Quick Resource Guide for Winter Maintenance BMPs

SOUTHWESTERN PENNSYLVANIA COMMISSION
SPC
WATER RESOURCE CENTER

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

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Introduction

This quick resource guide was developed to provide information to municipalities on how to improve winter maintenance operations by utilizing **best management practices (BMPs)** for the two most utilized materials in winter maintenance operations: **road salt** (chloride-based deicers) and **abrasives**. Solid and liquid chemicals (known as deicers) and abrasives (such as sand) may be used in combination with a mechanical removal method (such as plowing) to minimize accidents during the winter months.

In this guide, we begin with a brief history of winter maintenance practices and the concerns associated with them. Winter maintenance chemicals and their associated impacts are explained and recommendations for winter maintenance BMPs that reduce chlorides are also provided. Alternatives to deicers, application rates and additional considerations including MS4 minimum control measures, specifically for MCM6: Pollution Prevention/Good Housekeeping, are also discussed. The section on MS4 considerations is not intended to be comprehensive, but provides a good starting point for improving your program.

Some of the BMPs covered in this booklet will include:

- Calibration of equipment
- Brine
- Anti-icing
- Pre-wetting
- Retrofitting trucks and equipment

The BMPs that are covered in this quick resource guide are intended to provide the most efficient and effective way to reduce chlorides in the environment without compromising public safety. The BMPs have been proven to: improve the level of service and safety, reduce impacts, and save money and resources. Although there is an initial start-up cost required to begin the process of implementing BMPs, the costs are shown to be recovered after implementation.

Figure 1: Liberty Avenue, March 5, 1917 Source: Pittsburgh City Photographer Collection, 1901-2002, AIS.1971.05 Archives Service Center, University of Pittsburgh

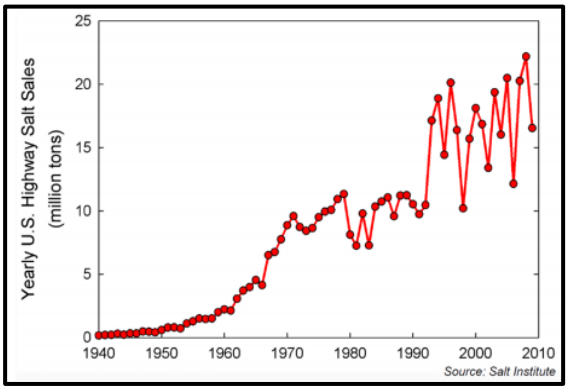

Figure 2: Yearly US Highway Salt Sales. Source: Salt Institute

History and Background

Over time, the traveling public's view of snow on roadways changed significantly. In the 18th and 19th centuries horse-drawn carts traded wheels for ski-like runners in the winter. The more packed snow on the roads, the better. In areas where covered bridges were located, snow was added so travel was not interrupted. By the mid 1800s the first snow plow was invented. In 1862, Milwaukee became the first major municipality to try one.

In the 18th and 19th centuries, "snow was never a threat" to road travel, "but rather it was an asset" - Eric Sloane

In the early 1920s, car-mounted snow plows were first invented and since then snow and ice management has continued to evolve. In addition to the removal of snow and ice by plowing or other mechanical means, chemicals have been utilized to further improve winter driving conditions. The most common chemical utilized is sodium chloride (NaCl), or more commonly referred to as road salt. Figure 2 from the Salt Institute illustrates an increasing trend of salt use. Along with the increased use of salt, levels of chloride in surface and groundwater and associated impacts will also increase.

Concerns with Winter Maintenance Practices

Negative impacts have proven to be associated with the use of snow and ice control materials and have become a real concern in some states.

As of June 2016, there are no ambient water quality standards for chlorides, chloride or salinity in Pennsylvania; therefore no TMDLs have been established. Although ambient water criteria are not yet adopted, the **Municipal Separate Storm Sewer System (MS4)** program does require that permittees comply with **Minimum Control Measures (MCMs)** that would apply to maintenance practices that deal with use and storage of both deicers and abrasives. These topics will be covered in greater detail under the MS4 Considerations section.

Due to the amounts of deicers used in Pennsylvania during the winter months, it is probable that impairments may exist. Municipalities can take a proactive management approach by adopting BMPs that other states have found effective at reducing the amounts of chemical needed. BMPs can improve the level of service and provide cost savings while making snow and ice management move conveniently and reduce environmental impacts.

The Commonwealth of Pennsylvania Department of Environmental Protection (DEP) Bureau of Point and Non-Point Source Managements draft rationale for the development of ambient water quality criteria for chloride protection of aquatic life use stated that: "The existing chloride criterion in PA was developed primarily for the protection of potable water supplies. Although this criterion, a maximum of 250 mg/l, may be protective of instream aquatic life uses when applied, it is not applied in all waters of the Commonwealth, but rather only at the point of water supply intake, pursuant to 25 Pa. Code § 96.3(d) (relating to water quality protection requirements)".

The impacts from road salt and abrasives are shown below in Figure 3.

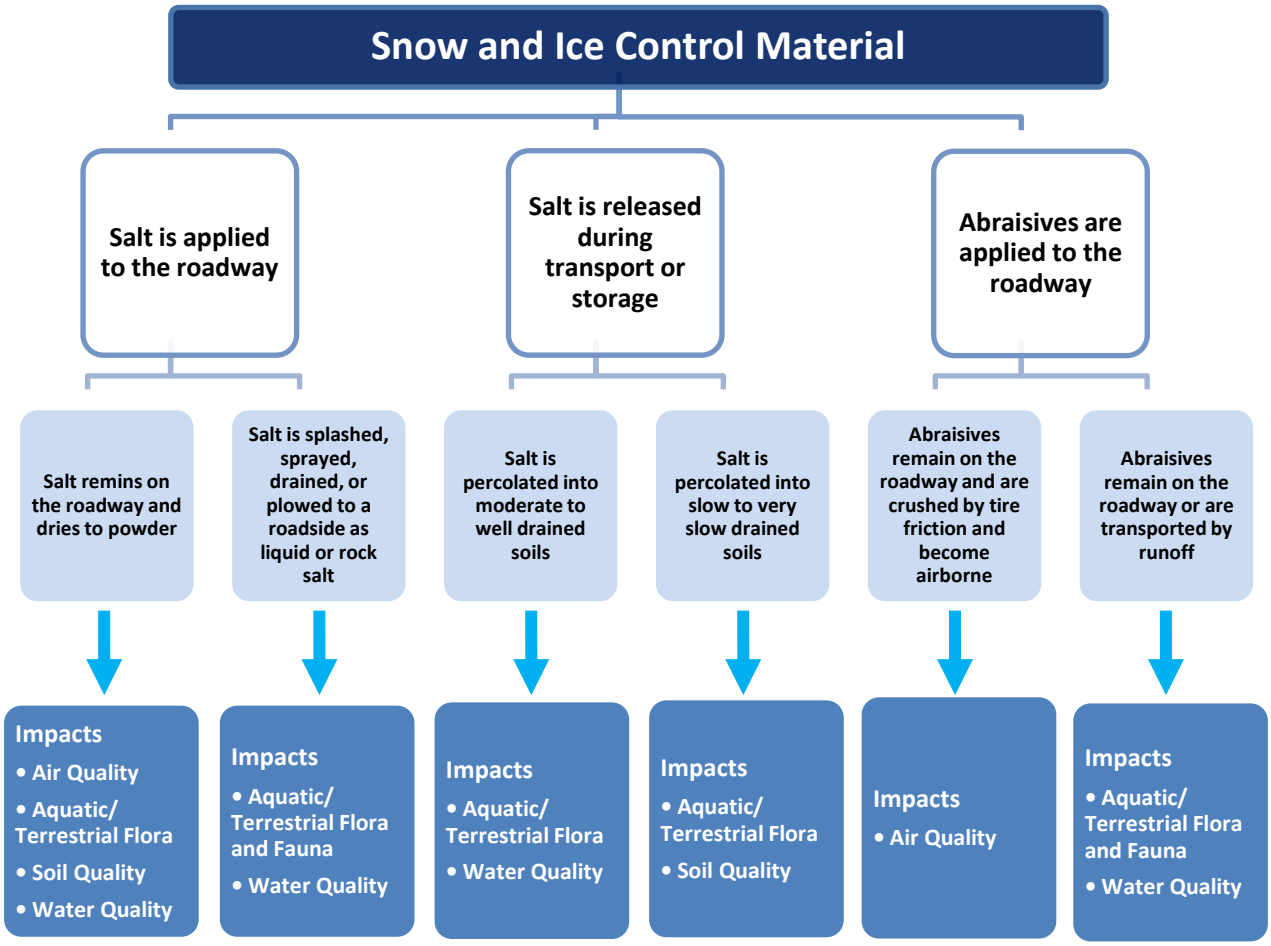

Figure 3: Impacts from road salt and abrasives. Source: Strategies to Mitigate the Impacts of Chloride Roadway Deicers on the Natural Environment

It takes only one teaspoon of road salt to permanently pollute 5 gallons of water. Once in the water, there is no way to remove the chloride, and at high concentrations, chloride can harm fish and plant life. Less is more when it comes to applying road salt.
Source: MN Pollution Control Agency

Many states have chloride impaired waterways and have US Environmental Protection Agency (EPA) approved **Total Maximum Daily Load (TMDL)** plans for chlorides. According to the EPA National Summary of Impaired Waters and TMDL Information website, the following states have an EPA established or approved TMDL for chlorides, chloride or salinity: AR, CA, GA, CO, IL, KS, KY, LA, MN, OH, NH, OK, SD, TX, VA, WV and WY.

One state that has implemented BMPs to reduce chlorides as a result of TMDLs is New Hampshire. TMDLs are in place to reduce pollutants in impaired waterways so that they meet water quality standards. TMDLs focus on identifying sources of impairment and implementing corrective actions based on the best available data and information. Additional monitoring and data collection will occur to track progress and better characterize pollutant sources, loadings and the effectiveness of control measures and BMPs.

During the development of the Chloride Reduction Implementation Plan for Dinsmore Brook Watershed in New Hampshire, the following key issues that lead to the over-application of road salt were identified:

One common issue found in DEP/EPA audits is that the Stormwater Management Program does not identify pollutants of concern, "impairments" or address TMDLs.

For more information about the Integrated Water Quality Report (formerly 303(d) and TMDL list):

http://www.dep.pa.gov/Business/Water/CleanWater/WaterQuality/Integrated%20Water%20Quality%20Report-2016/Pages/default.aspx

- Key Issue #1: Not knowing that certain conditions may not warrant salt application
- Key Issue #2: Not knowing and/or tracking how much material is being applied
- Key Issue #3: Not knowing how much material is needed to achieve desired results
- Key Issue #4: Over-application of chlorides due to liability concerns
- Key Issue #5: Decisions are made without knowledge of new technologies and practices

The key issues above offer valuable insight to understanding why road salt was over-applied. A municipality may use this information to develop/revise a winter maintenance plan to reduce rates applied prior to a TMDL needing to be issued. Particular practices that are associated with the above issues and overlap with the MS4 permit MCMs could be a topic of focus for staff education. In New Hampshire, they addressed Key Issue #4 by creating state legislation that reduces the liability from slip and fall claims for the private sector salt applicators.

Helpful Tips

- **New Hampshire legislation for salt applicators**
  - **RSA 489-C: Salt Applicator Certification Option**
  - **RSA 508:22 Liability Limited for Winter Maintenance**
- **For more information on the state of New Hampshire and their management of chlorides, please see http://des.nh.gov/organization/divisions/water/wmb/was/salt-reduction-initiative/index.htm.**

Winter Maintenance Chemicals

Chloride-Based Deicers and Associated Impacts

Sodium Chloride (NaCl): Road Salt

Road salt or sodium chloride (NaCl), is the cheapest and most readily available chemical that efficiently melts ice and can be easily applied to our roadways and parking lots. The purpose of using salt on roadways is to prevent or minimize the snow and ice bond to the pavement, keep the snow and ice in a condition so that it is easily plowed off, and prevent the formation of snow and ice on the road.

