WESTERN CONNECTICUT COUNCIL OF GOVERNMENTS

Winter Maintenance Guide

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FORWARD

This report was developed under contract for the Western Connecticut Council of Governments by Patrick Santoso of Axiomatic. Patrick holds an BS and MS in Civil Engineering from the University of New Hampshire. He is a nationally-recognized expert in salt reduction and has been involved in numerous aspects of environmentally-friendly winter maintenance since 2007.

Patrick was instrumental in the development of the New Hampshire Department of Environmental Services Green Snow Pro Certification program and was responsible for both the creation of course materials and the first-in-the-nation salt accounting web application. Patrick has trained over 1,500 winter maintenance professionals in Maine, New Hampshire, Vermont, Massachusetts, and Nevada, and has spoken at numerous environmental, snow and ice, and salt reduction conferences and symposiums. He is a founding member of the annual New Hampshire Salt Symposium, an event which highlights new technology and best practices and is regularly attended by over 100 winter maintenance professionals. He is the recipient of the New Hampshire “Shaken, not Stirred Salt Shaker Award for the James Bond of the salt profession, exemplifying a fearless, confident approach to salt reduction”. In 2015 Patrick was presented with the EPA environmental merit award for his work on salt reduction in New England. Patrick wrote the New Hampshire Best Management Practices and was a contributing author on the “Snow and Ice Control Environmental Best Management Practices Manual for Minnesota Department of Transportation” in 2013

INTRODUCTION

This winter maintenance best practices guide has been prepared for the Western Connecticut Council of Governments (WestCOG) municipalities. The best practices presented herein are intended to serve as guidelines and should not be construed as appropriate for all applications, road conditions, or winter storm events. Each decision related to winter maintenance operations is specific to the weather, roadway conditions, traffic, time of day, available resources, and equipment. It is the experience, discretion, and resourcefulness of public works professionals that make it possible to maintain passable and safe road networks in the face of the harsh New England weather.

It is important to recognize the challenges of planning for and responding to winter storms in New England. The variability of each storm can be extreme and each season public works professionals are required to plan for an unknown number of events with a fixed budget. This variability of cost versus capacity is illustrated in Figure 1.

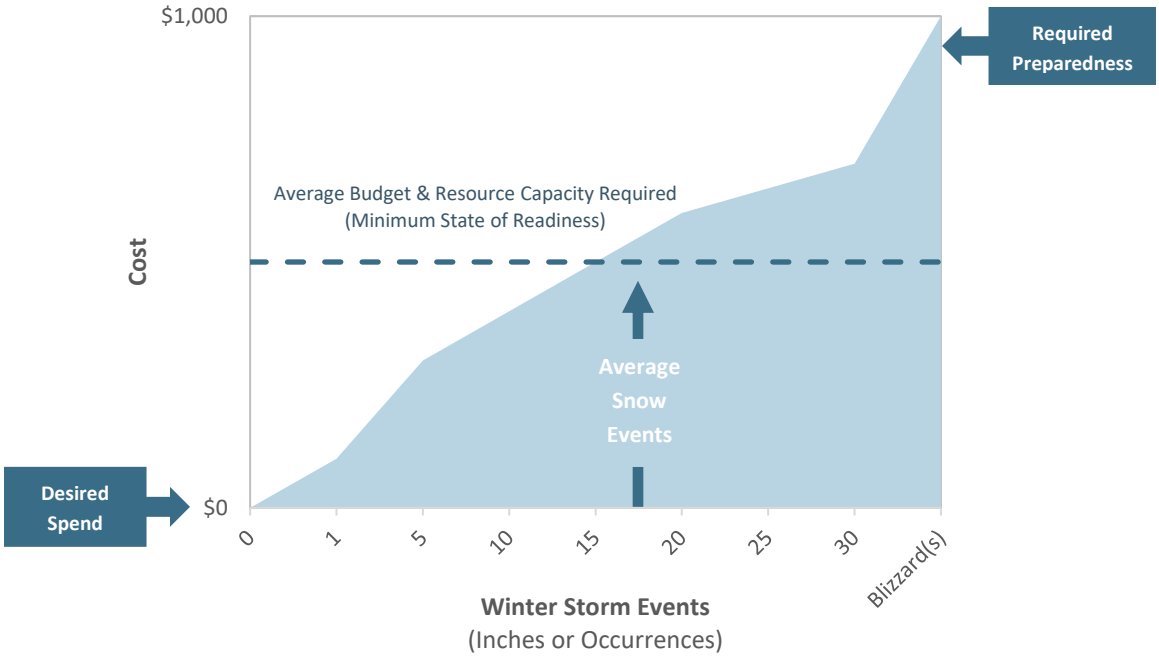

Figure 1: Snow & Ice Management Cost and Capacity Curve[1]

This guide endeavors to provide practical best management guidelines while recognizing the inherent difficulties of planning for and responding to winter storms in New England.

[1] *Source: Phil Sexton, Snow and Ice Management Association*

CHLORIDE SALTS AND OTHER DEICING MATERIALS

This section reviews chloride-based anti-icing and deicing chemicals and addresses the environmental impacts of chlorides as well as chloride alternatives (including winter sand). Recommended application rates can be found in the *During the Storm* section of this manual on page 23.

CHLORIDE-BASED WINTER MAINTENANCE MATERIALS

Chloride-based chemicals are the most commonly used anti-icing and de-icing products. Liquid chemicals are used for anti-icing applications to prevent the snow and ice from bonding to the surface of the pavement. Liquids can also be used to pretreat solid material at the public works facility or to pre-wet solid material as it is dispensed from the vehicle's spreader. In either case, the addition of liquid to the dry material jump-starts the melting process and reduces material bounce and scatter. There are many proprietary solid and liquid de-icing products on the market which are not directly addressed in this guide (e.g. Cargill ClearLane™, Envirotech MeltDown™). When using proprietary materials, follow the storage, application, and clean-up guidelines provided by the manufacturer.

LIQUID & SOLID CHEMICALS

The most commonly-used chloride-based winter maintenance chemicals are identified in Table 1. These chemicals are available in solid and liquid (brine) forms. The lowest working temperatures indicates the temperature at which the material becomes ineffective at melting snow and ice. The temperature-based effectiveness of salt is further discussed in the section *During the Storm* on page 23.

Chemical	Form	Working Temp.	Concentration	Cost	Agitation
Sodium Chloride	Solid Rock Salt, Brine	>15°F	23.3%	$	No
Magnesium Chloride	Flakes, Pellets, Liquid	>5°F	27-30%	$$	Yes
Calcium Chloride	Flakes, Pellets, Liquid	>-20°F	30%	$$$	No

Table 1: Chloride-based liquid products.

Brines, most commonly salt (Sodium Chloride) brine are an effective tool in winter maintenance. The brine can be used to pre-wet or pre-treat salt as well as to anti-ice roadways. All three techniques are discussed in subsequent sections. Salt brine can be made by combining 2.5lb of sodium chloride (rock salt) with 1 gallon of water to create a 23.3% solution brine. The concentration of this solution is extremely important as any less salt will raise the freezing temperature of the solution, which could lead to the liquid freezing on the roadway creating a dangerous condition. The concentration of the brine can be verified using a Salometer (brine hydrometer). Salometer's are weighted glass devices which float in the water column, the salinity is measured at the water surface as shown in Figure 1.

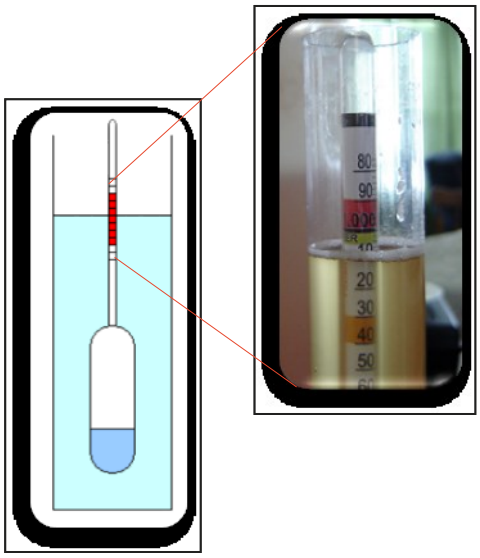

Figure 2: Hydrometer/Salometer

Some hydrometers may read in different units. For reference, a 23.3% salt solution is equivalent to 85% salinity or a specific gravity of 1.176.

