



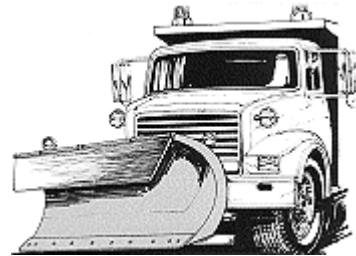
Transportation Association of Canada



# Salt SMART

Spreading, **M**anagement, **A**pplication **R**ates and **T**iming

## Learning Guide



### Module 1 Setting the stage

*June 2004*

## ***Transportation Association of Canada***

The Transportation Association of Canada is a national association with a mission to promote the provision of safe, efficient, effective and environmentally and financially sustainable transportation services in support of Canada's social and economic goals. The association is a neutral forum for gathering or exchanging ideas, information and knowledge on technical guidelines and best practices. In Canada as a whole, TAC has a primary focus on roadways and their strategic linkages and inter-relationships with other components of the transportation system. In urban areas, TAC's primary focus is on the movement of people, goods and services and its relationship with land use patterns.

## ***Wellspring Consulting Inc.***

Wellspring Consulting is an instructional design company, specializing in adapting reference information into self-contained learning guides through the application of proven adult learning principles. With the Wellspring methodology, learners are first engaged through an enjoyable, easy to follow and entertaining writing style, then challenged using interactive techniques like problem-solving and role-playing. This fresh and stimulating approach enables learners to effectively transform dry technical information into vital, practical knowledge.

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***June 2004***

## Salt SMART Train-The-Trainer Program

TAC offers trainer workshops to accompany the Salt SMART Learning Guide in support of the best practices for the environmental management of road salts. They range from one-day overview sessions to two-day all-inclusive sessions.

*Make a SMART investment today and book your “at-home”  
trainer workshop or attend one in Ottawa!*

### Overview session

This one-day session is for trainers with formal training and experience. It is designed to walk through the *Salt SMART Learning Guide* to highlight key messages and to discuss potential areas of resistance and how to handle them.

**Member price at a member-selected location:** \$5,000 flat fee for up to 10 participants plus expenses (e.g. training room and AV equipment, catering, TAC trainer’s travel and accommodation).

**Member price in TAC-Ottawa training room:** \$899 per participant. A minimum class size is required and dates will depend on attendee preferences and trainer’s availability.

### All-inclusive session

This two-day session is for those who have little or no training experience. It offers the one-day overview combined with an extra day devoted to soft skills training (trainer techniques, adult learning principles, lesson planning).

**Member price at a member-selected location:** \$6,500 flat fee for up to 10 participants plus expenses (e.g. training room and AV equipment, catering, TAC trainer’s travel and accommodation).

**Member price in TAC-Ottawa training room:** \$1099 per participant. A minimum class size is required and dates will depend on attendee preferences and trainer’s availability.

*TAC non-members pay a 20% premium on all sessions.*

To book your trainer workshop, or for further information, contact the TAC Training Manager, Diane Jodouin at (613) 736-1350, ext. 261 or [djodouin@tac-atc.ca](mailto:djodouin@tac-atc.ca)

# Acknowledgements

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TAC gratefully acknowledges the dedication, guidance and input of the Subject Matter Reviewers; and the quality of work performed by the Instructional Designer.

This Learning Guide is truly a team effort by all those who have contributed financially and/or technically.

# Preface

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## TAC Learning Guide

There are some things that should be taken with a grain of salt. The information in this learning guide is not one of them.

When you consider that the nation's extensive transportation network supports a wide range of economic and social activities, it's not putting too a fine point on it to state that safe and efficient road traffic throughout the year is essential to our way of life. We rely on the road network for transport to the workplace and other economic uses, for recreation and leisure activities, and for emergency and security services.

Road salt is the deicer of choice for winter road maintenance.

There's something else that we rely on: road salt. It's the deicer of choice for keeping roads passable throughout the winter.

The benefits of using road salt to keep the thoroughfares open don't come without costs, both economic and environmental. Recognizing this, and concerned about the environmental implications of road salt applications, the Transportation Association of Canada's (TAC) Chief Engineers' Council, the Road Salt Working Group (a subcommittee of the Maintenance and Construction Standing Committee), and the Environment Council launched an initiative to identify and document new ways of handling and using road salt. Transportation professionals from across the country worked together through the 20-member project steering committee and 17-member project team to produce three important documents:

- *Road Salt and Snow and Ice Control Primer*: An executive summary of the project, written for the general public, that provides information on the importance of road salt use to maintaining a safe and efficient transportation system that sustains Canada's economy.
- *Road Salt Management Guide*: A comprehensive reference guide which addresses transportation and Canada's economy and quality of life, road salt and the environment and road salt management practices.
- *Syntheses of Best Practices for Road Salt Management*: A series of syntheses of best practices related to the effective management of road salt use in winter maintenance operations.

## This guide's for you

This learning guide is based on the best practices in the *Road Salt Management Guide* and the *Syntheses of Best Practices for Road Salt Management*. If you're an operator or supervisor, then this guide is for you.

As a winter road maintainer, you're on the front lines in the battle against snow and ice on roads. In fact, the only thing that gets out there ahead of you is your plow blade. You probably already know that road salt is the most effective, cheapest, and easily handled de-icing material. There may be alternatives out there, but they usually cost a lot more, require special care when handling, and are only effective under certain weather conditions. Road salt is still the most reliable de-icing chemical available.

## The "4 R's" of winter road maintenance

There was a time when winter road maintainers lived by a simple rule of thumb: "when in doubt, put it out." In other words, it was better to err on the side of caution and put down a lot of road salt—and put it everywhere—just to make sure. But those days are long gone.

The modern winter road maintainer has a new mantra: "put the **R**ight amount of the **R**ight material in the **R**ight place at the **R**ight time." In other words, use road salt more wisely and effectively. The benefit of this approach is that road salt usage is *optimized*. This translates into savings for the organization, and minimizes the impact of road salt on the environment. This guide is designed to teach you how to optimize road salt usage while continuing to keep winter roads safe for commercial, passenger, and emergency vehicles.

## Your guide to road salt optimization

Optimizing salt use means being smarter about you how put it down.

Optimizing road salt usage means being smarter about how you apply the material. In most cases it will mean that you use less road salt, but that is a result rather than an objective. In order to use road salt more wisely, you'll need to become a better decision-maker, and in order to do that, you need to improve your knowledge. That's where this learning guide comes in.

The guide consists of six modules:

- **Module 1** sets the stage by looking at the importance of transportation to our economy and way of life; the economic implications of winter maintenance; and the cost-benefits of winter maintenance.

- **Module 2** explores the science of road salt and ice. In Lesson 1 we look at the principles of ice formation. Lesson 2 examines the concept of freeze point depressants and how they work to prevent or break the bond between pavement and ice. In Lesson 3 we consider alternative de-icing chemicals and their role in winter road maintenance. Lesson 4 looks at application strategies, in particular anti-icing, a modern preventive approach that aims to keep the ice-pavement bond from forming.
- **Module 3** looks at equipment and technologies used by modern winter road maintainers. In Lesson 1 we survey plows and spreaders and how they can be put to work to optimize road salt usage. Lesson 2 examines pavement condition tracking and forecasting techniques and technologies, including road weather information systems.
- **Module 4** deals with road salt and the environment. In this module we look at the pathways by which road salt can make its way into soil and groundwater, and the effects it can have on vegetation and wildlife.
- **Module 5** looks at snow and road salt handling. In Lesson 1 we look at road salt handling and storage at the road maintenance yard. In Lesson 2 we examine disposal strategies and techniques at snow disposal sites.
- **Module 6** considers the importance of monitoring and record keeping in winter road maintenance.

The objective throughout these modules and lessons is to help you, as an operator or supervisor, to understand how it is possible to use road salt more effectively while continuing to provide safe roads during winter and minimizing the impact on the environment.

## The same, but different

You have a lot in common with winter road maintainers across the country.

As a winter road maintainer, you have a lot in common with operators and supervisors in other jurisdictions across the country. At the same time, your job is very unique. Every road jurisdiction has a different transportation infrastructure to service. No two agencies face the same weather conditions. Each organization has a different mix of human resources and equipment available to keep the roads open during winter. Levels of service differ from one jurisdiction to the next, winter maintenance strategies are designed to meet specific local challenges, and public expectations change from one jurisdiction to the next.

In other words, while all winter road maintainers may be out on the front lines keeping the roads open, they could be using very different means to achieve similar ends.

This learning guide deals with general principles of winter road maintenance that can be applied in every jurisdiction, but it is beyond the scope of this document to prescribe practices that apply to specific road authorities. The best practices upon which this guide is based have been carefully researched and prepared and are endorsed by the Transportation Association of Canada's (TAC) Chief Engineers' Council, the Road Salt Working Group (a subcommittee of the Maintenance and Construction Standing Committee), and the Environment Council.

This material is provided as advice to winter road maintainers for consideration when developing their own policies, practices, and procedures. Keep in mind that the best practices are to be used in concert with the legislation, manuals, directives, and procedures of your individual road agency.

The material in this learning guide will be incorporated into your agency's current or planned training programs.

## A word about what's inside

Before we dive into the learning guide, let's take a look at what you'll see inside. We know that your time is valuable, and that the technical nature of this subject-matter may not be the most exciting thing you've read lately. So we've tried to make the learning experience as easy and enjoyable as possible.

We want you to learn, and to enjoy doing it.

The first thing you'll notice is that, unlike a lot of those technical reference manuals and user guides you may have seen and tried to read, our tone is conversational. We talk directly to you in a casual voice that's free of jargon and technical terminology. We even throw in a bit of humour every now and then. Unlike those other documents, we want you to learn, and to enjoy doing it.

Each lesson begins with a summary of the topics that we'll be discussing. This is followed by a conversation among fictional characters in a fictional maintenance yard: Pine Junction. Any resemblance between these characters and anyone you may actually work with is entirely coincidental. This dialogue sets the stage for the material covered in the lesson. Once you've read the list of topics to be covered and the dialogue, you'll have a pretty good idea of what you're going to discover in the lesson.



## Getting around: Navigation aids

The margin along the left side of each page is an area that we call the “fast track.” This serves three purposes:

We call this area the “fast track.”

1. Document designers tell us that “white space” on the page is visually pleasing to the eye, making it easier for you to read what’s on the rest of the page.
2. We can provide a capsule summary of the important points on the page. If you don’t have time to read the whole thing, at least you’ll know what you’re missing, and you can come back to it later if you’re interested.
3. The capsule summaries serve as “navigation aids”, which means that they provide a reference point if you need to come back to a section of a lesson and find a particular piece of information.

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### -TIPS, NOTES, and WARNINGS-

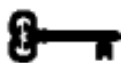
Although we feel that all of the information in the learning guide is important, some items need to have special attention drawn to them. We present these in the form of “Tips”, “Notes”, and “Warnings”. Information presented in this format is related to, but not part of, the discussion at hand.

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On the other hand, when we want to emphasize an important point *in* the discussion, we highlight it in this fashion.

If you only had time to skim a lesson, you could quickly grasp the essence of it by reading just the list of topics covered, the dialogue, the fast track items, the highlights, the tips/notes/warnings, and the summaries at the end, which we’ll discuss in a moment.

Our approach is based on the concept of self-assessment and instant feedback to confirm what you’ve just learned. Throughout this guide you’ll find “Quick Quizzes” that are designed to make you reflect on concepts that have been presented in the lesson. Once you’ve taken your best shot at answering the questions or offering solutions, you can check the answers that we provide following the quizzes. Look for the key to find out how you did. Sometimes there is no right or wrong answer, a reflection of the fact that operators in different jurisdictions might do things differently. We offer possible solutions, but our word isn’t always the final one.



When you reach the end of the lesson, we offer you a quick summary of where you’ve been. This is usually a restatement of the key points of the lesson that you should have picked up along the way. You’ll find it in the section entitled “Where have you been?”.



Knowing where you've been is useful, but knowing where you're going can be just as helpful. We'll let you know what's in store in the next lesson, in the context of what you've just learned. You'll find it in the section entitled "Where are you going?"

This guide can be used in different ways:

- You can use it at your desk, working and learning at your own pace.

-OR-

- You can use it in a classroom setting as a participant manual.

If you will be participating in a classroom training session, you will gain the maximum benefit by reading this guide in its entirety, if possible, before attending.

We hope that whatever you take from this guide will confirm the importance of the role you play as a winter road maintainer, and will generate discussions among your peers. Winter road maintenance is not a new profession, but there are always new techniques, technologies, and equipment coming along that change the way you operate. Keeping up with the changes, or staying ahead of the game, is a continuous learning process.

Let's start learning.

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# Module 1

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## Setting the stage

The snowplow heading down the highway in the middle of a blizzard is the tip of the iceberg. What the public doesn't see is the crucial importance of this activity to our very way of life.

### *Well, what shall we talk about?*

- The importance of the road network to the economy
- The economic and social benefits of the transportation infrastructure
- The economic, cultural, and social importance of winter maintenance activities
- The economic and environmental costs of winter maintenance activities

## The rest of the story

How does a winter road maintainer spell success? By providing the safest road surface possible through the efficient use of all available resources. Your job involves decision-making under constantly changing circumstances. After all, nothing changes like the weather.

This country has an extensive and varied road network, many diverse climates, and a seemingly endless series of unique weather events. You continually need to assess the



latest information, understand operational procedures, and know when to call out the appropriate staff, equipment, and materials. Whether you're an operator, supervisor, or manager, the ultimate objective of your efforts on the job is to provide conditions for the safe mobility of people and goods.

Ironically, the average member of the motoring public thinks that when it snows, you simply fire up the snowplow, load up the road salt, and head on down the road—hopefully just ahead of them. If only they knew the rest of the story.

The rest of the story revolves around road salt: the science, the level of service parameters, and strategies for pre-season planning, in-season decision-making, and post-season assessment.

This learning guide is all about discovering how road salt can be used in ways that maximize winter driving safety, yet minimize environmental impacts and economic costs.

### Quick Quiz

Which of the following statements is not true?

1. When you're not sure whether salting is required, it's best to err on the side of caution and start spreading as much and as quickly as possible.
2. Applying road salt strategically at key points throughout a storm is more effective in achieving the required level of service than a uniform, widespread application on all roads on your route.


Maximize winter driving safety. Minimize environmental impacts and costs.

Statement #1 is not true.

Statement #2 is true. Strategically applying the optimum amount of road salt at key points throughout a storm is more effective in achieving the required level of service than a uniform, widespread application on all roads on your beat.

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**Answer**



Think of road salt as a double-edged sodium chloride sword: apply too much and motorists become concerned about their vehicles rusting away while environmentalists worry about the effects of runoff on wildlife and water supplies; apply too little and those same motorists complain about unsafe road conditions.

How can you win? Follow the strategies presented in this guide and you'll find that you can please most of the people most of the time. But you'll probably never be able to please all of them all the time.

## Imagine this

Your job makes it possible for Canadians to maintain their standard of living.

Imagine a continent with millions of kilometers of roads spread out over a vast geographical space supporting a wide range of economic and social activities.

Imagine the challenges involved in keeping those roads free of ice and snow during winter so that the economic lifeblood of the nations can continue to flow.

Imagine what would happen to our quality of life if there were no winter road maintainers.

Now you've got a sense of how important your job is.

Outsiders may think that you simply plow roads and spread road salt, but what you're really doing is making it possible for them to maintain their standard of living.

Never underestimate the importance of winter road maintenance—nothing is more critical to the smooth functioning of the economy than a safe and reliable road network 12 months of the year.

## Call the snow busters

Before we examine everything you wanted to know about road salt and weren't afraid to ask, we should take a look at roads and why it's important to keep them passable during winter.



Roads constitute the country's central nerve system: almost every economic and social activity is related to transportation on the arterial network. Snow and ice constitute direct threats to the smooth operation of the transportation system.

Winter road maintainers keep the nation moving.

So, when a winter blizzard hits and the main highways are buried under a blanket of snow, who you gonna call? Our winter road maintainers quite literally keep the nation moving.

Let's see who's using the roads.

## Keep on truckin'

Anyone who has traveled down any major arterial roadway recently knows how much truck traffic has increased in recent years. Trucks haul commercial freight on roads all across the country, generating substantial revenues every year. This industry employs hundreds of thousands of people across the continent and pays billions of dollar in wages annually.



A one-day road and automobile plant closing can result in lost production of 3,000 vehicles per day.

Just-in-Time (JIT) delivery now plays a major role in the efficient operation of many businesses and business sectors. JIT delivery refers to the delivery of inputs to production or marketable commodities immediately before they are required. "Delivery windows", sometimes as short as 15 minutes, are allocated to suppliers to deliver the goods to the production plant. If parts cannot be delivered through these delivery windows, plant operations may cease.

A one-day road and automobile plant closing, for example, can result in lost production of 3,000 vehicles per day, with corresponding reductions in wages earned, and loss of indirect economic benefits.

## Public transportation

The other large sector that relies on clear roads year round is public transportation. Bus services generate over billions of dollars in revenues from the provision of transportation services in urban and rural areas.

Public passenger transit systems pay wages to almost hundreds of thousands of employees in Canada and the United States. Taxis also play a major role in moving citizens to and from business and leisure activities. The Canadian taxi industry, for example, employs over 42,000 people and generates almost \$2 billion in revenues each year.

### Where there's a wheel, there's a way to make money

The jobs of over a quarter million Canadians depend on you doing yours.

Here, at a glance, is what's at risk if roads are not well maintained during Canadian winters. Well over a quarter of a million employees wouldn't be able to do their jobs if you didn't do yours. And this doesn't include the hundreds of thousands of others who wouldn't be able to *get* to their jobs if the roads weren't cleared.

There's a lot more riding on your plow than a load of road salt.

Industry	Employees	Annual wages	Annual revenues
Trucking	150,000	+\$3 billion	+\$35 billion
Public transportation	80,000	+\$2.5 billion	+\$5.2 billion
Taxi and limousine	42,000	+\$1.0 billion	\$1.1 billion
<b>TOTALS</b>	<b>272,000</b>	<b>+\$6.5 billion</b>	<b>+\$41.3 billion</b>



## Driving Miss Daily

Every day, North Americans take to the roads in droves. Each year they rack up billions of vehicle-kilometres. That's the equivalent of driving back and forth to work many, many, many times.

Emergency and security services rely on our roads to ensure our safety.

Roads contribute to regional and remote economic development and productivity growth.

It certainly doesn't take a roads scholar to realize the importance of effective and efficient winter highway maintenance to the economic and social vitality of the nation.



Quite simply, safe roads are essential to our way of life. In the extreme climates experienced by Canada and the northern U.S. states, effective winter maintenance activities are essential to maintaining the beneficial uses of our roadways.

## Economic benefits of winter maintenance

Winter maintenance activities result in both direct and indirect benefits. Next to each of the benefits listed below, indicate whether you think it is a direct (**D**) or indirect (**I**) benefit.

### Quick Quiz

- \_\_\_\_\_ fewer accidents
- \_\_\_\_\_ economic productivity
- \_\_\_\_\_ maintenance of social activities
- \_\_\_\_\_ improved travel time
- \_\_\_\_\_ reductions in accident claims
- \_\_\_\_\_ reduced travel costs
- \_\_\_\_\_ provision of emergency services (e.g. police, fire)



- (I) provision of emergency services (e.g. police, fire)
- (D) reduced travel costs
- (I) reductions in accident claims
- (D) improved travel time
- (I) maintenance of social activities
- (I) economic productivity
- (D) fewer accidents

Answers

Quick Quiz

## Safety first: Fewer accidents

A number of studies have established links between road conditions and accident rates. Further studies have shown that maintenance activities that mitigate the effects of ice and snow on roads will result in a lowering of accident rates.

In your line of work, the conclusions of the road studies may appear so obvious that you'd wonder why they spent the money to conduct the research in the first place. But quantifying the data is an important step in determining the magnitude of the problem and deciding on strategic ways to address it.

If don't get the snow and ice off the road, the risk of accidents increases.

*The Road Salt Management Guide* contains details on many of the studies that were undertaken, and there are lots of stats to prove what you already know: if you don't get the snow and ice off the roads, there's an increased risk of motorists becoming involved in accidents.

We won't bog this lesson down with long lists of numbers and percentages. But we can't resist referring to a few findings of a Norwegian study, because they underscore the importance of your role as a winter road maintainer. And that's what this lesson is all about.

The study found that:

- road salting provides a larger accident reduction during the seasonal transition periods (October-November and March-April)
- road salting reduces the number of serious injury accidents more than it reduces the number of minor injury accidents
- road salting reduces the number of serious injury accidents in the daytime more than the number in the evening/night
- road salting has a larger effect on reducing the number of accidents where speed limits are greater than 70 km/h
- road salting reduces accidents more on roads with poor horizontal geometrics than on roads with good horizontal geometrics

One conclusion that leaps right off the page is that salting roads with poor horizontal geometrics during the day in zones where speed limits are greater than 70 km/hr results in a reduction of serious injury accidents in the transitional periods in spring and fall.

## Time savings: Tempus fugit

Excellence in Olympic sports is characterized by the motto: “Swifter, Higher, Stronger.”



Effective use of road salt saves time, fuel and money.

Excellence in winter road maintenance could be characterized by this motto: “Farther, Faster, Cheaper.” Effective winter maintenance activities allow motorists to travel farther and faster, saving money in the process.

Here’s how.

We refer to yet another study, this one finding that on a 60 kilometre stretch of road with a traffic volume of 4,000 vehicles per day and a speed limit of 80 km/hr, the travel time difference between a salted and unsalted road would amount to 25,000 vehicle-hours over a 140-day winter period. If time is money, then it’s easy to see the savings generated by winter maintenance.

## Fuel savings: Science friction

Unlike counselors and mediators, your job as a winter road maintainer is to *increase* friction. When the rubber hits the road, motorists realize fuel savings, and the judicious use of de-icers (to expose pavement) and abrasives (to increase traction on snow and ice) can help increase the friction between tires and driving surfaces.

Vehicles traveling on snow-packed and icy roads use more fuel.

Studies in both Canada and the United States have shown that vehicles travelling on snow-packed and icy roads consume an average of one-third more fuel, and in some cases as much as 50% more. The potential fuel cost savings actually outweigh the costs of winter road maintenance.

## Security of economic activity: A buck or two

In nations that rely on road networks as much as Canada and the U.S., anything that slows down traffic—or stops it altogether—represents a substantial economic cost.

Two things happen when winter roads become impassable:

1. Workers, supplies, and consumers can’t reach the workplace.
2. Finished goods can’t reach the marketplace.




---

–RUBBING SALT IN THE WOUND–

- ❖ The four-day “Blizzard of 1996”, which paralyzed the U.S. northeast, was estimated to have resulted in \$10 billion in lost production and an additional \$3-5 billion in lost sales.
  - ❖ In January 1999, Toronto ground to a halt during the biggest snowstorm ever to hit the city. The mayor declared a public emergency, public transit shut down, downtown office towers were deserted, and the army rolled into town to help clean up. Canada’s busiest airport, Pearson International, ran way behind schedule, causing delays all across North America.
- 

Winter maintenance activities that avoid shutdowns and slowdowns can have substantial and highly visible impacts on local and regional economies and result in considerable benefits for North Americans and their economy. It’s snow wonder that your job is so important.