Sodium (Na) can impact soil chemistry and release nutrients such as calcium, magnesium and potassium into the groundwater and surface water leading to increased nutrient concentrations impacting the aquatic environment. The USEPA has set an advisory limit for drinking water for public water systems at 20mg Na/L to assist doctors in making recommendations for those patients on a salt-restricted diet. **Chloride (Cl-)** is highly soluble, very mobile, and its density allows for it to settle to the bottom of a waterbody. Chloride is toxic to aquatic life at levels above 230 mg/l. There is no natural process by which chlorides are broken down, metabolized or taken up by vegetation.

Other Commonly Used Chlorides for Winter Maintenance

- **Calcium Chloride (CaCl)** – CaCl, the second most commonly used chemical, is available in flake, pellet or liquid. It is effective at lower temperatures with a practical melting temperature of -20°F. In liquid form it can be used to pre-wet salt or applied directly as an anti-icing technique which can help in preventing snow and ice from bonding to the pavement and reduce the application amount needed. Several disadvantages to CaCl include a higher cost, environmental impact due to chloride, corrosiveness to metal, difficulty handling and storage, and it can contribute to slippery conditions if applied incorrectly.
- **Potassium chloride (KCl)** - KCl is a naturally occurring material (muriate of potash) that is also used as fertilizer. It is available in liquid or crystal form with a practical melting temperature of 20°F. KCl can be damaging to concrete, has environmental impacts due to chloride and can inhibit plant growth and burn foliage.
- **Magnesium Chloride (MgCl)** - MgCl is available in liquid or crystal form that melts faster than rock salt with a practical melting temperature of 5°F. MgCl attracts moisture and can lead to slippery conditions if applied incorrectly. MaCl is corrosive and contributes to the chloride load in our waters. It is important to note that additives to road salt like ferrocyanide, which is used as an anti-caking compound in large salt supplies, can have impacts on both the environmental and human health due to cyanide ions being released by certain types of bacteria, as well as from exposure to sunlight.

The improper management of chlorides can have negative impacts. Impacts can vary and include, but are not limited to: infrastructure and vehicle impacts; human impacts associated with drinking water supply; and, environmental impacts.

Infrastructure and Vehicle Impacts

Within the Southwestern Pennsylvania Commission (SPC) region, there are a 5,281 state bridges and 1,341 local bridges over 20' long. According to the 2013 Structural Scorecard Report from the American Society of Engineers, 22.33% of state bridges and 33.56% of local bridges over 20' are classified as structurally deficient. Chloride use accelerates corrosion, including penetrating/deteriorating concrete on bridge decking and parking garage structures, damage to reinforcing rods, and compromising structural integrity. As infrastructure is replaced or repaired, it is recommended that suitable alternative(s) to chlorides be utilized to minimize future infrastructure impacts.

Figure 4: Significant damage from many years of salt and deicing chemical use from a leaking expansion joint. Source: Bridge retrofit using fiber reinforced polymer, cenews.com

Vehicle parts damaged from chlorides include: brake linings, frames, bumpers, and body corrosion. The cost of corrosion damage and protection practices for highways and auto industry have been reported to cost $16-19 billion per year *(City of Madison Wisconsin, Report to The Salt Use Subcommittee for the Commission on the Environment, 2006)*.

Human Impacts: Drinking Water

Rivers are a common drinking water supply in the region. The USEPA requires drinking water to be monitored for sodium. Public water suppliers are to report to local health authorities any concentration above 20 mg sodium per liter of water (20mg/l). Chloride is not toxic to human health at low levels but does pose taste and odor issues at concentrations exceeding 250 mg/l. In rural areas, private wells located near a road or parking lot may be impacted due to the improper storage of salt.

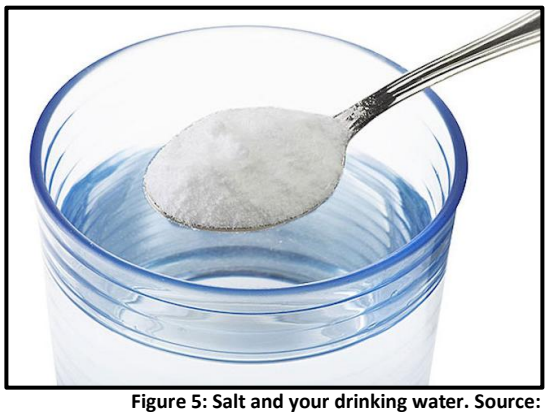

Figure 5: Salt and your drinking water. Source: Healthyfoodstar.com

Environmental Impacts

Chloride remains in a solution and is not subject to any significant natural removal methods. Chlorides are toxic to aquatic life at high concentrations. Study results are conflicting in regards to what time of the year aquatic ecosystems are at the greatest risk for exposure times to chlorides. Some studies suggest that during the summer months at times when there is low stream baseflow (ground water and surface water connection) there are higher chloride concentrations. The highest concentrations of chlorides are present when chlorides have been applied to roads and parking lots, running off into streams throughout the winter months.

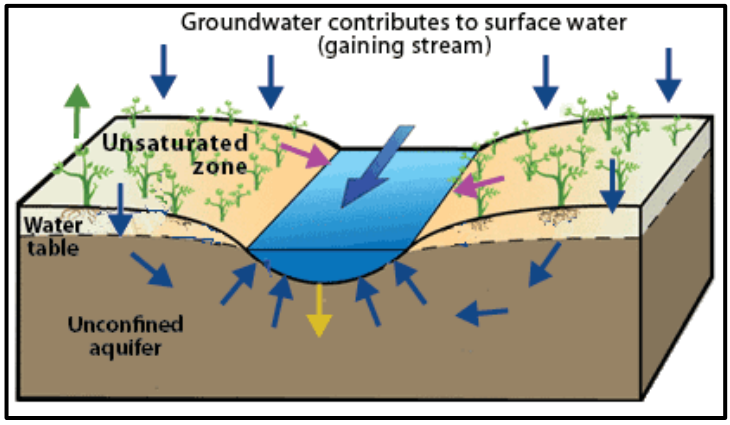

Figure 6: Groundwater contributes to surface water. Source: United States Geological Survey

Figure 6 shows how streams and groundwater can be interconnected, depending on the geology of the area. With this figure it is easy to see how groundwater may become impacted by chlorides that are transported to streams via runoff or how groundwater that is impacted can affect water quality in a stream.

Impacts can also occur in ponds and lakes. Over time chloride levels increase and a higher water density is created and settles at the deepest part of ponds and lakes where current velocities are low. This can lead to a chemical stratification (i.e., impedes turnover/mixing in the fall/spring preventing dissolved oxygen within the upper layers of the water from reaching the bottom layers and nutrients within the bottom layers from reaching the top layers). This results in the bottom layer of the water body becoming void of oxygen and becoming unable to support aquatic life.

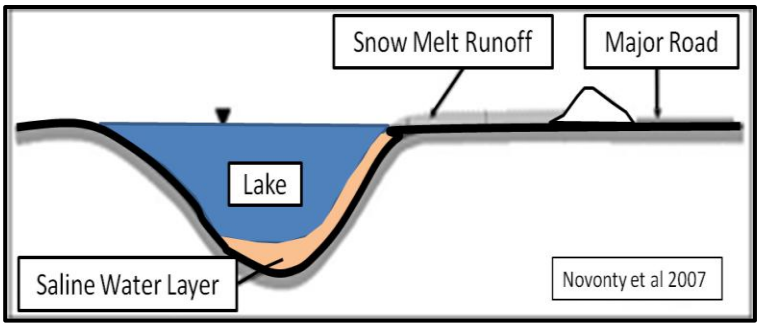

Figure 7: Stratification

Studies show that when safe and sustainable snowfighting practices are implemented the impact of road salt on the environment is minimal and manageable. **Source: Salt Institute**

Acetate and Formate-Based Deicers and Associated Impacts

Non-chloride deicers are acetate and formate-based deicers. Acetate-based deicers such as potassium acetate (KAc), sodium acetate (NaAc), calcium magnesium acetate (CMA) and formate-based deicers such as sodium formate (NaFm) and potassium formate (KFm) are the most commonly used.

Sodium acetate (NaAc) has excellent melting properties and works at lower temperatures than NaCl. CMA generally works as a deicer similar to NACl, yet it can require 50% more by weight than NaCl to achieve the same results (Wegner and Yaggim 2001).

Impacts from acetate-based deicers can include but are not limited to: elevated biochemical oxygen demand (BOD) in waterways and potential oxygen depletion, increased turbidity and hardness in waterways, and the leaching of heavy metals (Fay et al, June 2015).

Agriculturally-Derived Deicers and Associated Impacts

Various types of agriculturally/naturally-derived products have been developed for snow and ice control. Product types can include but are not limited to corn-based products such as corn syrup, and steeps and other derivatives; beet juice, cane molasses, distiller's grain and cheese brine by-product. See Figure 10 for more details. These products are used as additives and/or mixed with solids, liquids and abrasives to improve performance. They can also reduce deicer corrosiveness and enhance longevity of deicer treatments. Some common issues with these products are linked to high levels of phosphates, nitrates or total organic content when used on roadways adjacent to nutrient-impaired waterways.

Figure 8: Agricultural brines. Source: Deeproot.com

Beet juice is an effective alternative to salt alone because it lowers the freezing point of water to as low as -20 degrees. Salt only prevents water from freezing at temperatures of 5 degrees or higher. Source: Deicing with Beet Juice, Deeproot.com

Suitable products have been verified by third party organizations that have evaluated both environmental and health impacts, as well as their performance. As of December 2013, there were nearly 100 products identified on the Pacific Northwest Snow Fighters Qualified Products List. Also in 2013, nine manufacturers offering over 20 different products were provided in the *Design for the Environment–Recognized Products* report.