> *The lowest working temperature of sodium chloride brine is 15°F and it should not be utilized at colder pavement temperatures. Below 0°F salt brine may freeze. It is imperative to use 23.3% solution brine as it has the lowest freezing temperature.*

The primary difference between the different chloride-based liquids are their cost and working temperature. It should be noted that these various forms of brine can be mixed to create a cost optimized and working temperature reducing mixture.

ENVIRONMENTAL CONSIDERATIONS

Throughout the Northeast and other "snowbelt states", environmental impacts have been increasingly observed and attributed to the use of deicing chemicals. The use of chloride-based deicing chemicals, particularly sodium chloride and calcium chloride, have led to groundwater contamination in many watersheds. In addition to water quality concerns, chloride-based deicing chemicals are a significant operational expense and their efficient usage has positive impacts on municipal budgets.

Under the Federal and State water quality standards following the Federal Water Pollution Control Act (also known as the "Clean Water Act" or CWA), the Environmental Protection Agency considers chloride to be a regulated contaminate. Chloride is part of the secondary standards for drinking water and is regulated at 250mg/l. Secondary standards primarily impact (1) Aesthetics: undesirable taste or odor, (2) Cosmetic effects: discoloration or other effects, (3) Technical effects: damage to water equipment or reduced effectiveness of treatment for other contaminants. Chloride is primarily an Aesthetic concern in drinking water. This is further regulated by CT Statute Sec 22a-426-9 Environmental Criteria which specifics acute and chronic at 860 mg/l and 230 mg/l respectively for surface waters.

In the Northeast, Chloride contamination of groundwater is primarily caused by the application of deicing chemicals on impervious surfaces (parking lots, roads and highways). Chloride from road salt enters water resources through surface run-off from paved areas. During periods of low flow (summer and fall) chloride concentrations spike creating issues for aquatic species. While chloride is primarily an aesthetic concern in drinking water it is toxic to plant and animal life, even in small

concentrations (according to the EPA aquatic plants can become affected at as little as 200mg/l of chloride[2]). The impacts of chlorides are discussed below:

- **Human Health:** While chloride (Cl) is not a human health hazard and is primarily an aesthetic concern in drinking water sodium (Na) does pose human health risks. EPA now requires drinking water be monitored for sodium and public suppliers report concentrations above 20mg/l to local health authorities[2]. Individuals with hypertension (high blood pressure) who are on low sodium diets can have increased risks due to sodium in their water supply.

- **Pet Health:** Salt has negative impacts on paws and according to the ASPCA's pet poison control center can cause excessive drooling, vomiting, diarrhea, loss of appetite, excessive thirst, depression, weakness, low blood pressure, disorientation, decreased muscle function and in extreme cases cardiac abnormalities, seizure, coma, and even death. Exposure of your pet's paws to road salt can cause irritation and drying which is painful and slow to heal (www.aspca.org).

- **Wildlife Impacts:** Birds are the most sensitive to road salt with death occurring in small species after ingesting only a few road salt crystals. Additionally, wildlife such as deer and moose are attracted to roadway salt piles due to the high concentration of salt which can cause increased vehicle strikes. Negative impacts on vegetation can also create food shortages for many wildlife species.

- **Vegetation Impacts:** Increased salt concentration in water can cause dehydration by reducing the osmotic potential and cause foliage damage in plants (most commonly seen as 'burnt' grass or plants adjacent to salt treated pavements). This reduction in osmotic potential not only affects water update it also negatively impacts nutrient uptake and can cause root damage.

- **Soil Impacts:** Salt can destabilize soil structure and mobile heavy metals. The sodium ion promotes the release of Calcium, Magnesium, and Potassium as well as metals. This depletes the soil of nutrients and reduces the permeability of the soil (most commonly seen as rock hard soil adjacent to salt treated pavements). Salt contamination can also kill bacteria in the soil and lead reduced nutrient recycling and soil destabilization and erosion.

- **Infrastructure Impacts:** Chloride increases the conductivity of water and significantly accelerates corrosion. This can impact any steel, or concrete structure with reinforcing steel. Bridges and parking decks are particularly impacted, however vehicles, iron water pipes, and all manner of metal objects are susceptible.

[2] *USEPA Ambient Aquatic Life Water Quality Criteria for Chloride. EPA 440/5-88-001, 1988*

Several Total Maximum Daily Load (TMDL)[3] studies have been completed and include non-point source studies which concluded that the chloride present in watersheds is due primarily to three sources (1) State Roadways, (2) Municipal Roadways, and (3) Private Parking Lots. The composition of the chloride load from each sector is dependent on the composition of the pavement structures within the watershed. A sample of the sources of chloride from the Policy-Porcupine watershed, in Salem and Windham New Hampshire is shown in Figure 3.

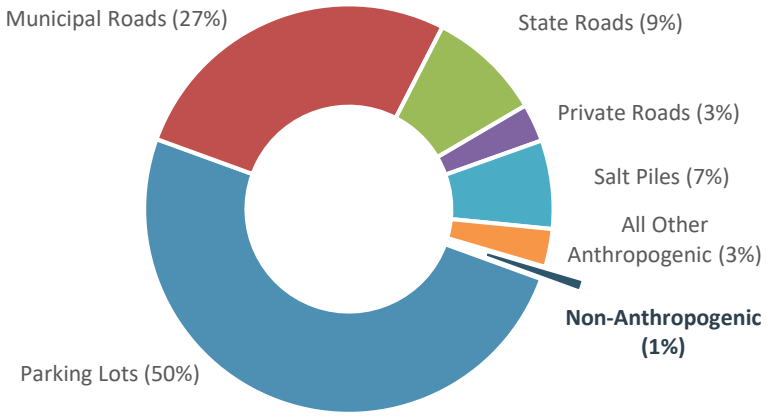

Figure 3: Relative contribution from anthropogenic sources to the total salt imports of the Policy-Porcupine Watershed[4]

It is widely recognized that there is no cost-effective alternative to chlorides for winter maintenance. Utilizing best management practices, including anti-icing, pre-wetting/pre-treating salts, and varying application with pavement temperatures are the most practical ways to reduce chloride imports into the environment. Chloride alternatives are briefly discussed below.

CHLORIDE ALTERNATIVE DEICERS: ACETATES

Magnesium Acetate and Potassium Acetate are the most commonly used chloride alternatives. Both materials are acetates and do not contain chloride and are effective at melting snow and ice. The cost of these chemicals can be up to 10x the cost of traditional calcium chloride and as such they are not commonly used on roadways. A summary of each chemical is provided in Table 2. As with all de-icing chemicals, each material has a lowest working temperature at which point it stops effectively melting snow and ice.

Chemical	Form	Working Temp.	Cost	Notes
Calcium Magnesium Acetate (CMA)	Pellets Liquid	>20°F	$1,000/ton $1.30/gal	Requires agitation to prevent settling.
Potassium Acetate	Liquid	>-23°F	$3.00/gal	Limited shelf life.

Table 2: Acetate (non-chloride) products.

[3] Total Maximum Daily Load references the amount of the contaminate (in this case salt) that can be introduced into the watershed without violating water quality standards.

4 Source: Total Maximum Daily Load (TMDL) Study For Waterbodies in the Vicinity of the I-93 Corridor from Massachusetts to Manchester, NH: Policy-Porcupine Brook in Salem and Windham, NH

Acetates are commonly used on residential sites, concrete parking decks and bridge structures that are deteriorating due to chloride induced corrosion. While the acetates do not contain any chloride, they are not without environmental impact. A study by the Colorado Department of Transportation found that as the metals dissociate from the acetate the oxygen levels in the water can be reduced, which causes harmful conditions for aquatic species. The dissociation of the heavy metals also has negative impacts on aquatic life as well as water quality (Lewis, 1999).

For more information see the TRB Special Report 235 comparing salt and Calcium Magnesium Acetate for an analysis of the cost and environmental impact of both chemicals.

CHLORIDE ALTERNATIVES: CARBOHYDRATES/AGRICULTURAL BY-PRODUCTS & SUGARS

Carbohydrates and agricultural by-products, particularly those containing sugars are rapidly becoming the environmentally friendly alternative to salt, particularly in brine form. Sugar based brines, a common waste from commercial and industrial processes, are increasingly being used for anti-icing as well as pre-wetting and pre-treating salt. The most commonly used compound is beet juice, however distillates from alcohol production, as well as cheese brine all make suitable alternatives to salt brine for winter maintenance applications. These agricultural based products are easily identifiable by their sweet smell and typically dark brown color.