## Security of social activity: Safety first

The road network supports a wide range of leisure activities, through some 250 billion vehicle-kilometres and about 475 billion passenger-kilometres of total travel. Winter maintenance activities support:

- local and distant travel to visit neighbours, friends, and family
  - recreation opportunities, for example at resorts and sporting events
  - cultural events, for example trips to museums and the theatre
- 

–NOTE–

**Fringe benefits:** Social activities generate economic spinoffs, for instance through ticket sales, gasoline sales, and purchases of special clothing, equipment, and products.

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Emergency services crews rely on winter maintenance to protect human health and life.

Winter maintenance activities also help maintain our road network for fire, police, and ambulance services. Winter maintenance is crucial to protecting human health and life from road and non-road accidents. Winter maintenance similarly plays a key role in ensuring that firefighters and police can serve the public efficiently.

## Accidents: The claim game

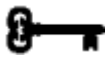
Winter maintenance activities that contribute to safer roadways can even help to reduce the number of insurance and legal claims for damages to people or property. These claims translate to increased premiums for the driving public. When you do your job well, you can actually have an impact on the frequency and severity of accidents and subsequently the frequency and severity of claims.



### Quick Quiz

List three occupations that are more important than winter road maintenance to the smooth, uninterrupted functioning of the economy.

1. \_\_\_\_\_
2. \_\_\_\_\_
3. \_\_\_\_\_



(We couldn't think of any, either.)

3.  
2.  
1.

---

**Answers**

Quick Quiz

## The good, the bad, and the green

The benefits of road salt must be weighed against the environmental costs.

There are two sides to the winter road maintenance coin. So far, we've discussed the importance of our road network and the benefits of keeping it safe for winter travel. The other side of the coin involves the environmental consequences of winter road maintenance activities.

In your opinion, which of the following describes the objective of winter road maintenance?

\_\_\_\_\_ **safe and efficient road travel**

\_\_\_\_\_ **economic and social productivity**

\_\_\_\_\_ **environmental protection**

If you selected all three, you're bang on. Winter maintenance activities, carried out wisely and efficiently, can help balance these seemingly contradictory objectives. You probably had no trouble selecting the first two objectives. But you may have wondered what "environmental protection" was doing there.

We're not suggesting that you now have to add "tree-hugger" to your résumé. You aren't expected to become a radical environmentalist.

This guide will give you the tools you need to deliver safe and efficient road travel, preserve economic and social productivity, and to do so in a way that protects the environment. It's a win-win situation all the way around.

But now you're probably wondering how you can use less road salt and still achieve the first two objectives. Our job is to show you how that can be done. So, if we do our job effectively, you'll be able to do the same.

What's behind the campaign to reduce the amount of road salt that is spread on the roads and, ultimately, ends up in non-road environments?

The catalyst is the need to save both greenbacks and greenery:

1. *Environment Canada has identified mismanaged road salt as an environmental threat.* When road salt is applied to the road surface, it's a transportation issue. When it migrates to the surrounding ditches and waterways, it becomes an environmental issue.

The objective of reduced salt use is to save money and protect the environment.

2. *Road salt contributes to corrosive damage effects to roads and structures such as bridges and parking lots.* Ongoing maintenance and repair costs represent large expenditures on an annual basis across the country.

In this learning guide, we'll explore ways to keep the roads safe during winter by using the least amount of road salt possible. Through improved handling and application efficiency, you'll probably end up using less road salt than you have in the past while continuing to provide safe driving conditions.

## Costs of winter maintenance

And now the other shoe drops. It's a well-known scientific principle that for every action, there is an equal and opposite reaction. Winter maintenance activities are not exempt from this universal principle—the benefits of keeping the roads safe for commerce and culture don't come without a cost.



The benefits of winter maintenance activities don't come without a cost.

The costs of winter maintenance come in three forms:

- economic costs to road authorities for conducting winter maintenance activities
- health and economic costs to road users
- environmental costs as a result of the application of anti-icing and deicing chemicals

## Road authorities: The cost of doing business

In the United States in the winter of 1995/1996, direct costs of snow-fighting were estimated to be \$2.1 billion by the Federal Highway Administration and \$5.0 billion by the Transportation Research Board. Although no comparable Canadian costs were found, even a conservative extrapolation would show the costs to be in the hundreds of millions of dollars a year.

Put the right amount of the right material in the right place at the right time.

By putting the right amount of the right material in the right place at the right time you can realize very significant cost-savings while continuing to provide safe roads.



## Road users: The cost is clear

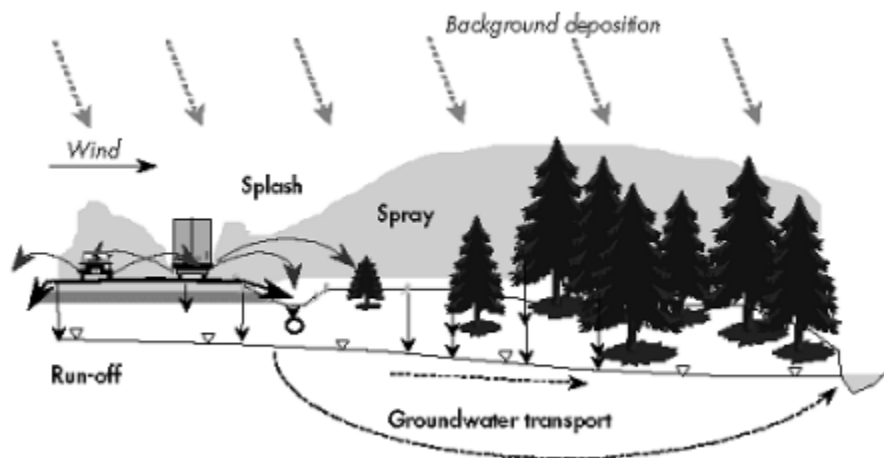
We can identify three areas in which the impact of the use of road salt as a winter maintenance tool is felt:

1. the natural environment
2. road infrastructure
3. costs to vehicles

### Natural environment: Drawing a saline in the sand

Road salt has a number of potential effects on the environment:

- chloride injury to roadside vegetation, for example, browning leaves, dying limbs and plants, and reduced fruit yields
- sodium accumulation in soils, causing reduced soil fertility in some cases
- increased salinity of surface and ground waters



Up to 10% of trees within 30 metres of roads may suffer from road salt-induced damage, while soil damage usually occurs within three metres of roadsides. Increased salinity occurs most prevalently in small streams and receiving bodies near heavily salted roads.

As you may have noticed by now, you can't judge a road salt crystal by its cover. It is a complex substance that is either good, bad, or just a cost to be reduced, depending upon your perspective.



We'll be looking at the environmental impacts of road salt more closely in Module 4, "Road salt and the environment."

## Road infrastructure: Less road salt, and the rust is history

Road salt causes deterioration of steel and concrete in bridge decks and parking garages. The Ontario Ministry of Transportation estimates that about \$216 million in damages result to bridge decks and parking garages from road salt annually. In the U.S., almost \$1 billion is spent every year treating and preventing damage from road salt to concrete bridge decks and parking garages.

**Less road salt = less rust = less cost. Easy math.**

## Vehicles: Reliable and rustworthy

Road salt damages motor vehicles through the corrosive effects of chlorides on metals. Motorists spend billions of dollars each year on motor vehicle corrosion damage and protection measures. We could look at this through the eyes of the rustproofing industry and suggest that even more salt on the roads would be better. But that wouldn't be responsible.

# Is it worth the effort?

Now that we know some of the costs and benefits of the work that you do during the winter months, how do we decide if it's worth the effort? Well, we already know that it's worth the effort. But it's always comforting to have a study to validate your knowledge.

The cost of not deicing roads is greater than all road salting costs combined.

The Institute for Safety Analysis (TISA) conducted the first major study to compare the benefits and costs of road salt use way back in 1976. The study calculated direct costs to agencies and benefits through crash reductions, savings in operating costs, and reduced travel times and the costs imposed by road salt on the roadway infrastructure and the environment. One of its major conclusions was that "failure to deice roads causes direct economic losses ... far greater than all costs of road salting combined."

This should not really come as a surprise to anyone in the winter road maintenance business, but it's good to know that your services will continue to be required for the foreseeable future. In other words, you're worth your salt.

---

–NOTE–



**A pinch of salt:** A study by the Marquette University School of Civil and Environmental Engineering in the early 1990s concluded that road salting reduced accident rates significantly, reduced the costs of accidents significantly, and had benefits which exceeded costs. Freeway road salt applications recovered their costs in 35 minutes, and two-lane roadways recovered their costs in 25 minutes. This is taking “more bang for your buck” to a whole new level.

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## Walking the tightrope

In a nutshell, this training program is all about learning to walk that fine line between spreading enough road salt to keep the economy flowing, but not so much that we cause traffic to come to a crashing halt.

In the lessons that follow, you’ll learn that you can continue to provide safe conditions for motorists while applying the right material in the right place at the right time. It’s all about optimizing road salt usage.

In some ways, you’ll be breaking new ground by adopting the latest techniques based on proven best practices. We’ll be taking a look at electronic spreader controllers, anti-icing, pre-wetting, Road Weather Information Systems (RWIS), and other innovative techniques and technologies.

Road authorities at all levels are depending to you to improve the management of road road salts.

You’ll be ensuring road safety, protecting the environment, and, in the final analysis, doing a more effective and efficient job.

It’s a win-win situation all the way around.

## Where have you been?



In this module we looked at the importance of Canada's road network and infrastructure to the national economy. We learned about the economic and social benefits of the transportation infrastructure and the economic and environmental costs of winter maintenance activities. Perhaps most importantly, we learned about the economic, cultural and social importance of winter maintenance activities.

The job that you perform as a winter road maintainer enables hundreds of thousands of others to do their jobs or to get to them. But there are costs associated with the use of road salt. Our mission in this learning guide is to show you that you can continue to provide safe roads while optimizing the amount of road salt that you apply. It's a new way of looking at your job. It involves judgement and decision-making based on data, information and knowledge.

## Where are you going?



Now that we've set the stage, demonstrating the value of roads and your role in keeping them free and clear during winter, we move on to Module 2, "The science of road salt and ice." We'll be taking a look at the science involved in the formation of ice on the road. It may not be as obvious as you think. The next module also deals with the chemistry of how road salt works, and strategies for applying it. You need to know the conditions that result in the various types of road surface conditions that you'll be battling. And you need to know which tools to use under different conditions.

Lesson 1 in the next module is designed to help you understand the sources of moisture that can form and freeze on the road surface. We'll also look at the role of pavement temperature in making snow and ice control decisions.

Let's slide on over to the ice lesson.



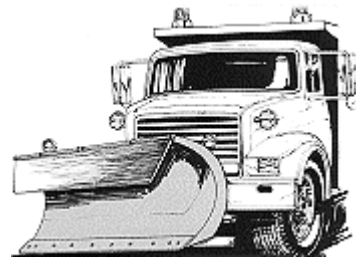
Transportation Association of Canada



# Salt SMART

Spreading, **M**anagement, **A**pplication **R**ates and **T**iming

## Learning Guide



Module 2, Lesson 1  
Ice 101: Principles of ice formation

*June 2004*

## ***Transportation Association of Canada***

The Transportation Association of Canada is a national association with a mission to promote the provision of safe, efficient, effective and environmentally and financially sustainable transportation services in support of Canada's social and economic goals. The association is a neutral forum for gathering or exchanging ideas, information and knowledge on technical guidelines and best practices. In Canada as a whole, TAC has a primary focus on roadways and their strategic linkages and inter-relationships with other components of the transportation system. In urban areas, TAC's primary focus is on the movement of people, goods and services and its relationship with land use patterns.

## ***Wellspring Consulting Inc.***

Wellspring Consulting is an instructional design company, specializing in adapting reference information into self-contained learning guides through the application of proven adult learning principles. With the Wellspring methodology, learners are first engaged through an enjoyable, easy to follow and entertaining writing style, then challenged using interactive techniques like problem-solving and role-playing. This fresh and stimulating approach enables learners to effectively transform dry technical information into vital, practical knowledge.

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***June 2004***

## Salt SMART Train-The-Trainer Program

TAC offers trainer workshops to accompany the Salt SMART Learning Guide in support of the best practices for the environmental management of road salts. They range from one-day overview sessions to two-day all-inclusive sessions.

*Make a SMART investment today and book your “at-home”  
trainer workshop or attend one in Ottawa!*

### Overview session

This one-day session is for trainers with formal training and experience. It is designed to walk through the *Salt SMART Learning Guide* to highlight key messages and to discuss potential areas of resistance and how to handle them.

**Member price at a member-selected location:** \$5,000 flat fee for up to 10 participants plus expenses (e.g. training room and AV equipment, catering, TAC trainer’s travel and accommodation).

**Member price in TAC-Ottawa training room:** \$899 per participant. A minimum class size is required and dates will depend on attendee preferences and trainer’s availability.

### All-inclusive session

This two-day session is for those who have little or no training experience. It offers the one-day overview combined with an extra day devoted to soft skills training (trainer techniques, adult learning principles, lesson planning).

**Member price at a member-selected location:** \$6,500 flat fee for up to 10 participants plus expenses (e.g. training room and AV equipment, catering, TAC trainer’s travel and accommodation).

**Member price in TAC-Ottawa training room:** \$1099 per participant. A minimum class size is required and dates will depend on attendee preferences and trainer’s availability.

*TAC non-members pay a 20% premium on all sessions.*

To book your trainer workshop, or for further information, contact the TAC Training Manager, Diane Jodouin at (613) 736-1350, ext. 261 or [djodouin@tac-atc.ca](mailto:djodouin@tac-atc.ca)

# Acknowledgements

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TAC gratefully acknowledges the sponsors for their generous contributions to the development of this Learning Guide. Their contribution exemplifies national cooperation in pursuit of the effective management of road salt use in winter maintenance operations.

The project team for this Learning Guide consisted of the following individuals:

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<b>Project Management Instructional Review</b>	Diane Jodouin Manager, Training Program Transportation Association of Canada

TAC gratefully acknowledges the dedication, guidance and input of the Subject Matter Reviewers; and the quality of work performed by the Instructional Designer.

This Learning Guide is truly a team effort by all those who have contributed financially and/or technically.



# Preface

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## TAC Learning Guide

There are some things that should be taken with a grain of salt. The information in this learning guide is not one of them.

When you consider that the nation's extensive transportation network supports a wide range of economic and social activities, it's not putting too a fine point on it to state that safe and efficient road traffic throughout the year is essential to our way of life. We rely on the road network for transport to the workplace and other economic uses, for recreation and leisure activities, and for emergency and security services.

Road salt is the deicer of choice for winter road maintenance.

There's something else that we rely on: road salt. It's the deicer of choice for keeping roads passable throughout the winter.

The benefits of using road salt to keep the thoroughfares open don't come without costs, both economic and environmental. Recognizing this, and concerned about the environmental implications of road salt applications, the Transportation Association of Canada's (TAC) Chief Engineers' Council, the Road Salt Working Group (a subcommittee of the Maintenance and Construction Standing Committee), and the Environment Council launched an initiative to identify and document new ways of handling and using road salt. Transportation professionals from across the country worked together through the 20-member project steering committee and 17-member project team to produce three important documents:

- *Road Salt and Snow and Ice Control Primer*: An executive summary of the project, written for the general public, that provides information on the importance of road salt use to maintaining a safe and efficient transportation system that sustains Canada's economy.
- *Road Salt Management Guide*: A comprehensive reference guide which addresses transportation and Canada's economy and quality of life, road salt and the environment and road salt management practices.
- *Syntheses of Best Practices for Road Salt Management*: A series of syntheses of best practices related to the effective management of road salt use in winter maintenance operations.

## This guide's for you

This learning guide is based on the best practices in the *Road Salt Management Guide* and the *Syntheses of Best Practices for Road Salt Management*. If you're an operator or supervisor, then this guide is for you.

As a winter road maintainer, you're on the front lines in the battle against snow and ice on roads. In fact, the only thing that gets out there ahead of you is your plow blade. You probably already know that road salt is the most effective, cheapest, and easily handled de-icing material. There may be alternatives out there, but they usually cost a lot more, require special care when handling, and are only effective under certain weather conditions. Road salt is still the most reliable de-icing chemical available.

## The "4 R's" of winter road maintenance

There was a time when winter road maintainers lived by a simple rule of thumb: "when in doubt, put it out." In other words, it was better to err on the side of caution and put down a lot of road salt—and put it everywhere—just to make sure. But those days are long gone.

The modern winter road maintainer has a new mantra: "put the **R**ight amount of the **R**ight material in the **R**ight place at the **R**ight time." In other words, use road salt more wisely and effectively. The benefit of this approach is that road salt usage is *optimized*. This translates into savings for the organization, and minimizes the impact of road salt on the environment. This guide is designed to teach you how to optimize road salt usage while continuing to keep winter roads safe for commercial, passenger, and emergency vehicles.

## Your guide to road salt optimization

Optimizing salt use means being smarter about you how put it down.

Optimizing road salt usage means being smarter about how you apply the material. In most cases it will mean that you use less road salt, but that is a result rather than an objective. In order to use road salt more wisely, you'll need to become a better decision-maker, and in order to do that, you need to improve your knowledge. That's where this learning guide comes in.

The guide consists of six modules:

- **Module 1** sets the stage by looking at the importance of transportation to our economy and way of life; the economic implications of winter maintenance; and the cost-benefits of winter maintenance.

- **Module 2** explores the science of road salt and ice. In Lesson 1 we look at the principles of ice formation. Lesson 2 examines the concept of freeze point depressants and how they work to prevent or break the bond between pavement and ice. In Lesson 3 we consider alternative de-icing chemicals and their role in winter road maintenance. Lesson 4 looks at application strategies, in particular anti-icing, a modern preventive approach that aims to keep the ice-pavement bond from forming.
- **Module 3** looks at equipment and technologies used by modern winter road maintainers. In Lesson 1 we survey plows and spreaders and how they can be put to work to optimize road salt usage. Lesson 2 examines pavement condition tracking and forecasting techniques and technologies, including road weather information systems.
- **Module 4** deals with road salt and the environment. In this module we look at the pathways by which road salt can make its way into soil and groundwater, and the effects it can have on vegetation and wildlife.
- **Module 5** looks at snow and road salt handling. In Lesson 1 we look at road salt handling and storage at the road maintenance yard. In Lesson 2 we examine disposal strategies and techniques at snow disposal sites.
- **Module 6** considers the importance of monitoring and record keeping in winter road maintenance.

The objective throughout these modules and lessons is to help you, as an operator or supervisor, to understand how it is possible to use road salt more effectively while continuing to provide safe roads during winter and minimizing the impact on the environment.

## The same, but different

You have a lot in common with winter road maintainers across the country.

As a winter road maintainer, you have a lot in common with operators and supervisors in other jurisdictions across the country. At the same time, your job is very unique. Every road jurisdiction has a different transportation infrastructure to service. No two agencies face the same weather conditions. Each organization has a different mix of human resources and equipment available to keep the roads open during winter. Levels of service differ from one jurisdiction to the next, winter maintenance strategies are designed to meet specific local challenges, and public expectations change from one jurisdiction to the next.

In other words, while all winter road maintainers may be out on the front lines keeping the roads open, they could be using very different means to achieve similar ends.

This learning guide deals with general principles of winter road maintenance that can be applied in every jurisdiction, but it is beyond the scope of this document to prescribe practices that apply to specific road authorities. The best practices upon which this guide is based have been carefully researched and prepared and are endorsed by the Transportation Association of Canada's (TAC) Chief Engineers' Council, the Road Salt Working Group (a subcommittee of the Maintenance and Construction Standing Committee), and the Environment Council.

This material is provided as advice to winter road maintainers for consideration when developing their own policies, practices, and procedures. Keep in mind that the best practices are to be used in concert with the legislation, manuals, directives, and procedures of your individual road agency.

The material in this learning guide will be incorporated into your agency's current or planned training programs.

## A word about what's inside

Before we dive into the learning guide, let's take a look at what you'll see inside. We know that your time is valuable, and that the technical nature of this subject-matter may not be the most exciting thing you've read lately. So we've tried to make the learning experience as easy and enjoyable as possible.

We want you to learn, and to enjoy doing it.

The first thing you'll notice is that, unlike a lot of those technical reference manuals and user guides you may have seen and tried to read, our tone is conversational. We talk directly to you in a casual voice that's free of jargon and technical terminology. We even throw in a bit of humour every now and then. Unlike those other documents, we want you to learn, and to enjoy doing it.

Each lesson begins with a summary of the topics that we'll be discussing. This is followed by a conversation among fictional characters in a fictional maintenance yard: Pine Junction. Any resemblance between these characters and anyone you may actually work with is entirely coincidental. This dialogue sets the stage for the material covered in the lesson. Once you've read the list of topics to be covered and the dialogue, you'll have a pretty good idea of what you're going to discover in the lesson.

## Getting around: Navigation aids

The margin along the left side of each page is an area that we call the “fast track.” This serves three purposes:

We call this area the “fast track.”

1. Document designers tell us that “white space” on the page is visually pleasing to the eye, making it easier for you to read what’s on the rest of the page.
2. We can provide a capsule summary of the important points on the page. If you don’t have time to read the whole thing, at least you’ll know what you’re missing, and you can come back to it later if you’re interested.
3. The capsule summaries serve as “navigation aids”, which means that they provide a reference point if you need to come back to a section of a lesson and find a particular piece of information.

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### -TIPS, NOTES, and WARNINGS-

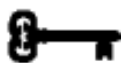
Although we feel that all of the information in the learning guide is important, some items need to have special attention drawn to them. We present these in the form of “Tips”, “Notes”, and “Warnings”. Information presented in this format is related to, but not part of, the discussion at hand.

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On the other hand, when we want to emphasize an important point *in* the discussion, we highlight it in this fashion.

If you only had time to skim a lesson, you could quickly grasp the essence of it by reading just the list of topics covered, the dialogue, the fast track items, the highlights, the tips/notes/warnings, and the summaries at the end, which we’ll discuss in a moment.

Our approach is based on the concept of self-assessment and instant feedback to confirm what you’ve just learned. Throughout this guide you’ll find “Quick Quizzes” that are designed to make you reflect on concepts that have been presented in the lesson. Once you’ve taken your best shot at answering the questions or offering solutions, you can check the answers that we provide following the quizzes. Look for the key to find out how you did. Sometimes there is no right or wrong answer, a reflection of the fact that operators in different jurisdictions might do things differently. We offer possible solutions, but our word isn’t always the final one.



When you reach the end of the lesson, we offer you a quick summary of where you’ve been. This is usually a restatement of the key points of the lesson that you should have picked up along the way. You’ll find it in the section entitled “Where have you been?”.



Knowing where you've been is useful, but knowing where you're going can be just as helpful. We'll let you know what's in store in the next lesson, in the context of what you've just learned. You'll find it in the section entitled "Where are you going?"

This guide can be used in different ways:

- You can use it at your desk, working and learning at your own pace.

-OR-

- You can use it in a classroom setting as a participant manual.