Figure 9: Solar Roadway. Source: PVBuzz.com

Helpful Tips

- **Model specifications have also been developed in other states. Ohio has developed *Ohio's Model Specifications for Natural/Agricultural-Based Deicing Liquid* and Ohio's DOT developed a contract for agricultural-based (called natural) deicing liquids.**
- **For more information see: http://www.dot.state.oh.us/Divisions/Operations/Maintenance/SnowandIce/Snow%20and%20Ice%20Best%20Practices/Agricultural%20De-icer%20Contract%20124-11.pdf**

Category	Type	Potential for Corrosion Impairment[3]				Environmental Impact[3]		
		Atmospheric Corrosion to Metals	Concrete Matrix	Concrete Reinforcing	Water Quality/Aquatic Live	Air Quality	Soils	Vegetation
Chloride Based Deicers	Sodium Chloride	High: Will initiate and accelerate corrosion	Low/moderate: Will exacerbate scaling; low risk of paste attack	High: Will initiate corrosion of rebar	Moderate: Excessive chloride loading/metals contaminants; ferrocyanide additives	Low: Leads to reduced abrasives use	Moderate/high: Sodium accumulation breaks down soil structure and decreases permeability and soil stability; potential for metals to mobilize	High: Spray causes foliage damage; osmotic stress harms roots; chloride toxicosis
	Calcium Chloride	High: Will initiate and accelerate corrosion; higher potential for corrosion related to hydroscopic properties	Low/moderate; Will exacerbate scaling; low risk of paste attack	High: Will initiate corrosion of rebar	Moderate: Excessive chloride loading; heavy metal contamination	Low: Leads to reduced abrasives use	Low/moderate: Improves soil structure; increases permeability; potential for metals to mobilize	High: Spray causes foliage damage; osmotic stress harms roots; chloride toxicosis
	Magnesium Chloride	High: Will initiate and accelerate corrosion; higher potential for corrosion related to hydroscopic properties	Moderate/high: Will exacerbate scaling; risk of paste deterioration from magnesium	High: Will initiate corrosion of rebar, evidence suggests MgCl2 has the highest potential for corrosion of chloride produces	Moderate: Excessive chloride loading; heavy metal contamination	Low: Leads to reduced abrasives	Low/moderate: Improves soil structure; increases permeability; potential for metals to mobilize	High: Spray causes foliage damage; osmotic stress harms roots; chloride toxicosis
Acetate Based Deicers	Calcium Magnesium Acetate	Low/moderate: Potential to initiate and accelerate corrosion due to elevated conductivity	Moderate/high: Will exacerbate scaling; risk of paste deterioration from magnesium reactions	Low: Probably little or no effect	High: Organic content leading to oxygen demand	Low: Leads to reduced abrasives use	Low/moderate: Improves soil structure; increases permeability; potential for metals to mobilize	Low: Little or no adverse effect; osmotic stress at high levels
	Potassium Acetate	Low/moderate: Potential to initiate and accelerate corrosion due to elevated conductivity	N/A	Low: Probably little or no effect	High: Organic content leading to oxygen demand	Low: Leads to reduced abrasives use	N/A	N/A
	Sodium Acetate	N/A						
Carbohydrates	Beet Juice	Low: Potential to initiate and accelerate corrosion due to elevated conductivity clams of mitigation of corrosion require further evaluation	Low: Probably little or no effect	Low: Probably little or no effect; claims of mitigation of corrosion require further evaluation	High Organic matter leading to oxygen demand; nutrient enrichment by phosphorus and nitrogen; heavy metals	Low: Leads to reduced abrasive use	Low: Probably little or no effect; limited information available	Low: Probably little or no effect
	Molasses	N/A						
	Corn Syrup	N/A						

Figure 10: Impairments Associated with Commonly Used Deicing Chemicals. Source: NCHRP Report 577

Winter Maintenance Best Management Practice Recommendations

Almost all chloride applied to roads, sidewalks and parking lots will reach our lakes and streams via runoff or infiltration. The BMPs within this guide focus on source control, and applying less material. Stormwater management BMPs that use capture and infiltration methods (e.g., swales, ponds, and catchment basins) primarily slow or catch water and allow suspended solids to settle out and for infiltration to occur. These BMPs do not work well for removing chlorides due to their high solubility. Chlorides do not degrade in the environment; instead they accumulate and therefore infiltration is not a good practice for addressing chloride impairments specifically.

Benefits of implementing winter maintenance BMPs can include:

- **Improved Level of Service**: A winter maintenance plan that is informative, knowledgeable and well-executed results in consistent services to the public.
- **Improved Safety**: A good understanding of materials, application rates, weather, and equipment can minimize dangerous road conditions.
- **Reduction of Impacts**: Understanding and implementing BMPs will reduce the amount of impacts associated with these products and reduce pollutants for the protection of infrastructure and the environment.
- **Save Money and Resources**: Knowing how to use the right treatment at the right time will save time, money, and materials.

BMPs	Description
Alternative Snow-Removal Methods	• Use mechanical means to remove snow, such as, plowing, shoveling or blowing as much as possible.
Calibration and Equipment Maintenance Retrofitting	• Calibrate your equipment. This will save chemical cost and reduce environmental impacts. Keep a record of your calibration. Each truck will be calibrated based on how it operates, and should be calibrated for varying types of materials. • Do not overfill your truck. Only put the amount of salt in your truck that you need for the route. • Retrofit trucks for use of on-board application regulators with temperature sensors that monitor air and pavement temperatures (or purchase hand-held unit); equip trucks with GPS; tanks and equipment for anti-icing and/or pre-wetting practices (with brine). Use ground speed control on your spreader. • Retrofit your trucks with applicator regulators or if Road Weather Information System (RWIS) is available in your area, use RWIS to determine when to apply deicers and which ones to use.
Anti-icing	• Anti-icing is the proactive method of preventing snow and ice from bonding to pavement. It can be more than 50% more efficient than deicing. This can reduce the amount of chemical needed by 30%.
Pre-wetting	• Pre-wetting is the process of coating a solid deicer with a liquid before it is spread on a roadway. Deicing chemicals must form brine before they can begin melting ice. Pre-wetting your chemicals accelerates the brine making process, which improves the melting action of the material. Pre-wetting salt can reduce application rates by 20%.
Resource Management	• Create a winter snow and ice control policy that will outline levels of service, application rates and plowing frequency. • Keep a log of winter storm events, time, and application rates to help describe maintenance activities and results.
Good Housekeeping and Education	• Know the limits of deicing; choose the proper material and apply the correct amount. Rock salt is not effective at temperatures below 15°F. • Don't mix salt and sand. Salt is for melting and sand is for traction on top of the ice; they work against each other. • Attend training workshops and stay up-to-date with new technologies and practices.

Alternative Snow-Removal Method BMPs

There are various alternatives to using chlorides. The most common BMPs are calibration of equipment, use of brine, anti-icing, pre-wetting and retrofitting equipment.

Calibration of Equipment

Calibration of equipment allows you to monitor the amount of materials you apply and test application rates to ensure efficient use of materials. Calibrating equipment is the first step to reducing salt use and saving money. Knowing staff and their habits is also an important component of managing the amount of salt applied.

Knowing how much deicing material that is being applied by equipment is critical to every winter maintenance program. It is important to understand that each truck or piece of equipment can apply different amounts of deicer. Variations in spinner speed, RPMs, spinner throw distance and/or patterns, and belt speed can affect and vary the amount of salt being applied. It is important for the operators of each truck to know their equipment capabilities and identify any issues.

Calibration procedures should be part of yearly training prior to the winter season. Appendix 2 provides example calibration spreadsheets from the state of New Hampshire. Online manuals are available for most types of spreaders. The goal is to know how much material you are putting down for every setting on each of your trucks that you use. Each truck must be independently calibrated.

Helpful Tips

The Salt Institute: Snowfighters Handbook: Safe and Sustainable Snowfighting
http://www.saltinstitute.org/wp-content/uploads/2013/07/Snowfighters_HB_2012.pdf

LTAP: Technical Information Sheet #168 Winter Operations Strategies
http://www.dot7.state.pa.us/BPR_PDF_FILES/Documents/LTAP/Techsheets/techSheet168-color.pdf

LTAP: Technical Information Sheet #111: New Chemical Application Guidelines for Winter Operations
http://www.dot7.state.pa.us/BPR_pdf_files/Documents/LTAP/TechSheets/TS_111_revised%202009.pdf

Figure 11: An example of anti-icing BMP, where a brine solution is placed on a roadway prior to a winter storm. Photo credit: Darrel Lewis, Armstrong County.

Brine

Brine is commonly used for anti-icing and for pre-wetting practices. Brine is a mixture of salt and water mixed together to 23% salinity. The *Brine Making: NH Best Management Practice* fact sheet can be found in Appendix 2 or can be found at: http://des.nh.gov/organization/divisions/water/wmb/was/salt-reduction-initiative/documents/bmp-brine.pdf.

This fact sheet goes into the detail of how brine is made and also states that brine can be safely stored for up to a year, however its concentration should be tested before use. A 23% brine solution may be stored outside; however, if temperatures get below 0°F, the brine may freeze. A circulator pump will reduce the risk of freezing. Using salt with minimal debris will greatly reduce the amount of equipment clogging – solar salt is commonly used.

The Minnesota Department of Transportation Research Services provides technical information on *Salt Brine Blending to Optimize Deicing and Anti-Icing Performance* http://www.dot.state.mn.us/research/documents/201220.pdf.

Anti-Icing

The key to maintaining ice-free surfaces is to create a brine layer between the pavement and winter precipitation to prevent ice from forming and make it easier to remove if it does form. **Anti-icing** is a proactive method of applying a brine solution to the roadway, preventing snow and ice from bonding to pavement. It can be more than 50% more efficient than deicing. Typically anti-icing is most effective if applied 1-2 hours before the precipitation begins; however, it can be applied up to 24 hours in advance.

LEAVE SOME PAVEMENT BARE It's always best to use stream nozzles instead of fan tip to avoid creating a slippery condition. If the anti-icing liquid freezes the bare pavement will still provide a traction surface.
Source: NH Fact Sheet BMP

Anti-icing advantages:

- Anti-icing returns road surfaces to normal faster, resulting in fewer accidents and delays.
- Salt needs moisture to be effective. Applying brine jumpstarts the melting process.
- Brine sticks to the road surface. It will not bounce and scatter like road salt.
- Application of brine to a road surface can result in 25%-30% less salt needed.
- The time required to treat lanes is reduced, therefore labor costs can be reduced if snow falls on the weekend or during hours where overtime would be paid.

Knowing when to employ anti-icing is dependent on weather and pavement conditions. Figure 12 below can act as a guide in assisting you with making the determination when to anti-ice.

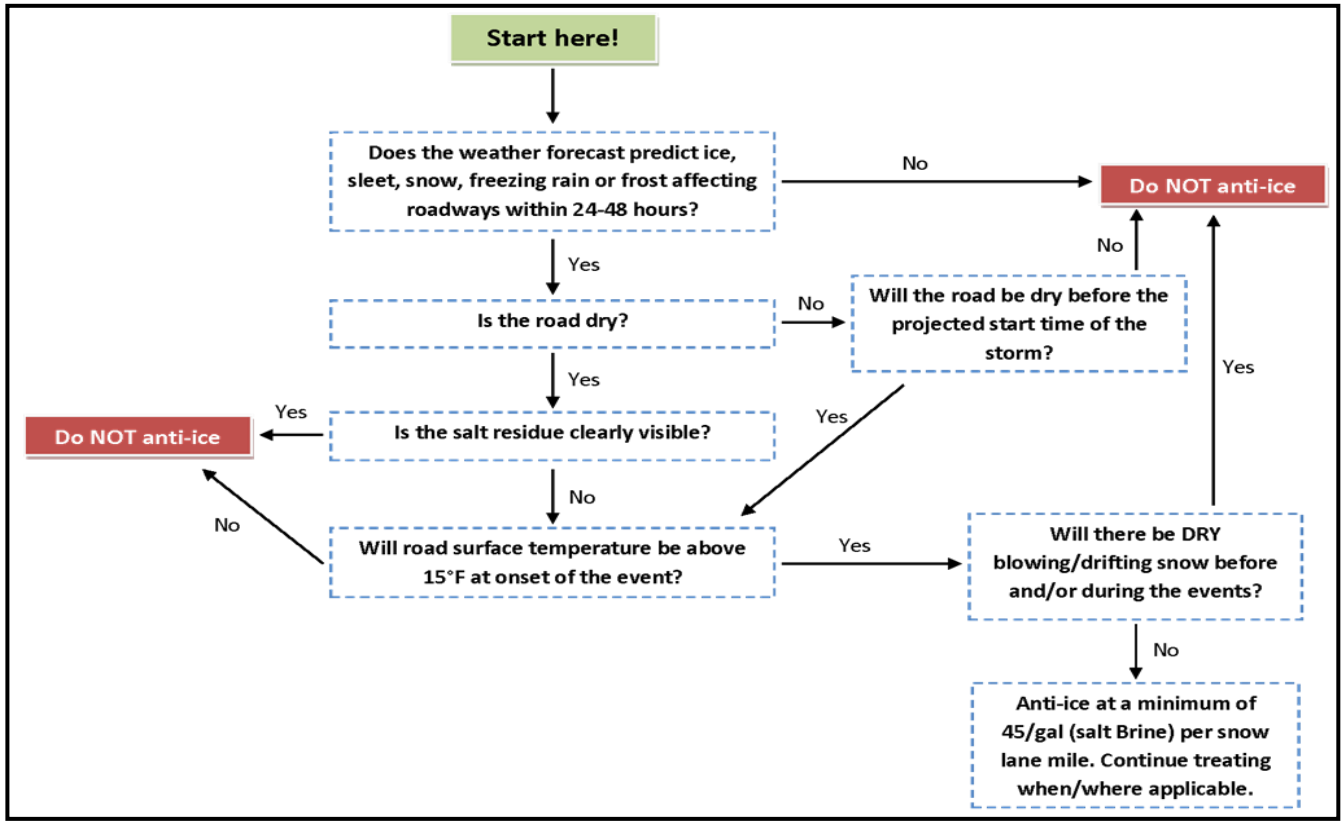

Figure 12: Anti-ice Decision Tree. Source: PennDOT Maintenance Manual

For more information, see the links below and the resources section in Appendix 4:

- http://www.dot7.state.pa.us/BPR_pdf_files/Documents/LTAP/TechSheets/TS_129.pdf
- http://www.fhwa.dot.gov/reports/mopeap/mop0296a.htm

Pre-wetting

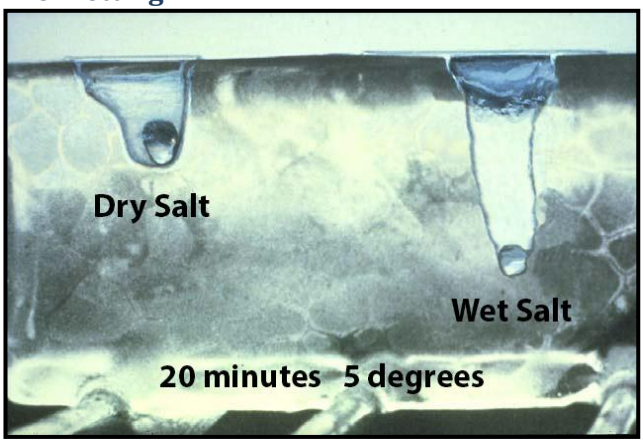

Figure 13: Pre-wetted salt works faster than dry salt. Image source: Wisconsin DOT Transportation Bulletin

reduces the total amount of deicer needed to obtain the desired results. As seen in Figure 14, Michigan DOT found a cost savings of one-third over the use of dry salt and 78% of the pre-wetted salt remained within the center of the roadway when applied.

Pre-wetting can be accomplished by applying the liquid chemical onto the material at the spinner as the material is being applied, or over the truck bed or loader bucket at the stockpile. If the liquid chemical is to be added at the stockpile, care should be taken to perform this operation on an impervious pad to alleviate leaching problems.

Pre-wetting salt is being used by more agencies than ever before. Their experience has proven the cost-effectiveness and increased safety of pre-wetted salt. The Salt Institute recommends the application rates to the right in gallons of liquid per ton of salt for the three commonly used chemicals.

As with any recommended application rate, be sure to test and adjust the rates based on current weather and pavement conditions within your municipality.

Dry salt needs to form a brine to start its melting action. **Pre-wetting** is the process of coating a solid deicer with a liquid before it is spread on a roadway. Pre-wetting your chemicals accelerates the brine making process, which improves the melting action of the material. In some cases, depending on the liquid used, this process can also lower the material's effective working temperature allowing for chemical deicers to work at lower pavement temperatures.

Pre-wetting also reduces the amount of bounce and scatter on the roadway, which keeps the material on the roadway. It also

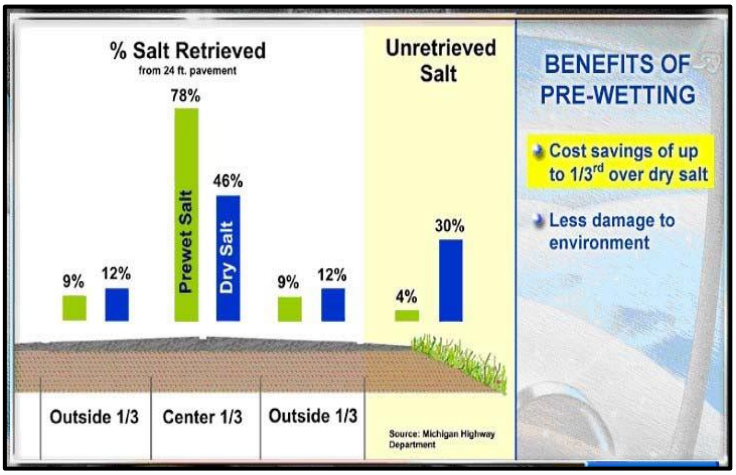

Figure 14: Benefits of Pre-Wetting. Image Source: Michigan Highway Department

Prewetting Agent	Application Rate (gallons per ton of salt)
Salt Brine	8 – 10
Calcium Chloride	6 – 12
Magnesium Chloride	6 – 8

Source: "Pre-wetting Salt: Another Cost Effective Took for Your Winter Maintenance Toolbox." Source: The Salt Institute.

Helpful Tips

- **A good rule of thumb is to use 8-10 gallons of pre-wetting liquid for every ton of deicer.**
- **If you are pre-wetting, don't forget to reduce your application rates accordingly.**
- **For more information about anti-icing please see:**
  - **FHWA: Manual of Manual of Practice for an Effective Anti-icing Program: A Guide For Highway Winter Maintenance Personnel http://www.fhwa.dot.gov/reports/mopeap/mop0296a.htm**
  - **http://environment.transportation.org/environmental_issues/construct_maint_prac/compendium/manual/8_0.aspx**

Retrofitting Trucks

Retrofitting trucks with equipment for the use of on-board application regulators, temperature sensors that monitor air and pavement temperatures, and anti-icing or pre-wetting practices can help significantly reduce the amount of salt used. Retrofitting trucks and investing in equipment can be costly, but you may discover that over a few years, with reduced materials applied, the equipment pays for itself. Below are a few examples of the cost savings that can be associated with retrofitting existing equipment to use anti-icing and pre-wetting practices.

Adding pre-wet capabilities to plow and spreader trucks requires investment to purchase the saddle tanks, pumps and nozzles that are capable of applying a liquid at the spreader's spinner. During initial start-up programs, modification of existing equipment may be the most economical.

Figure 15: Salt skirt retrofitted on a municipal truck to target salt application at the center line. Source: Minnesota DOT.

Local Highlight:
North Fayette Township, Allegheny County

North Fayette Township began utilizing brine in 2013. In their very first year of operations, in 2014, they went from spending $311,000 to $202,000 on winter maintenance operations for a savings of $109,000.

North Fayette experiences, on average, 30 snowfall events per year. For each pass (township-wide), they use about 90 tons of salt to treat 100 lane miles. It takes between 5 and 10 tons of salt to make enough brine to treat all of their roads. Utilizing brine for pre-treating roadways, North Fayette estimates that 80 tons of salt during each snowfall event is saved, which equates to an average savings of about $4,700 per event. The potential savings is around $141,000 a year.

Helpful Tips from North Fayette:

- One ton of salt can yield between 1,600 to 1,800 gallons of salt brine depending on the size of the salt crystals used
- The adjusted salt brine price for North Fayette Township is around 14 cents per gallon
- Average yearly costs associated with manufacturing brine is approximately $46,000 a year
- By pre-treating roads prior to a snow event, it is estimated that they saved 80 tons of salt per event

Their upfront costs consisted of:

- Equipment and retrofit: $18,000/truck (GPS, spreader controls, tanks and equipment)
- Original mixing equipment and tank: $95,000
- Pre-wetting tower for brine: $10,000

The example data below shows how the cost savings can be realized through simple calculations.

Example Base Data	Example Material Cost Savings
Salt Usage: 1,000 tons of salt per year **Cost of Salt:** $45.00 per ton **Cost of Calcium Chloride (CaCl):** $0.85 per gallon **Rate:** 10 Gallons CaCl per ton of salt **Percent Reduction of Salt:** 30%	**Amount of Salt Saved**: 1000 tons x 30% reduction = 300 tons/year **Cost of Salt Saved**: 300 tons x $45.00/ton = $13,500 **Amount of CaCl Used:** 10 gallons/ton x 700 tons = 7,000 gallons **Cost of CaCl Used**: 7,000 gallons x 0.85/galonl = $5,950
Annual Net Material Savings: $13,500 - $5,950 = $7,550 **Annual Labor Cost Savings:** Less Salt to Spread + Return Trips to Re-Salt Eliminated	

Figure 16: Cost savings example. Source: PennDOT LTAP Technical Information Sheet #129 (Prices reflected as of 2006)

Alternatives to Deicers

There are various alternatives to using deicers near sensitive aquatic resources. Some alternatives may have their own impacts; be sure to research and select the alternative that is most suitable.

Abrasives

Abrasives serve to provide a temporary friction layer on the road surface and are relatively inexpensive. They are commonly used on roads with low levels of service (LOS) or in areas that may need immediate traction; such as hills, curves, and intersections or other problem areas. Abrasives provide limited effectiveness on snowy or icy roads with higher vehicle speed and have substantial clean-up costs due to repeated applications that are needed. Abrasives can negatively impact water quality and aquatic species, air quality, vegetation and soil. Abrasives accumulate in stormwater inlets and pipes and travel into waterways via stormwater runoff and snowmelt. It is estimated that 50% to 90% of sand applied may remain somewhere in the environment after clean-up (Parker, 1997).

If you use a 50/50 salt/sand mix, you're generally either half right or half wrong. Using a salt/sand mix leads to overapplication of both materials.
Source: MN Snow and Ice Control

Under the current PennDOT publications, abrasives (antiskid materials) fall into two categories: 1) Aggregates and 2) Cinders, coke, crushed coal boiler bottom ash, or burned anthracite coal mine refuse. Although abrasive piles need to have salt applied to them so that they do not freeze, applying a salt/abrasive mix to the road is generally not recommended. Salt reduces the effectiveness of abrasives, and abrasives reduce the effectiveness of salt. However, a salt/abrasive mix may be helpful in certain situations such as a freezing rain event where the salt is washed away quickly. Some reports state that a abrasive/salt mixture can be effective in increasing friction in icy situations by sticking the abrasive to the surface, like sandpaper.

Recommended Abrasives Applications

Road Type	Recommended Practices	Use of Dry Abrasives
High Speed Urban Roads	Plow and apply chemicals to achieve bare pavement.	Inappropriate
Low Speed Urban Roads	Abrasives should be limited to parts of the road where motorists must brake, accelerate, or maneuver. Even then, abrasives should be applied only when it will likely take a long time to provide bare pavement.	Only in certain locations, and when snow pack will persist
Urban Intersections	Abrasives should be used only when an intersection might be snow or ice-covered beyond a normal period.	Only when snow pack will persist
Rural Roads, Paved	Abrasives should be applied on hills and curves only on low-speed low-volume roads. Paved rural roads should be plowed and chemical applied to achieve bare pavement.	Inappropriate
Rural Roads, Gravel	The recommended approach should be to simply groom the snow pack.	Only on low speed sections (perhaps hills and curves)
Rural Intersections	The preferred approach for paved roads is to plow and apply chemicals to achieve bare pavement. On gravel parts of intersections, abrasives may be applied over the part of the road where speeds less than 30 mph are expected.	Only on low speed approach length of gravel roads

Snow Fences

Blowing snow can impair motorists' visibility, cause accidents and make clearing the road more difficult. Reductions of blowing snow can be reduced by constructing snow fences. By reducing the amount of snow blowing across the road, snow fences can improve motorist's visibility, and reduce the amount of drifting snow on the road. New lightweight plastic fencing makes snow fences more portable and convenient to install than previous versions that were made of wood. Living

snow fences are made up of trees or vegetation that are strategically planted to act in the same manner as a traditional snow fence. Living snow fences are ideal in situations where a natural setting is desired, are more aesthetically pleasing and do not have the maintenance associated with them as portable snow fences.