Sugar-based liquids such as beet juice stick to the roadway better than salt-based products and as such can be applied up to 48 hours in advance of the storm for anti-icing applications.

There are also many proprietary liquids that are sugar-based. These may also include chloride inhibitors and other chemicals to boost performance. These chemicals are most commonly obtained directly from distributors and have not commonly been obtained directly from their source. Since these chemicals are largely propitiatory see the manufacturers guidance for appropriate temperature ranges. It should also be noted that the breakdown of these types of products can cause increased biological oxygen demand (BOD) and cause temporary oxygen depletion.

CALCIUM CHLORIDE: A SPECIAL CASE

Calcium chloride is frequently used in roadway deicing in extreme cold temperatures. It can effectively melt snow and ice at pavement temperatures as low as -20°F. Calcium chloride ($CaCl_2$) contains two chloride molecules, which is double that of sodium chloride (NaCl). For this reason, calcium chloride is twice as harmful to the environment as sodium chloride and should be avoided in sensitive watersheds.

ABRASIVES: WINTER SAND

Winter sand (sand that has been mixed with 20-50% road salt) is not a deicer and is of limited value on icy roadways. In a recent study, “The Use of Abrasives in Winter Maintenance” conducted by the Iowa DOT, and Iowa Transportation Research Board, it was concluded that:

“Applying abrasives dry is of limited value in providing lasting friction enhancement. This represents a substantial change in current practice. Nonetheless, the results of a variety of studies are unequivocal in finding that abrasives applied to roads where significant traffic travels at high speeds are swept off the road rapidly, remaining in place (and providing friction enhancement) for somewhere between 10 and 100 vehicle passages, at most.”

In addition to its limited effectiveness, sand applied to roadways must be swept up and vacuumed out of drainage structures. Any material must be disposed of as solid waste. This practice is highly ineffective as an Oregon DOT study concluded that 50-90% of sand applied remained on the roadway after cleanup (DOT, December 1997). Much of the sand is retained in culverts, catch basins, and other storm water structures, reducing their effective capacity.

Studies have also determined that sand being pulverized by vehicles contributes to air pollution and can account for 45% of small particles found in the air. It also migrates into streams, rivers and lakes causing increased turbidity and sedimentation which is the most widespread cause of violation of state water quality standards (Frederick, 2018). The increased turbidity also inhibits photosynthesis in aquatic plants and can lead to morbidity in bottom dwelling fish and invertebrates (Venner Consulting and Parsons Brinckerhoff, 2004).

BEST MANAGEMENT PRACTICES

The most practical way to reduce salt usage is through the implementation of best management practices as outlined in this Winter Maintenance Guide including:

- Winter maintenance and salt reduction training and certification
- Plow route review and optimization
- Equipment calibration
- Anti-Icing
- Pre-treating/pre-wetting salt
- Groundspeed oriented spreaders

Additional details regarding environmental impacts and implementation of salt reducing efforts can be found in the NCHRP Project 25-25, Task 4, Report: Environmental Stewardship Practices, Procedures, and Policies for Highway Construction and Maintenance, Chapter 8: Winter Operations and Salt, Sand, and Chemical Management.

MATERIAL STORAGE

Solid chemicals should be stored and handled in a manner that prevents them from leaching into the environment. This includes:

- Store on an impervious surface such as concrete or asphalt
- Store in a salt shed, or cover entirely with a secure tarp
- Load equipment as close to the pile as possible to prevent spillage
- If spillage occurs sweep it up and return it to the pile
- Do not overload equipment to prevent spillage while turning or going over bumps.

Liquid chemicals should be stored in accordance with federal, and state guidelines, including the following best management practices:

- Store liquids in a double-walled, tank OR have secondary containment which can contain 10% of all tanks, or 100% of the largest tank, whichever volume is larger.
- Avoid gravity discharge (bottom discharge), in favor of top discharge (pump-based discharge) to reduce the risk of accidental spills due to valve or hose failure.
- Always properly label liquid tanks and have Material Safety Data Sheets (MSDS) available for any proprietary chemicals.

BEST MANAGEMENT PRACTICES

The guidelines and information presented in this section concerns activities that should be performed prior to the start of the winter season, before the first winter storm events, and during winter storm events.

BEFORE THE SEASON

There are many pre-season activities which are beneficial to winter operations. Generally, these activities take place from late August through the first snowfall, although they can occur at any time throughout the year.

TRAINING & CONFERENCES

Staying abreast of the latest technologies and best practices is important for public works leadership as well as staff. This is best accomplished through attending training and conferences.

Training on winter maintenance best practices is available from several resources including:

- **CT Technology Transfer Center** (link): The Technology Transfer Center at the University of Connecticut is Connecticut's Local Technical Assistance Program, one of the 58 centers in the United States. The center provides education and technical assistance to members of Connecticut's Transportation and Public Safety Community, on transportation related issues.
- **Smart About Salt** (link): The Smart About Salt council is Canada based not-for-profit organization which offers training to improve winter salting practices.
- **Snow and Ice Management Association** (link): SIMA is the industry association for winter maintenance professionals. It focuses primarily on private sector but offers online training in snow and ice management technologies.
- **WestCOG** (link): WestCOG offers “Pass the Salt” training on salt reduction and best practices in winter maintenance through Axiomatic. To schedule a regional pass the salt training contact WestCOG

There are several conferences which provide the opportunity for industry professionals to stay abreast of current technology and trends across the country. Some of the conferences are more focused on private sector professionals, however the presented technologies apply to public works as well.

- **CASHO Snow Plow Safety Rodeo** (link): An annual snow plow safety Rodeo held annually in CT.
- **American Public Works Association Snow and Ice Conference** (link): APWA’s snow and ice specific conference held annually.
- **New England American Public Works Association Conference** (link): New England’s regional APWA conference. This is not winter maintenance specific.
- **Regional Salt Symposiums:** There are single day salt symposiums in New Hampshire, Lake George, and Vermont
- **SIMA Snow & Ice Symposium** (link): The Snow and Ice Management association snow and ice conference held annually. This conference is more focused on private sector applications.

EQUIPMENT MAINTENANCE & ROUTE REVIEWS

Prior to the season it is important to inspect and test all winter maintenance equipment and perform any necessary maintenance in advance of the season.

Plows & Wings

- Inspect and adjust/replace blades and feet as necessary
- Install and test plow and wing operation including all hydraulic functions
- Inspect all hydraulic connections and hoses, replacing as necessary
- Be sure hydraulic quick connects have dust covers to prevent infiltration of debris
- Replace hydraulic filters, and test your hydraulic fluid (replace as necessary based on contamination)
- Lubricate hinges and plow-frame mounts

Spreaders

- Inspect all hoses, hydraulic connections, belts, chairs, and gears. Replace or repair as necessary
- Install spreader (if not using all-season body) and spinner, and test operation at a variety of speeds
- Lubricate and adjust chains and gears as appropriate
- Test spread-width and adjust baffles to avoid spreading material outside of paved areas.

Anti-Icing Equipment

- Test flow of liquid through all anti-icing equipment and remove clogs as necessary
- Inspect and test any brine making equipment as necessary
- Agitate any brine stored from last year to reduce stratification and settling.

Trucks & Loaders

- Perform scheduled or required maintenance in advance of the winter season

It is also a recommended to assign and review plow routes in advance of the winter season. It is critical to allow drivers time to review their routes on paper and plan their driving path as well as time in the field to drive the route.

Route Inspection

- Evaluate pavement quality to identify maintenance that can be performed
- Flag/note any obstacles (e.g. raised manhole covers, bridge expansion joints) which could obstruct plows
- Inspect traffic signs, particularly turn warnings, stop and yield signs for obstructions. Be sure all signage is visible to prevent accidents in slippery conditions
- Identify any areas which will need extra attention application including: Hills, dangerous intersections.

SNOW & ICE POLICY REVIEW

Municipal snow and ice policies are helpful to set expectations for residents and provide an operational framework for municipal leadership, and public works staff. Each year the policy should be reviewed and updated as necessary. While this is primarily done by leadership and municipal elected officials, it is also valuable to provide the policy to all public works staff to increase compliance and awareness with approved practices. Any changes to the policy should be voted on by the governing body at a public meeting.

EQUIPMENT CALIBRATION

Equipment calibration is extremely important and should be performed on all spreaders in advance of the winter season. All equipment, regardless of age, can be calibrated. Equipment with electronic controls (e.g. you can enter the application rate “300lb/lane mile”), should be calibrated in accordance with manufacturer recommendations.

