Road Salt Report – 2010
Prepared by Rick Wenta and Kirsti Sorsa, Public Health Madison – Dane County
31 January 2011

Overview

The City of Madison added road salt as sodium chloride to its winter road maintenance arsenal in 1959. Concern over the environmental consequences of its use was voiced by the Common Council in just three years. Although a 1962 assessment by the Madison Department of Public Health (MDPH), found minimal environmental impact, the Common Council promulgated a resolution to reduce the use of road salt in the Lake Wingra watershed. The plan called for a 50% reduction (from the amount used in the winter of 1972-1973) in road salt use in the Lake Wingra watershed starting in December of 1973. The salt use reduction objective was extended to include all of Madison in December of 1977. MDPH was directed to monitor the effects and submit an annual report to the Madison Common Council.

Despite nearly 50 years of concern, observation and efforts at reduction, the use of road salt continues to increase. 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. As these surges enter local waterways, they have the potential of harming fish and other aquatic organisms. Additional efforts to reduce road salt applications are needed if Madison is going to achieve the goals set in the 1970s. New information in this report includes a decade by decade look at salt reduction efforts and how they affected chloride levels in Lake Wingra.

Discussion

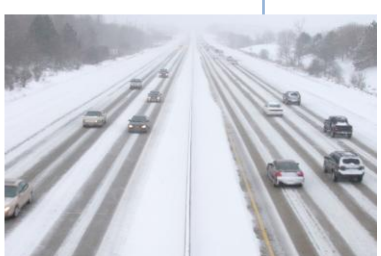
When evaluating Madison winter road maintenance policy and the use of deicers, it is useful to examine their impacts by monitoring trends in Lake Wingra's chloride content. The Wingra watershed was urbanized long ago, so changes in chloride levels can be attributed to salt application rather than land use practices. Also, it is a small water body with a short residence time, so chloride levels react quickly to changes in salt application. However, the vagaries of weather have confounding effects on chloride content. An increase in precipitation may mean heavy snowfalls, which require addition salt applications, or it may indicate heavy rainfall, which dilutes a lake's chloride concentration. Or, it may be a combination of both (see figure 1).

The use of road salt in winter road maintenance started in Madison in 1959 (see timeline following this section). At that time, salt was just applied until the streets were clear. But, the salt reduction goal of 1977 required the Streets Department to cut the use of road salt from the 5,692 tons used in 1972-73 to 2,846 tons. As a result, the salt application rate was set at 50 pounds per mile, and segmented salting was initiated. This consisted of salting several blocks, then leaving the next several blocks unsalted. It was hoped that traffic would distribute salt to the unsalted sections. However, segmented salting didn't clear the streets adequately, so it was discontinued in 1980.

Winter Road Maintenance History

1970 | 1980 | 1990 | 2000 | 2010 | 2020

- Use of road salt begins (1959)
- Initial road salt impact study (1962)
- Wingra watershed salt reduction (1973)
- City-wide salt reduction (1977)
- Salt application rate set at 50 lbs/mile (1977)
- Segmented salting begins (1977)
- Segmented salting discontinued (1980)
- Salt spreader calibration (1992)
- CaCl pre-wetting test (1997)
- Computerized spreader calibration (1999)
- 100 % beet juice efficacy tested (1999)
- Calcium magnesium acetate test (2000)
- Coal ash as an abrasive (2002)
- CaCl pre-wetting agent (2004)
- 23% salt brine pre-wetting agent (2007)
- Ice slicer test (2008-2010)
- Salt brine anti-icing test (2009)
- Anti-icing with salt brine (2010)
- Auger inserts w/fixed tailgates (2010)
- Salt crusher at tailgate (2010)
- Geomelt 70/30 anti-icing agent (2011)



Although these policies were deemed inadequate for street maintenance, they were successful at reducing salt use. From 1977 through 1980, total salt use averaged 2,464 tons, an average reduction of almost 57% from the base year (winter of '72-'73). Chloride levels in Lake Wingra responded accordingly, dropping to the lowest level observed since 1968 (Figure 1). Precipitation during this time period was average, about 31.6 inches per year.