Pervious Pavement

The University of New Hampshire's research suggests that porous asphalt, if installed correctly and functioning as designed, reduces the formation of ice on the pavement surface, so that the use of deicing chemicals may be drastically reduced. It is very important that sand and abrasives not be used for winter maintenance, as they will clog the pores. It is recommended that vacuum sweeping be performed at least twice a year.

The National Ready Mixed Concrete Association has produced a new *Pervious Concrete Pavement Maintenance and Operations Guide* which provides more detail on maintenance including specific recommendations on Winter Maintenance. The guide lists a number of deicing chemicals that should never be used and suggests some significant limitations on the type of equipment to be used for mechanical removal. The guide can be downloaded at: http://www.perviouspavement.org/downloads/pervious_maintenance_operations_guide.pdf.

Application Rates

Pennsylvania experiences a broad range of winter conditions so there is no one single set of application rate standards that will give "proper application rates" for all storm conditions because no two storms are exactly alike. Generally speaking, only apply enough chemical deicer to permit plows to remove the snow or melt ice. Several resources for application rate guidelines are provided in this section and are included in the resources at the end of this document.

Figure 17: Over-application. Source: Howard County, Maryland

Some of the resources may provide guidelines that you are used to using, while others that are recommended for the reduction of chloride may be a new concept. As stated earlier in this document, some of the reasons that lead to the over-application of chlorides can be due to not knowing that certain conditions may not warrant salt application; not knowing and/or tracking how much material is being applied; not knowing how much material is needed to achieve desired results; and decisions being made without knowledge of new technologies and practices.

It is recommended that you research BMPs and associated application rates. Test, document, and refine your practices based on your findings.

Helpful Tips

There are many resources are available to help with your winter maintenance program.

- **Minnesota Snow and Ice Control Field Handbook for Snowplow Operators: Second Revision http://www.mnltap.umn.edu/publications/handbooks/documents/snowice.pdf**
- **Winter Parking Lot and Sidewalk Maintenance Manual https://www.pca.state.mn.us/sites/default/files/parkinglotmanual.pdf**
- **FHWA: Manual of Practice for an Effective Anti-icing Program: A Guide for Highway Winter Maintenance Personnel http://www.fhwa.dot.gov/reports/mopeap/mop0296a.htm**
- **The Salt Institute: Snowfighters Handbook: Safe and Sustainable Snowfighting http://www.saltinstitute.org/wp-content/uploads/2013/07/Snowfighters_HB_2012.pdf**

Additional Considerations

In addition to applying chlorides to roads, parking lots and sidewalks, salt can also impact the environment from chemicals at storage areas and snow storage/dump areas.

Figure 18: Salt Storage Area. Source: SPC regional partners

Storage Recommendations for Deicing Chemicals

General rules for salt facilities and piles:

- Locate away from water sources
- Locate on an impervious surface
- Adequate drainage controls to prevent runoff
- After loading materials clean up any spills that occur
- Locate all salt and deicing areas outside the 100-year floodplain, areas of localized flooding and away from stormwater facilities
- Cover all salt and deicing material storage piles with tarps, hard shelters or within dikes or berms

The Pennsylvania Department of Environmental Protection (PADEP) has established minimum requirements for exposed salt storage piles under its National Pollutant Discharge Elimination System (NPDES) Industrial General Permit. (Note: This information was accurate as of June 2016. Please check for any changes that may occur when new permits are issued.)

For piles less than 3,000 tons:	For piles greater than 3,000 tons:
Recommendations and BMPs from the Salt Institute's Salt Storage Handbook must be incorporated. These piles must be covered by a permanent structure and be located on an impermeable base.	Recommendations and BMPs from the Salt Institute's Voluntary Salt Storage Guidelines for Distribution Stockpiles must be incorporated. These piles must be on an impermeable base and must be covered at all times with canvas, polyethylene or other synthetic material, except when receiving salt, building the stockpile, or loading out to customers, and then only the working face may be exposed.

Many states have considerations for siting new municipal deicing storage/salt facilities. These are good practices to consider within each municipality.

Ohio	• Avoid locating within 300 feet of any well, whether used for drinking, irrigation, or industrial water supply. • Avoid locating within 100 feet of features that have the capability to serve as a rapid pathway for salty water to migrate, such as storm drains and ditches (including roadside ditches). Avoid locating within 300 feet of dry wells (drains directly into subsurface). • Avoid locating within the 100-year floodplain of a stream or within 300 feet of a stream, river, lake, pond, or wetland.
New Jersey	• Locate at least 200 hundred feet from streams, wells, reservoirs and ground water sources. • Avoid wellhead protection areas. • Top elevation of the pad and access way should be higher than the 100-year storm level. • Divert storm water away from storage area.
Connecticut	Per Connecticut guidance, in order to prevent a new salt storage facility from becoming a source of pollution, it should **not** be located in any of the following: • Within a 100-year flood plain • Within 250 feet of a well that is utilized for potable water • Within an Aquifer Protection Area • Where adjacent surface water bodies are tributary to public water supply reservoirs, unless it is not feasible to locate the facility in a less sensitive area • In areas where the groundwater has been classified as GAA or GA, unless it is not feasible to locate the facility in a less sensitive area

Snow Storage/Dump Area Recommendations

Figure 19: Dumping snow into a waterway is not recommended. Photo Credit: Flickr.com

Consideration must also be given to the disposal of snow removed from roadways. This snow may contain higher concentrations of roadway salts and sediments. Snow storage areas should be located in upland areas only, where abrasives and other debris will remain after snowmelt for later removal. Large quantities of snow (and the sand and debris) may also cause blockage of storm drainage systems, and may result in increased chance for localized flooding, so do not locate them on or close to drainage systems.

Once the winter season is over and all the snow/ice has melted clean, remove all debris and sediment from storm drains, ditches and basins. Complete street sweeping practices per MS4 permit requirements.

Do not dump accumulated snow:

- **Into waterways, wetlands, on top of storm drains**
- **On stream or river banks that slope toward the water, where sand and debris can get into the watercourse**
- **In areas immediately adjacent (within at least 100 feet) of private or public drinking water well supplies (due to the possible presence of road salt)**
- **In stormwater management/green infrastructure BMP areas**

Figure 20: Snow dump area. Source: Minnesota DOT

Salt Truck Wash Water Management

Salt truck wash water and runoff from salt storage facilities can contain high levels of sodium, chloride, cyanide, and other associated pollutants. When possible, capture, treat, and recycle salt-containing wash water or storage facility runoff. Capture and recycle salt-containing wash water or storage facility runoff for use as salt-brine in salt pre-wetting and anti-icing materials, or properly route the collected runoff to a wastewater treatment facility. For additional information regarding wash water containment and recycling see the Vehicle Washing fact sheet in Appendix 4.

The *Innovative Environmental Management of Winter Salt Runoff Problems at INDOT Yards* publication describes beneficial salt truck wash water reuse. The report states six key factors for the reuse of salt truck wash water involves: 1) wash water collection, 2) wash water pretreatment, 3) temporary wash water storage, 4) brine manufacturing hardware and operational details, 5) product brine storage, and 6) brine application procedures and timing.

Helpful Tips

- **Bring extra salt back to the pile, do not use it up on the route if not needed. Clean out salt from truck thoroughly before washing truck.**
- **The Salt Institute: Salt Storage Handbook: Safe and Sustainable Salt Storage http://www.saltinstitute.org/wp-content/uploads/2013/09/Salt-Storage-Handbook-2015.pdf.**

MS4 Considerations

Stormwater regulations associated with the Federal Clean Water Act (CWA) are administered under the Municipal Separate Storm Sewer System (MS4) Program by the EPA. In Pennsylvania, the MS4 program is managed by PADEP, with oversight from EPA. MS4s are conveyances or systems of conveyances including roads with drainage systems, municipal streets, catch basins, curbs, gutters, ditches, man-made channels, or storm drains that are owned and operated by a public entity, are designed or used for collecting or conveying stormwater, and are not a combined sewer or part of a publicly-owned treatment works. A municipality is bound by USEPA regulations for an MS4 when all or a portion of a municipality lies within an urbanized area, as determined by the US Census Bureau.

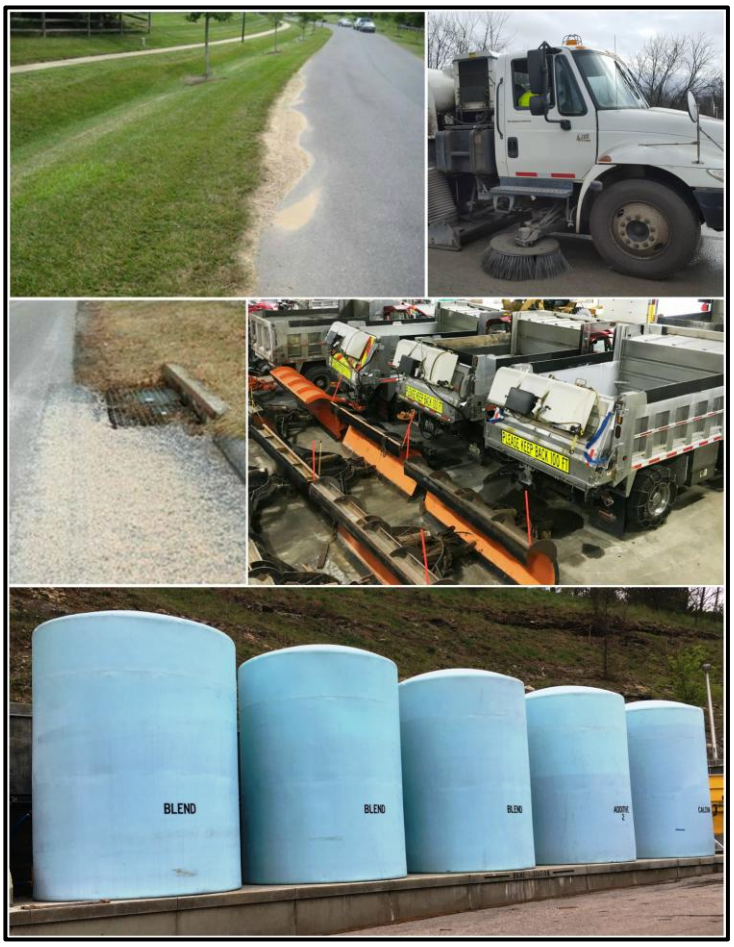

Figure 21: Municipal facilities and activities (Source: SPC, regional partners, and the Chesapeake Stormwater Network)

Chloride reduction also affects these MS4 municipalities. Currently, there are over 200 MS4 municipalities in the Southwestern Pennsylvania region. Winter BMPs are directly tied to Minimum Control Measure (MCM) 6, which focuses on Good Housekeeping and Pollution Prevention within the municipality to reduce the amount of pollution that is discharged to waterways, including chlorides. Municipal activities, including winter maintenance practices must be identified and staff training on pollution reduction, which includes chloride reduction, is a requirement of the program. Regulating authorities will also expect to see logs of specific municipal activities, such as snow removal, deicing and anti-icing. Standard operating procedures (SOPs) should be created for these winter maintenance activities.

Record-keeping and documentation is a very important aspect when developing and implementing your municipal pollution prevention and good housekeeping program. There are many resources and companies that offer tracking, reporting and record-keeping services, which may be the right option for you, depending on budget constraints and technology preferences. It is also fairly simple to keep your efforts organized and documented by using inexpensive three-ring binders. These binders should be updated, organized, and easily accessible to staff responsible for MS4 compliance.