Equipment calibration allows operators with adjust gate height and augur/belt speed to achieve a desired application rate. Application rates should be selected based on pavement temperature.

Calibration Best Practices

- Calibrate each spreader at least annually.
- Re-calibrate whenever hydraulic equipment or components have been replaced
- Identical equipment should be calibrated separately
- As a guide, each spreader should have a low, medium, and high application rate
- Alternative calibration techniques may be used (a general technique is shown below)

Contact WestCOG for an excel version of the calibration sheet which performs all calculations automatically

Step 1: Load the Truck

Partially load the truck. Half of a full load should be more than adequate for calibration purposes.

Step 2: Set Your Controls

Gate Height: Set the gate height to its lowest practical setting (~ 2"). This should be kept constant throughout the calibration process. If you find that not enough material is dispensed with this setting, try 2.5" to 3".

Engine Speed: Warm the truck up and run the engine at the typical rate seen during spreading (approximately 2000 rpm).

Step 3: Measure Spread Width

Measure the width that the material covers during spreading. Do this for each conveyor/auger setting you are calibrating. Round your numbers to the nearest half foot and record them in column "**W**" of the calibration chart (see reverse side).

Step 4: Collect & Weigh Material

You will need either a sheet of canvas, a tarp, or a bucket to collect the material that is dispensed from the spreader, as well as a scale. Weight the object you are using to collect the material in, and record that value in the purple box above the discharge rate column. Collect material for 1 minute. Weigh the collected material and subtract the weight of the tarp/canvas/bucket. Record this value in the first purple column of the calibration chart. Do this 3 times for each conveyor/ auger setting that is typically used. Average these three values together and record in the orange column in the calibration chart.

Step 5: Perform Calculations

Go inside and calculate your discharge rate using the calibration chart for each truck speed and conveyor/auger setting you normally use. Refer to the reverse side of this fact sheet for calculation instructions. The formula you will be using is shown below:

$$D = \frac{B \times C}{A}$$

Step 6: Distribute Completed Calibration Cards!

Put a copy of the calibration chart in the truck you just calibrated. Also, leave a copy of the calibration chart in the office so you have a copy incase the original is damaged.

Figure 4: Spreader calibration steps (source: NH Best Management Practices, Patrick Santoso).

Calibration Chart (Hydraulic Type)

Material: _____ Truck/Spreader ID: _____

Date: _____ Performed by: _____

Tarp/Canvas/Bucket Weight: _____

Conveyor or Auger Setting	W	A	Discharge Rate (lb/min.)			B	D					
	Spread Width (ft.)	5.28 × W	Run 1	Run 2	Run 3	Average Discharge Rate *((Run 1 + Run2 + Run3)/3)*	Pounds of Material Discharged per 1000 square ft. *(D = B × C ÷ A)*					
							5 mph (C = 12)	10 mph (C = 6)	15 mph (C = 4)	20 mph (C = 3)	25 mph (C = 2.4)	30 mph (C = 2)
1												
2												
3												
4												
5												
EX	14	5.28 × 14= **73.92**	87	92	93	(87+92+93)÷3= **90.67**	12 × 90.67 ÷ 73.92= **14.72**	6 × 90.67 ÷ 73.92= **7.36**	4 × 90.67 ÷ 73.92= **4.91**	3 × 90.67 ÷ 73.92= **3.68**	2.4 × 90.67 ÷ 73.92= **2.94**	2 × 90.67 ÷ 73.92= **2.45**

Calculation Instructions: Multiply the spread width from column **W** by **5.28** and record the answer in column **A**. For each conveyor/auger setting, add **Run 1**, **Run 2**, and **Run 3** together. Divide the result by **3** and record in column **B** to get the average discharge rate. To find the pounds of material discharge per 1000 square feet, you must know the number of minutes it takes to travel one mile at every truck speed you intend to calibrate for. These numbers are designated as variable "C". The "C" value for each travel speed is shown in red under that given speed. Multiply column **B** by the "C" value for that speed and divide by the **A** column to find the number of pounds of material discharged per 1000 square feet for the given speed. Record these numbers in the **D** columns. The full equation is shown here:

$$D = \frac{B \times C}{A}$$

Figure 5: Calibration Chart (source: NH Best Management Practices, Patrick Santoso).

EFFECTS OF TEMPERATURE

The effectiveness of deicing chemicals varies with pavement temperature and it is important that it be used instead of air temperature, as that is where the deicing chemicals are applied, and the melting occurs. As the pavement temperature drops, the effectiveness of salt decreases and more produce is required to achieve the same effect. The melting capacity of sodium chloride changes with temperature as shown in Figure 6. It should be noted that below a pavement temperature of 15°F sodium chloride becomes ineffective. Pavement temperature can be obtained with simple hand-held infrared thermometers, or truck mounted temperature sensors.

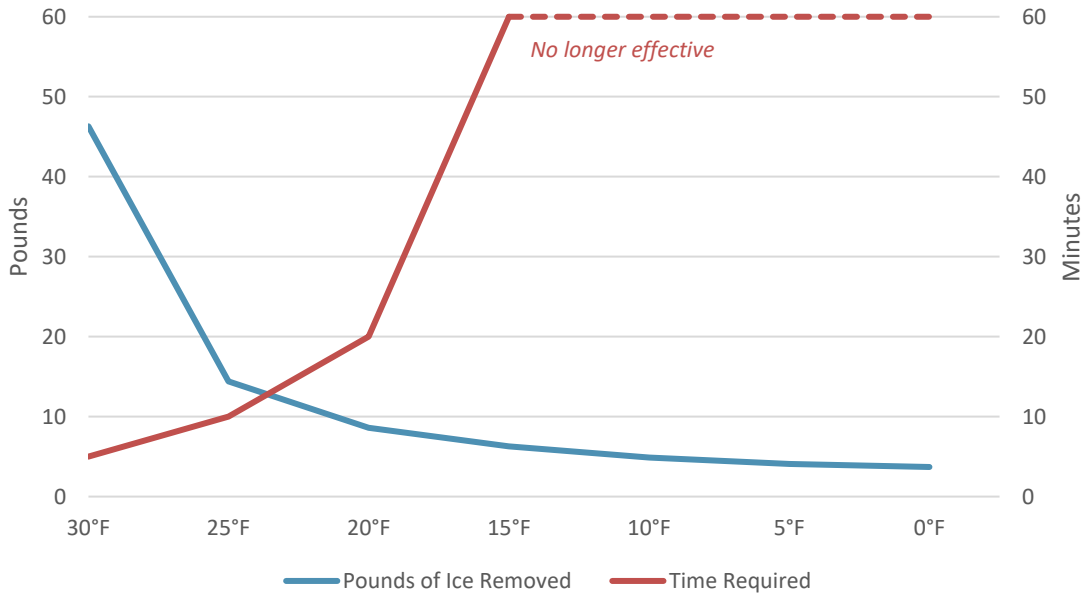

Figure 6: Effectiveness of one pound of sodium chloride relative to pavement temperature.

This maintenance guide does not establish preference for any set of application rates. Rather several application rate standards are presented for the reader to evaluate.

SALT INSTITUTE

The Salt Institute 2013 edition Snow-fighters Handbook presents the following application rate guidelines.

Stormfighting Practices	
The following chart is designed to combat various types of storms. Local conditions and policies will be the final determining factor.	
Condition 1 **Temperature** Near 30 **Precipitation** Snow, sleet or freezing rain **Road Surface** Wet	If snow or sleet, apply salt at 500 lb per two-lane mile. If snow or sleet continues and accumulates, plow and salt simultaneously. If freezing rain, apply salt at 200 lb per two-lane mile. If rain continues to freeze, re-apply salt at 200 lb per two-lane mile. Consider anti-icing procedures.
Condition 2 **Temperature** Below 30 or falling **Precipitation** Snow, sleet or freezing rain **Road Surface** Wet or Sticky	Apply salt at 300-800 lb per two-lane mile, depending on accumulation rate. As snowfall continues and accumulates, plow and repeat salt application. If freezing rain, apply salt at 200-400 lb per two-lane mile. Consider anti-icing and deicing procedures as warranted.
Condition 3 **Temperature** Below 20 and falling **Precipitation** Dry Snow **Road Surface** Dry	Plow as soon as possible. Do not apply salt. Continue to plow and patrol to check for wet, packed or icy spots; treat them with heavy salt applications.
Condition 4 **Temperature** Below 20 **Precipitation** Snow, sleet or freezing rain **Road Surface** Wet	Apply salt at 600-800 lb per two-lane mile, as required. If snow or sleet continues and accumulates, plow and salt simultaneously. If temperature starts to rise, apply salt at 500-600 lb per two-lane mile, wait for salt to react before plowing. Continue until safe pavement is obtained.
Condition 5 **Temperature** Below 10 **Precipitation** Snow or freezing rain **Road Surface** Accumulation of packed snow or ice	Apply salt at rate of 800 lb per two-lane mile or salt-treated abrasives at rate of 1500 to 2000 lb per two-lane mile. When snow or ice becomes mealy or slushy, plow. Repeat application and plowing as necessary.
Note: The light, 200 lb application called for in Condition 1 and 2 must be repeated often for the duration of the condition.	