If you will be participating in a classroom training session, you will gain the maximum benefit by reading this guide in its entirety, if possible, before attending.

We hope that whatever you take from this guide will confirm the importance of the role you play as a winter road maintainer, and will generate discussions among your peers. Winter road maintenance is not a new profession, but there are always new techniques, technologies, and equipment coming along that change the way you operate. Keeping up with the changes, or staying ahead of the game, is a continuous learning process.

Let's start learning.

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# Module 2, Lesson 1

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## Ice 101: Principles of ice formation

Tracking air temperatures and weather conditions is as important as monitoring pavement temperature trends. Remember to look up and look down.

*Well, what shall we talk about?*

- Sources of moisture that can form on road surfaces
- Factors affecting air and pavement temperatures
- How to determine if and when ice will form on the road
- Forms of precipitation and the conditions that create them
- The significance of the dew point
- Up or down? The importance of pavement temperature trends



## The lunchroom. Pine Junction maintenance yard. October.



Hey Roch. What're you reading?" John Rhodes asked as he sat on the bench at the lunchroom table.

"It's that learning guide I got at the course last week. I was just re-reading the part that explains how ice forms. We learned all about the dew point," explained Roch Salterelli.

"They sent you on a course to learn how ice forms?! You've been plowing roads for over 10 years now, and you don't know how ice forms? How much did they spend on that course?" Rhodes asked in surprise.

"Relax, Johnny, there's more to the course than that. That's just one piece of the puzzle. You gotta look at the whole picture. This is important stuff, believe it or not. I actually learned a thing or two from that course."

"Like what—how to turn on the spreader? What angle to put your blade at?"

"Very funny. Listen, do you know what a dew point is? I'll bet you can't tell me. I know you're kind of new in this business, but you've been around long enough to know a bit about weather. What's a dew point, Johnny?"

"I don't know. My mother never taught me about a dew point. But she did teach me about do not point. No, wait, I know what it is—when you water the lawn too much and all the dew worms come out because their homes are flooded."

"Johnny, you've got serious problems. You really don't know, do you?"

"I remember learning about it in high school, but they made us memorize all these long formulas, and they lost me somewhere along the way. Anyway, we have dew point calculators here, and I know how to read those, so why do I need to know what the dew point is?"

"Well, you probably know how to read a thermometer, too, but that doesn't mean you understand what's going on in your body if your temperature's 103 degrees. You have to know what it means when the instrument tells you that the dew point is at 12 degrees today. What do you do with that information? Is that a significant reading? What does it tell you about road conditions—or potential road conditions?"

"Well, you're the expert, Roch. You took the course. Why don't you tell me?"

"Funny you should say that, Johnny. I've been delegated to teach you guys what I learned at that course. That's why I'm reviewing this book."

"Well, then, if I need to know anything, I'll know who to ask."

"Wrong. If I had to learn it, you're going have to do the same. I'm not going to tell you what the dew point is all about. I want you to read this lesson from the learning guide, and then we'll talk. You'll enjoy reading it, Johnny. You might even learn something."

## Lessons from the ice sage

Ice can mean many things to many people: to the bartender, it's a tool of the trade; to a hockey player, it's the workplace; to an ice-fisherman, it's a surface on which to erect the hut and store the beer; to a motorist, it's something to be avoided at all costs; and to the winter road maintainer, it's Public Enemy #1.

In battle, the more you know about your enemy, the better prepared you'll be to defeat him.

This lesson is called "Ice 101" because we get down to the very basics. Some of this may seem elementary, but it's important to have a clear understanding of the enemy. In battle, the more you know about your enemy, the better prepared you'll be to defeat him. It's the same for snow and ice fighting—know everything there is to know about ice and how it gets there, and you'll be better equipped to remove it, or prevent it from occurring in the first place.

### Ice-olating the source of the problem

Ice forms on the road—or anywhere else, for that matter—when the following two conditions apply:

- water is present in a liquid form
- the temperature of the water drops below the freezing point

Water can find its way to the road surface from a number of sources.

Sounds simple, doesn't it? In theory it is, but in reality, there are a number of sources from which water can find its way to the road surface. And there's more than one way that the temperature of water can fall below freezing:

- It can freeze in the atmosphere and land as ice.
- It can land as liquid on cold pavement and freeze solid.

In this lesson we'll explore the sources of moisture, factors that affect air and pavement temperatures, and the intricate relationship between these variables.

Most of the decision-making in winter maintenance involves consideration of multiple factors and variables. And the more factors that you need to weigh, the more complex it can be. If only it were as simple as looking out the window, noticing that it's starting to snow, and then deciding when to send out the plows. In reality, there is a barrage of information flowing in from a variety of sources. The trick

Road maintenance decision-making involves interpreting information from a variety of sources.

is to be able to interpret what will happen when all the variables interact.

The bottom line is to try and determine if and when ice will begin to form on the road, and then decide how you're going to deal with the challenge.

### Quick Quiz

**Individually, none of the following conditions is inherently problematic: moisture on the road; air temperatures below freezing; high air moisture levels; pavement temperatures below freezing. But the combination of two or more could create problems.**

**In your opinion, which combination(s) of conditions could lead to ice formation on the road surface? Explain why.**

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#### Answer

Moisture on the road and pavement temperatures below freezing is the most likely combination. Regardless of the ambient air temperature, if the pavement temperature is below freezing and there is moisture on the surface, ice will form. High air moisture levels along with both air and pavement temperatures below freezing will also cause ice to form. When air temperatures fall below the dew point, moisture will condense on the road surface. If the pavement temperature is also below freezing, ice will form.

Regardless of the form in which it arrives, when precipitation threatens to become ice on the road surface, winter road maintainers need to become concerned. Understanding the types of conditions that can lead to ice formation on the road enables you to understand how to use road salt for effective, proactive *anti-icing* action.

Pavement temperature is the determining factor in whether moisture will turn into ice.

The formation of ice on the road is a very common winter phenomenon, but what is often not well understood is that it is the temperature of the surface on which the water forms or lands—not necessarily the surrounding air temperature—that will affect the temperature of the water.

Later in this lesson we'll see that the air temperature at different vertical elevations does determine the type of precipitation that falls, but it is the pavement temperature that has the biggest influence on whether or not that moisture will become—or remain—ice.

### Quick Quiz

**Explain two ways that ice can occur on road surfaces.**

1.

2.



**Answer**

It can freeze in the atmosphere and land as ice, or it can land as liquid on cold pavement and freeze solid.

## Neither rain, nor sleet, nor snow...nor dew?

What is precipitation? In simplest terms, it is cloud droplets that fall to the ground. Chicken Little may have needlessly pushed the panic button when he warned that the sky was falling. But he wouldn't have been overstating things had he announced that the clouds were falling.

The vertical temperature profile determines the form of precipitation that will land on the road surface.

Precipitation falls from the clouds in one of five different forms—and sometimes a combination of one or more of these forms—before it comes into contact with the road surface. The vertical temperature profile is the determining factor.

### Rain

Rain occurs when tiny cloud droplets collide to form bigger droplets. This keeps happening until the droplet is too heavy for the air to support it. Gravity wins the battle, and the droplet begins to fall, colliding with more cloud droplets as it gains in size. If the liquid water does not encounter a deep layer of sub-freezing air, it will remain liquid and fall to the ground as rain.

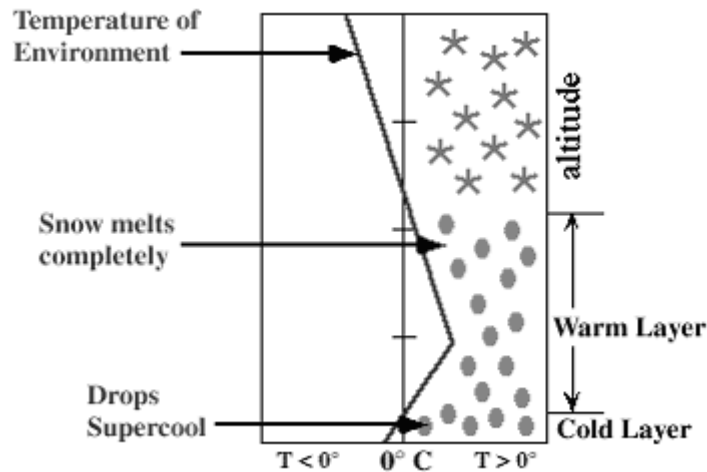
If the pavement temperature is above freezing, this is not a cause for concern. Otherwise, it is necessary to plan proactive anti-icing action, or prepare for de-icing later.

### Freezing rain

Freezing rain is the most dangerous type of precipitation. Because there is no noticeable difference between freezing rain and rain, motorists may not realize that it can cause such things as black ice on roadways. Freezing rain occurs when there is a shallow layer of sub-freezing air at the surface underlying an above-freezing layer of air above it. The precipitation falling through the warmer layers does not freeze. When it hits the sub-freezing layer it is rapidly cooled, but still does not freeze. When it hits the surface, which in winter is usually below freezing, the super-cooled water droplets will freeze on contact.

Freezing rain is the *bête noire* of winter road maintainers, and is always a cause for concern.

The following diagram shows the atmospheric temperature profile that can cause freezing rain.

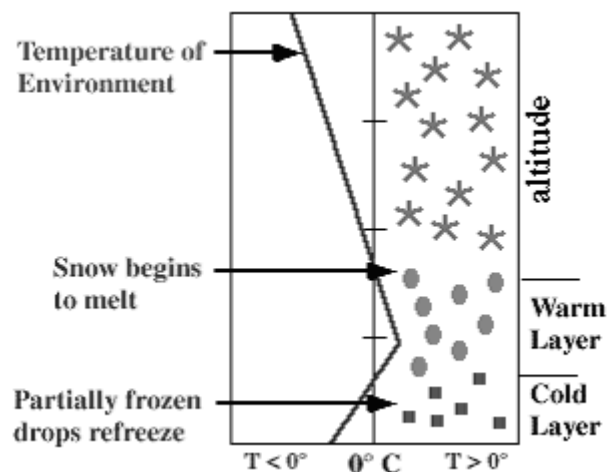


## Sleet

Sleet is nothing more than frozen raindrops. It occurs when there is a warm layer of air above a relatively deep sub-freezing layer at the surface. The layer above freezing will allow for liquid precipitation but as the drops hit the cold layer, they will freeze and hit the ground as frozen water droplets. Sleet usually doesn't last long and mainly occurs ahead of warm fronts during winter months.

Sleet in itself does not necessarily cause a lot of problems on the roads, but the conditions that produce it can quickly change and result in the formation of freezing rain. Winter road maintainers should closely monitor weather conditions when sleet is in the forecast or is already falling.

The following diagram shows the temperature profile typically associated with sleet.

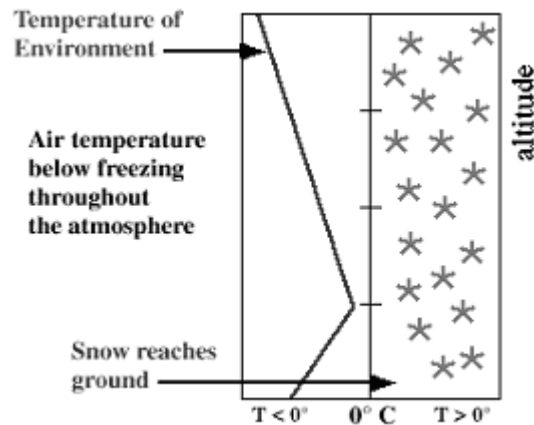


## Snow

Snow occurs when the layer of the atmosphere from the surface of the earth through the cloud is entirely below freezing. The precipitation falls from the cloud as snow and does not melt at all while falling to the ground.

Snow that lands on dry pavement with below freezing temperatures does not represent an ice problem, but if it is accompanied by high winds, drifting may be a concern.

The following diagram shows the vertical temperature profile associated with snow.



## Hail

Hail forms as a by-product of strong updrafts that exist in thunderstorms. The cumulonimbus clouds that are associated with thunderstorms can grow to heights where the temperature is below freezing. Drops of water will rise up with the upward directed wind as they collide with other droplets and grow larger. This will eventually result in the droplet freezing into a hailstone. When it grows too large for the updrafts to keep it suspended, it will fall to the ground.

Although hails is not usually associated with winter storms, extreme events under the right conditions can result in ice formation on road surfaces. In these instances, it may be necessary to plow or de-ice.

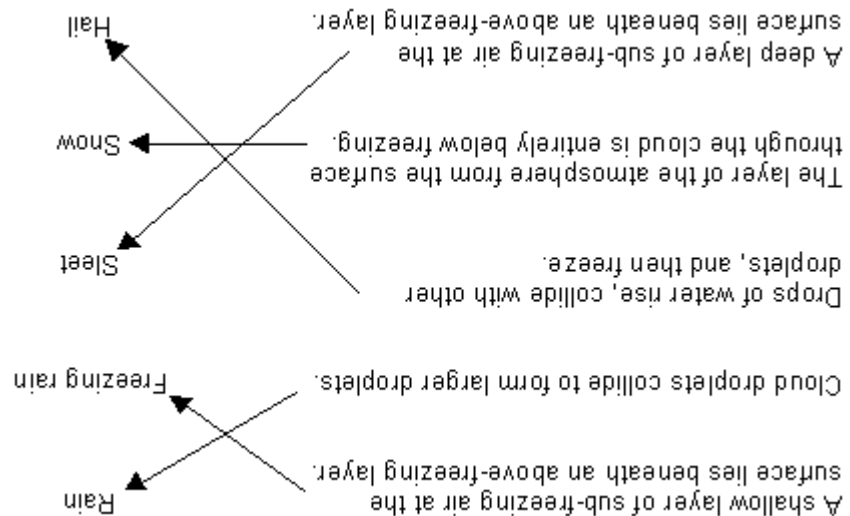
## Quick Quiz

Test your recently acquired precipitation knowledge in the table below by matching the weather phenomenon on the left with the precipitation event on the right. The answers are above in the section we've just covered, as well as at the end of this lesson in the "What do you know?" section.

1. A shallow layer of sub-freezing air at the surface lies beneath an above-freezing layer.	Rain
2. Cloud droplets collide to form larger droplets.	Freezing rain
3. Drops of water rise, collide with other droplets, and then freeze.	Sleet
4. The layer of the atmosphere from the surface through the cloud is entirely below freezing.	Snow
5. A deep layer of sub-freezing air at the surface lies beneath an above-freezing layer.	Hail



### Answer





## How do you dew?

Precipitation in its many forms is the most obvious source of moisture that can cause problems on roads. But water can find its way onto the road surface in other, more subtle, ways—and these can be more troublesome to winter road maintainers.

In order to make sound decisions on how to deal with ice problems, you need to understand the “dew point.”



In order to make sound decisions on how to deal with potential or existing ice problems, you need to understand the “dew point” and its implications for winter road maintenance.

Air contains moisture, but usually less than that required to saturate it. The relative humidity is a measure of the percent of saturation humidity. It is measured as a ratio of how much moisture the air is holding to how much more moisture it could hold at a given temperature. If the air is gradually cooled while maintaining the moisture content constant, the relative humidity will rise until it reaches 100%.

The temperature at which the moisture content in the air will saturate the air is called the dew point. If the air is cooled further, some of the moisture will condense.

The important thing to remember is that the *relative humidity rises as air cools*. The warmer the air, the more moisture it can hold. This is why extremely cold winter air is very dry. It almost never snows when the temperatures are bitterly cold. And it also explains the high humidity levels on those sweltering summer days, when plowing snow is very far from your thoughts.

Moisture in the air condenses on the road surface when the temperature falls below the dew point.

The reason that moisture forms on the outside of a beer bottle, frost forms on your windshield on a cold morning, the bathroom mirror gets fogged up after a hot shower and—most importantly—ice forms on road is that those surfaces lower the temperature of the moist air touching it until it falls below the dew point, at which time moisture condenses on the surface.

If this surface happens to be pavement with a temperature below zero, then the moisture will freeze and frost will appear on the road, often in the form of “black ice.” If the surface is above freezing, then the moisture won’t freeze and we simply get dew. When this happens in the Rockies, we get mountain dew.

The air temperature rises and falls more quickly than that of solids, including road surfaces.

Moisture is very non-discriminating: it will form on any surface whose temperature is below the dew point when the surrounding air comes into contact with it. This can happen even if the ambient air temperature is above the freezing point. The explanation for this anomaly is that the air temperature rises and falls more quickly than that of solids, including road surfaces.

There are various mathematical formulae that have been devised to calculate the dew point. There is no easy formula, however, because the relative humidity levels and temperatures are variable. Different combinations of humidity and temperature will result in different dew points.

It would be wise to purchase one of the many relatively inexpensive dew point calculators available on the market. There are also meteorology textbooks that contain dew point tables.

### Quick Quiz

**temperature is above freezing.**

**If the dew point is always less than or equal to the air temperature, explain what happens to the dew point as the atmosphere gets drier.**

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**Answer**

**Q:** How can water freeze on a surface when the air temperature is above the freezing point?

**A:** Water freezes on wires, cars, and roads when those surface temperatures are below freezing. They lower the water temperature to the point that it freezes. This can happen even if the ambient air temperature is above the freezing point. The explanation for this anomaly is that the air temperature rises and falls more quickly than that of solids, including road surfaces.

**Q:** If the dew point is always less than or equal to the air temperature, what happens to the dew point as the atmosphere gets drier?

**A:** As the atmosphere gets drier, the dew point drops.

## A pain in the asphalt

In our discussion of the dew point, we saw that air coming into contact with a surface having a cooler temperature will result in condensation if the dew point is reached. In this section we'll take a look at what happens when moist air touches cold pavement.

Snow and ice behave differently on concrete and asphalt pavement surfaces.

Pavement surfaces generally consist of either concrete or asphalt. There are subtle differences in the way that snow and ice behave on different road surfaces in winter and how they need to be maintained. We'll be looking more closely at those in Lesson 2, "Freeze point depressants."

Heating and cooling occur differently at different times of the year, depending on the temperature of the underlying materials. This makes monitoring of pavement temperatures critical to making accurate snow and ice control decisions.

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-TIP-



**Taking the heat**

*Concrete pavements* heat up and cool down more slowly than do asphalt pavements, due to their light colour and higher thermal mass.

*Asphalt pavements* can heat up to considerably higher temperatures during the day but, once the solar effect is gone after sunset, they tend to cool down more quickly than adjacent concrete pavements.

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## Hot and cold: Temperature tantrums

It's important to monitor pavement temperatures because they can fluctuate significantly depending upon the time of day, degree of cloud cover, sub-surface conditions (i.e. frost penetration, moisture presence, thermal retention properties, etc.) and type of pavement.

Pavement temperatures should be monitored because they can fluctuate significantly.

In fact, your snow and ice control decision-making should be based on *pavement* temperature trends rather than *air* temperatures.

After all, ice will only form when the pavement is below freezing. A rising or falling temperature will affect your decisions differently.

### Quick Quiz

This exercise is designed to test your understanding of the relationship between the dew point and the pavement temperature. Let's consider two highways: one is a heavily travelled commuter route with a concrete pavement surface; the other is a scenic parkway with an asphalt pavement surface along a river.

It's early morning, mid-week, late autumn, under a clear sky. What factors and conditions will affect the dew point at the surface of these two roads?

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In the early morning hours during late autumn the temperatures will likely be near, or below, the freezing point, particularly due to radiative cooling under the clear night sky. As the sun rises, air temperatures will begin to climb.


The temperature of the concrete pavement surface on the commuter route will rise more slowly than the air temperature. The difference in temperature will affect the dew point. However, the friction from the tires of the heavy commuter traffic on the route will cause the pavement temperature to rise. This will also affect the dew point.

The temperatures of the asphalt pavement surface on the parkway along the river will rise more quickly than that of the concrete surface. Therefore, the difference from the air temperature will not be as great. However, the air along the river contains more moisture than the air surrounding the commuter route. This will also affect the dew point. Because the scenic route is less heavily travelled, tire friction will not be a factor.

Other potential weather events that could have an impact on both routes: formation of clouds, leading to radiative heating; increased wind, causing turbulent transfer. What other meteorological/traffic events could affect the dew point on these two roads?

**Answer**

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## A trend in need is a trend indeed

Pavement temperature trends can be identified by means of infrared thermometers (hand-held or truck-mounted) or fixed pavement sensors. Though both are only accurate to a degree, they do give an indication of a heat trend as you monitor the surface.

Road Weather Information Systems (RWIS) can also provide a surface and subsurface pavement temperature at a fixed location, and can support the generation of a pavement condition forecast as well as real-time pavement condition information. We'll be taking a closer look at these tools and technologies in Module 3, "Equipment and technologies."

## Quick Quiz

If pavement temperatures are falling and rain is forecast, on which type of surface is freezing rain most likely to develop first: asphalt or concrete? Why?

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### Answer

Concrete pavements tend to heat up and cool down more slowly than do asphalt pavements, due to their light colour and higher thermal mass. Asphalt pavement temperatures are likely to drop below the freezing point before concrete pavement. Therefore, freezing rain is likely to form on asphalt pavements first.

Similarly, depending upon the extent of frost penetration into the ground, late winter pavement temperatures may be below those of the surrounding atmosphere.

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**-TIP-**

**Precisely:** Pavement temperature trends should be recorded in daily logs, along with pavement conditions, weather conditions, and winter treatment strategy. Pavement temperature monitoring equipment should be tested at least annually to ensure that it is operating correctly. Inaccurate equipment should be recalibrated, repaired, or replaced.  
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## Cloud and clear

Radiative heating and cooling, along with wind chill, can affect pavement temperatures.

Pavement temperatures are affected by *radiative heating* during the daytime and *radiative cooling* at night, both of which are in turn affected by the insulating effects of cloud cover. Sunshine raises the pavement temperature of black asphalt and, to a lesser degree, that of white concrete. At night, clear skies will result in greater cooling than when there is cloud cover.

Another phenomenon influencing pavement temperatures is *turbulent transfer*. This sounds like a description of changing from one urban transit bus to another during rush hour. In everyday parlance, it's known as the "wind chill factor" for bodies that release heat. Turbulent transfer through wind will cause a human body to feel cooler than it actually is.

Although inanimate objects such as roads are not directly affected by a wind chill factor, turbulent transfer will cause a road surface to cool quickly to a stable temperature.



**Radiative cooling:** The cooling process of the Earth's surface and adjacent air which occurs when infrared (heat) energy radiates from the surface of the Earth upward through the atmosphere into space. Air near the surface transfers its thermal energy to the nearby ground through conduction, so that radiative cooling lowers the temperature of both the surface and the lowest part of the atmosphere.

**Radiative heating:** During the day, the Earth absorbs the short-wave radiation that passes through the atmosphere. The heat gained by the Earth is re-radiated back toward outer space. When water vapour is present, this long-wave radiation is absorbed by the vapour and then radiated toward the Earth. This process effectively keeps the heat from escaping from that portion of the Earth. This accounts for the higher temperatures on nights when a cloud cover is present.

**Turbulent transfer (wind chill factor):** A phenomenon that makes human bodies feel colder in winter than the air temperature really is. Temperature and wind cause heat loss from body surfaces. A combination of cold and wind makes a body feel colder than the actual temperature.