For a more information on the MS4 Program, refer to SPC's "Quick Resource Guide to the MS4 Program" found at http://spcwater.org/ed_facts.shtml.

Helpful Tips

There are several available plans that give good operations and maintenance guidance:

- **City of Hamilton Public Works Department Operations and Maintenance Division: Road Salt Management Plan (TOE02129a)**
- **Good Housekeeping O&M Program http://www.lancasterintermunicipalcommittee.org/OM%20Program%20Template.pdf**
- **BMP Fact Sheet: GH-23 Salt Storage http://www.lancasterintermunicipalcommittee.org/GH%2023%20Salt%20Storage.pdf**

When developing and implementing a municipal pollution prevention and good housekeeping program, priorities should be based on a series of principles. Documentation and processes help fine-tune your winter maintenance program. Consider the topics below and the proper documentation needed for your winter maintenance MCM6 MS4 permit compliance.

Develop Salt Management Policies and Objectives	✓ Adopt a salt management policy that commits to measurable improvements in salt management practices ✓ Review current practices to form a benchmark ✓ Document policies, procedures and guidelines for your salt management practices, including: level of service for each roadway type, salt/sand application rates, managed salt/sand storage, good housekeeping practices, equipment calibration and re-calibration, training, snow disposal, incorporation of salt management consideration into road design and construction, and salt vulnerable areas ✓ Address the following areas of concern in your policies: general road use, salt use in salt vulnerable areas, salt storage and mixing, and snow storage and disposal ✓ Create a policy to minimize the use of potential pollutants, such as road salt and abrasives
Prevent Pollution at its Source	✓ Sweep streets and clean catch basins (abrasives removal, litter, organic debris removal from snow dump areas) ✓ Store solid deicers on impervious surfaces and provide secondary containment at storage sites for liquid deicers (must have secondary containment for valves and hoses) ✓ Re-vegetate eroding slopes from vegetation that may have been killed by the over-application of salt
Manage Clean Water Runoff and Minimize Pollutant Exposure to Clean Water	✓ Have structural cover over storage sites ✓ Site drainage design/runoff diversion ✓ Maximize infiltration of runoff away from potential pollutant sources ✓ Be able to identify where runoff outlets to
Plan for Spills and Accidents	✓ Develop spill prevention and response policies and procedures for ALL facilities that use or store chemicals ✓ Provide secondary containment ✓ Equip the facility to handle any size of spill ✓ Assign a responsible person/team for response ✓ Post procedures and emergency contacts
Practice Preventive Maintenance	✓ Use dry cleanup methods rather than washing (do not dump left over road salt or brine after finished with a run, clean out truck using dry methods prior to washing the truck) ✓ Establish an inspection calendar and incorporate into records/data system (equipment calibration and salt application records) ✓ Establish equipment maintenance and calibration calendar and incorporate those into records/data system
Identify Potential Pollution Sources	✓ Identify all material storage sites, especially those with any outside loading or unloading operations ✓ Plan for new facilities to include stormwater pollution prevention
Improve Data Collection, Mapping, and Records Maintenance	✓ Assign responsibility for monitoring and recording data collection ✓ Maintain chemical usage data for deicers and abrasives ✓ Benchmark the annual amount of salt applied per unit of weather/precipitation, such as degrees below 32°F or per inch of snow ✓ Records for street sweeping activities ✓ Cleaning catch basins and what you do with the materials ✓ If taken to a landfill, you need to be able to show documentation ✓ Make use of application rate guidelines
Train and Reward Employees	✓ Provide targeted training on policies ✓ Provide procedures and best management practices for staff ✓ Annually review the previous year's salt management practices and results to review progress ✓ Emphasize communication and coordination for municipal departments and operations with county and state agencies, organizations and institutions
Educate your Public	✓ Develop public outreach and participation regarding municipal pollution prevention activities ✓ Educate the public on proposed and existing winter maintenance practices ✓ Public education information could include adjusting driving behavior based on roadway condition

Source: Information adapted from NYS Municipal Pollution Prevention And Good Housekeeping Program Assistance, May 2006

MS4 Considerations for Brine and Other Liquids

All liquid containers must be labeled and protected from vehicle impacts and should have secondary containment. Secondary containment can consist of a bunker, berm, building, double-walled tank, etc. Spills from ice control products can occur during production, delivery and transfer so secondary containment is also needed for valves, hoses and pumps.

MS4 Considerations for Abrasives and Anti-Skid Materials

MS4 auditors may request the following street sweeping operations information:

- Does the permittee regularly sweep streets or municipal owned parking lots?
- What is the sweeping schedule?
- Are areas scheduled for sweeping based on aesthetics only, or is consideration given for reducing impacts on the stormwater and surface waters?
- What types of sweepers are used?
- How is street sweeping debris disposed? If the debris is dewatered, how is it done? How is the decanted water disposed?
- Are records kept of the amount of debris collected and amount of debris properly disposed of?
- How does the municipality use the data to further its program or evaluate program effectiveness? Are the data used to help prioritize cleaning frequency?

MS4 auditors may request the following catch basin cleaning operations information:

- Does the municipality have a schedule for routine maintenance or cleaning of basins?
- How many are cleaned and how often?
- Has the municipality targeted certain areas for more frequent maintenance? Does this targeting help minimize stormwater pollution?
- Are goals set for how many basins are inspected and cleaned each year?
- How are basin cleaning and maintenance needs tracked and recorded?
- What information is documented? Does the municipality track how much material is removed from each basin?
- What are the procedures for disposal of waste removed from basins or drains?
- Does flushing occur that could potentially discharge to surface water?
- If the material is removed by wet vacuum, how is the material dewatered? How is the decanted water disposed?
- Does the municipality have a schedule for routine maintenance or inspection of stormwater pipes?
- What are the maintenance procedures for cleaning clogged stormwater pipes?

MS4 auditors may request the following winter maintenance operations information:

- What type of winter anti-icing, deicing, and traction materials are used?
- How are the materials stored? Is the material covered and/or graded with a berm to prevent runoff?
- Does the municipality track the location and volumes of agents applied?
- Is the material picked up after the winter event? Is there a schedule for cleaning up after an event?

Helpful Tips

- **Keep in mind that the evaluator will question both managers and field staff regarding procedures used. The evaluator will ascertain the level of understanding at the field level as well as what procedures are deemed appropriate and feasible for your specific winter operations and MS4 maintenance activities.**
- **Website resources: LTAP Technical Information Sheets https://www.dot7.state.pa.us/LTAP/Public/PublicDocs_GenInfo.aspx**
- **Secondary containment options for liquids can be found at www.oregon.gov/ODOT/HWY/OOM/emsdoc/section3.pdf**

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Appendix 1: Minnesota Deicing Application Rate Guidelines

Deicing Application Rate Guidelines for Roads

24' of pavement (typical two - lane road)

The Minnesota Snow and Ice Control Field Handbook Manual 2005-1 recommended application rates have proven to be effective. MN application rates may be lower than PA Guidelines. MN and other states have TMDLs issued for Chlorides and as a result, have reduced application rates. Develop your own application rates by adjusting your current rates incrementally downward towards these guidelines. Where temperature rates overlap, select the rate most applicable to your situation.

Pavement Temp. (ºF) and Trend ( )	Weather Condition	Maintenance Actions	Application Rate in lbs/two - lane mile			
			Salt Prewetted/ Pretreated With Salt Brine	Salt Prewetted/ Pretreated With Other Blends	Dry Salt	Winter Sand (abrasives)
>30º ↑	Snow	Plow, treat intersections only	80 (40/lane mile)	70	100*	Not Recommended
	Frz. Rain	Apply chemical	80 - 160	70 - 140	100 - 200*	Not Recommended
30º ↓	Snow	Plow & apply chemical	80 - 160	70 - 140	100 - 200*	Not Recommended
	Frz. Rain	Apply chemical	150 - 200	130 - 180	180 - 240*	Not Recommended
25 - 30º ↑	Snow	Plow & apply chemical	120 - 160	100 - 140	150 - 200*	Not Recommended
	Frz. Rain	Apply chemical	150 - 200	130 - 180	180 - 240*	Not Recommended
25 - 30º ↓	Snow	Plow & apply chemical	120 - 160	100 - 140	150 - 200*	Not Recommended
	Frz. Rain	Apply chemical	160 - 240	140 - 210	200 - 300*	400
20 - 25º ↑	Snow or Frz. Rain	Plow & apply chemical	160 - 240	140 - 210	200 - 300*	400
20 - 25º ↓	Snow	Plow & apply chemical	200 - 280	175 - 250	250 - 350*	Not Recommended
	Frz. Rain	Apply chemical	240 - 320	210 - 280	300 - 400*	400
15º to 20º ↑	Snow	Plow & apply chemical	200 - 280	175 - 250	250 - 350*	Not Recommended
	Frz. Rain	Apply chemical	240 - 320	210 - 280	300 - 400*	400
15º to 20º ↓	Snow or Frz. Rain	Plow & apply chemical	240 - 320	210 - 280	300 - 400*	500 for freezing rain
0 to 15º ↑ ↓	Snow	Plow, treat with blends, sand hazardous areas	Not Recommended	300 - 400	Not Recommended	500 - 750 spot treat as needed
< 0º	Snow	Plow, treat with blends, sand hazardous areas	Not Recommended	400 - 600**	Not Recommended	500 - 750 spot treat as needed

From the *Winter Parking Lot and Sidewalk Maintenance Manual*. June 2006, revised 2010. Produced by: Minnesota Pollution Control Agency and Mississippi Watershed Management Organization – 2010 revision. Written by Fortin Consulting Inc.

Deicing Application Rate Guidelines for Parking Lots and Sidewalks

The Minnesota Snow and Ice Control Field Handbook Manual 2005-1 recommended application rates have proven to be effective. MN application rates may be lower than PA Guidelines. MN and other states have TMDLs issued for Chlorides and as a result, have reduced application rates. Develop your own application rates by adjusting your current rates incrementally downward towards these guidelines. Where temperature rates overlap, select the rate most applicable to your situation.

Pavement Temp. (ºF) and Trend ( )	Weather Condition	Maintenance Actions	Application Rate in lbs/1000 square foot area			
			Salt Prewetted/ Pretreated With Salt Brine	Salt Prewetted/ Pretreated With Other Blends	Dry Salt	Winter Sand (abrasives)
>30º↑	Snow	Plow, treat intersections only	0.75	0.5	0.75	Not Recommended
	Frz. Rain	Apply chemical	1.25	1	1.5	Not Recommended
30º↓	Snow	Plow & apply chemical	1.25	1	1.5	Not Recommended
	Frz. Rain	Apply chemical	1.5	1.25	1.75.	Not Recommended
25 - 30º ↑	Snow	Plow & apply chemical	1.25	1	1.5	Not Recommended
	Frz. Rain	Apply chemical	1.5	1.25	1.75	Not Recommended
25 - 30º ↓	Snow	Plow & apply chemical	1.25	1	1.5	Not Recommended
	Frz. Rain	Apply chemical	1.75	1.5	2.25	3.25
20 - 25º ↑	Snow or Frz. Rain	Plow & apply chemical	1.75	1.5	2.25	3.25 for frz. rain
20 - 25º ↓	Snow	Plow & apply chemical	2	2	2.75	Not Recommended
	Frz. Rain	Apply chemical	2.5	2	3	3.25
15º to 20º↑	Snow	Plow & apply chemical	2	2	2.75	Not Recommended
	Frz. Rain	Apply chemical	2.5	2	3	3.25
15º to 20º↓	Snow or Frz. Rain	Plow & apply chemical	2.5	2	3	3.25 for frz. rain
0 to 15º ↑ ↓	Snow	Plow, treat with blends, sand hazardous areas	Not Recommended	3	Not Recommended	5.0 spot treat as needed
< 0º	Snow	Plow, treat with blends, sand hazardous areas	Not Recommended	4.5	Not Recommended	5.0 spot treat as needed

From the *Winter Parking Lot and Sidewalk Maintenance Manual*. June 2006, revised 2010. Produced by: Minnesota Pollution Control Agency and Mississippi Watershed Management Organization – 2010 revision. Written by Fortin Consulting Inc.