CLEAR ROADS

The 2015 Clear Roads Best Practice guide presents the following application rates guidelines for pre-treated salt.

Salt Application Rate Guidelines

Prewetted salt @ 12' wide lane (assume 2-hr route)							
Surface Temperature (° Fahrenheit)		33-30	29-27	26-24	23-21	20-18	17-15
lbs of salt to be applied per lane mile	Heavy Frost, Light Snow	50	75	95	120	140	170
	Medium Snow 1/2" per hour	75	100	120	145	165	200
	Heavy Snow 1" per hour	100	140	182	250	300	350

Prewetted salt @ 12' wide lane (assume 3-hr route)							
Surface Temperature (° Fahrenheit)		33-30	29-27	26-24	23-21	20-18	17-15
lbs of salt to be applied per lane mile	Heavy Frost, Light Snow	75	115	145	180	210	255
	Medium Snow 1/2" per hour	115	150	180	220	250	300
	Heavy Snow 1" per hour	150	210	275	375	450	525

NEW HAMPSHIRE APPLICATION RATES

New Hampshire's application rates were developed in partnership with the New Hampshire Departments of Environmental Services, and transportation. These rates are presented in Table 3.

Pavement Temp. (°F) and Trend (↑ ↓)	Weather Condition	Maintenance Actions	Application Rate (lbs/per lane mile)			
			Salt Prewetted/Pretreated with salt brine	Salt Prewetted/Pretreated with other blends	Dry salt	Winter sand
>30 ↑	Snow	Plow, treat intersections only	285	253	285	Not recommended
	Frz. Rain	Apply chemical	364	333	412	Not recommended
30 ↓	Snow	Plow and apply chemical	364	333	412	Not recommended
	Frz. Rain	Apply chemical	412	364	444	Not recommended
25 - 30 ↑	Snow	Plow and apply chemical	364	333	412	Not recommended
	Frz. Rain	Apply chemical	412	364	444	Not recommended
25 - 30 ↓	Snow	Plow and apply chemical	364	333	412	Not recommended
	Frz. Rain	Apply chemical	444	412	523	665
20 - 25 ↑	Snow or frz. Rain	Plow and Apply chemical	444	412	523	665 for frz. Rain
20 - 25 ↓	Snow	Plow and apply chemical	364	475	602	Not recommended
	Frz. Rain	Apply chemical	444	475	634	665
15 - 20 ↑	Snow	Plow and apply chemical	475	475	602	Not recommended
	Frz. Rain	Apply chemical	554	475	634	665
15 - 20 ↓	Snow or Frz. Rain	Plow and apply chemical	523	475	634	665 for frz. Rain
0 to 15 ↑↓	Snow	Plow, treat with blends, sand hazardous areas	Not recommended	634	Not recommended	824 and spot-treat as needed
< 0	Snow	Plow, treat with blends, sand hazardous areas	Not recommended	1457	Not recommended	824 and spot-treat as needed

Table 3: New Hampshire roadway application rates.

The federally funded NCHRP Report 528 provides a federal basis for application rates as shown in Table 4.

Pavement Temperature (°F)	Adjusted dilution potential	Ice pavement bond	Application rate	
			Solid (1) lb/LM	Liquid (2) gal/LM
Over 32° F	Low	No	90 (3)	40 (3)
		Yes	200	NR (4)
	Medium	No	100 (3)	44 (3)
		Yes	225	NR (4)
	High	No	110 (3)	48 (3)
		Yes	250	NR (4)
32 to 30	Low	No	130	57
		Yes	275	NR (4)
	Medium	No	150	66
		Yes	300	NR (4)
	High	No	160	70
		Yes	325	NR (4)
30 to 25	Low	No	170	74
		Yes	350	NR (4)
	Medium	No	180	79
		Yes	375	NR (4)
	High	No	190	83
		Yes	400	NR (4)
25 to 20	Low	No	200	87
		Yes	425	NR (4)
	Medium	No	210	92
		Yes	450	NR (4)
	High	No	220	96
		Yes	475	NR
20 to 15	Low	No	230	NR
		Yes	500	NR
	Medium	No	240	NR
		Yes	525	NR
	High	No	250	NR
		Yes	550	NR
15 to 10	Low	No	260	NR
		Yes	575	NR
	Medium	No	270	NR
		Yes	600	NR
	High	No	280	NR
		Yes	625	NR
Below 10°F	A. If unbonded, try mechanical removal without chemical. B. If bonded, apply chemical at 700 lb/LM. Plow when slushy. Repeat as necessary. C. Apply abrasives as necessary.			

NR = Not recommended.

Specific Notes:
1. Values for "solid" also apply to prewet solid and include the equivalent dry chemical weight in prewetting solutions.
2. Liquid values are shown for the 23-percent concentration solution.
3. In unbonded, try mechanical removal without applying chemicals. If pretreating, use this application rate.
4. If very thin ice, liquids may be applied at the unbonded rates.

General Notes:
5. These application rates are starting points. Local experience should refine these recommendations.
6. Prewetting chemicals should allow application rates to be reduced by up to about 20% depending on such primary factors as spread pattern and spreading speed.
7. Application rates for chemicals other than sodium chloride will need to be adjusted using the equivalent application rates shown in Table A-6.
8. Before applying any ice control chemical, the surface should be cleared of as much snow and ice as possible.

Table 4: Application rates for solid, pre-wetted solid, and liquid sodium chloride.

BEFORE THE STORM

In the days leading up to a storm, public works professionals can prepare by monitoring the weather, and conducting anti-icing operations if the conditions are appropriate.

WEATHER MONITORING

Weather monitoring is among the most important tasks in preparing for and responding to a storm. Public works professionals should monitor the weather for key variables that will impact their response. Many municipalities elect to hire private meteorologists for custom weather forecasts. This can be particularly valuable for WestCOG communities that have distinct weather zones due to elevation changes or proximity to the Long Island Sound. When monitoring the weather, it is important to consider predicted temperature during the storm. Colder storms typically lead to more accumulation and If the temperature drops below 15°F Sodium Chloride based deicers become ineffective

ANTI-ICING

Anti-icing is a proactive technique in which liquid or solid deicing chemical is applied to the pavement surface before the storm to prevent snow and ice from bonding to the pavement. This can lead to significant reduction in total material used, time spent plowing and deicing. Departments can realize additional cost savings as Anti-Icing can take place during regular business hours and avoids overtime.

Anti-icing can be done with any number of liquid chemicals, with the most common being Sodium Chloride Brine, Calcium Chloride Brine, and Magnesium Chloride Brine. The properties of each of these brine solutions, including their required concentrations are presented in the *Chloride Salts and Other Deicing Materials* section of this document. Many experienced departments will make a mixed brine using all three materials. The addition of the other chemicals to the sodium chloride brine lowers the effective melting temperature and increases the effectiveness of the brine, without significant cost increase.

Anti-icing involves spreading brines, which are mostly water, onto roadways prior to a storm. If the temperature drops dramatically, or your brine is not at the proper concentration freezing can occur. For this reason, following best management practices is extremely important! Anti-icing is not recommended for all storms!

Anti-Icing Best Management Practices:

- If utilizing Salt Brine (Sodium Chloride) make sure it is 23.3% solution by testing it as discussed in *Chloride-Based Winter Maintenance Materials* section on page 5
- Only Anti-Ice when pavement temperatures are between 15°F-35°F
- Use stream-type nozzles (not fan) to leave bare pavement to provide some traction if freezing occurs
- Use ¼ inch nozzles spaced approximately 8 inches apart for best results (see Figure 7)
- Anti-icing can take place up to 24 hours in advance of the storm.
- Leave a sur-charge of material at the top of hills. This will migrate down the hill over time, and keep the hill coated.
- Above 35°F Magnesium Chloride and Calcium Chloride can become very slippery.