## Taking the heat: Endothermic reactions

An application of solid road salt can cause a sudden drop in pavement temperatures.

For snow to melt or for a solid to dissolve to form a solution, heat is required. In scientific jargon, this is known as an *endothermic reaction*. While traffic tire action can provide some of the required heat, in most cases this heat is drawn from the pavement. Road authorities using automated pavement sensors as part of their RWIS system have observed sudden and dramatic drops in pavement temperatures with the onset of a snowfall, or the application of solid road salt.

This drop could result in pavement temperatures being lowered to below the freeze point and causing a flash freeze.



**Endothermic reaction:** Chemical reaction in which the energy content of the products is greater than that of the reactants, causing heat to be taken in by the system.

## The icing on the deck

Do you know what happens when you spread a full application of solid salt to a marginally damp road or bridge deck at temperatures below zero?

If there is enough moisture, but not enough heat at the time of application, you can end up actually “icing” the road or bridge deck.

This happens because the salt draws heat from the deck, resulting in a short term drop in surface temperature which can solidify the moisture into ice before the formation of a sufficient amount of brine. Coincidentally, a bridge deck may be colder than the approaches on grade, resulting in a different melt action as well.

This phenomenon is not an issue with the application of straight liquid chemicals since there is no phase change from a solid to a liquid that would require heat.



## Where have you been?



In this lesson we learned that moisture can come from a variety of sources and land on the road surface in a number of different forms. But the bottom line is that, under the right combination of conditions, the moisture can become ice and lead to problems.

Tracking pavement temperature trends is as important as watching the weather. “Look up and look down” would be good advice for the wise winter road maintainer.

## Where are you going?



Now that we know how the ice gets there, we need to find out how salt works to remove it. Or prevent it from occurring in the first place. In the next lesson we’ll see how the ice-pavement bond is formed, and look at how salt brine works to break it.

We’ll take a look at the chemistry of salt in order to understand how you can make the most efficient use of the most important item in your snow and ice fighting arsenal.



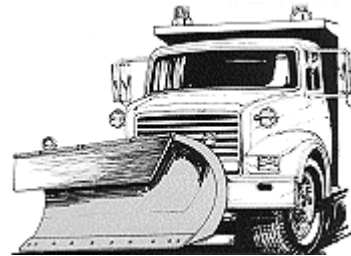
Transportation Association of Canada



# Salt SMART

Spreading, Management, Application Rates and Timing

## Learning Guide



Module 2, Lesson 2  
Freeze point depressants

*June 2004*

## ***Transportation Association of Canada***

The Transportation Association of Canada is a national association with a mission to promote the provision of safe, efficient, effective and environmentally and financially sustainable transportation services in support of Canada's social and economic goals. The association is a neutral forum for gathering or exchanging ideas, information and knowledge on technical guidelines and best practices. In Canada as a whole, TAC has a primary focus on roadways and their strategic linkages and inter-relationships with other components of the transportation system. In urban areas, TAC's primary focus is on the movement of people, goods and services and its relationship with land use patterns.

## ***Wellspring Consulting Inc.***

Wellspring Consulting is an instructional design company, specializing in adapting reference information into self-contained learning guides through the application of proven adult learning principles. With the Wellspring methodology, learners are first engaged through an enjoyable, easy to follow and entertaining writing style, then challenged using interactive techniques like problem-solving and role-playing. This fresh and stimulating approach enables learners to effectively transform dry technical information into vital, practical knowledge.

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***June 2004***

## Salt SMART Train-The-Trainer Program

TAC offers trainer workshops to accompany the Salt SMART Learning Guide in support of the best practices for the environmental management of road salts. They range from one-day overview sessions to two-day all-inclusive sessions.

*Make a SMART investment today and book your “at-home”  
trainer workshop or attend one in Ottawa!*

### Overview session

This one-day session is for trainers with formal training and experience. It is designed to walk through the *Salt SMART Learning Guide* to highlight key messages and to discuss potential areas of resistance and how to handle them.

**Member price at a member-selected location:** \$5,000 flat fee for up to 10 participants plus expenses (e.g. training room and AV equipment, catering, TAC trainer’s travel and accommodation).

**Member price in TAC-Ottawa training room:** \$899 per participant. A minimum class size is required and dates will depend on attendee preferences and trainer’s availability.

### All-inclusive session

This two-day session is for those who have little or no training experience. It offers the one-day overview combined with an extra day devoted to soft skills training (trainer techniques, adult learning principles, lesson planning).

**Member price at a member-selected location:** \$6,500 flat fee for up to 10 participants plus expenses (e.g. training room and AV equipment, catering, TAC trainer’s travel and accommodation).

**Member price in TAC-Ottawa training room:** \$1099 per participant. A minimum class size is required and dates will depend on attendee preferences and trainer’s availability.

*TAC non-members pay a 20% premium on all sessions.*

To book your trainer workshop, or for further information, contact the TAC Training Manager, Diane Jodouin at (613) 736-1350, ext. 261 or [djodouin@tac-atc.ca](mailto:djodouin@tac-atc.ca)

# Acknowledgements

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TAC gratefully acknowledges the sponsors for their generous contributions to the development of this Learning Guide. Their contribution exemplifies national cooperation in pursuit of the effective management of road salt use in winter maintenance operations.

The project team for this Learning Guide consisted of the following individuals:

<b>Subject Matter Review</b>	Barry Belcourt, R.E.T. Director, Roadway Maintenance City of Edmonton, Alberta, Canada  Richard L. Hanneman President Salt Institute, Alexandria, Virginia, USA
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<b>Project Management Instructional Review</b>	Diane Jodouin Manager, Training Program Transportation Association of Canada

TAC gratefully acknowledges the dedication, guidance and input of the Subject Matter Reviewers; and the quality of work performed by the Instructional Designer.

This Learning Guide is truly a team effort by all those who have contributed financially and/or technically.

# Preface

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## TAC Learning Guide

There are some things that should be taken with a grain of salt. The information in this learning guide is not one of them.

When you consider that the nation's extensive transportation network supports a wide range of economic and social activities, it's not putting too a fine point on it to state that safe and efficient road traffic throughout the year is essential to our way of life. We rely on the road network for transport to the workplace and other economic uses, for recreation and leisure activities, and for emergency and security services.

Road salt is the deicer of choice for winter road maintenance.

There's something else that we rely on: road salt. It's the deicer of choice for keeping roads passable throughout the winter.

The benefits of using road salt to keep the thoroughfares open don't come without costs, both economic and environmental. Recognizing this, and concerned about the environmental implications of road salt applications, the Transportation Association of Canada's (TAC) Chief Engineers' Council, the Road Salt Working Group (a subcommittee of the Maintenance and Construction Standing Committee), and the Environment Council launched an initiative to identify and document new ways of handling and using road salt. Transportation professionals from across the country worked together through the 20-member project steering committee and 17-member project team to produce three important documents:

- *Road Salt and Snow and Ice Control Primer*: An executive summary of the project, written for the general public, that provides information on the importance of road salt use to maintaining a safe and efficient transportation system that sustains Canada's economy.
- *Road Salt Management Guide*: A comprehensive reference guide which addresses transportation and Canada's economy and quality of life, road salt and the environment and road salt management practices.
- *Syntheses of Best Practices for Road Salt Management*: A series of syntheses of best practices related to the effective management of road salt use in winter maintenance operations.

## This guide's for you

This learning guide is based on the best practices in the *Road Salt Management Guide* and the *Syntheses of Best Practices for Road Salt Management*. If you're an operator or supervisor, then this guide is for you.

As a winter road maintainer, you're on the front lines in the battle against snow and ice on roads. In fact, the only thing that gets out there ahead of you is your plow blade. You probably already know that road salt is the most effective, cheapest, and easily handled de-icing material. There may be alternatives out there, but they usually cost a lot more, require special care when handling, and are only effective under certain weather conditions. Road salt is still the most reliable de-icing chemical available.

## The "4 R's" of winter road maintenance

There was a time when winter road maintainers lived by a simple rule of thumb: "when in doubt, put it out." In other words, it was better to err on the side of caution and put down a lot of road salt—and put it everywhere—just to make sure. But those days are long gone.

The modern winter road maintainer has a new mantra: "put the **R**ight amount of the **R**ight material in the **R**ight place at the **R**ight time." In other words, use road salt more wisely and effectively. The benefit of this approach is that road salt usage is *optimized*. This translates into savings for the organization, and minimizes the impact of road salt on the environment. This guide is designed to teach you how to optimize road salt usage while continuing to keep winter roads safe for commercial, passenger, and emergency vehicles.

## Your guide to road salt optimization

Optimizing salt use means being smarter about you how put it down.

Optimizing road salt usage means being smarter about how you apply the material. In most cases it will mean that you use less road salt, but that is a result rather than an objective. In order to use road salt more wisely, you'll need to become a better decision-maker, and in order to do that, you need to improve your knowledge. That's where this learning guide comes in.

The guide consists of six modules:

- **Module 1** sets the stage by looking at the importance of transportation to our economy and way of life; the economic implications of winter maintenance; and the cost-benefits of winter maintenance.

- **Module 2** explores the science of road salt and ice. In Lesson 1 we look at the principles of ice formation. Lesson 2 examines the concept of freeze point depressants and how they work to prevent or break the bond between pavement and ice. In Lesson 3 we consider alternative de-icing chemicals and their role in winter road maintenance. Lesson 4 looks at application strategies, in particular anti-icing, a modern preventive approach that aims to keep the ice-pavement bond from forming.
- **Module 3** looks at equipment and technologies used by modern winter road maintainers. In Lesson 1 we survey plows and spreaders and how they can be put to work to optimize road salt usage. Lesson 2 examines pavement condition tracking and forecasting techniques and technologies, including road weather information systems.
- **Module 4** deals with road salt and the environment. In this module we look at the pathways by which road salt can make its way into soil and groundwater, and the effects it can have on vegetation and wildlife.
- **Module 5** looks at snow and road salt handling. In Lesson 1 we look at road salt handling and storage at the road maintenance yard. In Lesson 2 we examine disposal strategies and techniques at snow disposal sites.
- **Module 6** considers the importance of monitoring and record keeping in winter road maintenance.

The objective throughout these modules and lessons is to help you, as an operator or supervisor, to understand how it is possible to use road salt more effectively while continuing to provide safe roads during winter and minimizing the impact on the environment.

## The same, but different

You have a lot in common with winter road maintainers across the country.

As a winter road maintainer, you have a lot in common with operators and supervisors in other jurisdictions across the country. At the same time, your job is very unique. Every road jurisdiction has a different transportation infrastructure to service. No two agencies face the same weather conditions. Each organization has a different mix of human resources and equipment available to keep the roads open during winter. Levels of service differ from one jurisdiction to the next, winter maintenance strategies are designed to meet specific local challenges, and public expectations change from one jurisdiction to the next.

In other words, while all winter road maintainers may be out on the front lines keeping the roads open, they could be using very different means to achieve similar ends.



This learning guide deals with general principles of winter road maintenance that can be applied in every jurisdiction, but it is beyond the scope of this document to prescribe practices that apply to specific road authorities. The best practices upon which this guide is based have been carefully researched and prepared and are endorsed by the Transportation Association of Canada's (TAC) Chief Engineers' Council, the Road Salt Working Group (a subcommittee of the Maintenance and Construction Standing Committee), and the Environment Council.

This material is provided as advice to winter road maintainers for consideration when developing their own policies, practices, and procedures. Keep in mind that the best practices are to be used in concert with the legislation, manuals, directives, and procedures of your individual road agency.

The material in this learning guide will be incorporated into your agency's current or planned training programs.

## A word about what's inside

Before we dive into the learning guide, let's take a look at what you'll see inside. We know that your time is valuable, and that the technical nature of this subject-matter may not be the most exciting thing you've read lately. So we've tried to make the learning experience as easy and enjoyable as possible.

We want you to learn, and to enjoy doing it.

The first thing you'll notice is that, unlike a lot of those technical reference manuals and user guides you may have seen and tried to read, our tone is conversational. We talk directly to you in a casual voice that's free of jargon and technical terminology. We even throw in a bit of humour every now and then. Unlike those other documents, we want you to learn, and to enjoy doing it.

Each lesson begins with a summary of the topics that we'll be discussing. This is followed by a conversation among fictional characters in a fictional maintenance yard: Pine Junction. Any resemblance between these characters and anyone you may actually work with is entirely coincidental. This dialogue sets the stage for the material covered in the lesson. Once you've read the list of topics to be covered and the dialogue, you'll have a pretty good idea of what you're going to discover in the lesson.

## Getting around: Navigation aids

The margin along the left side of each page is an area that we call the “fast track.” This serves three purposes:

We call this area the “fast track.”

1. Document designers tell us that “white space” on the page is visually pleasing to the eye, making it easier for you to read what’s on the rest of the page.
2. We can provide a capsule summary of the important points on the page. If you don’t have time to read the whole thing, at least you’ll know what you’re missing, and you can come back to it later if you’re interested.
3. The capsule summaries serve as “navigation aids”, which means that they provide a reference point if you need to come back to a section of a lesson and find a particular piece of information.

---

### -TIPS, NOTES, and WARNINGS-

Although we feel that all of the information in the learning guide is important, some items need to have special attention drawn to them. We present these in the form of “Tips”, “Notes”, and “Warnings”. Information presented in this format is related to, but not part of, the discussion at hand.

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On the other hand, when we want to emphasize an important point *in* the discussion, we highlight it in this fashion.

If you only had time to skim a lesson, you could quickly grasp the essence of it by reading just the list of topics covered, the dialogue, the fast track items, the highlights, the tips/notes/warnings, and the summaries at the end, which we’ll discuss in a moment.

Our approach is based on the concept of self-assessment and instant feedback to confirm what you’ve just learned. Throughout this guide you’ll find “Quick Quizzes” that are designed to make you reflect on concepts that have been presented in the lesson. Once you’ve taken your best shot at answering the questions or offering solutions, you can check the answers that we provide following the quizzes. Look for the key to find out how you did. Sometimes there is no right or wrong answer, a reflection of the fact that operators in different jurisdictions might do things differently. We offer possible solutions, but our word isn’t always the final one.



When you reach the end of the lesson, we offer you a quick summary of where you’ve been. This is usually a restatement of the key points of the lesson that you should have picked up along the way. You’ll find it in the section entitled “Where have you been?”.



Knowing where you've been is useful, but knowing where you're going can be just as helpful. We'll let you know what's in store in the next lesson, in the context of what you've just learned. You'll find it in the section entitled "Where are you going?"

This guide can be used in different ways:

- You can use it at your desk, working and learning at your own pace.

-OR-

- You can use it in a classroom setting as a participant manual.

If you will be participating in a classroom training session, you will gain the maximum benefit by reading this guide in its entirety, if possible, before attending.

We hope that whatever you take from this guide will confirm the importance of the role you play as a winter road maintainer, and will generate discussions among your peers. Winter road maintenance is not a new profession, but there are always new techniques, technologies, and equipment coming along that change the way you operate. Keeping up with the changes, or staying ahead of the game, is a continuous learning process.

Let's start learning.

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# Module 2, Lesson 2

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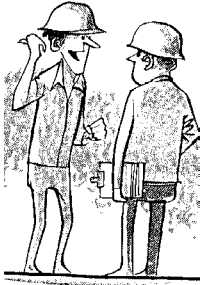
## Freeze point depressants

Today's winter road maintenance is all about finding solutions, creating chemical solutions, breaking sodium chloride and ice-pavement bonds, and doing it wisely.

*Well, what shall we talk about?*

- Freeze point depressants
- Chemical composition and structure of salt
- Role of brine in breaking the ice-pavement bond
- Understanding the sodium chloride/water phase diagram
- Understanding the eutectic point of chemical concentrations

## The locker room. Pine Junction maintenance yard. October.



“Hey, Johnny, finished that learning guide yet?” Roch Salterelli asked John Rhodes as he slipped into his coveralls.

“Well, I read all the top ten lists, that’s a start,” laughed Rhodes.

“Yeah, good start. Why not try reading the parts in between next. Some of it is pretty timely, especially at this time of year when the shipments of road salt are arriving. Did you read the chapter on road salt, by the way?”

“You mean *freeze point depressants*? Why don’t they just call it what it is?”

“They did. It’s about road salt and *other* chemicals that we use to lower the freezing point of water. It’s not just salt.”

“Well, it’s almost all road salt around here. Why do we need to know about the other stuff?”

“I keep telling you, Johnny, times are changing. They’re discovering new things. Expand your horizons. Open your mind. It won’t hurt you. Honest.”

“He’s right,” interjected Brine Watters, who had just arrived for work 15 minutes late, as usual. “Liquids are where it’s at.”

“Well, not entirely,” Salterelli corrected. “There’s a time and place for everything. It all depends on the time, though, mostly. If you’re taking preventive action, liquids are great. But if you wait too long, and you’re doing clean-up, then maybe solid road salt is the best thing.”

“Did you learn that at the course, too?” Rhodes asked, shaking his head.

“Well, some of it. I mean, I was surprised at how much of this stuff I already knew, but it was good to see it all put together like that. It made a lot of sense, and there was a lot of new information too.”

“When do I get my copy of the guide, Roch?” Watters wondered.

“You should start charging royalties, Roch,” Rhodes suggested.

“Forget the royalties, boys. But the first one of you who can tell me what a *eutectic point* is can leave early today.”

“What’s with you and all these points, Roch?” Rhodes complained. First it was the dew point, now it’s the eutectic point. What’s next—frequent flyer points? What’s the point?”

“Read your book, Johnny, it’s all in there. You wouldn’t want me to tell you all the answers and give away the ending would you? Anyway, my offer stands. And you, Brine, of all people, should know the answer to this one.”

## Keeping an ion the brine

As a winter road maintainer, you already know that using road salt is the most effective and cost-efficient way to melt ice and snow. Even if you never did well in chemistry class, and couldn't tell the difference between atom and Eve, you know that road salt works. What you may not know is why. The clue lies in the title of this lesson.

Road salt is a “freeze point depressant”. That’s just a shorter way of saying “lowers the freezing point of water to something colder than zero degrees Celsius.” In the field of winter road maintenance, a substance that can delay the onset of ice is a good thing.

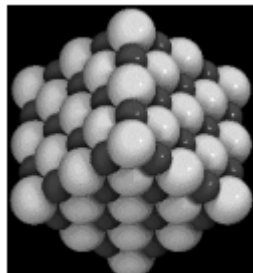
While there are many alternative chemicals that can depress the freeze point of water, road salt remains the depressant of choice because it costs a lot less than the alternatives, is easier and safer to handle, and reliably achieves safe driving conditions.

Salt is the depressant of choice because of its cost, ease of use, and reliability.

In this lesson we'll take a look at the chemical makeup of road salt and how it works to break the strong bond that can develop between ice and pavement. You'll learn the importance of temperature, moisture, and time as controlling factors in the process of melting, and you'll understand what happens when you use too much or too little road salt in relation to the pavement temperature.

**Ironically, you could actually cause the very phenomenon you are trying to prevent by applying road salt in the wrong amounts at the wrong time.**

## United they stand, divided they melt



Source: Salt Institute

Contrary to popular opinion, rock salt doesn't melt anything. Salt is made up of negatively charged chloride ions and positively charged sodium ions. They are bound together to form crystals, and as long as they remain united, they have no effect on ice. In order for salt to melt ice, it must be dissolved in water to form brine. And that's about as technical as this chemistry lesson gets.

You may be asking yourself why this matters. Well, if your job were simply to go out during a storm and broadcast as much road salt as possible on every road on your route, it wouldn't matter whether or not you understood that brine—and not rock salt—is what melts ice. But that was then and this is now.

You have to be careful about how much salt to use, when to use it, and whether you should use it.

And *now* you have to be careful about how much road salt to apply, when to apply it, and even *whether* you should apply it. The goal of the winter road maintainer today is to achieve the pre-determined level of service (LOS). To do this, you need to optimize the effectiveness of the road salt used by applying the right amount at the right time in the right place. To make these kinds of informed decisions, you need to understand the chemical behaviour of road salt.

## Quick Quiz

List three reasons why road salt is the preferred freeze point depressant. While you're at it, define "freeze point depressant."

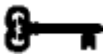
1.

2.

3.

### Answer

While there are many alternative chemicals that can depress the freeze point of water, road salt remains the depressant of choice because it costs a lot less than the alternatives, is easier and safer to handle, and reliably achieves safe driving conditions. Road salt is a "freeze point depressant". That's just a shorter way of saying "lowers the freezing point of water to something colder than zero degrees Celsius."



So now that you know what you have to know and why you have to know it, let's continue the chemistry lesson. If you have ever swum in an ocean, you know how much easier it is to float in salt water than in fresh water. While this is good news for non-swimmers who fall into salt water, we'll see that it's also good news for winter road maintainers.

When you add salt to water, or vice-versa, the salt dissolves into ions.

Salt water is denser and heavier than fresh water. Density is a measure of how much matter takes up a certain amount of volume, or space. When you add salt to water or vice-versa, the salt dissolves into ions. The volume increases by an infinitesimal



amount, but the mass increases by as much as 25% because the ions in salt are separated when the salt goes into solution and are attracted and bound closely to the water molecules themselves. Since the mass increases faster than the volume when you add salt, the density increases. And since this isn't a guide designed to teach you how to float in salt water, you may be wondering where we're going with this.

## The name's bond...ice-pavement bond

The last thing on your mind as you're making your way down the highway in the middle of a blizzard is how salt ions attach themselves to water molecules. So let's transfer this knowledge out to the road and put it into context.



Source: www.gov.nl.ca

Ice that is bonded to pavement is difficult to remove by mechanical means.

As snow accumulates on the road and is packed down by traffic it bonds to the pavement, making it difficult to remove by mechanical means. If you thought that the bond was strong between a smoker and his cigarette, or between a gambling addict and a slot machine, you haven't tried to break the ice-pavement bond in the middle of January using only your plow blade.

**The only way to break the ice-pavement bond is with a chemical such as road salt.**

During normal deicing operations, road salt is applied on top of the snow pack. If there is enough moisture and heat, usually as the result of a combination of sunshine, traffic, and warmer daytime temperatures, the road salt dissolves and forms brine.

The shrinking road salt particles, now coated in brine, will then auger down through the snow pack to the surface of the road, melting all the way. In snow pack conditions, you need larger, heavier crystals of road salt with the staying power to be able to melt down to the road surface. Due to its density, brine (which is just another word for salt water) moves downward through the snow pack to the road surface.

## Quick Quiz

Explain why salt water is denser than fresh water. Explain the significance of this phenomenon from the perspective of:

a) someone swimming in Great Salt Lake

b) a winter road maintainer

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### Answer

When you add salt to water, or vice-versa, the salt dissolves into ions. The volume increases by a small factor, but the mass increases by a bigger factor because the salt ions are attracted and bind closely to the water molecules themselves. Since the mass increases faster than the volume when you add salt, the density increases.

a) When you swim in dense salt water you are more buoyant than in fresh water.

b) Salt brine solution augers down through the snow and ice pack to the surface of the pavement.

