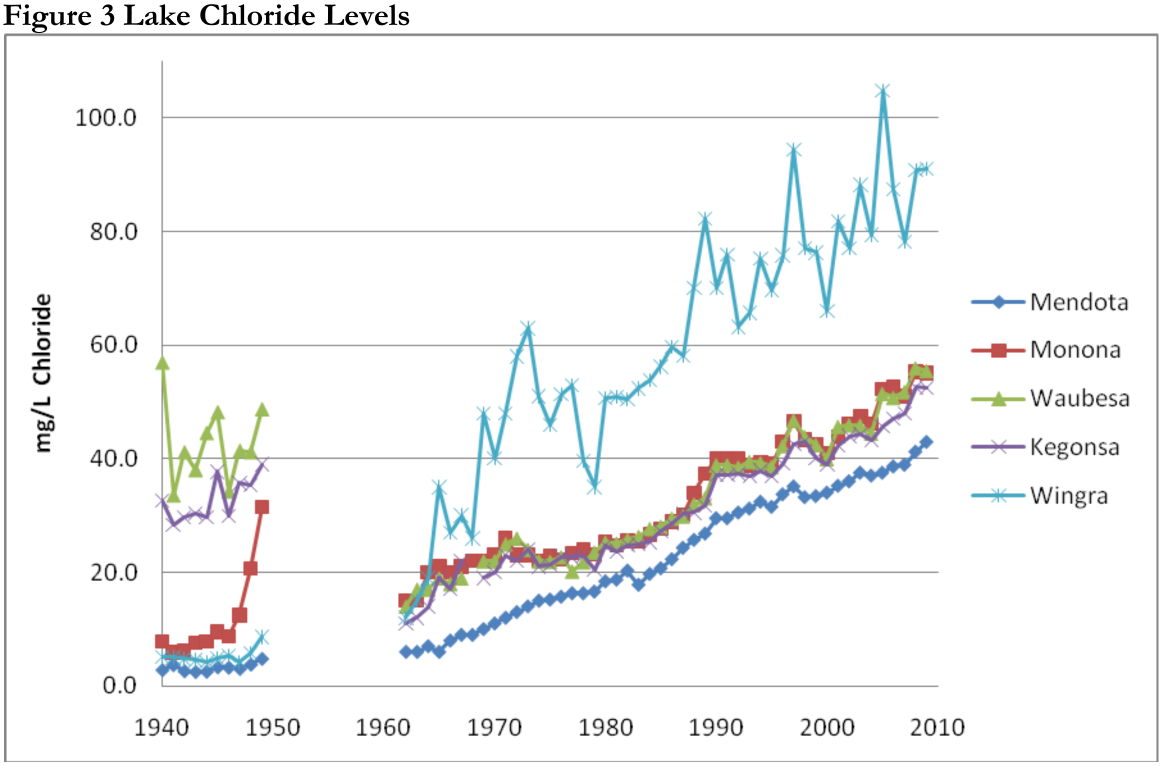
Year	Tons of Salt	Year	Tons of Salt
1981	1618	1996	8094
1982	4010	1997	9862
1983	2890	1998	7451
1984	4980	1999	6644
1985	2897	2000	7978
1986	5574	2001	12485
1987	3274	2002	6423
1988	4491	2003	9010
1989	4393	2004	7853
1990	5605	2005	12037
1991	5836	2006	9762
1992	4950	2007	10984
1993	7147	2008	17946
1994	6825	2009	9781
1995	5920		

Additional substantive salt inputs may be coming from private property. Commercial applications to parking lots and residential applications to driveways, parking lots, and sidewalks remain unknown and may constitute a considerable contribution to sodium and chloride levels.

Sodium and Chloride Levels in the Yahara Lakes.

Sodium and chloride levels in the lakes continue to increase. Lake Wingra has seen sodium and chloride levels increase by almost 100% since 1975. All the other lakes in the chain have experienced increases in sodium and chloride of 140-180%. The chloride concentration in Lake Wingra reached a level of 112 mg/L in April of 2009 (see Figure 3). Canadian researchers have estimated that 5 percent of aquatic species would be affected at chloride concentrations of about 210 mg/L, and 10 percent of species would be affected at chloride concentrations of about 240 mg/L[1]. The Wisconsin Department of Natural Resources (WDNR) has established a chronic toxicity criterion of 395 mg/L for chloride.