Figure 7: City of Sheboygan Wisconsin Anti-Icing Operations with Stream Type Nozzles

Anti-Icing with Solid Materials: Anti-icing is most effective when it is done with a liquid chemical, however, anti-icing with solids is possible. There are two drawbacks:

1. All pavement is slopped for drainage; the solid material that is applied in advance of the storm quickly migrates off the roadway due to vehicle traffic
2. Much of the applied solid material will also be removed with the first plow pass. With those drawbacks, anti-Icing with solids can be effective, and is recommended prior to freezing rain events.

Anti-icing With Solid Materials Best Management Practices:

- Apply solid chemical as close to the beginning of precipitation as possible.
- Avoid use on high-speed roadways, the salt can become airborne and crack windshields.
- On Roadways apply near the crown of the road.
- On Parking lots broadcast evenly.
- It can be helpful to leave a surcharge of material at the top of hills. It will migrate downhill with traffic.
- Anti-icing with solids is not as effective on areas with no vehicle traffic.

Tips for Testing and Promoting Anti-Icing:

- A 23.3% brine solution can be achieved by mixing 2.5lb of salt per 5 gallons of water
- Choose a small area of pavement in your own yard and apply the brine to it a few hours before the storm.
- Take pictures before, during and after and note any material or time savings clearing that pavement.
- Use this demonstration to help justify adopting anti-icing in your community!

DURING THE STORM

During the storm winter operations focus on plowing and de-icing. It is important to note that plowing should always take place before de-icing. It is recommended to remove as much snow and ice as possible by plowing before applying de-icing chemicals. Applications of deicer may be applied throughout the storm as necessary to maintain a safe roadway.

PLOWING

Plowing is the most efficient, effective, and lowest cost method of removing snow and ice from pavement. It is advisable to plow early, and often to prevent snow and ice from building up on pavement and forming hard-pack. Plowing should take place before de-icing as plowing removes most of the deicing chemicals. It should be recognized that it can be necessary to apply deicing during the storm prior to and during plowing operations at the discretion of the public works department.

There are several types of plow blades to be considered:

- **Steel Blades:** Steel blades are the most common and cheapest plow blades. They wear more quickly than carbide blades.
- **Carbide Blades:** Carbide blades are also very common and cost significantly more than steel blades. They are harder steel and don't wear as quickly, however they can chip.
- **Rubber Blades:** Rubber blades are sold on a roll and cut to fit the plow. They have excellent squeegee action and are particularly good at clearing slush and have a very smooth ride. They are not as effective at removing hard-pack.
- **Composite (Carbide Inserts Incased in Rubber) Blades:** There are several proprietary articulating blade systems that include carbide or steel sectional inserts encased in rubber. These blades provide the squeegee action of the rubber blade with the stiffness to clear hard pack of a steel or carbide. They are also known to have a smooth ride. THX and JOMA are examples of this composite articulating blade systems.

DE-ICING

There are several different chemicals that can be used for deicing. These alternatives are reviewed in the *Chloride Salts and Other Deicing Materials* and *Environmental Considerations* sections. The most commonly used deicing chemical is sodium chloride. The purpose of deicing is to loosen the bond between the snow and ice and the pavement so that it can be mechanically removed by the plows.

De-icing should begin once plowing has removed as much snow and ice as possible. Naturally plowing must continue after de-icing has begun to remove the snow and ice, and for certain storms it may be appropriate to begin de-icing at the beginning of the storm.

Deicing chemicals should be applied to the crown of the road, or to the high side of super-elevated curves. Baffles should be narrowly set to avoided overspray off the road surface. Application rates should be used in accordance with one of the provided templates in the *Effects of Temperature* section of this guide on page 16.

When de-icing with dry rock salt, there are two key disadvantages which can be resolved by pre-wetting or pretreating with a liquid chemical:

1. Dry rock salt tends to bounce and scatter off the pavement surface
2. The dry salt does not effectively begin to melt until a salt brine has been formed

PRETREATING & PREWETTING

Salt does not begin to effectively melt snow and ice until a brine has formed. For this reason, the addition of a brine to the salt before it hits the pavement jump starts the melting process as shown in Figure 8. Any of the previously discussed brines are effective for this application, and there are several proprietary chemicals which are chloride-, acetate-, or sugar-based.

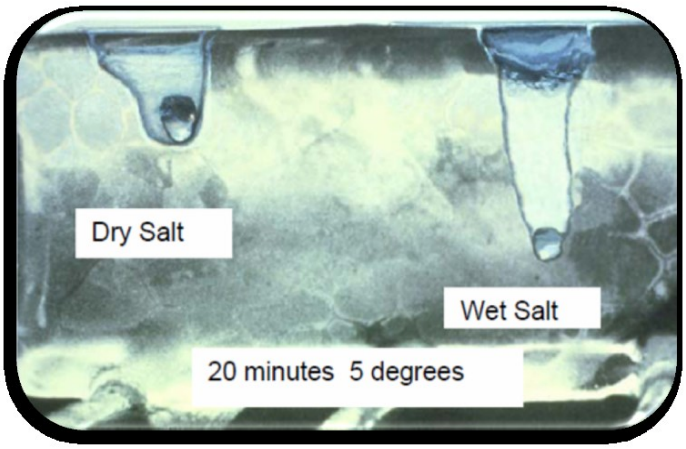

Figure 8: Effect of Salt Pre-wet with a salt Brine (Source: Wisconsin DOT Bulletin 22).

In addition to jump starting the melting process the addition of a liquid brine makes the salt stick to the roadway and reduces "Bounce and Scatter". A study conducted by the Michigan Highway Department spread salt onto a roadway and swept it up to determine how much stayed on the pavement. As shown in Figure 9, 30% of the dry salt bounced off the roadway, while only 4% of the pre-wet salt was unaccounted for. This can add up to significant material savings.

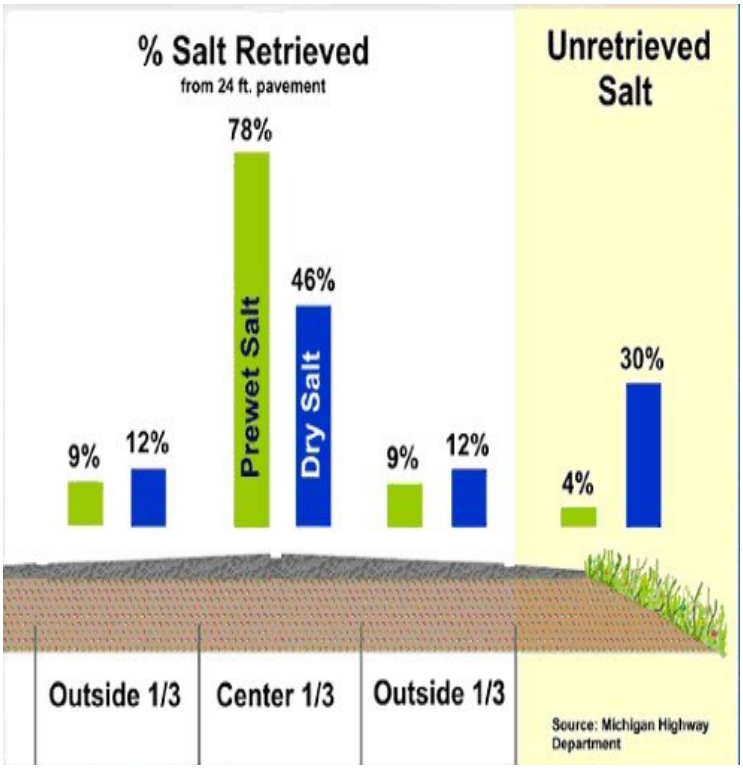

Figure 9: Michigan Highway Department Pre-treated Salt Study

Pre-Treating: The simplest way to get started with a wet salt is to pre-treat it with a liquid. Salt can be purchased pre-treated with a brine or proprietary chemical, or vendors will come and spray your pile. When pre-treating you can use approximately 6-10 gallons of brine or other liquid chemical per ton of salt. If using a salt brine it's important to make sure it's 23.3% solution to prevent freeze up.

Pre-Wetting: Pre-wetting is the application of a brine or other liquid to the salt as it is coming out of the spinner. This requires installation of saddle brine tanks, as well as a sprayer system to spray the dry salt as it's coming out of the shoot, or as it's hitting the spinner. Pre-wetting systems generally have better control and allow all salt to be stored dry until used.