# All-Brine: The cereal that gets you moving

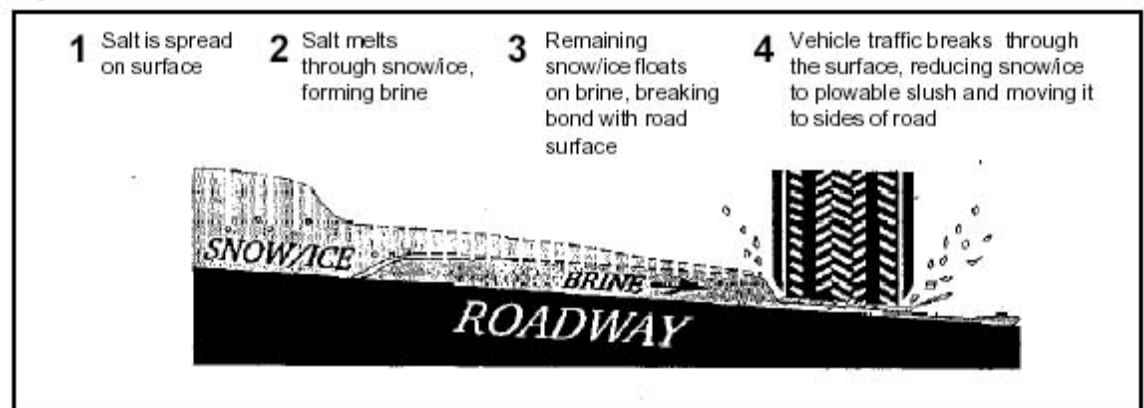
We now know how road salt turns into brine. And we know that brine is heavier than water and helps the salt crystals auger down to the surface of the road. Once it arrives at its destination, then what?

## What is the role of brine on pavement in winter?

Let's follow the process as its shown in Figure 1.

1. Salt is spread on the surface.
  2. Salt draws moisture and forms brine.
  3. Brine weakens ice-pavement bond.
  4. Traffic action creates slush.
1. *Road salt is spread on the surface.* The surface could be snow pack, ice, or freshly fallen snow that hasn't yet been packed down by traffic.
  2. *The road salt draws moisture from the snow or ice and begins to form brine.* The salt crystals are now coated with a layer of brine, enabling them to begin auguring down to the surface. When the brine reaches the interface between the snow/ice and pavement, it flows down the crossfall.
  3. *Due to the brine action, the bond begins to weaken as the ice melts.* Eventually the bond is broken and the remaining snow/ice floats on the brine layer rather than on the pavement.
  4. *Vehicular traffic breaks through the surface and reduces the remaining snow/ice to slush.* Continuing traffic moves the slush to the sides of the road. After an appropriate time period, to ensure that all of the salt crystals have melted and become diluted, it's time to bring out the plows and clear the remainder of the slush away. Once the road dries, and assuming that no further precipitation falls, bare pavement should be achieved within a reasonable period after the plows have passed by.

Figure 1 – The Role of Salt in Ice Removal



Source – Salt Institute

The key to more efficient road salt use and safer road conditions is to apply it at the beginning of the storm to create a road condition that will prevent freezing and the formation of the ice-pavement bond.

This preventative approach requires less road salt than is required to deice the road once the ice pack has formed. Therefore, proper and timely use of a chemical such as road salt is critical to restoring safe road conditions where snow and ice conditions occur.

## Quick Quiz

#3

**Applying road salt at the beginning of a storm may cause considerable problems under certain drifting conditions. Explain why.**

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### Answer

Applying road salt at the beginning of a storm may cause considerable problems under certain drifting conditions. When the road surface is dry, drifting snow may not stick to the surface. However, an application of road salt can create a wet road surface, causing blowing snow to stick to the road resulting in more hazardous conditions.



Road salt is also applied in freezing rain conditions, often along with abrasives, to establish rapid traction and melt the ice. The preferred approach is to apply road salt early in the storm, sometimes as a liquid, to prevent the bond from forming. This approach, part of an anti-icing strategy, is much more efficient and uses less road salt than deicing.



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-WARNING-

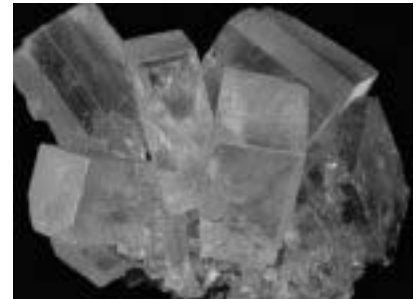
**Solid advice:** If you are going to apply an anti-icing agent to a dry road in advance of freezing rain, you should use a liquid solution only. Applying a solid chemical will result in an endothermic reaction that will cause the pavement temperature to drop. This could exacerbate the freezing rain conditions.  
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## Size matters: Comparing gradations

In Canada, road salt is most often mined from halite, a mineral layer deep in the earth's surface. It is also derived as a by-product of potash production. Regardless of how it is obtained, there are standard specifications that refer to the chemical composition and physical gradation requirements for sodium chloride that is destined to end up on road surfaces.

Traditional deicing uses coarse gradations to ensure that the salt particle can produce enough brine to break the ice-pavement bond.

Gradation, which refers to the particle size distribution, is usually classified as either coarse or fine. If you're operating in a coastal area or marine type environment, where humidity is high and frosting is prevalent, chances are good that you're spreading a fine gradation on your roads. Finer gradations are also used for blending with winter road sand.



The traditional deicing approach uses coarse gradations. This is to ensure that the salt particle is large enough to produce the amount of brine required to generate the melt action that will break the bond of snow and ice from the road surface.

With coarse gradations, there may be undissolved particles that are prematurely removed from the road to the shoulder or ditch.

As discussed earlier, larger salt particles will dissolve and auger down through the snow and ice thickness to form a brine layer at the pavement surface, thereby releasing the bond from the overlying snow pack. However, when the coarse gradation is used as a standard application on a road with a bare pavement objective, the larger particles may last longer than necessary based on the spreading and plowing frequency. As a result, at the time the slush is plowed from the road, there may be undissolved salt particles that are prematurely removed from the road to the shoulder or ditch.



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-TIP-

**Remove no salt before it's time:** Premature removal of road salt from a road surface reduces its effectiveness in breaking the ice-pavement bond. It also has environmental consequences: when undissolved salt particles end up in the ditch or on the roadside, vegetation and wildlife could suffer. We'll discuss the environmental impacts of road salt in more detail in Module 4, "Road salt and the environment."  
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Furthermore, the larger particles, though they have a larger mass and will not be prone to blowing off the road, will roll and bounce more during spreading and have a lower retention rate on the road surface. A finer gradation rock salt may better serve these early applications. On the other hand, it can be prone to caking as well as sticking to the spreader chute.

### Quick Quiz

**Different conditions call for different salt crystal gradations. Indicate whether you would recommend the use of a "coarse" (C) or "fine" (F) gradation next to each of the road conditions listed below. Score bonus points by explaining the reasons for your choices.**

**Black ice** \_\_\_\_\_

**Dry pavement in advance of freezing rain** \_\_\_\_\_

**Snow/ice firmly packed after storm** \_\_\_\_\_

**Light snow pack with accumulation during storm** \_\_\_\_\_

#### Answer

- **Black ice:** Fine
- **Dry pavement in advance of freezing rain:** Windrow dry or pre-wetted salt on the elevated side of the road, not in the wheel path. A liquid would prevent the bond, but liquids are quickly washed off the road surface by rain.
- **Snow/ice firmly packed after storm:** Coarse
- **Light snow pack with accumulation during storm:** Coarse

## TMT: A powerful mixture

There are three factors that will determine the effectiveness of road salt as a melting agent. As a winter road maintainer, your working schedule revolves around, and is dictated by:

- Temperature
- Moisture
- Time

It is the interplay among these three ingredients that determines when and if you apply road salt, or some other freeze point depressant, how long it stays on the road, and when you bring out the plows to clean up the mess.

Think of this mixture as **TMT**—it's not quite as powerful as nitro glycerine, but it can affect the safety of many people on the roads. Let's break it down and have a look.

## Temperature: Taking the heat

The pavement temperature trend is more critical than air temperature.

Temperature is the critical factor in the salt-to-brine process. As we learned in Lesson 1, the pavement temperature *trend* is more critical than air temperature when deciding on a salting strategy. Road salt is a chemical made up of sodium chloride crystals held together by an electrolytic bond.

Heat is required to break this bond, causing the separate sodium and chloride ions to go into solution. When there isn't enough heat present in the atmosphere, the road salt will draw it from the nearest available source—which is the pavement—as it dissolves into brine. Under certain conditions, it may be advisable to apply a heat-producing catalyst such as liquid calcium chloride, which may be especially beneficial at lower temperatures.

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-NOTE-

**Quick solution:** The endothermic properties of road salt should not be overstated. It does absorb heat when dissolving, but this is not a major concern for most authorities. More important is the fact that salt only begins to depress the freeze point once it is in solution. The objective is to get it into that state as quickly as possible. Calcium chloride has exothermic properties, but these do not come into play in most cases, since most authorities use it as a solution. In the -12 C to -18 C range (10.4 F to 0 F), liquid calcium chloride is very effective at getting road salt into liquid form.  
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## Moisture: The wetter the better

A solid salt particle will dissolve in the first moisture it encounters, provided the temperature is adequate to provide the necessary heat. Dry salt will remain dry unless moisture is introduced from precipitation, humidity, or directly by means of pre-wetting.

The pre-wetting technique involves adding a liquid to the road salt either in the salt spreader hopper or on the spreader conveyer before the salt hits the road. It's fair to say that if you want to be part of the solution and not part of the problem, then you have to make sure that the salt will go into solution before it is removed from the road by premature plowing or traffic action, thereby creating a potential environmental problem.




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### —STEADY AS SHE GOES—

If you get nervous on your way to the altar, it is called “pre-wedding jitters.” If you get nervous the first time that you add liquid to the salt in the spreader hopper or on the conveyer, it's called “pre-wetting jitters.”

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Once road salt starts to go into brine solution, it will continue to melt snow and ice, producing more moisture, which in turn dissolves more of the particles. The early brine solution is considered saturated—no more salt can dissolve into the moisture. If there is enough precipitation and moisture, the dissolving reaction will continue until all of the salt particles have dissolved into brine. Any moisture added beyond that point would dilute the brine, reducing its effectiveness.

Sodium chloride—rock salt—is saturated at about a 26% concentration and is most effective at 23.3%. Other chemicals have different, higher concentrations at which they work most efficiently.

## Time: The great healer

When road salt is applied early in the storm, the first precipitation provides the moisture required to break the electrolytic salt bonds and create the brine, reducing the possibility of snow and ice sticking or packing on the pavement surface. It also prevents a later build-up and allows the plow to remove the snow easier and earlier.

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### —TIP—

**To salt or not to salt:** As the temperature drops, the effectiveness of road salt decreases until it becomes completely ineffective. Many jurisdictions identify a minimum threshold temperature, below which road salt should not be applied, but these guidelines are not absolute—whether or not you use road salt depends on the presence of sun, degree of traffic volume, and the resulting road surface temperature.

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Dry salt should not be applied to bare pavement because traffic will blow it off the roadway.

If road salt applied early in the storm is good, then you might expect that road salt applied earlier would be even better. But dry salt should not be applied to bare pavement in advance of a storm because traffic will blow it off the roadway; pre-storm application of dry salt should be in a windrow off the wheel path. You should also refrain from salting pavement during a storm if the surface is dry and the snow is simply blowing across it but not packing or polishing.

Adding road salt under these conditions can result in a wet pavement surface, causing the snow to stick. In that case, you'd be part of the problem, rather than part of the solution.

Most operating procedures typically identify a minimum period of time prior to plowing following the application of road salt to prevent the salt particles from being removed from the road before they have had a chance to dissolve.

The amount of **time** required for salt to become brine and for melting to occur is determined by **moisture** and **temperature**.

The amount of time required for the salt to go into solution and for melting to occur is determined by temperature and moisture, since the resulting brine volume must be dispersed down the road surface crossfall or by traffic tracking. The pavement temperature trend will speed or slow the chemical reaction. The characteristics of the salt being used will also affect the time to react. As a road maintainer, you need to understand how much time it will take for the salt being used to work. Based on your observations and research, you can develop general time requirements to guide field decision makers based on the type of road salt used in their area.

### Quick Quiz

**Why is it inadvisable to apply solid road salt to dry pavement in advance of an approaching storm?**

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When solid road salt is added to dry pavement it will draw heat from the surface by means of an endothermic reaction, as we learned in Lesson 1. This could lower the temperature of the pavement and cause moisture to freeze on contact. By "icing" the road, you will have created, rather than prevented, a problem. The other reason not to apply solid road salt to dry pavement is that much of it will be lost as a result of bouncing off the surface as it leaves the spreader. Some of the salt that does remain on the road will also be moved to the sides of the road by traffic action. Undissolved salt crystals on the roadside and in ditches represent an environmental hazard.

Answer

**Quick Quiz**

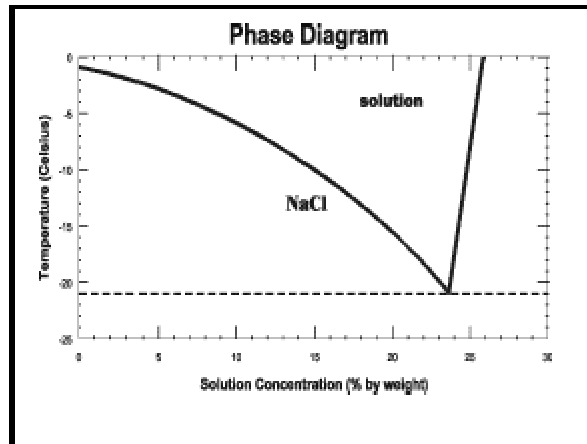
## A phase to phase discussion

Most of us learned at a relatively young age that water turns to ice when it falls below the freezing point. We're not asking you to forget what you learned about the properties of water, but in this lesson we're going to increase your knowledge by challenging conventional assumptions.

In order to effectively perform your duties as a winter road maintainer, you need to understand that the freezing point of water is anything but static—in fact, it changes in relation to the concentration of freeze point depressant in the brine solution.

The phase diagram plots the freezing point of a solution of salt in water.

To do your job effectively and make sure that you initiate the proper strategy for the conditions, you need to understand the sodium chloride/water phase diagram. The diagram plots the freezing point of a solution of salt in water. The line represents different concentrations that will provide a minimum melt point temperature and below which ice crystals form.



All points below the curve represent ice crystals along with the solution of sodium chloride and water.

All points above the curve and in the middle represent sodium chloride crystals along with the solution of sodium chloride and water.

In the area to the right of the eutectic point, there is too much salt, so refreezing occurs.

When salt particles are completely dissolved, further melting of snow or ice dilutes the solution, causing the temperature at which further melting will occur—and at which salt crystals form—to increase toward 0 degrees C. As the brine solution further dilutes, ice crystals form. This causes water to come out of the solution, thereby increasing the concentration of the remaining brine and increasing the amount of time that the salt brine is effective in preventing complete freezing.

As the salt concentration in the brine increases, its freezing point drops. For example, a 10% brine concentration will not freeze until the temperature drops to around -6 degrees Celsius as compared to zero for pure water.

The temperature at which the brine will freeze continues to decrease as more salt is added and the concentration is raised. The lowest freezing point that can be achieved with sodium chloride is -21 degrees Celsius with a brine concentration of 23.3% by weight. This optimum concentration, which provides the lowest possible freezing point, is called the *eutectic point*. Each freeze point depressant has its own eutectic point.

The eutectic point is the lowest possible freezing point of a solution.

As the amount of solution is reduced and the dilution is nearly complete (approaching water), a “corn slush” will form which then can be plowed from the surface before a subsequent application road salt.

## Do not pass Go; do not pass the eutectic point

While this is all useful information, perhaps the most important thing to understand is that once the concentration goes beyond the eutectic point the freezing temperature rises rapidly, with 30% salt brine freezing at temperatures near zero.

Notice the nice gradual descent of the line on the left in the phase change diagram. Then notice how suddenly the line on the right spikes upward. All you need to do is go over the 23.3% concentration level by a couple of percentage points, and the freezing point of the brine escalates up to zero again quite rapidly.

**As a winter road maintainer, it is important to understand these properties of phase change:**

- The reason we add road salt is to lower the freezing temperature so that we can break the ice-pavement bond.
- As temperatures drop, a greater concentration of road salt will be needed to prevent freezing.
- As the snow and ice melt and dilute the brine, thereby reducing the concentration, the freezing temperature will rise—so refreeze is possible.
- Road salt will only work down to  $-21$  degrees C, although it is not recommended much below  $-10$  degrees C.

Besides understanding the principles of phase change, you'll also need to know how much ice road salt will melt at various temperatures. Table 1 shows that at  $-1$  degree Celsius, one kilogram of road salt will melt about 45 kilograms of ice. However, as the temperature drops to  $-4$  degrees, the same kilogram of road salt will only melt about 15 kilograms of ice, and at  $-10$  degrees it only melts about 5 kilograms of ice.

<b><i>Kilograms of ice melted per kilogram of road salt</i></b>	
<b>Temperature in Degrees C</b>	<b>One kilogram of NaCl will melt</b>
-1	46.3 kg of ice
-4	14.4 kg of ice
-6.7	8.6 kg of ice
-9.4	6.3 kg of ice
-12	4.9 kg of ice
-15	4.1 kg of ice
-18	3.7 kg of ice
-21	3.2 kg of ice

**Table 1: Relationship between temperature and amount of ice melted by salt**

Fortunately, your objective is not to melt all of the ice—all you want to do is break the bond at the road surface. This relationship, and an understanding of the phase diagram, forms the basis for the standard road salt application rates used in Canada.



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–SALT FACT–

**At any rate:** There are no universally accepted road salt application rate standards. Depending upon local conditions and policies, they can range from 80 to 600 kilograms per two-lane-kilometre.

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## It's your call

We have seen that there are a number of variables involved in effective road salt use:

- pavement temperature trend
- quantity of chemical applied
- size, shape and density of chemical grains
- moisture available for the chemical to dissolve into solution
- mixing action provided by traffic
- change in concentration of salt brine present
- time to allow dissolving process and optimal dilution

Base winter road maintenance decisions on the *interactions* of the variables.

Winter road maintenance decision-making is based on a clear understanding of how these variables interact. None of them should be considered in isolation.

For example, the pavement temperature trend will affect the time it takes for the road salt to dissolve and reach the optimal dilution. The moisture available will determine the concentration of salt brine present. You have to look at the whole picture, process the information based on your knowledge and understanding of each of the variables, then make the call.

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–NOTE–

**What's the point?** Calcium chloride has a eutectic point of –51 degrees Celsius at around a 30% concentration.

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## Quick Quiz

It's 2:00 pm on Wednesday in early autumn. In less than two hours, the roads will become clogged with commuter traffic. The air temperature is +1 C and a light snow has begun to fall on bare pavement. The forecast is for 10 centimetres of snow over the next six hours followed by high winds and a sudden drop in temperature as a high-pressure system moves in.

Explain the strategy that you would use to deal with the expected road conditions. Justify your decision based on what you already know from your own experience, but keeping in mind the seven variables listed above.

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There is no "correct" answer to this scenario. There could be as many solutions as there are road agencies. Here are some of the variables that will influence an agency's response to these conditions:


- whether or not the agency has a bare pavement policy
- whether or not the agency has operators on shift 24 hours a day
- whether or not the spreaders have been mounted, given that it is early autumn

Each agency will have its own processes, procedures, policies, and checklists that dictate how it responds to weather events. Regardless of how an agency responds to these conditions, certain factors need to be addressed:

- when the temperature drops from +1 to -10, ice will form on the pavement
- rush hour traffic will occur as the snow starts to build up on the roads
- the next day is a work day, so the roads have to be ready to accommodate the morning rush hour

Given all these variables and factors, explain how your agency would expect you to respond to this weather event.

**ANSWER**



## Making the most of your road salt

Salt is the preferred deicer because of its lower cost, easier handling, and predictability of results.

There has been considerable research into the use of alternative de-icing chemicals. These chemicals have different properties and in many cases have reduced environmental impacts. Some of the alternatives actually work at lower temperatures than does road salt, particularly for post-storm deicing when temperatures often plunge. Many road authorities have tried these alternatives but usually return to road salt because of its significantly lower cost, its preferred handling characteristics and its predictability in achieving a safe driving condition.

Research is continuing in hopes of finding a cost-effective alternative to road salt. However, in the meantime the best way to reduce the amount of road salt being used is through better forecasting about when it is needed, better handling practices, and improved technology for placing it.

## Where have you been?



In this lesson, we looked at freeze point depressants; specifically we looked at the chemistry, properties and structure of road salt and how it works to melt ice and snow. The main reason for applying salt to roads is to prevent or break the ice-pavement bond. The brine solution plays a key role in that task.

Selecting the right amount of road salt to use—and the appropriate gradation for the circumstances—is a critical component of winter road maintenance decision-making. In order to make the right call, you need to understand that temperature, moisture, and time are critical factors in the transformation of solid salt particles to liquid brine. The interaction of those variables is captured in the sodium chloride/water phase diagram. By plotting the eutectic points of various concentrations of brine, you can select just the right mix for the conditions.

Your knowledge of salt science will help you to make better decisions.

## Where are you going?



Freeze point depressants come in both solid and liquid form. There is a time and place for both, as we'll see in the next lesson on "Liquid chemicals and pre-wetting." We'll take a look at how to make brine concentrations—and how to do it safely. Quality control and chemical concentration are critical factors in the use of liquid chemicals for anti-icing operations. Let's move on down the road to Lesson 3.





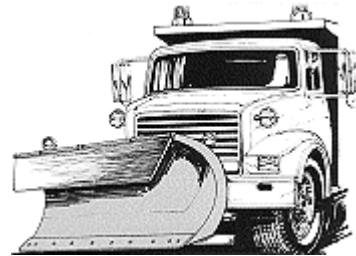
Transportation Association of Canada



# Salt SMART

Spreading, Management, Application Rates and Timing

## Learning Guide



Module 2, Lesson 3  
Road salt replacements  
and supplements

*June 2004*

## ***Transportation Association of Canada***

The Transportation Association of Canada is a national association with a mission to promote the provision of safe, efficient, effective and environmentally and financially sustainable transportation services in support of Canada's social and economic goals. The association is a neutral forum for gathering or exchanging ideas, information and knowledge on technical guidelines and best practices. In Canada as a whole, TAC has a primary focus on roadways and their strategic linkages and inter-relationships with other components of the transportation system. In urban areas, TAC's primary focus is on the movement of people, goods and services and its relationship with land use patterns.

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***June 2004***

## Salt SMART Train-The-Trainer Program

TAC offers trainer workshops to accompany the Salt SMART Learning Guide in support of the best practices for the environmental management of road salts. They range from one-day overview sessions to two-day all-inclusive sessions.

*Make a SMART investment today and book your “at-home”  
trainer workshop or attend one in Ottawa!*

### Overview session

This one-day session is for trainers with formal training and experience. It is designed to walk through the *Salt SMART Learning Guide* to highlight key messages and to discuss potential areas of resistance and how to handle them.