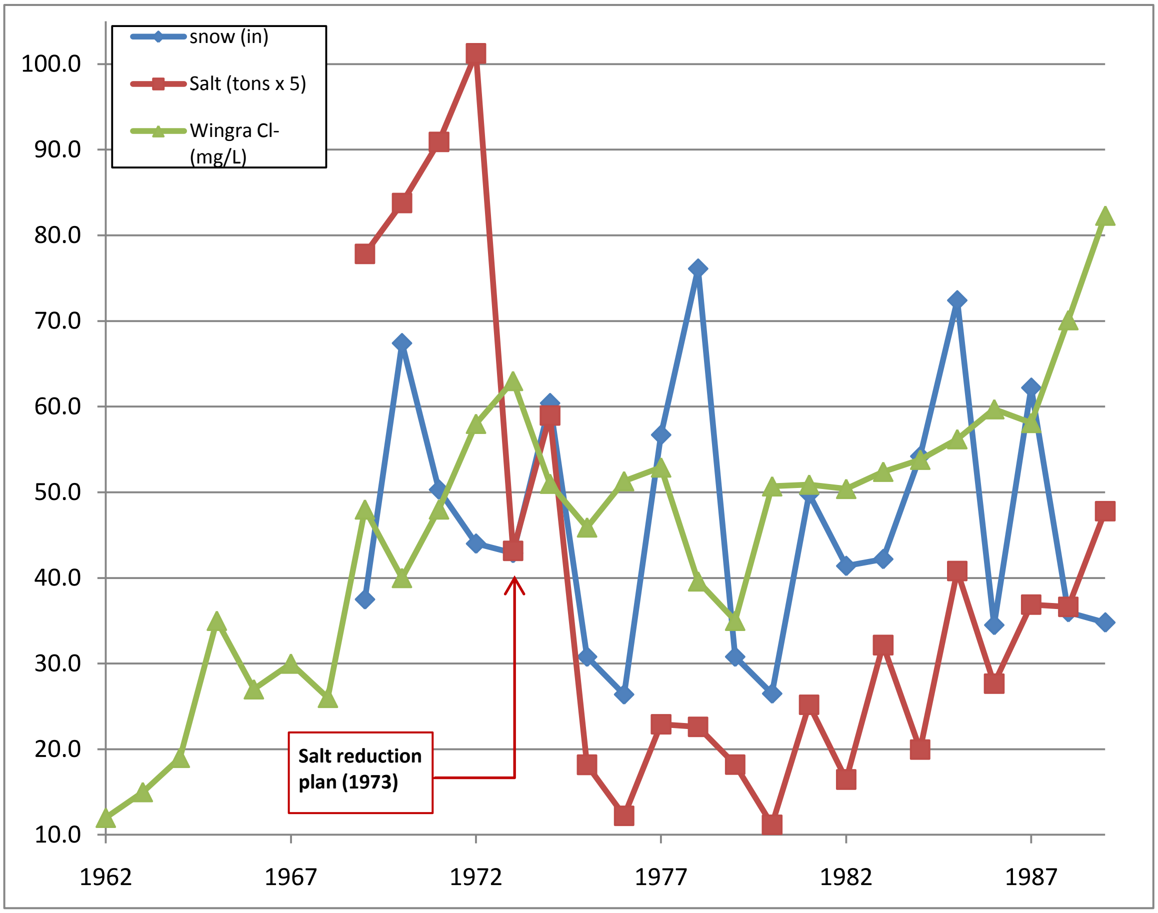