Figure 3 Lake Chloride Levels



[1]Environment Canada: 1999 Canadian Environmental Protection Act, 1999. Priority Substances List Assessment Report. Road Salts.

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By definition, this is the concentration that cannot be exceeded for more than four days once every three years without causing adverse effects to aquatic life. While none of the Yahara Lakes have approached these levels during dry weather monitoring, University Bay Creek and Dunn's Marsh have been found to be much higher.

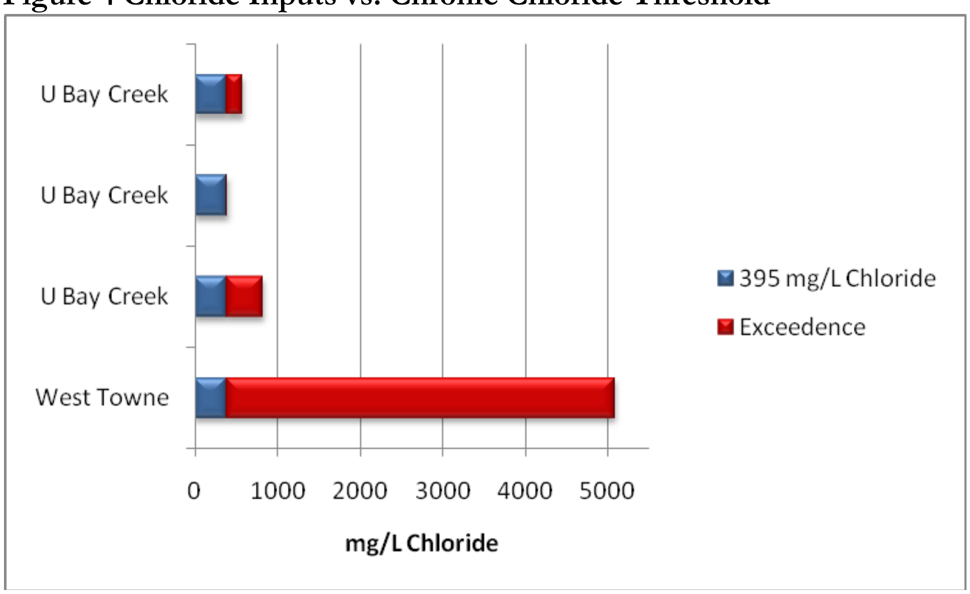
Public Health Madison and Dane County samples the lakes monthly following a requisite three-day period of dry weather. Each lake is sampled at its outflow, although some early data is from samples collected from the lake basins. The chloride levels depicted in figure 3 represent yearly average chloride concentrations from monthly samples. Some years have less than twelve monthly values.

The earliest Health Department data indicate Lakes Mendota and Wingra had stable chloride levels, with Lake Mendota averaging about 3 mg/L and Lake Wingra averaging about 5 mg/L chloride. Lake Monona chloride levels were fairly stable at 6-10 mg/L until it received sewage effluent in 1947-49 while Madison Metropolitan Sewage District's (MMSD) eastside interceptor was being built[2]. The elevated chloride levels in Lakes Waubesa and Kegonsa during the 1940's reflect the influence of MMSD effluent on water quality.

Although there is a 13-year gap in the data, it is evident that Lake Wingra has been strongly influenced by winter road maintenance activities since road salt applications began in 1959. The average chloride level in Lake Wingra in 1962 was 12 mg/L. By 1973, this level had peaked at 63 mg/L, the same year the road salt reduction policy was implemented. Chloride levels trended downward through 1979. Following the termination of segmented salting in 1980, chloride levels have continued to increase.

Surface water drainage and storm sewer contributions to the Yahara Lakes.
Dry weather monitoring of Dunn's Marsh, University Bay Creek, and the West Towne Mall outfall has again revealed chloride levels above the chronic toxicity level (See Figure 4).

Figure 4 Chloride Inputs vs. Chronic Chloride Threshold



[2]Lathrop, R.C. June 1988. Chloride and Sodium Trends in the Yahara Lakes. Bureau of Research-Wisconsin Department of Natural Resources.