**Member price at a member-selected location:** \$5,000 flat fee for up to 10 participants plus expenses (e.g. training room and AV equipment, catering, TAC trainer’s travel and accommodation).

**Member price in TAC-Ottawa training room:** \$899 per participant. A minimum class size is required and dates will depend on attendee preferences and trainer’s availability.

### All-inclusive session

This two-day session is for those who have little or no training experience. It offers the one-day overview combined with an extra day devoted to soft skills training (trainer techniques, adult learning principles, lesson planning).

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**Member price in TAC-Ottawa training room:** \$1099 per participant. A minimum class size is required and dates will depend on attendee preferences and trainer’s availability.

*TAC non-members pay a 20% premium on all sessions.*

To book your trainer workshop, or for further information, contact the TAC Training Manager, Diane Jodouin at (613) 736-1350, ext. 261 or [djodouin@tac-atc.ca](mailto:djodouin@tac-atc.ca)

# Acknowledgements

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TAC gratefully acknowledges the sponsors for their generous contributions to the development of this Learning Guide. Their contribution exemplifies national cooperation in pursuit of the effective management of road salt use in winter maintenance operations.

The project team for this Learning Guide consisted of the following individuals:

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TAC gratefully acknowledges the dedication, guidance and input of the Subject Matter Reviewers; and the quality of work performed by the Instructional Designer.

This Learning Guide is truly a team effort by all those who have contributed financially and/or technically.

# Preface

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## TAC Learning Guide

There are some things that should be taken with a grain of salt. The information in this learning guide is not one of them.

When you consider that the nation's extensive transportation network supports a wide range of economic and social activities, it's not putting too a fine point on it to state that safe and efficient road traffic throughout the year is essential to our way of life. We rely on the road network for transport to the workplace and other economic uses, for recreation and leisure activities, and for emergency and security services.

Road salt is the deicer of choice for winter road maintenance.

There's something else that we rely on: road salt. It's the deicer of choice for keeping roads passable throughout the winter.

The benefits of using road salt to keep the thoroughfares open don't come without costs, both economic and environmental. Recognizing this, and concerned about the environmental implications of road salt applications, the Transportation Association of Canada's (TAC) Chief Engineers' Council, the Road Salt Working Group (a subcommittee of the Maintenance and Construction Standing Committee), and the Environment Council launched an initiative to identify and document new ways of handling and using road salt. Transportation professionals from across the country worked together through the 20-member project steering committee and 17-member project team to produce three important documents:

- *Road Salt and Snow and Ice Control Primer*: An executive summary of the project, written for the general public, that provides information on the importance of road salt use to maintaining a safe and efficient transportation system that sustains Canada's economy.
- *Road Salt Management Guide*: A comprehensive reference guide which addresses transportation and Canada's economy and quality of life, road salt and the environment and road salt management practices.
- *Syntheses of Best Practices for Road Salt Management*: A series of syntheses of best practices related to the effective management of road salt use in winter maintenance operations.

## This guide's for you

This learning guide is based on the best practices in the *Road Salt Management Guide* and the *Syntheses of Best Practices for Road Salt Management*. If you're an operator or supervisor, then this guide is for you.

As a winter road maintainer, you're on the front lines in the battle against snow and ice on roads. In fact, the only thing that gets out there ahead of you is your plow blade. You probably already know that road salt is the most effective, cheapest, and easily handled de-icing material. There may be alternatives out there, but they usually cost a lot more, require special care when handling, and are only effective under certain weather conditions. Road salt is still the most reliable de-icing chemical available.

## The "4 R's" of winter road maintenance

There was a time when winter road maintainers lived by a simple rule of thumb: "when in doubt, put it out." In other words, it was better to err on the side of caution and put down a lot of road salt—and put it everywhere—just to make sure. But those days are long gone.

The modern winter road maintainer has a new mantra: "put the **R**ight amount of the **R**ight material in the **R**ight place at the **R**ight time." In other words, use road salt more wisely and effectively. The benefit of this approach is that road salt usage is *optimized*. This translates into savings for the organization, and minimizes the impact of road salt on the environment. This guide is designed to teach you how to optimize road salt usage while continuing to keep winter roads safe for commercial, passenger, and emergency vehicles.

## Your guide to road salt optimization

Optimizing salt use means being smarter about you how put it down.

Optimizing road salt usage means being smarter about how you apply the material. In most cases it will mean that you use less road salt, but that is a result rather than an objective. In order to use road salt more wisely, you'll need to become a better decision-maker, and in order to do that, you need to improve your knowledge. That's where this learning guide comes in.

The guide consists of six modules:

- **Module 1** sets the stage by looking at the importance of transportation to our economy and way of life; the economic implications of winter maintenance; and the cost-benefits of winter maintenance.

- **Module 2** explores the science of road salt and ice. In Lesson 1 we look at the principles of ice formation. Lesson 2 examines the concept of freeze point depressants and how they work to prevent or break the bond between pavement and ice. In Lesson 3 we consider alternative de-icing chemicals and their role in winter road maintenance. Lesson 4 looks at application strategies, in particular anti-icing, a modern preventive approach that aims to keep the ice-pavement bond from forming.
- **Module 3** looks at equipment and technologies used by modern winter road maintainers. In Lesson 1 we survey plows and spreaders and how they can be put to work to optimize road salt usage. Lesson 2 examines pavement condition tracking and forecasting techniques and technologies, including road weather information systems.
- **Module 4** deals with road salt and the environment. In this module we look at the pathways by which road salt can make its way into soil and groundwater, and the effects it can have on vegetation and wildlife.
- **Module 5** looks at snow and road salt handling. In Lesson 1 we look at road salt handling and storage at the road maintenance yard. In Lesson 2 we examine disposal strategies and techniques at snow disposal sites.
- **Module 6** considers the importance of monitoring and record keeping in winter road maintenance.

The objective throughout these modules and lessons is to help you, as an operator or supervisor, to understand how it is possible to use road salt more effectively while continuing to provide safe roads during winter and minimizing the impact on the environment.

## The same, but different

You have a lot in common with winter road maintainers across the country.

As a winter road maintainer, you have a lot in common with operators and supervisors in other jurisdictions across the country. At the same time, your job is very unique. Every road jurisdiction has a different transportation infrastructure to service. No two agencies face the same weather conditions. Each organization has a different mix of human resources and equipment available to keep the roads open during winter. Levels of service differ from one jurisdiction to the next, winter maintenance strategies are designed to meet specific local challenges, and public expectations change from one jurisdiction to the next.

In other words, while all winter road maintainers may be out on the front lines keeping the roads open, they could be using very different means to achieve similar ends.

This learning guide deals with general principles of winter road maintenance that can be applied in every jurisdiction, but it is beyond the scope of this document to prescribe practices that apply to specific road authorities. The best practices upon which this guide is based have been carefully researched and prepared and are endorsed by the Transportation Association of Canada's (TAC) Chief Engineers' Council, the Road Salt Working Group (a subcommittee of the Maintenance and Construction Standing Committee), and the Environment Council.

This material is provided as advice to winter road maintainers for consideration when developing their own policies, practices, and procedures. Keep in mind that the best practices are to be used in concert with the legislation, manuals, directives, and procedures of your individual road agency.

The material in this learning guide will be incorporated into your agency's current or planned training programs.

## A word about what's inside

Before we dive into the learning guide, let's take a look at what you'll see inside. We know that your time is valuable, and that the technical nature of this subject-matter may not be the most exciting thing you've read lately. So we've tried to make the learning experience as easy and enjoyable as possible.

We want you to learn, and to enjoy doing it.

The first thing you'll notice is that, unlike a lot of those technical reference manuals and user guides you may have seen and tried to read, our tone is conversational. We talk directly to you in a casual voice that's free of jargon and technical terminology. We even throw in a bit of humour every now and then. Unlike those other documents, we want you to learn, and to enjoy doing it.

Each lesson begins with a summary of the topics that we'll be discussing. This is followed by a conversation among fictional characters in a fictional maintenance yard: Pine Junction. Any resemblance between these characters and anyone you may actually work with is entirely coincidental. This dialogue sets the stage for the material covered in the lesson. Once you've read the list of topics to be covered and the dialogue, you'll have a pretty good idea of what you're going to discover in the lesson.



## Getting around: Navigation aids

The margin along the left side of each page is an area that we call the “fast track.” This serves three purposes:

We call this area the “fast track.”

1. Document designers tell us that “white space” on the page is visually pleasing to the eye, making it easier for you to read what’s on the rest of the page.
2. We can provide a capsule summary of the important points on the page. If you don’t have time to read the whole thing, at least you’ll know what you’re missing, and you can come back to it later if you’re interested.
3. The capsule summaries serve as “navigation aids”, which means that they provide a reference point if you need to come back to a section of a lesson and find a particular piece of information.

---

### -TIPS, NOTES, and WARNINGS-

Although we feel that all of the information in the learning guide is important, some items need to have special attention drawn to them. We present these in the form of “Tips”, “Notes”, and “Warnings”. Information presented in this format is related to, but not part of, the discussion at hand.

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On the other hand, when we want to emphasize an important point *in* the discussion, we highlight it in this fashion.

If you only had time to skim a lesson, you could quickly grasp the essence of it by reading just the list of topics covered, the dialogue, the fast track items, the highlights, the tips/notes/warnings, and the summaries at the end, which we’ll discuss in a moment.

Our approach is based on the concept of self-assessment and instant feedback to confirm what you’ve just learned. Throughout this guide you’ll find “Quick Quizzes” that are designed to make you reflect on concepts that have been presented in the lesson. Once you’ve taken your best shot at answering the questions or offering solutions, you can check the answers that we provide following the quizzes. Look for the key to find out how you did. Sometimes there is no right or wrong answer, a reflection of the fact that operators in different jurisdictions might do things differently. We offer possible solutions, but our word isn’t always the final one.



When you reach the end of the lesson, we offer you a quick summary of where you’ve been. This is usually a restatement of the key points of the lesson that you should have picked up along the way. You’ll find it in the section entitled “Where have you been?”.



Knowing where you've been is useful, but knowing where you're going can be just as helpful. We'll let you know what's in store in the next lesson, in the context of what you've just learned. You'll find it in the section entitled "Where are you going?"

This guide can be used in different ways:

- You can use it at your desk, working and learning at your own pace.

-OR-

- You can use it in a classroom setting as a participant manual.

If you will be participating in a classroom training session, you will gain the maximum benefit by reading this guide in its entirety, if possible, before attending.

We hope that whatever you take from this guide will confirm the importance of the role you play as a winter road maintainer, and will generate discussions among your peers. Winter road maintenance is not a new profession, but there are always new techniques, technologies, and equipment coming along that change the way you operate. Keeping up with the changes, or staying ahead of the game, is a continuous learning process.

Let's start learning.

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# Module 2, Lesson 3

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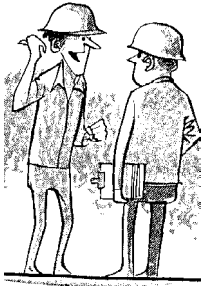
## Road salt replacements and supplements

The best way to optimize the amount of road salt you're using is to use it more effectively. Replacing or supplementing it with other chemicals can help you achieve that goal.

*Well, what shall we talk about?*

- Other chlorides and alternatives to sodium chloride
- Properties of various chemicals
- How to pre-wet, and why you'd want to do it
- Equipment that you need to make brine
- Straight up and neat: Liquid-only applications

## Salt storage dome. Pine Junction maintenance yard. November.



“Hey, Roch,” yelled Cal Leach, “what about this load of salt that came in this morning—do you want me to pre-treat it?”

“No, we stopped doing that. Too inefficient,” Roch Salterelli explained to Leach, who was new to the organization.

“Sorry,” apologized Leach. “I just noticed in your procedure manual that you’re supposed to pre-treat the sand and salt piles.”

“Yeah, I know. I should have let you know that that changed. We have to update the manual. When we have time. Like next summer, maybe.”

“Why is it inefficient? Sounds like it would save time to do it ahead of time.”

“New theories, new equipment. Things are always changing. They say that it’s more efficient to spray the brine on the salt as it leaves the spreader chute on the truck. They call it pre-wetting.”

“What’s the difference where you spray it? Doesn’t the brine end up in the same place anyway?” wondered Leach.

“Hey, I don’t invent these theories. They’ve done studies, and they found that the salt granules don’t get coated uniformly. They also found that a lot of the liquid sprayed on the pile drained out. Then the environmentalists get in on the act. All that salt flowing into the streams. The new way is supposed to require less brine, so it’s more cost-effective, and safer for the plants and wildlife.”

“Hey Cal, enjoying the lecture?” laughed John Rhodes as he strolled across the yard. “He’s just a fountain of knowledge since he took that training. Says he’s gonna teach us everything he knows about salt management. Shouldn’t take long. Maybe you’ve just heard it all already.”

“Johnny, you’ll be my first victim when I’m ready to start teaching. Don’t disillusion Cal. He hasn’t been here long, and we want to keep him around. You might scare him off. John’s living proof of that old saying that you can’t teach an old dog new tricks,” Salterelli explained as he turned to his new employee.

“Hey, the old ways worked when my father was doing this job. What’s changed? Snow and ice are still snow and ice,” protested Rhodes defensively.

“A lot’s changed, Johnny. I keep telling you that. You just have to start listening to me. Your father probably didn’t know how the ice-pavement bond formed. Didn’t need to know that. But with new chemicals and new strategies, like anti-icing, you

have to know how to fight the enemy. Knowledge is your best weapon. Your plow blade alone just won't cut it anymore."

"What new chemicals, Roch? Nothing works like salt," Rhodes shot back.

"Well, I can think of at least 10 chemicals besides salt, and they all have their pros and cons. But for special conditions, you can use specialized chemicals. We're going to be experimenting with four new chemicals this winter, to see how they work in the winter conditions we get in this part of the country. If we're lucky, we'll be able to reduce the amount of salt we use. That will keep the environmentalists and the accountants off our backs."

"Hey, I'm not a pharmacist. Where does it say I have to learn about chemicals?" asked Rhodes.

"Johnny, why do you think I kept asking you about the dew point and the eutectic point? You need to know these things if you want to put the right chemical down at the right time. Every chemical has different properties. Take potassium acetate—it can bring the freezing point of water down to minus 60. Way more efficient than salt, not that we'd ever need that kind of performance here, but you never know."

"Well, Cal, I hope you did better in high school chemistry than I did," said Rhodes to his new co-worker. "Looks like this job involves more than just plowing roads, like it used to in the good old days. Welcome to the chemical age."

"Relax, Johnny. We still need the roads plowed. And we'll always use salt. We're just looking for ways to use less of it, and help you do a better job when it comes time to remove the mess from the roads. We're just going to start working smarter, that's all."

"If you say so, Roch. As long as I don't have to write the prescriptions for all those chemicals you're gonna lay down on the roads."

## An a-salt on wasteful practices

How much you spread depends upon where you live. Salt application rates vary considerably across the country, which is not surprising given the wide variety of weather conditions that we experience from coast to coast. However, regardless of how much salt you're using in your region, you can probably use less by better targeting of treatment to conditions.

Targeting treatment to conditions requires effective use of equipment, staff, and materials.

Properly targeting the treatment to the conditions requires effective use of equipment, staff, and materials. It also requires knowledge of how ice forms, how salt works, what alternatives are available, and how to apply salt strategically. We've covered the first two already, and in the next lesson we'll look at how to apply chemicals strategically for anti-icing purposes.

This lesson is all about alternatives. We'll look at alternative chemicals, and then at alternative ways to treat them prior to application.

## Less is more...more or less

For more than 60 years, Canada has relied on salt to keep its winter roads clear and safe for motorists. The growing awareness of the environmental impacts of road salt has led to efforts to find ways to reduce the amounts entering the environment.

The search for solutions has accelerated since Environment Canada conducted an environmental assessment of the four chloride salts from 1995 to 2001.

We know that there are really only two ways to reduce the amount of road salt entering the environment:

1. Use something other than salt.
2. Optimize salt use by applying it strategically.

A lot of research has been conducted on alternative deicing chemicals.

A considerable amount of research has been conducted on alternative deicing chemicals. In a perfect world, this research would lead to the discovery of a completely non-toxic, environmentally friendly, plentiful, inexpensive substitute for salt that wouldn't cause vehicles and structures to corrode and that would be easy and safe for humans to handle.



But in reality, the hope is to find alternative substances that can be used as salt replacements or supplements to help reduce the total amount of salt entering the environment and draining the winter road maintenance budgets.

Road authorities have tried alternatives, but usually return the reliable standby: salt

Many road authorities have experimented with alternatives, but in the end they usually return to that reliable old standby: salt. And they do so because of its significantly lower cost, its routine handling characteristics, and its predictability in achieving a safe driving condition.

The *TAC Road Salt Management Guide* lists the deicing performance and the health and environmental effects of the four chloride “road salts” (sodium chloride; calcium chloride, magnesium chloride, and potassium chloride) and seven “alternatives. All of them have different properties; some work at lower temperatures than does road salt; many have reduced environmental impacts; some can damage pavement surfaces; and some are volatile and toxic, making them difficult to handle.

In this lesson, we’ll take a look at four of the alternatives that show the most promise as salt substitutes or supplements. All but one has a working temperature lower than that of salt; and all of them have a eutectic temperature below that of salt.

The best way to reduce the amount of salt you’re using is to use it more effectively.

As the research continues in the hopes of finding a cost-effective alternative to road salt, the best way to reduce the amount that you’re using is to use it more effectively. You can achieve this through better forecasting about when salt is needed, better handling practices and improved technology for placing salt. We’ll be looking at all of these practices and technologies in later lessons.

For now, we’ll look at the four most commonly used alternative chemicals; we’ll also look at pre-wetting and the use of liquids as practical, efficient ways to reduce the total amount of salt required to achieve the level of service requirements for roads in your jurisdiction.



## Deicing chemicals: Salt and others

The five most commonly used deicing and anti-icing treatment chemicals, three “road salts” and two “alternatives” are listed in Table 1. Some of the others listed in the guide have high negative environmental impacts (urea); are toxic to humans and wildlife if ingested (glycols); are volatile, flammable and toxic (methanol); or have not been studied enough to determine their safety and usefulness (sodium formate).

Chemical	Practical working temperature °C	Eutectic temperature °C	Eutectic concentration %
calcium chloride (CaCl <sub>2</sub> )	-31.6	-51	29.8
sodium chloride (NaCl)	-9.4	-21	23.3
magnesium chloride (MgCl <sub>2</sub> )	-15	-33	21.6
calcium magnesium acetate (CMA)	-6	-27.5	32.5
potassium acetate	-26	-60	49

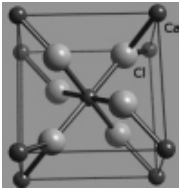
Table 1: Anti-icing properties of road salt and other chemicals

## Chemical vitae

Let's listen in as the road maintenance manager interviews the five commonly used chemicals. At the end, you'll be asked to make some decisions based on what you heard, so listen closely.

We join the interview with calcium chloride in progress:

### Calcium chloride ( $\text{CaCl}_2$ ): Versatile and exothermic



**Manager:** It can get awfully cold out there. Would that bother you?

**$\text{CaCl}_2$ :** Nope. I'm built for cold. In fact, one of my assets is that I operate at lower temperatures than the others.

**Manager:** Exothermic, eh? That's good. Just between you and me, this is one of salt's weaknesses. Put it on the road and it draws heat out of the pavement before it starts going into solution. The last thing we want is to lower the road surface temperature and cause freezing.

**$\text{CaCl}_2$ :** I know what you mean. That's why I think I'd be a good fit. I absorb moisture from the atmosphere and, as I said, give off heat when I turn to liquid. I'd be the perfect complement to salt. I could prevent that pavement freezing problem and provide the moisture that salt needs to go into solution. And I work at  $-15\text{ C}$  or less, which has salt beat by several degrees.

**Manager:** That's exactly what I was thinking. We can certainly use a pre-wetting agent to mix with the sand to keep it from freezing. And you could work well with salt. It says here that you are a natural liquid, but are also available in solid flake and pelletized form. So I guess that means we could distribute you using our regular salt-spreading equipment.

**$\text{CaCl}_2$ :** Absolutely. If I had to name one defining characteristic, I'd say I was "versatile."

**Manager:** However, we're also aware your propensity to draw moisture from the air, while an asset under certain circumstances, could also lead to handling problems during humid conditions. In fact, this might also slow the process of reaching a bare dry pavement state after a storm.

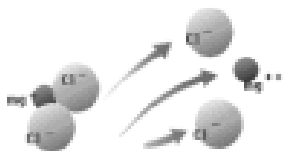
**$\text{CaCl}_2$ :** I can't dispute that.

**Salt manager:** Even so, you do provide us with some options, such as mixing you with salt. We've got options. Thanks for stopping by. We'll be planning our strategies and will get back to you soon. Before winter.

**$\text{CaCl}_2$ :** Thank you. And if I might just add—you don't need to wait until winter. I'm also an effective anti-dust agent on those gravel roads in summer.

**Salt manager:** Yes. As you said, very versatile. But dust control is the subject of another learning guide.

## Magnesium chloride ( $\text{MgCl}_2$ ): “Anti-freeze for the road”



**Manager:** Good morning. Nice to meet you. We’ve been hearing great things about you.

**MgCl<sub>2</sub>:** Well, I guess that’s appropriate, since I come from Great Salt Lake brines.

**Manager:** Ah, Utah. A beautiful state. I visited there a few years ago. Now, it says here that you are a “hygroscopic” chemical. Can you explain what that means? We had calcium chloride in here earlier, and it said the same thing in its CV. I meant to ask what that meant.

**MgCl<sub>2</sub>:** Oh, sure. That just means that I take up and retain moisture. From wherever I can get it—the air, the pavement, snow and ice. Whatever. I know that water retention can be a real problem for people trying to lose weight, but for me it’s a very useful characteristic.

**Manager:** I see. As I recall, sodium chloride is also hygroscopic. Now, I think you know why we’re looking for substances that can help reduce the need for salt, or in some cases replace it. What can you offer?

**MgCl<sub>2</sub>:** To put it simply, I can prevent snow from sticking to the road and prevent frost or black ice. They simply spray me onto the roads before a storm arrives.

**Manager:** They spray a liquid right onto the bare pavement? Wouldn’t that cause problems for motorists?

**MgCl<sub>2</sub>:** I suppose it would, if I were water. But my eutectic temperature is  $-33.6\text{ C}$ . Think of me as “anti-freeze for the road.” I lower the freezing temperature of water and prevent ice from forming a strong bond to the road. The roads don’t become slick, safety is improved, and accidents are reduced.

**Manager:** Well, those are all certainly in line with our level of service objectives. When calcium chloride was here it spoke about its versatility. Would you describe yourself as versatile?

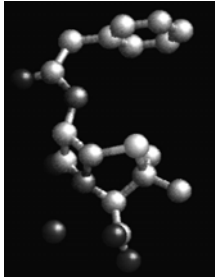
**MgCl<sub>2</sub>:** I’m nothing if not versatile. For example, I can be used as an anti-icing agent, as I described a moment ago. Or, if there is already an ice bond on the pavement, I am effective in breaking it. I’m very skilled at preventing black ice and am often used in freezing rain. And if you use me as a pre-wetting agent for sand, I cause the abrasive to stick to the snow pack better.