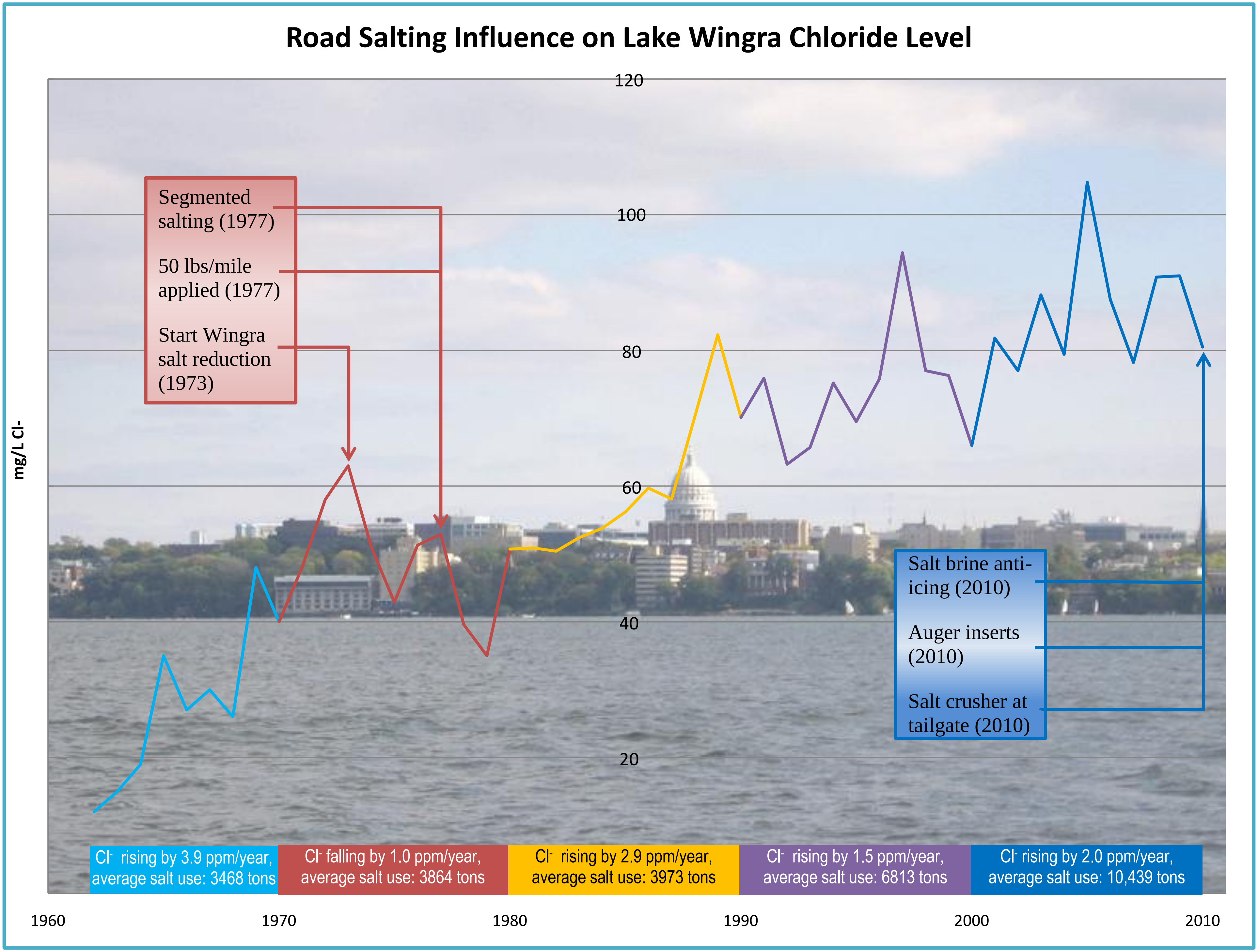