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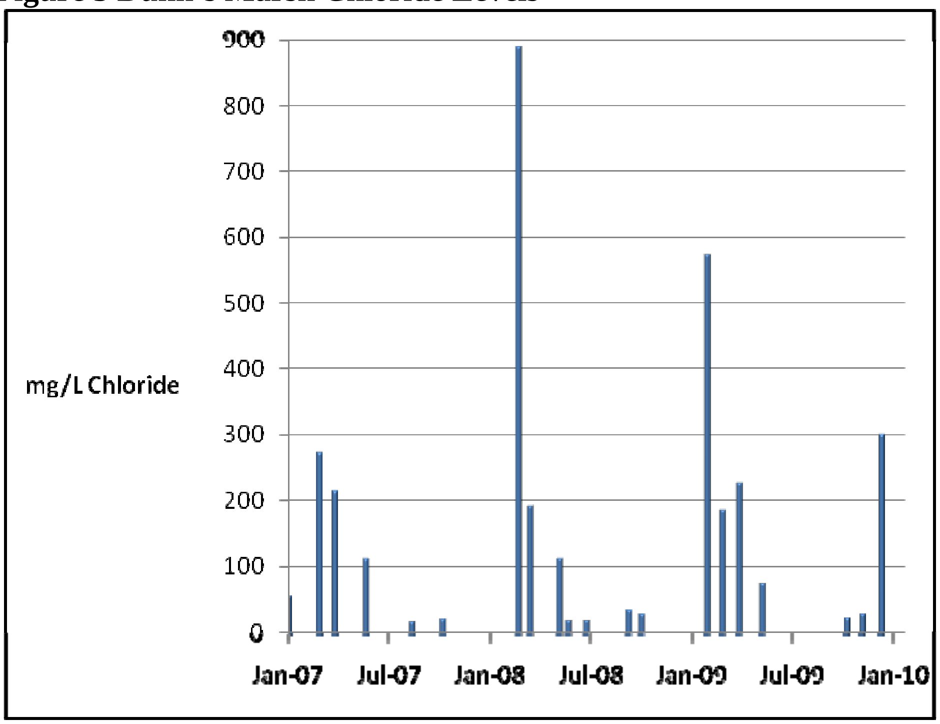
The University Bay Creek samples represent monthly outfall monitoring taken in (top to bottom): December 2008; January 2009; and February 2009. The West Towne sample represents a single event snowmelt from privately maintained streets and sidewalks from February 2008.

Although it is part of the Rock River Basin, Dunn's Marsh does not drain to the Yahara Lakes. However, because it is a small water body with an urban watershed, it is part of PHMDC's monthly dry-weather monitoring program. It continues to show seasonal variations in chloride levels attributable to road salt use (See Figure 5). Per the WDNR definition, it has exceeded the chronic toxicity level of 395 mg/L chloride often enough to cause adverse effects on the biota.

Figure 5 Dunn's Marsh Chloride Levels



Monthly monitoring of Starkweather Creek, an urban stream draining to Lake Monona, was initiated in 2008. Although there is insufficient data to observe trends; seasonal chloride fluctuations have been observed.

Road salt influences on Madison's drinking water.
It is important to realize that road salt application also degrades the quality of Madison's groundwater resources. Deep aquifers supply our drinking water and must be protected to ensure high quality water. Some Madison drinking water wells appear to be impacted by road salt application. Levels of chloride in Madison's drinking water are below the WDNR Secondary Maximum Contaminant Level (SMCL) of 250 mg/L. However, well #23 contained chloride at 103 mg/L in 2009. Chloride levels in this well are almost 40% higher than last year. Continued road salt application will likely result in ongoing increases in chloride levels in groundwater. Also, decreases in chloride and sodium in Madison's

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drinking water may not be realized for many years after road salt applications have been reduced. See Table 2 for sodium and chloride levels in Madison's most impacted wells.