**Manager:** We also have to be very sensitive to the effects on the environment of what we apply to our roads. Do you pose any potential environmental problems? We’ve heard that you are one of the only chemicals that can moderately deteriorate concrete. Mind you, it does say that you are “slow” to attack concrete. Is there anything else you’d like to tell us?

**MgCl<sub>2</sub>:** I just hope that you’ll weigh the good and bad. Some tests have shown that, if applied properly, I have no negative effects on ground water, surface water, or vegetation. And unlike sand, I won’t crack your windshield or chip the paint on your car. So, although I may cost a bit more than some of the others, if you look at the big picture, I’m actually very cost-effective.

**Manager:** We’ll need time to weigh all the factors, consider the pros and cons, and decide how we can use you in our winter maintenance strategies. Thanks for stopping by.

## Calcium magnesium acetate (CMA): Vinegar and oatmeal



**Manager:** Good afternoon, CMA. Maybe we could begin by you telling us a little bit about your background. Your CV is certainly interesting.

**CMA:** Thanks. First of all, who am I? I guess we all ask ourselves this question from time to time. I am a patented chemical formulation of dolomitic limestone and acetic acid. I've got 25 years experience on the job. They know quite a bit about my corrosion impacts, environmental effects, and deicing efficiency. What else? Well, I can be used in liquid form or combined with salt or sand. When I'm used as a liquid, it's generally for anti-icing purposes.

**Manager:** Your credentials are impressive. However, I must ask you about something that I read the other day. It said that CMA doesn't melt ice and snow. Is that true? If so, what are you doing here among the other freeze point depressants?

**CMA:** Well, technically that is true, but it shouldn't be interpreted to mean that I'm not a useful anti-icing agent. What I'm good at is turning ice and snow into an oatmeal texture. This makes it easy for plows to remove, and if there's a lot of traffic action, that tends to move the slush off to the sides very effectively as well. But I have to be applied at the outset of a storm, before a lot of snow accumulates.

**Manager:** And why is that?

**CMA:** Because I'm more effective as an anti-icer than as a deicer. I can keep snow from compacting into ice and bonding to the pavement, but once that's already happened, you'll need to get something else to break that bond. I'm a specialist in that regard.

**Manager:** It's always wise to stick to what you do best. One of our big concerns is the environment. You seem quite congenial, but are you also environmentally friendly?

**CMA:** If I do say so myself, this is my most endearing feature. In more than 30 years of testing and use, they've found that I have no effect on soil compaction or strength. I'm biodegradable. I exhibit poor mobility in soils so am unlikely to reach groundwater. And since I smell like vinegar—something of which I'm *not* particularly proud, by the way—I'm not attractive to animals like salt is. In Scandinavia, they use me in deer management areas to prevent vehicle/animal accidents.

**Manager:** You do appear to be the "greenest" of the alternatives. We're also concerned with your corrosiveness. What did the studies find in that regard?

**CMA:** To make a long story short, they found that I'm less corrosive to metals than salt. I don't contribute to spalling or scaling on new reinforced concrete. In my case, lack of rust is the basis for a good relationship.

**Manager:** I can see a very specialized role for you in our operations, particularly in environmentally sensitive areas. We also have a few regions where roadside wildlife is a problem, so we could consider using you there. We're still formulating our strategies. We'll get back to you when we've made our decisions. Thanks for stopping by.

## Potassium acetate: A slight BOD



**Manager:** Good afternoon. Let me begin by saying how impressed we all were by your eutectic point. Can you tell me a little bit about yourself?

**Potassium acetate:** Certainly. I should mention just briefly that I am produced by the reaction of acetic acid with potassium carbonate. I've been applied primarily as a runway deicer, but I've also been used to keep rail switches open, free manhole covers, and even as an antifreeze in toilet water—not my favourite gig, by the way.

**Manager:** Understandably. What about roads? Have you any experience in winter road maintenance?

**Potassium acetate:** Yes, they have put me in products designed for roadway use. I'm most effective in extreme winter conditions when temperatures are very low. I'd have to say that I'm most useful as a pre-wetting agent for CMA, road salt, and other solid deicers and sand.

**Manager:** Where would you say your strengths lie—as a deicer or as an anti-icer?

**Potassium acetate:** I'd say that I'm equally effective in both roles. If I'm applied at the beginning of a storm, I can help prevent the formation of the ice-pavement bond. An additional benefit is that I leave a residue on the road that acts as an anti-icing agent for the next storm. I'm known for my staying power.

**Manager:** We're always looking for ways to get more bang for the buck, and that certainly sounds like one of them. We're also interested in learning about your effects on the environment. This is a hot issue right now.

**Potassium acetate:** So I've heard. First and foremost, I'm biodegradable. I decompose to potassium and acetate. As I metabolize to carbon and water, I require a slight amount of oxygen. The guys in the lab coats call that "Biological Oxygen Demand," or BOD for short. I guess having a slight BOD isn't a bad thing, is it? The only negative thing they found is that I'm toxic to fish at elevated concentrations. But you know what they say—too much of anything is bad, right?

**Manager:** Yes—and that goes for rust, too. What can you tell me about your corrosiveness?

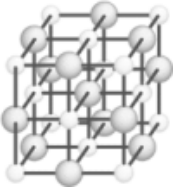
**Potassium acetate:** Generally speaking, I'm considered non-corrosive, but they say that I shouldn't be put into contact with galvanized metals.

**Manager:** So, if I were to sum you up, I would say you can put in a good effort at extremely low temperatures, you're not much of a threat to the environment, and you cause very little rust or corrosion, with some exceptions. Would that be accurate?

**Potassium acetate:** Right on. Let me just add that if you do decide to keep me around, you'll need to keep me in a clean sealed container. Otherwise, I could start to prematurely biodegrade and exhibit biological growth. And no one likes having to look at that.

**Manager:** Indeed. We'll let you know what we decide. Thanks for stopping by today.

## Sodium chloride: The Old Salt



**Manager:** You've been around a long time. To what do you attribute your longevity?

**Sodium chloride:** I'm a product of nature. I could be hundreds of millions of years old—or I might have been grown only a year ago in a solar salt pond. Highway agencies have used me for about 60 years on our roads. I'm the most studied and best understood of the deicing materials available. Why have I been used for so long? Because I work—quickly, reliably and inexpensively. That's what most managers like yourself are looking for, isn't it?

**Salt manager:** Indeed. But some of the competitive products operate at much lower temperatures. Doesn't that put you at a disadvantage?

**Sodium chloride:** Not necessarily. You see, most snow and ice events occur well within the temperature range where I work best: above  $-9^{\circ}\text{C}$ . At that temperature, the performance differences between the alternatives are almost indistinguishable. They work equally fast. Since many storms are followed by plunging temperatures, the new popularity of anti-icing—applying the deicer before or early in the storm—makes me an even more attractive alternative. When temperatures are too low to use me alone, I work great when pre-wet with one of these “hotter” deicers. It's a lot cheaper to pre-wet me than to put down the more expensive option straight.

**Salt manager:** Since you mentioned temperature, is it true that you *lower* the temperature as you get ready to go to work while some of the others actually *raise* pavement temperature? I've learned that pavement temperature is a really critical consideration.

**Sodium chloride:** That's right. Pavement temperature is probably the most important variable. It's true that I will lower pavement temperature, but that effect is less than one degree Celsius and the duration is five minutes or less; then the effect disappears. Some of my competitors will raise the temperature just about as much, but that effect also disappears quickly. In the real world, that just doesn't make a difference.

**Salt manager:** Your competitors claim that they attract moisture to jump-start their effectiveness, but you require moisture from the frozen precipitation.

**Sodium chloride:** Again, true as far as it goes. More and more agencies are putting me down pre-wet or in solution as brine, so I go to work immediately. However, when the storm's over, I help dry off the roadway surface, getting it back to its top safety condition. Some of my hygroscopic competitors keep attracting moisture, keeping the road from drying as quickly.

**Salt manager:** You mentioned using sodium chloride as a liquid brine or pre-wet solid. Wouldn't it be easier to just buy a liquid rather than have to mess around making a brine?

**Sodium chloride:** That's entirely up to you, but you can make brine on-site for a lot less cost than buying a liquid. And my properties are well-understood—your workers are used to dealing with me, so using me is cheap and easy. No muss. No fuss.

**Salt manager:** Bottom line, don't be modest now, if you had to tell me your best “competitive advantage,” what would that be?

**Sodium chloride:** Clearly, cost. Most agencies are looking for the most cost-effective solution. Often that's me. Not always. I'd like to think that I'm at least *part* of the answer and in many cases, I'm the best answer all by myself. Why pay seven times the cost—or more—when you know how I work and know that I can get the job done for you?

**Salt manager:** Hard to argue with that logic. Thanks for coming in.

## Quick Quiz

You've heard the interviews. You know about the properties of salt and the four alternative chemicals. If you want even more details, you can consult Chapter 1 of the *TAC Salt Management Guide*.

Based on what you already know, what you've learned so far in this learning guide, and what you heard in the interviews, try and answer the following questions.

1. Which of the five chemicals is most environmentally friendly? Why?

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2. Which of the five chemicals would be the most effective pre-wetting agent for road salt? Why?

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3. Which of the five chemicals would be most effective as a straight liquid application? Why?

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4. Which of the five chemicals is the least corrosive? Explain.

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## Answer

### 1. Which chemical is most environmentally friendly?

Any substance that is applied inappropriately can have an adverse impact on the environment in areas that are vulnerable to stress.

- *Calcium chloride*: If too much is used, it can leave harmful oily residues behind.

- *Magnesium chloride*: Tests have not shown any negative effects on ground water, surface water, or vegetation. However, it can contribute to deterioration of concrete.

- *Sodium chloride*: Excessive amounts can have negative environmental impacts in stress-vulnerable areas.

- *Calcium magnesium acetate (CMA)*: Biodegradable. Unlikely to reach groundwater, therefore less susceptible to leaching than salt. It has no detrimental effects on roadside plants or aquatic organisms. It is also unattractive to roadside animals, and is less corrosive to metals than salt.

- *Potassium acetate*: Biodegradable. As it decomposes to potassium and acetate, and metabolizes to carbon and water, it requires a slight amount of oxygen.

### 2. Which chemical would be the most effective salt pre-wetting agent?

Different chemicals will be more "effective" at different temperatures and humidity levels. The most cost-effective pre-wet chemical is sodium chloride, because most storm conditions are appropriate for its use, most locations are compatible with its environmental impact, and it is the least expensive. Calcium chloride can also be very effective under the appropriate conditions. It absorbs moisture from the environment and gives off heat as it turns to liquid. The moisture that it absorbs kick-starts the process by which salt turns into brine solution. Since this is an endothermic reaction that can take the required heat that is given off by the exothermic reaction of calcium chloride going into solution, they complement to each other well.

### 3. Which chemical would be most effective as a straight liquid application?

It depends upon the conditions and how the chemical is applied. Straight liquid applications of magnesium chloride have been used successfully in Idaho and other jurisdictions in the American and Canadian west. Because of its low eutectic temperature the risk of it freezing on the surface is also low. It's effective at melting black ice, freezing rain, and as a deicer applied directly to the snow pack.

### 4. Which chemical is the least corrosive?

Calcium magnesium acetate is less corrosive to metals than salt. It doesn't contribute to spalling or scaling on new reinforced concrete.



## Pre-wetting: Jump-starting the brine



You'll recall from Lesson 2 that brine—not solid salt—melts ice and snow, and that one of the critical factors in the process is time. The other two factors are moisture and temperature, and while we can't do much to control those, there is something that we can do to reduce the amount of time needed for solid salt to become brine. One of the most effective ways to achieve this is to apply salt brine along with the solid salt, which is known as pre-wetting.

Reduce the time required for solid salt to become brine by pre-wetting.

When a liquid is applied to a rock salt particle it absorbs a minor amount of the liquid.



This increases its density and also begins the dissolving process as the liquid softens and encapsulates the particle. When the wetted salt particle hits the road surface, it has less of a tendency to bounce and slide; and because of the moisture around its perimeter, traffic action will not tend to blow it off as easily as a dry particle.

Throughout the North American snow belt, many organizations have found that they can increase the reaction time of salt and also provide melting action at lower temperatures by prewetting salt at the following concentrations:

- 23% solution of liquid sodium chloride
- 32 % solution of liquid calcium chloride
- 32 % solution of magnesium chloride
- 25% solution of CMA
- 42% solution of potassium acetate

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-NOTE-

**For good measure:** Pre-wetting is usually done at rates of 8 to 10 gallons of liquid for each ton of salt.  
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These options provide a higher level of service at all temperatures. Pre-wet salt goes into solution faster, speeding its friction-recovering mission. And pre-wet salt also sticks better to the roadway surface so that more stays in the travel lanes rather than bouncing off where its ability to enhance safe driving is lost. This increased efficiency means pre-wetting may reduce the quantity of salt required.



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**-TIP-**

**Making the grade:** An application of fine salt will bounce less on the road, be better distributed across the road surface, and react more quickly under given circumstances. At reduced application rates a finer grade of salt responds better to frosting or freezing rain events where standard applications of coarser salt would be excessive. Since the demand for finer salt is low in some areas, salt producers may not be able to readily supply it at an appropriate price.

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## Putting it on

There are four methods of applying pre-wetting liquids:

1. On-board where the liquid is in a tank on the spreader and dispensed as the salt leaves the spreader.
2. Applied to each loader-bucket of salt just prior to placing salt in the spreader.
3. Applied to the entire load of salt in the spreader.
4. Applied to the entire salt stockpile prior to winter season.

The preferred pre-wetting practice is to spray the salt as it is discharged from the chute, or at the spinner.

Spraying stockpiles and truckloads has also been termed “pre-treating”, but this practice is not as practical since the granules are not uniformly coated, the liquid may drain out of the solid material, and the performance on the road is not consistent throughout the route. Therefore, the preferred pre-wetting practice is to spray the salt as it is discharged from the chute, or at the spinner.



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**-TIPS-**

**Nozzle up to the salt:** One of the most critical factors in pre-wetting is the adjustment of the spray nozzles. In a series of tests by a transportation department in the U.S., they never achieved more than 60% coverage of the salt. The remaining 40% of the pre-wetting liquid ended up being applied directly on the road.

As the pre-wetting agents are corrosive, it's important to use corrosion-resistant nozzles. Use non-contact pumps to ensure dependable performance.

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## Quick Quiz

The advantages of pre-wetting are numerous. The following is a list of benefits of pre-wetting. Only one of the list items is *not* a benefit associated with pre-wetting. Can you identify it?

1. Faster brine formation and therefore melting of the snow and ice
2. Longer-lasting effect
3. Helps prevent formation of snow drifts during high wind conditions
4. More uniform spreading due to less bouncing
5. Less loss due to bouncing and traffic action
6. More salt is retained on road to work because granules adhere to surface better
7. Wetted salt doesn't bounce as much so it can be spread at higher speeds
8. Less salt is needed because less is wasted and therefore there is less deadheading to refill the spreaders
9. In some cases the road surface dries more quickly
10. Reduction in resources for maintaining the highway since a lower application rate translates into a spreader load covering more area

### Answer

**Item #3.** Pre-wetting is not an activity normally associated with snowdrift prevention. As a matter of fact, if you were to apply salt, pre-wetted or not, to a dry road during high wind conditions, you could cause the snow to stick to the surface rather than blow across it. This is how snowdrifts start to form—and it's an example of how the solution can become part of the problem.



The greatest benefit of pre-wetting comes with the first salt application. With the higher retention rate and more rapid melting action, bare pavement can be achieved more quickly and with less overall salt. This has the added benefit of reduced environmental impacts without compromising safety.

At least one jurisdiction wanted to verify the benefits of pre-wetting and conducted a study. The Michigan Highway Department discovered that up to 96% of pre-wetted rock salt applied in a windrow along the centreline remained in the centre and outside two-thirds of the road surface. That number dropped to 70% when they used dry rock salt. In other words, *almost one-third of the dry salt ended up on the shoulder and in the ditches.*

**Quick Quiz**

**There are at least three reasons why it is undesirable for up to 1/3 of the salt applied to the road to end up on the shoulder and in the ditches. Can you describe them?**

1.

2.

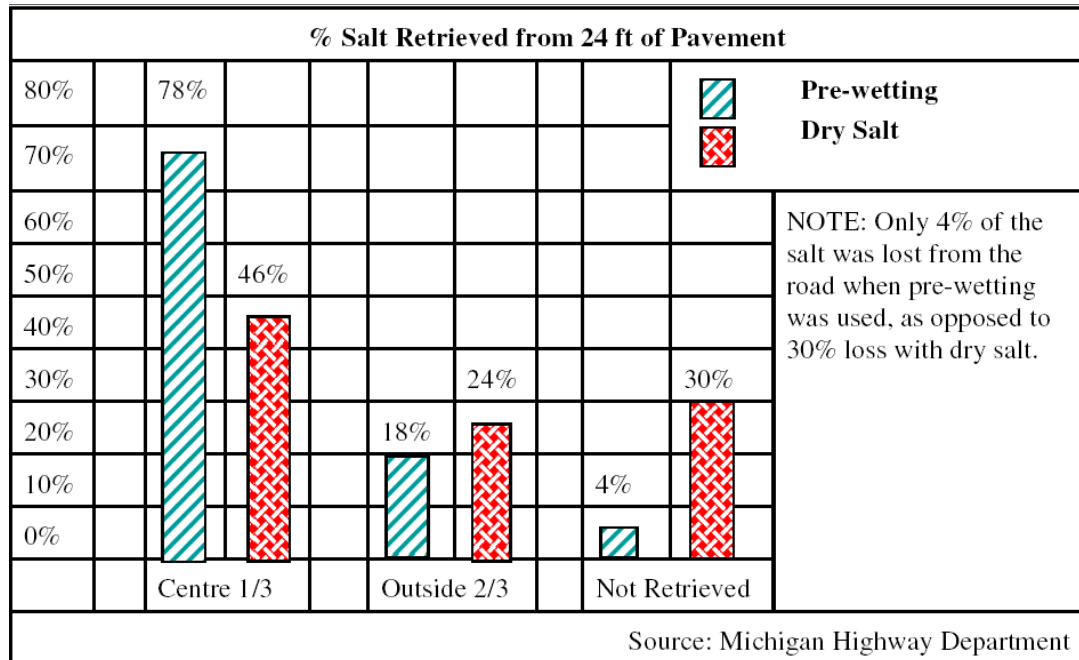
3.



**Answer**

1. Salt on the shoulder and in the ditches contributes nothing to the fight against the ice-pavement bond.
2. Large amounts of salt in the roadside environment affect plants and animals adversely, and may even end up polluting drinking water.
3. Salt is too expensive to throw away needlessly.

Table 2 illustrates clearly and dramatically the results of the Michigan study. Notice that a total of 54% of the dry salt ended up either off the road, or on the outside two-thirds. This is not an efficient use of an expensive chemical.



**Table 2: Comparison of dry and pre-wetted road salt loss**

### Worth the effort?

Toronto was the first municipality in Canada to formulate a salt management program for its 5300 kilometres of roadway and 7100 kilometres of sidewalks. Two new programs—anti-icing and pre-wetting—have proven to be safe and clean alternatives to road salt.



In anti-icing, they spray a 23% salt brine solution on the roads. Pre-wetting is a two-step process in which one truck sprays brine while another one applies salt. A third of the city's fleet has pre-wetting capabilities, but they hope to have the equipment installed on all trucks by 2005.

In the first two years, the city saved 40,000 tonnes of salt and about \$2 million.

Worth the effort? Absolutely.

## Pre-wetting with water: Not an option

You have several options from which to choose when selecting a liquid to use for pre-wetting. Water is not one of the choices. While you could use straight water as the pre-wetting solution, there is a risk of freezing in the truck-mounted storage tank, in the supply line to the nozzles, at the nozzles themselves, or on the road. Therefore, it's preferable to use a chemical solution.

We'll take a look at the equipment involved in brine production and liquid storage in Module 3, Lesson 1.



### York Region finds a solution

Ontario's York Region provides upkeep for a number of arterial roads such as Yonge St. and Highway 7. This upkeep includes a winter maintenance schedule of snow removal, road salting and sanding. Following a successful trial program in 2002, trucks now apply a salt-brine solution on heavily used roads prior to snow events to help reduce the amount of salt required for safe driving conditions.

York Region employs 62 plow/sander trucks (49 are privately contracted) to manage the over 1,000 km of roads under its care. Barring traffic jams, it takes an average of just over two hours to clear snow, and 75 minutes to salt or sand.

(Source: <http://www.region.york.on.ca.>)

## Getting your street wet: Using liquids



Some jurisdictions are moving to the use of liquid-only applications for some storm situations. This involves the application of straight brine in advance of the storm, and is often referred to as anti-icing. However, as we'll see in the next lesson, "Application strategies: Anti-icing and deicing," any application of chemical in advance of the storm to *prevent the formation of the ice-pavement bond* can be referred to as anti-icing. It's the strategic timing of the applications, not the chemical that is used, that defines anti-icing.

The benefits of liquid-only applications are the same as those of pre-wetting, except that even less total salt is needed. Liquid anti-icing is particularly suited to routes with higher levels of service, which also tend to involve higher salt use.

Liquid brine gives you a head start on maintaining surface friction.

Liquid brine applications are particularly efficient at accurately wetting the pavement to get a head start on maintaining surface friction. The melt reaction time is quicker without requiring the TMT (temperature, moisture, time) required to dissolve solid salt. Subsequent applications are often required, and may be either liquid or solid depending on the precipitation type, intensity, and duration.



You may also need a concluding application of straight liquid brine, depending upon the conditions. The effectiveness of the application will be determined by the application rate and the concentration of the brine. This is more easily achieved with a liquid than with a solid.

It cannot be stressed too heavily that you need good pavement temperature information if you are going to use liquids. You always need to control the concentration carefully, keeping the sodium chloride/water phase diagram in mind.

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-CAUTION-



**Mixing it up:** It would be reasonable to expect that combining certain chemicals would enhance their effectiveness. Although we know that salt and calcium chloride is a safe and effective combination, there have been no studies that have proven the effectiveness or safety of other combinations, so don't mix and match until you know for sure what the result will be.

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### Quick Quiz

**This exercise is designed to test your knowledge of the phase diagram that we discussed in the previous lesson. Based on what you know about eutectic temperatures, explain why it is important to carefully control the concentration of liquid chemicals.**

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As we learned in the previous lesson, the freezing point of a brine solution is determined by the concentration of chemical in the solution by weight percentage. For example, the lowest possible freezing point for salt, which is its eutectic point, is  $-21\text{ }^{\circ}\text{C}$  at a 23.3% concentration. If the temperature is expected to be  $-6\text{ }^{\circ}\text{C}$ , a brine solution, usually applied at 23% concentration, will still have melting power even if it has been diluted to only a 10% concentration. Below that, watch out! This is why it is important to keep an eye on the temperature. It will determine what concentration you need to achieve. Learn to read, and interpret, the phase diagram, and you'll be able to come up with the right treatment for the conditions.