Whether using pre-wet or pre-treated salt remember to reduce your application rates, it doesn't take as much material to achieve the same melt with a treated salt.

ABRAISIVES

Abrasives (e.g. sand and sand-based products) have been used in winter maintenance since the 20th century. Typically, sand is mixed with ~10-25% salt by weight to prevent it from freezing in the pile and add some limited melting capacity. Abrasives are primarily used to provide traction. There are several environmental and infrastructure concerns related to the use of sand, however it is still used in many communities.

Benefits

- Provides traction
- Increases solar heat gain
- Visible to drivers

Weakness

- Not effective for melting
- Must be swept up
- Sweeping only collects 10-15%
- Harmful to lakes rivers, and streams water quality
- Harmful to aquatic life
- Clogs drainage structures

Winter sand is only recommended when the pavement temperature is below the effective temperature of the chemical deicer being used (15°F for rock salt), or in dangerous intersections, hills, or walkways.

AFTER THE STORM

There are several important activities that should be conducted after the storm event. These are typically performed after storm operations are complete, and staff have rested and returned to a normal work schedule. These activities include:

- **Equipment Inspection and Maintenance:** Each piece of equipment should be inspected for damage taken during the storm. Any reported deficiencies should be addressed, and any required maintenance performed. Frequently emergency repairs have been completed during the storm, which require follow up after the storm for permanent fixes.
- **Record Keeping:** It is recommended to track tons of salt per truck per storm, as well as duration of storm and total inches of precipitation. This can be useful to track the performance of each truck and identify any potential material over-use from equipment malfunction or driver error. Having weight from scales is preferable, however it is perfectly acceptable to approximate the amount loaded each fill-up.

OTHER CONSIDERATIONS

EQUIPMENT REPLACEMENT

When and how to upgrade equipment is largely a municipal specific decision and is based on several factors including, use, age, and condition of existing fleet, as well as budgetary concerns. Winter maintenance equipment operates under extreme conditions, in highly corrosive environments, and usually under high operating loads for long periods of time. For this reason, it is important plan for equipment maintenance and replacements.

The American Public Works Association (APWA) Guidance Position Statement on timely replacement of fleet assets (link) asserts that as vehicles age their operating costs increase and their capital costs decrease as shown in Figure 10. The operating and capital costs are added to generate the total cost. When the total cost curve begins to flatten is generally when the equipment should be replaced.

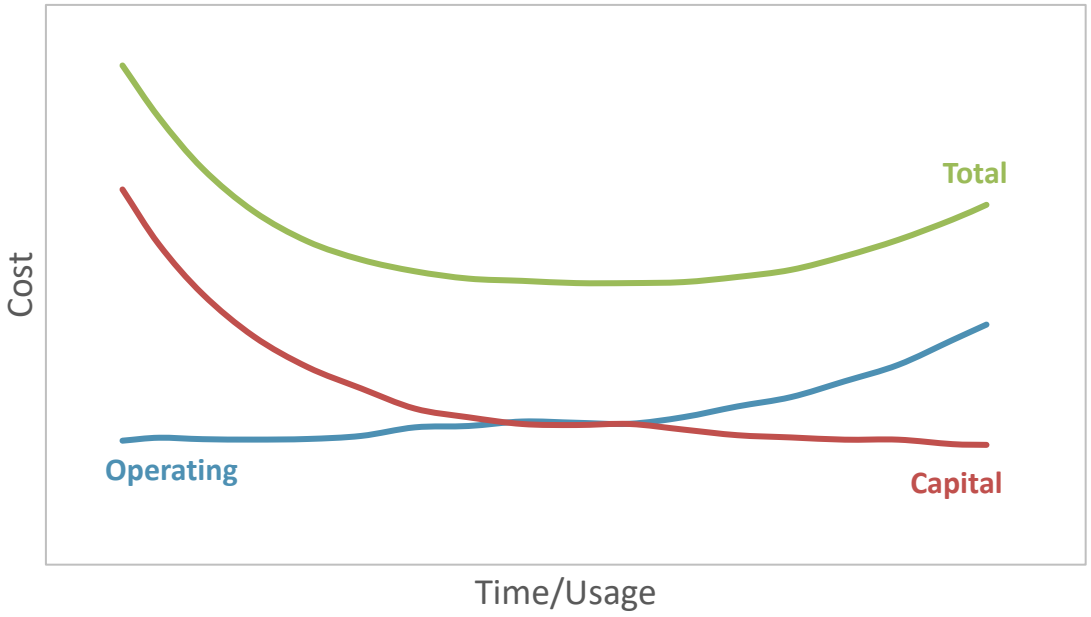

Figure 10: Economic Theory of Vehicle Replacement[5]

A study performed for the Utah Department of Transportation, which tracked the operating and capital costs of their class 8 snow plows concluded that they should be replaced at roughly 9 years of age (Asset Management Associates). It is advantageous for municipalities to track operating (maintenance), and capital (equipment cost) expenses overtime and tracking the total cost curve for optimization.

[5] *Source: APWA*

PAVEMENTS

MAINTENANCE & PRESERVATION

A major factor in winter maintenance is the quality of the pavement. Pavement distresses including: longitudinal and transverse cracking, edge cracking, alligator cracking, rutting and potholes can make it difficult or impossible to remove some and ice from the pavement. Any depression in the pavement is a space for snow and ice to accumulate creating a potentially dangerous situation. Pavement distresses allow water ingress into the pavement substructure, which when paired with freeze thaw cycles can cause ice lenses formation, and frost heaves further impacting pavement quality,

To the extent that budgets allow, pavement maintenance should be conducted to all manner of cracking prior to the winter season to allow the best possible winter maintenance to occur.

POUROUS PAVEMENT

Porous pavement has been introduced into many roadways and parking lots across the country. This highly engineered pavement has special aggregate gradations and compacting techniques that result in voids in the asphalt or concrete pavement structure. These voids allow water to permeate into the base and sub base, both of which are highly engineered for permeability and filtration.

The nature of this pavement can cause several unique issues for winter maintenance. They are outlined below:

- **No Sand:** Sand should never be used on porous pavement as it will quickly clog it.
- **Vacuuming:** Porous pavement should be vacuumed at least twice a year. This is critical to keep it from clogging.
- **Solar Exposure:** Porous asphalt pavement, if it has significant solar exposure may melt snow and ice and drain the snowmelt preventing re-freeze. This does not commonly occur with porous concrete pavements or in the shade.
- **Deicers:** Porous pavement drains meltwater so there is less re-freeze, however it also drains the salt brine which is needed for melting. For this reason, application rates typically need to be increased on porous pavements.
- **Watch and Learn:** Porous pavement installations are unique, pay special attention them during your winter maintenance and learn what works best for your situation!

REGIONAL COOPERATION & MUTUAL AID

Coordination on bidding as well as equipment and material sharing can be extremely beneficial to public works departments. It is advantageous to enter into mutual aid agreements with neighboring communities which allow the sharing of equipment, materials and personnel to aid in response to winter storm events, and emergencies year-round. The mutual aid agreement is an important tool to ensure proper insurance coverage and to provide a forum for public comment during its adoption.

There are additional opportunities for equipment sharing particularly as it relates to pilot projects. Brine makers may be shared and can be mounted on trailers to allow for transport to multiple municipal sites. This format of mobile brine production allows each municipality to maintain their own storage tanks and use their own water and salt to produce brine. Consideration should be given to brine making and storage capacity to allow all participating municipalities to replenish their supplies within a 2 to 3-day period. While this could lead to brine shortages if multiple storms occur rapidly it is appropriate for a pilot or demonstration project. For long term implementation it will likely be necessary to obtain individual brine making capacity for each municipality.

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APPENDIX A: MATERIAL MARKET

ROCK SALT SUPPLIERS

The primary suppliers in southwestern CT are Morton, Cargill, DRVN Enterprises, American Rock Salt Company, and International Salt Company. Salt is transported to the municipalities from ports and distribution centers including the Gateway Terminal in New Haven (Morton), the newly opened state pier in New London (DRVN Enterprises opened in 2014), Mt. Mary, New York (Cargill), and Mount Morris, New York (American Rock Salt). Prior to 2014, salt had not been available in New London for a 15-year period. In Prior years the *state bid* was awarded to American Rock Salt. Contact information for regional suppliers can be found in Table 5.