Table 2 Sodium and Chloride Levels (mg/L) in Madison Wells

Year	UW #14		UW #15		UW #17		UW #23		UW #27	
	Na	Cl	Na	Cl	Na	Cl	Na	Cl	Na	Cl
1975		12			9	13		8		
1976		13			9	13		8		
1977		13			12	17		9		
1978		13			10	15		9		
1979		17			10	18		11		
1980		19			16	34		14		
1981		20			14	24		16		
1982		21			12	23		18		
1983		23			14	25		21		
1984		23			14	24		35		
1985		27			14	24		33		
1986					12	21				
1987					9	17				
1988					13	28				
1989					11	12				
1990					13	28				
1991					20	47				
1992					15	36				
1993	12.0	41.0	8.0	21.0	20.0	49.0	14.0	48.0	16.0	39.0
1994	8.5	20.5	4.8	12.4	4.2	6.5	4.4	4.5		
1995	14.0	41.0	9.0	22.0	11.0	21.0	15.0	49.0	12.0	30.0
1996	15.0	51.7	8.8	23.7	21.0	52.8	15.0	51.8	11.0	25.9
1997	16.0	52.5	10.0	25.9	22.0	54.4			11.0	24.8
1998	17.0	54.7	10.0	26.5	12.0	25.9	16.0	54.8		23.4
1999	18.0	59.1	10.0	29.5	20.0	49.6	13.0	39.8	10.0	23.1
2000	19.0	58.3	11.0	29.6	23.0	53.5	13.0	39.4	9.7	19.5
2001	21.0	60.1	12.0	32.2	12.0	23.6	14.0	45.0	11.0	22.6
2002	22.7	64.1	12.8	34.4	ND	23.5	16.2	46.6	11.0	21.8
2003	22.4	68.8	13.6	36.5	25.2	58.1	15.6	46.4	11.6	24.4
2004	21.7	69.2	14.0	38.7	20.0	49.7	22.5	72.6	13.7	31.0
2005	25.2	69.9	14.8	40.6	21.0	55.6	17.6	56.0	17.8	31.6
2006	26.5	76.8	15.5	41.6	17.6	43.9	27.0	82.0	16.7	38.6
2007	27.1	75.0	16.3	42.9	14.8	32.8	19.1	54.2	18.5	43.4
2008	30.5	88.1	17.3	44.6	16.8	38.4	21.7	62.6	28.9	64.5
2009	32.5	92.0	18.2	47.8	20.8	50.4	35.2	103.1	16.8	34.5

Sodium is also entering the groundwater as a result of road salt use. The United States Environmental Protection Agency has issued a health-based drinking water guideline of 20 mg/l or less of sodium for individuals with a restricted sodium diet. There is also a taste threshold for sodium: 30 to 60 mg/L. Wells 14, 17 and 23 exceeded the 20-mg/L guideline in 2009.

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Conclusions.
Winter road maintenance personnel deal with a multitude of variables that affect their ability to reach their goal – safe roadways. Temperature, time of day, snowfall forecast, plowing and deicing efficacy, cost, and many other factors must all be considered. Additionally, due consideration needs to be given to the effects that deicing materials have on the environment.

Considering that Dane County and the City of Madison are the two largest users of road salt in the Mendota and Monona watersheds, further efforts to reduce the influence of deicing activities on area water resources should focus on their policies. However, both entities have already reduced their salt use and continue to explore methods to reduce it further. Despite these measures, salt use continues to rise. Repeat applications spurred by the public's demand for bare pavement have fueled this increase.

Madison's groundwater resources continue to show increasing trends in sodium and chloride levels. Groundwater moves slowly, so by the time contamination is a concern, a large volume of water has been affected. Contaminant levels will persist long after remedial action has been taken.

Given the newest estimate of municipalities' salt applications in the watersheds, the City's efforts to substantially reduce the impacts of road salt may be ineffective if it acts alone. However, reducing sodium and chloride levels in the Lake Wingra watershed is within the City's ability. A concerted effort in this basin may illuminate the costs and benefits associated with such an endeavor. Undoubtedly, the public's expectations for clear roadways must be lowered if any salt reduction goal is to be met. If it is instituted on the smaller scale of the Wingra basin, it may gain public acceptance before the din of complaints can negate the policy.

Clearly, the biggest obstacle to achieving the desired salt reduction is the public's understanding and acceptance of salt reduction for the benefit of the environment. A concerted effort to prioritize safety, and then the environment ahead of the public's desire for bare pavement is needed.

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