Figure 1 - response of Lake Wingra chloride levels to the 1973 road salt reduction. Chloride levels trended downward until 1980 then began a steady rise. Note the reduced salt use for the winter of '78-'79 when Madison received 76 inches of snow.

Winter road maintenance continued through the 1980's with no significant modifications to equipment or procedures. Average salt use for the decade was 3973 tons, an average decrease of 30% from the base year. Yet, regression analysis reveals chloride levels in Lake Wingra rose sharply through the 1980's, trending upward at an average rate of 2.9 parts per million per year. Precipitation for the decade was average.

Salt spreader calibration became the norm during the decade of the 1990's. Although Madison began calibrating its spreaders in about 1992, there were only two settings available; 300 pounds and 500 pounds per two-lane mile were used. The calibrated spreaders were upgraded to computerized versions in about 1998. This provided accurate record keeping of the amount of salt actually applied. An additional calibration setting


Road Salting Influence on Lake Wingra Chloride Level
mg/L Cl-
120
100
80
60
40
20
1960
1970
1980
1990
2000
2010
Segmented salting (1977)
50 lbs/mile applied (1977)
Start Wingra salt reduction (1973)
Salt brine anti-icing (2010)
Auger inserts (2010)
Salt crusher at tailgate (2010)
Cl- rising by 3.9 ppm/year, average salt use: 3468 tons
Cl- falling by 1.0 ppm/year, average salt use: 3864 tons
Cl- rising by 2.9 ppm/year, average salt use: 3973 tons
Cl- rising by 1.5 ppm/year, average salt use: 6813 tons
Cl- rising by 2.0 ppm/year, average salt use: 10,439 tons

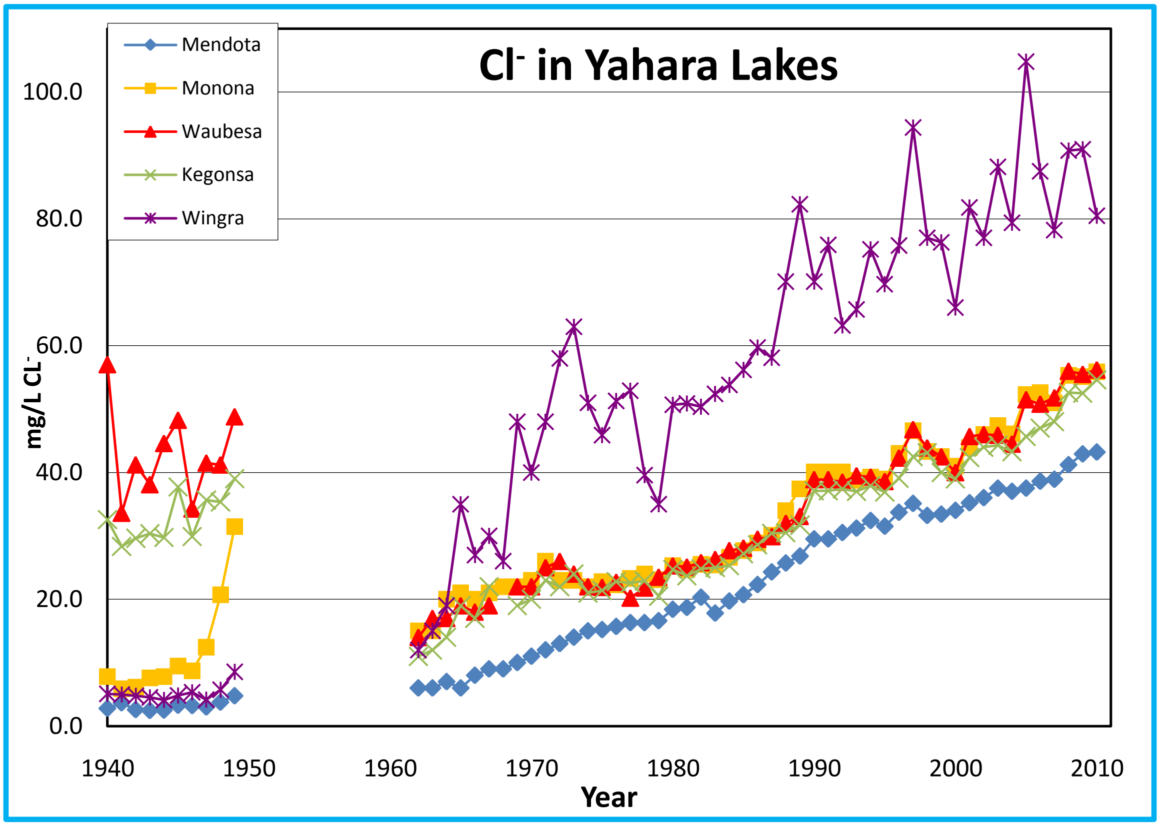
of 200 pounds per two-lane mile was added also. Salt spreader calibration seems to have been a significant improvement in salt application management, but average salt use for the 1990's rose to 6813 tons per year, which is 140% above the goal. However, the trend in Lake Wingra chloride levels showed a smaller average increase of 1.5 parts per million per year. Average annual rainfall for the decade was 33.6 inches.