Hydraulic-Run Spreader Calibration

NH Best Management Practices

WHY CALIBRATE?

You can't reduce your salt use if you don't know how much salt you actually use! The goal of calibrating is to know how much material you are putting down on a roadway or parking lot for every setting on your truck that you use. This is why calibrating your equipment is the first step to reducing salt use and saving money!

REMEMBER:

Each truck must be independently calibrated for each material it will be used to spread (the salt calibration chart *will* be different than the sand calibration chart).

Calibrations should be preformed annually, or after a spreader is serviced.

CALCULATIONS:

There are a few simple calculations you must perform in order to complete the calibration. Once all of the necessary data is recorded, head back inside and warm up! Refer to the reverse side of this fact sheet for calculation instructions.

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.

Produced in partnership with:

NEW HAMPSHIRE DEPARTMENT OF Environmental Services

New Hampshire DOT

Technology Transfer Center
New Hampshire LTAP at UNH

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 *((Run1 + 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:

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

Pony Motor-Run Spreader Calibration

NH Best Management Practices

WHY CALIBRATE?

You can't reduce your salt use if you don't know how much salt you actually use! The goal of calibrating is to know how much material you are putting down on a roadway or parking lot for every setting on your truck that you use. This is why calibrating your equipment is the first step to reducing salt use and saving money!

REMEMBER:

Each truck must be independently calibrated for each material it will be used to spread (the salt calibration card *will* be different than the sand calibration card).

Calibrations should be preformed annually, or after a spreader is serviced.

CALCULATIONS:

There are a few simple calculations you must perform in order to complete the calibration. Once all of the necessary data is recorded, head back inside and warm up! Refer to the reverse side of this fact sheet for calculation instructions.

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 to start (approximately 1" to 1.5"). After the truck is calibrated for the lowest gate setting, calibrate for each 1/2" increment greater than the lowest setting. Continue until all gate settings you use are calibrated.

Engine Speed: Set the pony motor speed to the maximum setting, or to the setting you would normally use.

Step 3: Measure Spread Width

Measure the width that the material covers during spreading. Do this for each gate 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 gate opening 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 gate 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 card in the truck you just calibrated. Also, leave a copy of the calibration card in the office so you have a copy incase the original is damaged.

Produced in partnership with:

NH Department of Environmental Services

New Hampshire DOT

Technology Transfer Center
New Hampshire LTAP at UNH

Calibration Chart (Pony Motor Type)

Material: _____ Truck/Spreader ID: _____

Date: _____ Performed by: _____

Tarp/Canvas/Bucket Weight: _____

Gate Opening	W	A	Discharge Rate (lb/min.)			B	D					
	Spread Width (ft.)	5.28 × W	Run 1	Run 2	Run 3	Average Discharge Rate *((Run1 + 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”												
1.5”												
2”												
2.5”												
3”												
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 gate 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:

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

Technical Update

OHIO LTAP | Local Technical Assistance Program

Snow and Ice Control Treatments – Salt with Salt Brine

Winter weather events present roadway agencies responsible for Snow & Ice removal with options on treatment materials to improve roadway safety. Due to budgetary or equipment-related limitations, some smaller local agencies might not be able to take full advantage of available treatment materials/options (see page 4). In this *R*oute *o*f *N*avigation (RON) technical update, we address the scenario where salt and salt brine might be the only materials being used at the local agency for treating a roadway.

Material Types:

Salt

Salt is sodium chloride, NaCl, a white crystalline substance with its characteristic taste found in natural beds, in seawater, etc. The mineral form is *halite*, also called "rock salt". Salt used for winter maintenance operations is sometimes referred to as "road salt".

Salt was first used to treat snow and ice covered roads in the mid-1940s, but its use wasn't fully embraced until the fifties. Use increased as more agencies became aware of the higher level of service salt could provide in addition to plowing and as the North American road system expanded.

Salt Brine

Salt brine is made by mixing salt in water to approximately a 23% solution by weight (23% salt / 77% water). Salt brine is commonly used in anti-icing operations and for pre-wetting solid rock salt.

The proportion of salt to water is critical to the effectiveness of the brine. Too much or too little salt affects the freezing point depressing qualities of the brine. The proper salt brine mixture is 23.3% at which the freezing point is –6°F **Caution:** If the solution of brine dilutes below its effective concentration, you will not achieve any reduction of ice bonding to the pavement.

Salt brine is widely used because it is:

- Readily available (easy to produce)
- Very economical
- Effective for events occurring at moderate subfreezing temperatures

Green brine is recommended to be used as much as possible. It is the salty water runoff from washing snow plow trucks after each snow storm which is collected in an onsite storm water retention pond that also collects storm water from the salt barn(s), loading area, and remaining site area. This water is beneficially reused by transferring it to a tank specially designed to mix brine.

EPA regulations must be met when using this green brine. This usually means running the wastewater through an oil-water separator, collection and storage, and filtration of heavy metals. Contact your local Ohio EPA office when considering this alternative.

Treating Asphalt, Brick, and Concrete Surfaces:

If conditions and timing allow, operators should apply anti-icing materials to the road prior to a snow fall.

Anti-icing is the application of a deicing material to the roadway prior to a snowfall event to prevent the bond from occurring between the snow and the roadway. Anti-icing materials are typically a brine, or in some cases rock salt. Anti-icing practices can also be used to prevent the formation of black ice on roadways.

Deicing is the application of a deicing material to the roadway after a snowfall event has occurred and the snow has bonded to the roadway. Always plow before applying treatment material to a snow covered roadway. Plowing is the most cost effective means of removing snow and ice from the roadway. Reversing the order will result in plowing deicing material off the roadway. It is usually not cost-effective to apply salt alone at pavement temperatures below 15 degrees Fahrenheit.

Salt's effectiveness can be increased by pretreating and pre-wetting.

Pretreating is mixing a non-caking liquid into the stockpile of salt before it is applied. It does not require changes to an agency's plow trucks and requires no new capital investment for application equipment if it is applied by a vendor.

Pre-wetting is adding a liquid to the salt as it is being applied-either at the spinner or through a soaker pipe in the auger box to reduce bounce and scatter and to accelerate the melting process. Although pre-wetting requires some changes to an agency's plow truck, it provides flexibility to switch the liquid chemical makeup depending on conditions. You can also switch from dry application immediately-just turn down the liquid application rate.

Note the Ohio Department of Transportation may sell salt brine to local government agencies at local sites where salt brine is produced. Contact your local Ohio Department of Transportation facility for more details.

Use an appropriate **amount** of salt.

Use a calibrated, speed-synchronized spreader and good judgment in selecting application rates and truck speeds. Apply just enough material to prevent or loosen the bond between the road and the snow or ice so it can be plowed off.

These guidelines are a starting point. Reduce or increase rates incrementally based on your experience according to your local conditions.

Application Rates:

The following salt application rates are for typical 24' two-lane roads, during the specified pavement temperatures, with the listed precipitation:

Dry Pavement Light Snow Less Than 2"/Hour					
Above 32° F (Rising)	Above 32° F (Falling)	25° F to 32° F	20° F to 25° F	15° F to 20° F	Below 15° F
Bridges and Icy Spots	Acceptable	Recommended	Recommended	Recommended	Recommended
Plow and treat @ 50 to 100 lb./mile #	Plow and treat @ 50 to 100 lb./mile #	Plow and treat @ 50 to 100 lb./mile #	Plow and treat @ 100 to 200 lb./mile #	Plow and monitor conditions	Plow and monitor conditions
Wet Pavement Light Snow Less Than 2"/Hour					
Above 32° F (Rising)	Above 32° F (Falling)	25° F to 32° F	20° F to 25° F	15° F to 20° F	Below 15° F
Bridges and Icy Spots	Acceptable	Recommended	Recommended	Recommended	Recommended
Plow and treat @ 50 to 100 lb./mile #	Plow and treat @ 50 to 100 lb./mile #	Plow and treat @ 50 to 100 lb./mile #	Plow and treat @ 100 to 200 lb./mile #	Plow and treat @ 300 to 400 lb./mile #	Plow and treat @ 400 lb. max/mile
Dry Pavement Heavy Snow More Than 2"/Hour					
Above 32° F (Rising)	Above 32° F (Falling)	25° F to 32° F	20° F to 25° F	15° F to 20° F	Below 15° F
Bridges and Icy Spots	Acceptable	Recommended	Recommended	Recommended	Recommended
Plow and treat @ 50 to 100 lb./mile #	Plow and treat @ 50 to 100 lb./mile #	Plow and treat @ 100 to 200 lb./mile #	Plow and treat @ 300 to 400 lb./mile #	Plow and monitor conditions	Plow and monitor conditions

- Pre-wet the material @ 8 to 10 gallons of salt brine/ton of salt

Wet Pavement Heavy Snow More Than 2"/Hour					
Above 32° F (Rising)	Above 32° F (Falling)	25° F to 32° F	20° F to 25° F	15° F to 20° F	Below 15° F
Bridges and Icy Spots	Acceptable	Recommended	Recommended	Recommended	Recommended
Plow and treat @ 100 lb./mile #	Plow and treat @ 100 to 200 lb./mile #	Plow and treat @ 100 to 200 lb./mile #	Plow and treat @ 400 lb. max/mile #	Plow and treat @ 400 lb. max/mile #	Plow and treat @ 400 lb. max/mile #
Freezing Rain					
Above 32° F (Rising)	Above 32° F (Falling)	25° F to 32° F	20° F to 25° F	15° F to 20° F	Below 15° F
Bridges and Icy Spots	Recommended	Recommended	Recommended	Recommended	Recommended
Plow and treat @ 100 lb./mile #	Plow if needed and treat @ 200 to 300 lb./mile #	Plow only Plow if needed and treat @ 300 to 400 lb./mile #	Plow if needed and treat @ 400 lb. max/mile #	Plow if needed and treat @ 400 lb. max/mile #	Plow if needed and treat @ 400 lb. max/mile #
Black Ice					
Above 32° F (Rising)	Above 32° F (Falling)	25° F to 32° F	20° F to 25° F	15° F to 20° F	Below 15° F
Bridges and Icy Spots	Recommended	Recommended	Recommended	Recommended	Recommended
Apply anti-icing material prior to the formation of black ice ^	Apply anti-icing material prior to the formation of black ice ^	Apply anti-icing material prior to the formation of black ice ^	Apply anti-icing material prior to the formation of black ice ^	Apply anti-icing material prior to the formation of black ice ++	Apply anti-icing material prior to the formation of black ice ++

- Pre-wet the material @ 8 to 10 gallons of salt brine/ton of salt

^ - Apply anti-icing brine @ 20 to 40 gallons/lane mile

++ - *Do not apply liquid anti-icing material when the pavement temperature is below 20° F.*

Additional Treatment Materials:

For information about additional treatment materials commonly used for winter roadway maintenance, please refer to the separate RON Technical Update on *Snow and Ice Control Treatments – Popular Materials*.
http://www.dot.state.oh.us/Divisions/Planning/LocalPrograms/LTAP/Documents/Popular_Materials_for_Snow_and_Ice_Control_Treatments.pdf

Information Sources:

Federal Highway Administration – www.fhwa.dot.gov
Ohio DOT – www.dot.state.oh.us; Scott Lucas, Office of Maintenance Operations – 614-644-6603
Salt Institute – www.saltinstitute.org
Minnesota Local Road Research Board – www.lrrb.org

DISCLAIMER: *This RON Technical Update is provided for purposes of general information. Interested persons should refer to the resources referenced herein for additional information as needed.*

Appendix 4: Document Sources and Additional Resources

Best Management Practices

- Pennsylvania Stormwater Best Management Practices Manual - Special Management Areas (Brownfields, Highways and Roads, Karst Areas, Mined Lands, Water Supply Well Areas, Surface Water Supplies and Special Protection Waters) http://www.elibrary.dep.state.pa.us/dsweb/Get/Document-48478/08_Chapter_7.pdf
- Pre-wetting Winter Materials. PennDOT LTAP Technical Information Sheet #129. 2006. http://www.dot7.state.pa.us/BPR_pdf_files/Documents/LTAP/TechSheets/TS_129.pdf
- Transportation Association of Canada - Synthesis of Best Practices Road Salt Management http://tac-atc.ca/en/bookstore-and-resources/free-resources-and-tools/syntheses-practice
- Transportation Research Circular E-C063: Proactive Snow and Ice Control Toolbox, June 7–9, 2004 http://onlinepubs.trb.org/onlinepubs/circulars/ec063.pdf

Blowing/Drifting Snow Control: Snow Fences

- Controlling Blowing and Drifting Snow with Snow Fences and Road Design http://www.esf.edu/willow/lsf/Litterature/Tabler%202003%20-%20Controlling%20Blowing%20and%20Drifting%20Snow.pdf
- LTAP Technical Information Sheet #63: Snow Fences
- Natural Resource Conservation Service: Tree Plantings in CRP Living Snow Fences, Field Windbreaks, and Shelterbelts https://prod.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs141p2_000874.pdf
- NCHRP Synthesis 449 http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_449.pdf

Cost Benefits

- Benefit-Cost of Various Winter Maintenance Strategies. Clear Roads. September 2015. http://clearroads.org/wp-content/uploads/dlm_uploads/FR_CR.13-03_Final.pdf
- Winter Maintenance. Pennsylvania DOT LTAP presentation. September 2014.
- The Real Cost of Salt use for Winter Maintenance in the Twin Cities Metropolitan Area. https://www.pca.state.mn.us/sites/default/files/wq-iw11-06bb.pdf

General Resources

- Environment Canada, Road Salt Case Studies https://www.ec.gc.ca/sels-salts/default.asp?lang=En&n=CBE1C6ED-1
- Highway Deicing: Road Salt Use in the United States. Transportation Research Board. http://onlinepubs.trb.org/onlinepubs/sr/sr235/017-030.pdf
- PennDOT LTAP Technical Information Sheet #63: Snow Fences
- Road Salt Moving Toward the Solution. Special Report December 2010 http://www.caryinstitute.org/sites/default/files/public/reprints/report_road_salt_2010.pdf
- Source Water Protection Practices Bulletin Managing Highway Deicing to Prevent Contamination of Drinking Water. July 2009 www.epa.gov/safewater

Guidance Manuals

- A Guide for Selecting Anti-icing Chemicals, Version 1.0.IIHR, Technical Report No. 420, 2001 http://dot.alaska.gov/stwddes/research/assets/pdf/anti_icing_guide.pdf.
- Controlling Blowing and Drifting Snow with Snow Fences and Road Design http://www.esf.edu/willow/lsf/Litterature/Tabler%202003%20-%20Controlling%20Blowing%20and%20Drifting%20Snow.pdf
- Federal Highway Administration (FHWA), Manual of Practice for an Effective Anti-icing Program: A Guide for Highway Winter Maintenance Personnel, FHWARD_ 95-202, June 1996 http://www.fhwa.dot.gov/reports/mopeap/eapcov.htm
- Manual of Practice for Anti-icing of Local Roads. October 1996. A Publication of the Technology Transfer Center University of New Hampshire. http://www.ltap.org/login/resource/entryupload/uploads/20100217122816_resource_yZm9.pdf

- Minnesota Snow and Ice Control Field Handbook for Snowplow Operators. Minnesota Local Road Research Board. August 2005. http://www.lrrb.org/media/reports/200501REV.pdf
- Road Salt Management. Adapted from Pollution Prevention/Good Housekeeping for Municipal Operations (USEPA). May 2006. Massachusetts Nonpoint Source Pollution Management Manual. http://projects.geosyntec.com/npsmanual/Fact%20Sheets/Road%20Salt%20Management.pdf
- The Snow fighters Handbook. The Salt Institute. 2012 http://www.saltinstitute.org/wp-content/uploads/2013/07/Snowfighters_HB_2012.pdf
- Winter Parking Lot and Sidewalk Maintenance Manual. June 2006, Revised: June2008. Fortin Consulting Inc., Minnesota Pollution Control Agency (MPCA), Minnesota Department of Transportation & Circuit Training and Assistance Program. http://www.pca.state.mn.us/publications/parkinglotmanual.pdf
- PADOT Maintenance Manual. Chapter 4: Winter Services. Updated January 2015. http://www.dot.state.pa.us/public/PubsForms/Publications/PUB%2023/Pub%2023-Chapter%204%20.pdf

MS4 Resources

- PennDOT LTAP: Sheet#167 Summer/2015 Abrasives and Anti-Skid Material http://www.dot7.state.pa.us/BPR_pdf_files/Documents/LTAP/TechSheets/TS_167.pdf
- Pollution Prevention and the MS4 Program: A Guide on Utilizing Pollution Prevention Activities to Meet MS4 General Permit Requirements https://www.pca.state.mn.us/sites/default/files/wq-strm4-26.pdf

Road Salt and the Environment

- Acute Toxicity of Sodium Chloride to Freshwater Aquatic Organisms. A Watershed Restoration Plan for the Root River Watershed. SEWRPC Community Assistance Planning Report No. 316. Appendix E.
- Environmental Impacts of Road Salt and Alternatives in the New York City Watershed. By William Wegner and Marc Yaggi. Stormwater July 2001. www.stormh2o.com/julyaugust-2001/salt-road-environmental-impacts.aspx
- Highway Deicing: Road Salt Impacts on Drinking Water. Transportation Research Board. http://onlinepubs.trb.org/onlinepubs/sr/sr235/099-112.pdf
- Highway Salt and Our Environment. The Salt Institute. 2004. http://www.saltinstitute.org/news-articles/road-salt-and-the-environment/
- Increase in Urban Lake Salinity by Road Deicing Salt. Novotny, E., D. Murphy, and H. Stefan. 2008. Science of the Total Environment 406 (2008) 131-144. http://www.ncbi.nlm.nih.gov/pubmed/18762321
- Rationale for the Development of Ambient Water Quality Criteria for Sulfate Protection of Aquatic Life Use. Commonwealth of Pennsylvania DEP Bureau of Point and Non-Point Source Management.
- Strategies to Mitigate the Impacts of Chloride Roadway Deicers on the Natural Environment. Transportation Research Board. http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_449.pdf
- Winter Operations and Salt, Sand, and Chemical Management. Center for Environmental Excellence by AASHTO. 2013. http://environment.transportation.org/environmental_issues/construct_maint_prac/compendium/manual/8_1.aspx

Road Salt Management Plan Examples

- City of Hamilton's Road Salt Management Plan TOE 021Salt Management Plan (TOE02129a) 2003 http://www2.hamilton.ca/Hamilton.Portal/Inc/PortalPDFs/ClerkPDFs/committee-of-the-whole/2003/Apr15/TOE02129(a).pdf
- Twin Cities Metropolitan Area, Chloride Management Plan, February 2016 https://www.pca.state.mn.us/sites/default/files/wq-iw11-06ff.pdf

Road Salt Storage

- Recommendations for Salt Storage Guidelines for Protecting Ohio's Water Resource, February 2013. http://www.epa.ohio.gov/portals/35/owrc/SaltStorageGuidance.pdf
- State Oversight of Road Salt Storage in Midwestern and Northeastern U.S. http://www.epa.ohio.gov/portals/35/owrc/StateSaltOversightSummary.pdf

- Virginia Transportation Research Council, Research Report, Recycling of Salt-Contaminated Stormwater Runoff for Brine Production at Virginia Department of Transportation Road-Salt Storage Facilities. May 2008. www.virginiadot.org/vtrc/main/online_reports/pdf/08-r17.pdf

Salt Wash Water Reuse

- FHWA Road Weather Management Best Practices http://www.ops.fhwa.dot.gov/weather/best_practices/1024x768/transform2.asp?xslname=publications_title.xslt&xmlname=publications.xml
- Innovative Environmental Management of Winter Salt Runoff Problems at INDOT Yards, 2004 http://docs.lib.purdue.edu/cgi/viewcontent.cgi?article=1601&context=jtrp

Snow Dumps and Regulations

- NH Department of Environmental Services: Environmental Fact Sheet WMB-3 2015, Snow Disposal Guidelines http://des.nh.gov/organization/commissioner/pip/factsheets/wmb/documents/wmb-3.pdf
- Private Snow Disposal Sites (On-Site Snow Storage Only) Operations Guidance---draft Prepared by Scott R Wheaton, MOA Watershed Management Services Winter 2003 http://anchoragewatershed.com/Documents/privtsnobmps.pdf

Useful Organizations and Websites

- American Association of State Highway and Transportation Officials http://www.transportation.org
- Cornell Local Roads Program: Workshops on snow and ice control www.clrp.cornell.edu
- Fortin Consulting, Inc. Road Salt Training (Minnesota) http://www.fortinconsulting.com/our-work/road-salt/certification/
- Maine Road Salt Risk Assessment Project. Margaret Chase Smith Policy Center, University of Maine http://mcspolicycenter.umaine.edu/?q=RoadSalt_Background
- Minnesota Pollution Control Agency Road Salt Education Program www.pca.state.mn.us/programs/roadsalt.html
- Pennsylvania Department of Transportation (PADOT) Local Technical Assistance Program (LTAP) https://www.dot7.state.pa.us/LTAP/default.aspx
- Road Salt and Water Quality. 1996. Environmental Fact Sheet, New Hampshire Department of Environmental Services. www.des.nh.gov
- Transportation Resource Board of the National Academies www.trb.org
- US Federal Highway Administration http://environment.fhwa.dot.gov
- The Salt Institute www.saltinstitute.org
- Safe Winter Roads www.safewinterroads.org

The Southwestern Pennsylvania Commission (SPC) hereby gives public notice that it is the policy of the Commission to assure full compliance with Title VI of the Civil Rights Act of 1964, the Civil Rights Restoration Act of 1987, Executive Order 12898 on Environmental Justice, and related statutes and regulations in all programs and activities. Title VI and other related statutes require that no person in the United States of America shall, on the grounds of race, color, sex, national origin, age, or disability, be excluded from the participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity for which SPC receives federal financial assistance. Any person who believes they have been aggrieved by an unlawful discriminatory practice by SPC under Title VI has a right to file a formal complaint with the Commission. Any such complaint must be in writing and filed with SPC's Title VI Coordinator within one hundred eighty (180) days following the date of the alleged discriminatory occurrence. For more information, or to obtain a Title VI Discrimination Complaint Form, please see our website at: www.spcregion.org or call 412-391- 5590.

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Southwestern Pennsylvania Commission Water Resource Center

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In 2013, SPC formed the Water Resource Center (WRC) to address various water issues within the region. WRC's Mission is to promote regional collaboration on water topics; be a leader in facilitating coordination and education; and provide technical assistance to its member governments.

For an electronic version of this guide, visit:
www.spcwater.org