Supplier	Contact
Morton Salt	Gateway Terminal New Haven, CT
DRVN Enterprises	State Pier, New London, CT
Cargill	Lansing, NY
American Rock Salt Co	Mt. Morris, NY
Eastern Salt Company	Lowell, MA

Table 5: Contact information for rock salt suppliers.

SAND SUPPLIERS

The primary sand suppliers for sand in the southwestern CT area are outlined in Table 6 below. As sand is also used in construction industries there are several sourcing alternatives. Table 6 includes a summary of commonly used sand suppliers.

Supplier	Contact
Stone Construction	168 Main St., Southbury, CT Ph: (203) 264-6501
Harlem Valley Sand and Gravel	138 Kent Rd., Wassaic, NY Ph: (845) 373-8200
Zwally Hauling	740 N Washington Ave., Bridgeport, CT Ph: (203) 335-1602
Island Sand & Gravel	64 Hawthorne Ave., Shelton, CT Ph: (203) 924-4346

Table 6: Contact information for sand suppliers.

ALTERNATIVE CHEMICAL SUPPLIERS

There are several alternative chemical suppliers for various proprietary chemicals and solutions. They are summarized in Table 7.

Supplier	Contact
Innovative Solutions	Ph: (203) 729-6434
Reed Systems	Ph: (845) 647-3660
Road Solutions	
Grillo Services	Ph: 877-SOIL-NOW
Middlesex Ice Control	Ph: 860-961-2893

Table 7: Contact information for alternative chemical suppliers.

There are also a few non-conventional alternatives in winter maintenance including distillery by-products brewery waste, cheese brines, and molasses can be added to road salt to further lower the melting temperature. Consider contacting local distilleries, breweries, and dairy producers to inquire about obtaining low-cost local agricultural by-products.

APPENDIX B: PROCUREMENT ALTERNATIVES

Material procurement should adhere to applicable municipal and state procurement rules and procedures. Advertisement of public bid for winter maintenance chemicals without terms which unduly limit the number of respondents should be considered. Municipalities should have clear evaluation criteria for selecting the winning vendor selection is not based strictly on low-bid. There are three primary bidding alternatives which should be evaluated for each municipality.

- **State Bid:** The Connecticut Department of Transportation annually advertises a statewide bid which municipalities can elect to participate in. Leveraging the buying power of multiple municipalities as well as the state DOT can lead to very competitive pricing. It also lessens the administrative burden on the municipality.
- **Regional Bid:** Some municipalities elect to bid as a group, this can be facilitated by a Council of Governments, or simply by neighboring municipalities. The regional bid can provide advantages if a particularly supplier is very close and provide more competitive delivery pricing for proximal communities. Including multiple communities increases buying power and reduces rates.
- **Municipal Bid:** Individual municipal bids generally do not get better pricing than their state or regional counterparts due to the bulk discounts. Under certain circumstances, individual municipal bids may yield more advantageous results. Municipal bids are frequently used for low-volume material procurement or for materials not included in the state bid (treated salt, liquids etc.). They can also be used to engage a back-up or alternate source of materials.

No one procurement alternative will produce the least cost best value alternative. Each municipality should consider their own situations and choose the best option for their community.

MATERIAL ESTIMATION & DELIVERY

Estimating the materials needed for the upcoming winter season is one of the most challenging aspects of winter maintenance. Estimates are typically based on prior years usage and will vary with the amount of paved surface that has been added and the severity of previous winters. When estimating the Salt Institute's Salt Storage Handbook recommends (The Salt Institute, 2015):

- Estimate based on average usage over the past 5 or 10-year period. Do not plan on a mild winter or reduce estimates!
- Include the effect of any added road mileage or parking lots and factor that into your estimation.
- Include any changes in operations that might impact the amount of material used including: Anti-Icing, Pre-treating/Pre-wetting, or switching to straight salt.

The Salt Institute's Salt Storage Handbook also provides the following table for estimation of salt required (The Salt Institute, 2015).

SHORT TONS/METRIC TONS
Based on 4 applications per storm Per 2-lane Mi/Km

Number of Storms		Two Lane Highway on Bare Pavement						
	Mi	100	200	300	400	500	600	700
	Km	161	322	483	644	804	965	1126
4		400	800	1200	1600	2000	2400	2800
		363	724	1089	1452	1814	2177	2540
6		600	1200	1800	2400	3000	3600	4200
		544	1089	1633	2177	2722	3266	3810
8		800	1600	2400	3200	4000	4800	5600
		726	1452	2177	2903	3629	4355	5080
10		1000	2000	3000	4000	5000	6000	7000
		907	1814	2722	3629	4536	5443	6350
12		1200	2400	3600	4800	6000	7200	8400
		1089	2177	3266	4355	5443	6532	7621
14		1400	2800	4200	5600	7000	8400	9800
		1270	2540	3810	5080	6350	7621	8346
16		1600	3200	4800	6400	8000	9600	11200
		1452	2903	4355	5806	7258	8709	9253
18		1800	3600	5400	7200	9000	10800	12600
		1633	3266	4899	6532	8165	9798	10524
20		2000	4000	6000	8000	10000	12000	14000
		1814	3629	5443	7258	9072	10886	12700

Figure 11: Salt Institute Salt Required Per Season

Ordering material early and taking delivery during summer or fall will reduce costs and provide the easiest logistics.

The Salt Institute Salt Storage Handbook recommends that at least 100% of annual Requires salt be stored on-site to reduce costs.

Stockpiles should be closely monitored, if mid-season delivery is required it should be ordered early to provide the most flexibility for delivery logistics as winter weather can impact the delivery schedules and can close freshwater ports.

Clear Roads Manual of Best Management Practices for Road Salt in Winter Maintenance provides the following evaluation of salt procurement practices and their impact on costs as shown in Table 8 (Clear Roads)Table 8: Salt Procurement Best Practices.

Practice in Salt Procurement	Practical Impact of Practice
Having storage for 100% - 150% of average annual salt needs (AASN)	Lowers Cost
Having an emergency stockpile for 20% to 40% of AASN	Lowers Cost
Specifying salt quantities as tightly as possible	Lowers Cost

Requiring mid-winter delivery in a short time period	Raises Cost
Allow salt deliveries at any given time (rather than during work hours)	Lowers Cost
Requesting bids earlier in the year	Lowers Cost
Having multi-year contracts	Lowers Cost
Taking pre-season fills of salt	Lowers Cost

Table 8: Salt Procurement Best Practices

APPENDIX C: TOP COST & MATERIAL REDUCING PRACTICES

There are several high-value best management practices which should be considered while optimizing winter maintenance operations. They are presented below with order of magnitude cost estimates. It should be noted that with a variable number of storms annually and differing storm characteristics it is very difficult to precisely estimate savings. The numbers and methods below can be adapted for any municipality. The exact material savings will depend on existing municipal practices, as well as roadway, traffic and storm conditions. Top 5 BMP Recommendations are summarized in Table 9.

BMP	Municipal Recommendations	Reduction of Salt % Per Storm	Estimated Cost	Estimated Annual Savings (Assumed usage: 4,000 ton annually @$80/ton)
Spreader Calibration	Calibrate all spreaders minimally annually to ensure accuracy	5-30% (dependent on existing usage)	2 Staff @ 1hr/spreader ($200/ spreader) For 10 trucks $2,000	At 5% savings $16,000 At 30% savings $96,000
Adapt Rates to Pavement Temperatures	Utilize lower application rates at warmer pavement temperatures.	5-10% (dependent on existing usage)	Hand Held Temp. $100/per $1,000 for 10 staff Truck Mounted $500/Per $5,000 for 10 trucks	At 5% savings $16,000 At 10% Savings $32,000
Pre-Treated Salt	Utilize pre-treated salt	20% Reduction	$10 additional cost per ton for 4,000 tons $40,000	at 20% savings $64,000
Ground-Speed Controls	Equip trucks with ground speed controllers[6]	5% Reduction	$700 per spreader For 10 Trucks $7,000	At 5% savings $16,000
Anti-Icing[7]	Utilize Anti-Icing in advance of Storms	20% Reduction	$20,000 Brine Maker $15,000 Storage Tanks $150,000 Tanker Truck $185,000 Total Investment	At 20% Savings $64,000 (breakeven in ~3 years) At 10% Savings $32,000 (breakeven in ~6 years)

Table 9: Top 5 BMP Recommendations

[6] *Depending on age and equipment not all trucks can be equipped with ground-speed controllers.*

[7] *Estimated annual savings do not account for reduced staff time due to less application of de-icing chemicals outside of normal operating hours. Material cost of brine is considered in the % reduction of salt used.*