The Streets Department has continued to strive for efficient management of road salt through equipment upgrades and procedural improvements. Beet juice was tested during the first winter of 2000. However, the results were not as expected and didn't justify the expense; it was four times more expensive than salt. Calcium magnesium acetate was evaluated the following year, with similar results. Another test, the use of boiler slag as an abrasive (does not require 10% salt mixture to prevent freezing into chunks), was conducted during the winter of 2002-2003. The results were promising; the slag became imbedded in the packed snow more quickly and more securely than sand. However, cost, availability, and citizen complaints (slag was easily tracked into homes by people and pets) were unfavorable.

Additional attempts to improve winter road maintenance were also tested during the decade of 2000-2010. From 2004-2006, calcium chloride brine was used as a pre-wetting agent to stop the road salt from scattering when spread, and to hasten the melting process. It was deemed too costly and corrosive to be practical. However, the practice of pre-wetting the salt has continued, but the calcium chloride brine has been replaced with sodium chloride brine. An alternative salt called Ice Slicer was also tested (2008-2009). It also was too expensive and actually seemed to exacerbate icy conditions. Lastly, anti-icing with salt brine was tested in 2009-2010. The results were positive, so the practice will be continued. An average of 10,439 tons of salt was applied each of the last ten years. This level is over 265% above the goal. The trend in Lake Wingra chloride levels continued upward, too. The average increase for the past decade was 2.0 parts per million per year.

The Madison Streets Department does a commendable job of maintaining safe winter driving conditions while striving to reduce the use of road salt. To wit, several more salt reduction efforts are being evaluated during the winter of 2010-11. An auger insert for salt spreading trucks is being tested. This system functions with a fixed tailgate so the operator cannot bypass the computer-calibrated spreader by lifting the tailgate. A tailgate-mounted salt crusher is also being evaluated. This system reduces the size of the salt grains as they are applied. Doing so reduces the amount of salt that bounces off the road as it is applied and provides a larger surface area, allowing the salt to form brine more quickly. The effectiveness of the salt crusher has allowed, in some instances, an application rate reduction from 300 pounds per mile to 200 pound per mile. Lastly, Geomelt 70/30 will be tested. This anti-icier/deicer is 70% sodium chloride brine and 30% beet juice. It will be used at temperatures where salt is ineffective.

Figure 2

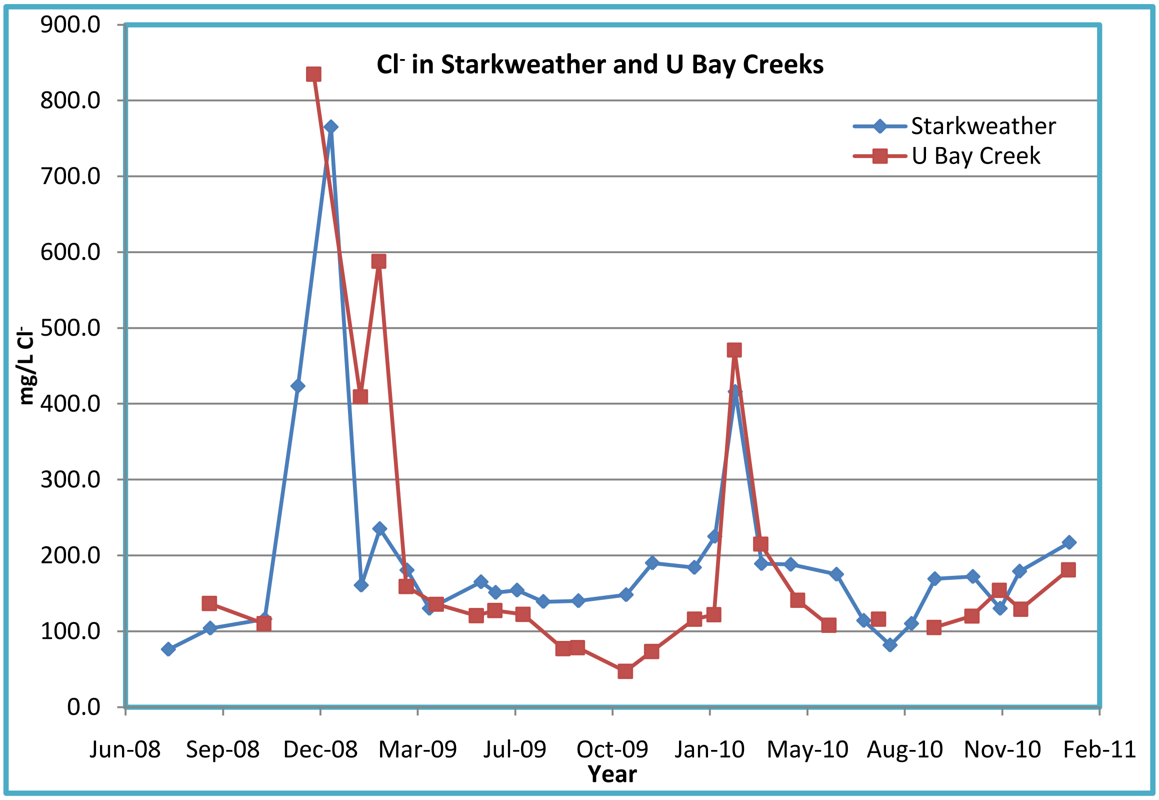


Despite the efforts put forth by the Streets Department, average annual salt use for the past decade was over 50% higher than that of the previous decade, while the miles of street maintained increased by 17%. Likewise, the levels of chloride in our environment continue upward. Chloride concentrations in the Yahara Lakes have increased 22%-40% in the last ten years (Figure 2).

Chloride continues to impact other areas of the environment as well. University Bay Creek has again experienced a spike in chloride above the Wisconsin Department of Natural Resources (WDNR) chronic toxicity limit of 395 mg/L. On February 16, 2010, a chloride concentration of 471 mg/L was recorded. A chronic toxicity exceedence for chloride was observed in Starkweather Creek in February as well. On February 17, 2010, Starkweather Creek contained 416 mg/L chloride (Figure 3).

Madison's drinking water continues to show increasing levels of sodium and chloride as well (see Table 2). Over half of the City's drinking water wells have sodium levels that are trending higher. Three wells are above the United States Environmental Protection Agency's drinking water guideline of 20 mg/L or less of sodium for individuals with a restricted sodium diet. A taste threshold for sodium is 30 to 60 mg/L. In 2010, well 14 had a sodium level of 34 mg/L.

Figure 3



Clearly, road salt continues to negatively impact our environment. Small, flowing surface waters that are heavily influenced by runoff, like Starkweather and University Bay Creeks, have the ability to rebound quickly from high inputs of salt. The Yahara Lakes have residence times of up to six years, but are still responsive to reductions in salt use, and their chloride concentrations have not yet reached a critical level.

The most persistent impact from road salt may well be increasing levels of sodium and chloride in our drinking water. Levels of chloride in Madison's drinking water are below the WDNR Secondary Maximum Contaminant Level (SMCL) of 250 mg/L. However, with three wells above the sodium restricted diet guideline of 20 mg/L, and many more with increasing sodium levels, Madison's drinking water may be substantively impacted long after road salt use has been meaningfully curtailed.

Summary

Past road salt reports have documented similar levels of salt application by other communities in the watershed. This report has delved into the history of Madison's efforts to use road salt judiciously. Yet, despite nearly 40 years of documented environmental costs of road salt application, its use continues to increase.

Sodium chloride is the de-icer of choice; it is cheap and effective. Until something more benign is developed, it will continue to be a major component of winter road maintenance. Although substantive efficiencies in road salt use have been realized, wise use alone will not result in a sufficient reduction in road salt use to negate its impacts on the environment.

The salt reduction goal of the seventies appears to be worthwhile. The period of 1975-1981 was the only time the goal was met and it was the only extended period of time, since the beginning of road salt use that chloride levels in Lake Wingra declined. But, further action is required. Motorists' expectations of bare pavement fuel the increase in road salt use. Yet, we zip down John Nolen Drive, admiring the view, without any idea of the cost associated with the convenience of bare pavement.

Acknowledgements:
Glenn Hyland – Public Health Madison and Dane County
Special thanks to Alan Schumacher and Chris Kelly, Madison Streets Division

Data Tables

Table 1

CITY OF MADISON STREET DIVISION SALT USE							
YEAR	Snow (in)	Salt (tons)	Brine (gals)	Street Miles	Tons/Mile	Salt + Brine (tons)	decade average
1972	44.0	5691.25		511.9	11.1	5,691.25	3,318.04
1973	42.5	3755.20		517.3	7.3	3,755.20	
1974	60.4	4853.80		517.4	9.4	4,853.80	
1975	30.8	2486.18		525.4	4.7	2,486.18	
1976	26.3	1519.96		529.1	2.9	1,519.96	
1977	56.7	2275.74		538.0	4.2	2,275.74	
1978	76.1	3282.40		547.7	6.0	3,282.40	
1979	30.8	2679.78		557.6	4.8	2,679.78	
1980	26.5	1617.76		562.6	2.9	1,617.76	3,973.29
1981	49.8	4010.05		565.4	7.1	4,010.05	
1982	41.4	2890.53		567.8	5.1	2,890.53	
1983	42.2	4980.10		552.1	9.0	4,980.10	
1984	54.2	2896.65		567.8	5.1	2,896.65	
1985	72.4	5574.10		561.1	9.9	5,574.10	
1986	34.5	3274.20		564.3	5.8	3,274.20	
1987	62.2	4491.30		571.0	7.9	4,491.30	
1988	36.0	4393.28		580.0	7.6	4,393.28	
1989	34.8	5604.95		587.4	9.5	5,604.95	
1990	55.0	5836.00		587.4	9.9	5,836.00	7,070.67
1991	42.4	4950.28		591.2	8.4	4,950.28	
1992	71.2	7146.88		595.2	12.0	7,146.88	
1993	73.7	6825.06		621.3	11.0	6,825.06	
1994	52.8	5919.64		627.8	9.4	5,919.64	
1995	60.5	8093.81		632.0	12.8	8,093.81	
1996	50.9	9862.15		636.0	15.5	9,862.15	
1997	53.9	7451.00		643.0	11.6	7,451.00	
1998	38.1	6644.03		655.0	10.1	6,644.03	
1999	34.1	7977.86		655.0	12.2	7,977.86	
2000	52.2	12485.03		707.1	17.7	12,485.03	10,724.61
2001	31.8	6423.02		710.0	9.0	6,423.02	
2002	28.8	9010.33		731.0	12.3	9,010.33	
2003	31.6	7852.65		732.1	10.7	7,852.65	
2004	43.9	12037.06	8066.0	733.5	16.4	12,047.14	
2005	47.6	9762.38	2040.0	750.0	13.0	9,764.93	
2006	55.1	10984.19	30324.5	758.0	14.5	11,022.10	
2007	101.4	17945.94	37669.0	758.1	23.7	17,993.03	
2008	72.0	9780.84	29456.0	764.1	12.8	9,817.66	
2009	51.6	10751.98	62571.0	765.7	14.0	10,830.19	

Table 2 - Sodium and Chloride in Select Water Utility Wells

Table 2Year	UW #6		UW #8		UW #9		UW #11		UW #14		UW #15		UW #16		UW #17		UW #23	
	Na	**Cl^-**	**Na**	**Cl^-**	**Na**	**Cl^-**	**Na**	**Cl^-**	**Na**	**Cl^-**	**Na**	**Cl^-**	**Na**	**Cl^-**	**Na**	**Cl^-**	**Na**	**Cl^-**
1993	7.0	23.0	6.0	11.0	10.0	29.0	6.0	15.0	12.0	41.0	8.0	21.0	5.0	14.0	20.0	49.0	14.0	48.0
1994	6.7	17.2	10.9	27.7	2.5	1.5	2.2	0.8	8.5	20.5	4.8	12.4	12.8	26.3	4.2	6.5	4.4	45.0
1995	8.0	23.0	9.0	17.0	10.0	35.0	6.0	18.0	14.0	41.0	9.0	22.0	5.0	14.0	11.0	21.0	15.0	49.0
1996	7.8	24.6	6.9	14.1	11.0	31.3	7.4	23.0	15.0	51.7	8.8	23.7	5.2	14.8	21.0	52.8	15.0	51.8
1997	7.7	22.7	7.4	14.4	12.0	31.0	8.2	25.6	16.0	52.5	10.0	25.9	5.7	15.4	22.0	54.4		
1998	7.9	23.7	7.5	14.1	12.0	30.9	9.2	27.8	17.0	54.7	10.0	26.5		16.5	12.0	25.9	16.0	54.8
1999	8.0	25.1	7.5	14.8	12.0	33.1	11.0	38.4	18.0	59.1	10.0	29.5	6.2	18.2	20.0	49.6	13.0	39.8
2000	8.9	25.8	7.6	13.2	12.0	31.1	12.0	37.5	19.0	58.3	11.0	29.6	6.9	18.3	23.0	53.5	13.0	39.4
2001	9.1	26.2	8.0	14.0	14.0	34.5	11.0	33.6	21.0	60.1	12.0	32.2	8.0	21.7	12.0	23.6	14.0	45.0
2002	9.4	26.2		19.2	14.1	33.3	12.0	33.5	22.7	64.1	12.8	34.4	9.0	24.5		23.5	16.2	46.6
2003	9.5	27.5	11.6	22.1	13.6	33.4	12.6	37.2	22.4	68.8	13.6	36.5	9.9	27.0	25.2	58.1	15.6	46.4
2004	9.4	28.4	8.9	17.0	13.4	34.4	12.7	39.0	21.7	69.2	14.0	38.7	10.4	29.6	20.0	49.7	22.5	72.6
2005	9.6	28.9	8.4	15.8	13.0	31.4	13.4	40.3	25.2	69.9	14.8	40.6	11.0	29.1	21.0	55.6	17.6	56.0
2006	9.8	28.9	8.7	16.0	13.8	33.0	15.4	47.3	26.5	76.8	15.5	41.6	12.5	34.2	17.6	43.9	27.0	82.0
2007	11.4	33.4	9.6	18.0	13.7	32.0	15.6	45.9	27.1	75.0	16.3	42.9	13.5	35.6	14.8	32.8	19.1	54.2
2008	11.2	30.7	10.4	22.3	13.9	30.9	16.0	45.2	30.5	88.1	17.3	44.6	13.0	34.3	16.8	38.4	21.7	62.6
2009	12.7	38.8	11.7	21.6	14.5	33.9	18.0	51.7	32.5	92.0	18.2	47.8	15.7	39.4	20.8	50.4	35.2	103.1
2010	13.1	37.8	9.0	17.0	15.4	36.4	17.9	52.4	34.0	94.0	19.0	49.3	16.1	43.7	22.6	55.5	26.4	72.7