Answer



The most popular liquid used for anti-icing is salt brine (NaCl), but all the chemicals we've discussed can be used and may be superior to salt in certain situations, particularly when applications are being made at very low temperatures (below  $-9\text{ }^{\circ}\text{C}$ ).

Scandinavian countries have reported substantial salt reductions by using light applications of straight salt brine at the start of the storm to prevent roads from becoming slippery. They have also been able to eliminate subsequent regular salt applications as long as this treatment remains effective.

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-TIP-

**Phase the facts:** Liquid deicers will refreeze if become diluted at low temperatures. Keep the phase diagram in mind.  
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When a storm is on the way, time is of the essence.

Many North American road authorities have used solid salt applications at the start of a storm to achieve similar results, but at higher total salt loads. The salt brine application has the added advantage that it can be done at close to the speed of other traffic because the brine adheres well to the road surface. When a storm is on the way, or has just arrived, time is of the essence in effective anti-icing operations.

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-NOTE-

**Tanks for everything:** Some liquids come from their manufacturer in liquid form, while others are more cost-effectively converted into liquids from solid chemicals delivered from the manufacturer. If your agency uses delivered liquids, your requirements will include storage tanks and pumps. If you're making your own, then you'll need brine-making equipment.  
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## Freezing points of chemical solutions

The solubility of all chemicals varies with temperature: the lower the temperature, the less the solubility. But the decrease in solubility has a limit, a point where no more of the chemical can dissolve and depress the freezing point. As we learned in Lesson 2, “Freeze point depressants,” this is known as the eutectic point.

A solid chemical applied as an anti-icing treatment must cover the highway pavement surface as rapidly as possible in solution form to act as a barrier to the formation of a bonded snow or ice layer anywhere on the road.

### Quick Quiz

There are two ways to accelerate the rate at which salt goes into solution. Can you explain them?

1.

2.



#### Answer

1. It can find free moisture or liquid on the pavement surface.
2. A liquid can be added to the surface of the salt particles before they are placed on the pavement surface (pre-wetting)

Solid calcium chloride, which is both hygroscopic and deliquescent, goes into solution much more quickly than salt. It begins absorbing moisture from the air at a relative humidity of 42% and higher, and continues to do so until it dissolves. Sodium chloride, on the other hand, will not begin to absorb moisture until the relative humidity reaches 76%.



**Deliquescent:** Tending to undergo gradual dissolution and liquefaction by the attraction and absorption of moisture from the air.

**Hygroscopic:** Readily taking up and retaining moisture.

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 -NOTE-



**You moist keep the humidity down:** The hygroscopic and deliquescent properties of calcium chloride are not always an advantage. Additional and costly measures need to be taken to ensure that the relative humidity remains below 42% during storage and handling. For this reason, salt is easier to store and handle.

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### Quick Quiz

**Calcium chloride and sodium chloride have very different chemical properties, but when they are combined, they complement each other, creating a highly effective snow and ice control solution. Why does this combination work so effectively?**

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#### Answer

1. The calcium chloride absorbs moisture and releases heat, reducing the amount of time required for the salt to go into solution. This produces brine quickly, which sustains the continued brine generation of the two chemicals.



### Using liquids: It pays



In 1996, the cities of Kamloops and Kelowna in British Columbia began trials funded by the Insurance Corporation of British Columbia (ICBC) to test the effectiveness of liquid de-icers in anti-icing and pre-wetting applications.

After a year, they reported significant reductions in the use of abrasives, as well as a reduction in material and operational costs. Encouraged by the great success, ICBC expanded the testing program to include 43 municipalities and 16 contractors servicing the province.

ICBC conducted two studies comparing accidents occurring during periods where liquid anti-icing techniques were used and periods where traditional de-icing methods were used, and found a **40% reduction in claims**. Overall, ICBC estimates a savings of over \$4 million was achieved as a result of fewer accident claims from the new programs.

## Where have you been?



In this lesson we learned that the most effective way to cut down on the amount of salt entering the environment is to use less of it. The two most effective ways to do that are to use something other than salt, or to use salt more strategically. There are chemical alternatives available that can be used as salt replacements or supplements. However they're used, the end result is that you'll use less salt. And if the chemicals are used properly, the end result will be even safer winter road conditions for motorists.

You can pre-wet salt with brines made from salt itself or the alternative chemicals, or you can apply the brines or straight liquids directly to bare pavement to prevent the ice-pavement bond from forming, or on top of the snow pack to break the bond once it has established itself. In order to use these chemicals strategically, and to your best advantage, you need to know how ice forms, how salt works, and the properties of the chemicals. Combine that with your knowledge of meteorological conditions and pavement temperatures, and you're well equipped to make the right decision.

This is at the heart of properly targeting the treatment to the conditions.

## Where are you going?



Properly targeting the treatment to the conditions involves more than just knowing what chemicals to use. You also have to know *when* to use them: before the storm, at the outset of the storm, during the event, or in the aftermath. Making a pre-emptive strike to prevent the ice-pavement bond from forming is known as anti-icing. The decision-making involved in this strategy brings together everything you know about ice, salt, alternative chemicals, weather, pavement conditions, equipment, and technology.

The more you know about these variables, and how they interact, the better equipped you'll be to make a good decision. Because anti-icing is all about strategic decision-making. It's not defined by *what* you put on the road, but by *when* and *how* you put the chemical down.

We'll explore the intricacies of proactive anti-icing and reactive deicing in the next lesson.



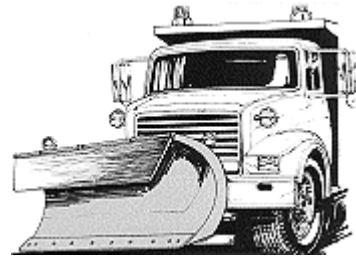
Transportation Association of Canada



# Salt SMART

Spreading, **M**anagement, **A**pplication **R**ates and **T**iming

## Learning Guide



Module 2, Lesson 4  
Application strategies:  
Anti-icing and deicing

*June 2004*

## ***Transportation Association of Canada***

The Transportation Association of Canada is a national association with a mission to promote the provision of safe, efficient, effective and environmentally and financially sustainable transportation services in support of Canada's social and economic goals. The association is a neutral forum for gathering or exchanging ideas, information and knowledge on technical guidelines and best practices. In Canada as a whole, TAC has a primary focus on roadways and their strategic linkages and inter-relationships with other components of the transportation system. In urban areas, TAC's primary focus is on the movement of people, goods and services and its relationship with land use patterns.

## ***Wellspring Consulting Inc.***

Wellspring Consulting is an instructional design company, specializing in adapting reference information into self-contained learning guides through the application of proven adult learning principles. With the Wellspring methodology, learners are first engaged through an enjoyable, easy to follow and entertaining writing style, then challenged using interactive techniques like problem-solving and role-playing. This fresh and stimulating approach enables learners to effectively transform dry technical information into vital, practical knowledge.

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***June 2004***

## Salt SMART Train-The-Trainer Program

TAC offers trainer workshops to accompany the Salt SMART Learning Guide in support of the best practices for the environmental management of road salts. They range from one-day overview sessions to two-day all-inclusive sessions.

*Make a SMART investment today and book your “at-home”  
trainer workshop or attend one in Ottawa!*

### Overview session

This one-day session is for trainers with formal training and experience. It is designed to walk through the *Salt SMART Learning Guide* to highlight key messages and to discuss potential areas of resistance and how to handle them.

**Member price at a member-selected location:** \$5,000 flat fee for up to 10 participants plus expenses (e.g. training room and AV equipment, catering, TAC trainer’s travel and accommodation).

**Member price in TAC-Ottawa training room:** \$899 per participant. A minimum class size is required and dates will depend on attendee preferences and trainer’s availability.

### All-inclusive session

This two-day session is for those who have little or no training experience. It offers the one-day overview combined with an extra day devoted to soft skills training (trainer techniques, adult learning principles, lesson planning).

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**Member price in TAC-Ottawa training room:** \$1099 per participant. A minimum class size is required and dates will depend on attendee preferences and trainer’s availability.

*TAC non-members pay a 20% premium on all sessions.*

To book your trainer workshop, or for further information, contact the TAC Training Manager, Diane Jodouin at (613) 736-1350, ext. 261 or [djodouin@tac-atc.ca](mailto:djodouin@tac-atc.ca)

# Acknowledgements

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TAC gratefully acknowledges the sponsors for their generous contributions to the development of this Learning Guide. Their contribution exemplifies national cooperation in pursuit of the effective management of road salt use in winter maintenance operations.

The project team for this Learning Guide consisted of the following individuals:

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TAC gratefully acknowledges the dedication, guidance and input of the Subject Matter Reviewers; and the quality of work performed by the Instructional Designer.

This Learning Guide is truly a team effort by all those who have contributed financially and/or technically.

# Preface

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## TAC Learning Guide

There are some things that should be taken with a grain of salt. The information in this learning guide is not one of them.

When you consider that the nation's extensive transportation network supports a wide range of economic and social activities, it's not putting too a fine point on it to state that safe and efficient road traffic throughout the year is essential to our way of life. We rely on the road network for transport to the workplace and other economic uses, for recreation and leisure activities, and for emergency and security services.

Road salt is the deicer of choice for winter road maintenance.

There's something else that we rely on: road salt. It's the deicer of choice for keeping roads passable throughout the winter.

The benefits of using road salt to keep the thoroughfares open don't come without costs, both economic and environmental. Recognizing this, and concerned about the environmental implications of road salt applications, the Transportation Association of Canada's (TAC) Chief Engineers' Council, the Road Salt Working Group (a subcommittee of the Maintenance and Construction Standing Committee), and the Environment Council launched an initiative to identify and document new ways of handling and using road salt. Transportation professionals from across the country worked together through the 20-member project steering committee and 17-member project team to produce three important documents:

- *Road Salt and Snow and Ice Control Primer*: An executive summary of the project, written for the general public, that provides information on the importance of road salt use to maintaining a safe and efficient transportation system that sustains Canada's economy.
- *Road Salt Management Guide*: A comprehensive reference guide which addresses transportation and Canada's economy and quality of life, road salt and the environment and road salt management practices.
- *Syntheses of Best Practices for Road Salt Management*: A series of syntheses of best practices related to the effective management of road salt use in winter maintenance operations.



## This guide's for you

This learning guide is based on the best practices in the *Road Salt Management Guide* and the *Syntheses of Best Practices for Road Salt Management*. If you're an operator or supervisor, then this guide is for you.

As a winter road maintainer, you're on the front lines in the battle against snow and ice on roads. In fact, the only thing that gets out there ahead of you is your plow blade. You probably already know that road salt is the most effective, cheapest, and easily handled de-icing material. There may be alternatives out there, but they usually cost a lot more, require special care when handling, and are only effective under certain weather conditions. Road salt is still the most reliable de-icing chemical available.

## The "4 R's" of winter road maintenance

There was a time when winter road maintainers lived by a simple rule of thumb: "when in doubt, put it out." In other words, it was better to err on the side of caution and put down a lot of road salt—and put it everywhere—just to make sure. But those days are long gone.

The modern winter road maintainer has a new mantra: "put the **R**ight amount of the **R**ight material in the **R**ight place at the **R**ight time." In other words, use road salt more wisely and effectively. The benefit of this approach is that road salt usage is *optimized*. This translates into savings for the organization, and minimizes the impact of road salt on the environment. This guide is designed to teach you how to optimize road salt usage while continuing to keep winter roads safe for commercial, passenger, and emergency vehicles.

## Your guide to road salt optimization

Optimizing salt use means being smarter about you how put it down.

Optimizing road salt usage means being smarter about how you apply the material. In most cases it will mean that you use less road salt, but that is a result rather than an objective. In order to use road salt more wisely, you'll need to become a better decision-maker, and in order to do that, you need to improve your knowledge. That's where this learning guide comes in.

The guide consists of six modules:

- **Module 1** sets the stage by looking at the importance of transportation to our economy and way of life; the economic implications of winter maintenance; and the cost-benefits of winter maintenance.

- **Module 2** explores the science of road salt and ice. In Lesson 1 we look at the principles of ice formation. Lesson 2 examines the concept of freeze point depressants and how they work to prevent or break the bond between pavement and ice. In Lesson 3 we consider alternative de-icing chemicals and their role in winter road maintenance. Lesson 4 looks at application strategies, in particular anti-icing, a modern preventive approach that aims to keep the ice-pavement bond from forming.
- **Module 3** looks at equipment and technologies used by modern winter road maintainers. In Lesson 1 we survey plows and spreaders and how they can be put to work to optimize road salt usage. Lesson 2 examines pavement condition tracking and forecasting techniques and technologies, including road weather information systems.
- **Module 4** deals with road salt and the environment. In this module we look at the pathways by which road salt can make its way into soil and groundwater, and the effects it can have on vegetation and wildlife.
- **Module 5** looks at snow and road salt handling. In Lesson 1 we look at road salt handling and storage at the road maintenance yard. In Lesson 2 we examine disposal strategies and techniques at snow disposal sites.
- **Module 6** considers the importance of monitoring and record keeping in winter road maintenance.

The objective throughout these modules and lessons is to help you, as an operator or supervisor, to understand how it is possible to use road salt more effectively while continuing to provide safe roads during winter and minimizing the impact on the environment.

## The same, but different

You have a lot in common with winter road maintainers across the country.

As a winter road maintainer, you have a lot in common with operators and supervisors in other jurisdictions across the country. At the same time, your job is very unique. Every road jurisdiction has a different transportation infrastructure to service. No two agencies face the same weather conditions. Each organization has a different mix of human resources and equipment available to keep the roads open during winter. Levels of service differ from one jurisdiction to the next, winter maintenance strategies are designed to meet specific local challenges, and public expectations change from one jurisdiction to the next.

In other words, while all winter road maintainers may be out on the front lines keeping the roads open, they could be using very different means to achieve similar ends.

This learning guide deals with general principles of winter road maintenance that can be applied in every jurisdiction, but it is beyond the scope of this document to prescribe practices that apply to specific road authorities. The best practices upon which this guide is based have been carefully researched and prepared and are endorsed by the Transportation Association of Canada's (TAC) Chief Engineers' Council, the Road Salt Working Group (a subcommittee of the Maintenance and Construction Standing Committee), and the Environment Council.

This material is provided as advice to winter road maintainers for consideration when developing their own policies, practices, and procedures. Keep in mind that the best practices are to be used in concert with the legislation, manuals, directives, and procedures of your individual road agency.

The material in this learning guide will be incorporated into your agency's current or planned training programs.

## A word about what's inside

Before we dive into the learning guide, let's take a look at what you'll see inside. We know that your time is valuable, and that the technical nature of this subject-matter may not be the most exciting thing you've read lately. So we've tried to make the learning experience as easy and enjoyable as possible.

We want you to learn, and to enjoy doing it.

The first thing you'll notice is that, unlike a lot of those technical reference manuals and user guides you may have seen and tried to read, our tone is conversational. We talk directly to you in a casual voice that's free of jargon and technical terminology. We even throw in a bit of humour every now and then. Unlike those other documents, we want you to learn, and to enjoy doing it.

Each lesson begins with a summary of the topics that we'll be discussing. This is followed by a conversation among fictional characters in a fictional maintenance yard: Pine Junction. Any resemblance between these characters and anyone you may actually work with is entirely coincidental. This dialogue sets the stage for the material covered in the lesson. Once you've read the list of topics to be covered and the dialogue, you'll have a pretty good idea of what you're going to discover in the lesson.

## Getting around: Navigation aids

The margin along the left side of each page is an area that we call the “fast track.” This serves three purposes:

We call this area the “fast track.”

1. Document designers tell us that “white space” on the page is visually pleasing to the eye, making it easier for you to read what’s on the rest of the page.
2. We can provide a capsule summary of the important points on the page. If you don’t have time to read the whole thing, at least you’ll know what you’re missing, and you can come back to it later if you’re interested.
3. The capsule summaries serve as “navigation aids”, which means that they provide a reference point if you need to come back to a section of a lesson and find a particular piece of information.

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### -TIPS, NOTES, and WARNINGS-

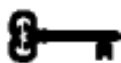
Although we feel that all of the information in the learning guide is important, some items need to have special attention drawn to them. We present these in the form of “Tips”, “Notes”, and “Warnings”. Information presented in this format is related to, but not part of, the discussion at hand.

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On the other hand, when we want to emphasize an important point *in* the discussion, we highlight it in this fashion.

If you only had time to skim a lesson, you could quickly grasp the essence of it by reading just the list of topics covered, the dialogue, the fast track items, the highlights, the tips/notes/warnings, and the summaries at the end, which we’ll discuss in a moment.

Our approach is based on the concept of self-assessment and instant feedback to confirm what you’ve just learned. Throughout this guide you’ll find “Quick Quizzes” that are designed to make you reflect on concepts that have been presented in the lesson. Once you’ve taken your best shot at answering the questions or offering solutions, you can check the answers that we provide following the quizzes. Look for the key to find out how you did. Sometimes there is no right or wrong answer, a reflection of the fact that operators in different jurisdictions might do things differently. We offer possible solutions, but our word isn’t always the final one.



When you reach the end of the lesson, we offer you a quick summary of where you’ve been. This is usually a restatement of the key points of the lesson that you should have picked up along the way. You’ll find it in the section entitled “Where have you been?”.



Knowing where you've been is useful, but knowing where you're going can be just as helpful. We'll let you know what's in store in the next lesson, in the context of what you've just learned. You'll find it in the section entitled "Where are you going?"

This guide can be used in different ways:

- You can use it at your desk, working and learning at your own pace.

-OR-

- You can use it in a classroom setting as a participant manual.

If you will be participating in a classroom training session, you will gain the maximum benefit by reading this guide in its entirety, if possible, before attending.

We hope that whatever you take from this guide will confirm the importance of the role you play as a winter road maintainer, and will generate discussions among your peers. Winter road maintenance is not a new profession, but there are always new techniques, technologies, and equipment coming along that change the way you operate. Keeping up with the changes, or staying ahead of the game, is a continuous learning process.

Let's start learning.

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# Module 2, Lesson 4

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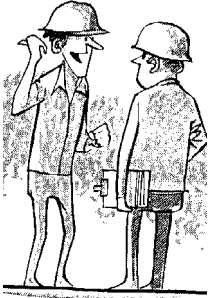
## Application strategies: Anti-icing and deicing

Follow the preventive route and you'll pay now and pay less; follow the reactive route and you'll pay later, but you may pay through the nose.

### *Well, what shall we talk about?*

- In theory: Anti-icing and deicing concepts
- Watching the clock: The importance of timing in anti-icing
- The shopping list: Questions and variables to guide decision-making
- LOS leader: The value of the Level of Service document
- The Three T's
- Brain power: The role of knowledge in anti-icing
- Breaking it down: Anti-icing strategy components
- Putting it down smartly: Best practices to optimize salt usage

## Cafeteria. Pine Junction maintenance yard. November.



“I’d like input from everyone here,” Roch Salterelli explained to the group assembled around the table with him in the cafeteria. “We all need to understand what has to be done, we all must buy into it, and who knows—you might have some good ideas to contribute. Even you, Johnny,” he laughed, turning to John Rhodes at the end of the table.

“I’ve got an idea already, Roch,” Rhodes responded. “How about we break for lunch?”

“Johnny, this *is* your lunch break. It’s called a “lunch and learn” session, remember? Everyone agreed to it.

“OK, OK. You can’t blame me for trying, though.”

“You’re trying at the best of times, Rhodes,” cracked Rusty Steele.

“OK, guys,” Roch interjected. “It’s lunch and learn, not crash and burn. Can we get back to the session? Let’s go around the table. I’d like each of you to tell me what you think the difference is between anti-icing and deicing. Let’s start with you, Rusty.”

“Pretty much the same thing, I think,” Rusty answered. “It’s just a different way of saying it.”

“Thanks, Rusty. Johnny, what do you think?”

“Anti-icing involves liquids and the other one uses solid rock salt.”

“OK. Crystal, you’re next.”

“I had a look through your learning guide, Roch. It was out on the desk. So I know the answer. Do you want me to say it?” asked Crystal Ion.

“Sure, but let’s just see if anyone else has an idea first. Brine?”

“I think one is done before the storm, and the other is done afterwards,” Brine Watters offered.

“What about you, Cal? I know you’re new here, but do you have any idea?”

“Well, I’ve only heard the word ‘deicing’ for planes on the runway, so I’m not sure. Is it for keeping the ice off the salt trucks? I don’t really know what anti-icing is,” Cal Leach explained.



“Some of you were close. Why don’t you explain the difference, Crystal?”

“Well, if I remember what I read in the guide, anti-icing is preventive action to keep ice from forming on pavement. You apply either a dry or pre-wet solid, or a liquid, to prevent the bond. Usually you do this before the storm or in its early phases, but then you can continue once the storm is underway. Deicing is what you do in reaction to ice that’s already formed. Anti-icing is supposed to take less road salt.”

“Perfect. That’s it,” replied Roch. “As you know, we’re going to be using an anti-icing strategy as much as possible this winter. It’s still new, so things may not always go according to plan. Our objective for the first winter is to reduce the amount of road salt we use by 15%. I don’t think it’ll be too hard to achieve that if we do things smarter.”

“What’s wrong with the way we’ve been doing it, Roch?” asked Rhodes. “The roads have been kept clean, and I don’t remember seeing a long list of complaints from drivers about slippery conditions.”

“Absolutely, Johnny,” Roch agreed. “And we’re going to keep providing that same level of service. But we’re going to do it by optimizing our use of road salt. And in order to do that, we have to use the road salt, and the rest of the equipment, in a different way. More strategically. Target the treatment to the conditions instead of just spreading as much road salt as possible on every road during every storm.”

“How will we know what treatment to provide on what road during what conditions?” asked Watters.

“Good question, Brine,” Roch answered. “We’ve already begun to review our level of service standards, and this process will continue. Once we know what the road authority expects, and we can determine what the public expects, we’ll know what we have to do to keep everyone happy. It’s an ongoing process, and you guys will be kept in the loop every step of the way. Meetings like this will become more common.”

“Happy meals,” grumbled Rhodes. “We’ll have to put up some golden arches.”

“Well, just put them high enough to get the trucks under, Johnny,” laughed Roch.

## Anti-icing or deicing: Pay now...or pay later

You've probably heard the expression, "you can pay me now or you can pay me later." You may have heard it from your auto mechanic as he explained that it would cost a few bucks to replace that ailing oil pump now—but a lot more to replace it later, after it fails and causes extensive engine damage.

Either way, you're going to have to pay. Follow the preventive route and you'll pay now and pay less; follow the reactive route and you'll pay later, but you may pay through the nose.

You have two options when it comes to keeping the roads clear: preventive or reactive.

The same principle applies to snow and ice fighting on the roads. You have two options when it comes to keeping the roads clear and safe before, during, and after winter storm events: preventive or reactive.

- One approach is called *anti-icing*. It is a *preventive*, systematic winter road maintenance strategy. Its objective is to prevent the formation or development of bonded snow and ice for easy removal. If a bond does form after an initial anti-icing treatment, it will be a weak bond that can be removed more easily than one that has formed in the absence of any initial treatment.

Anti-icing can support the requirements for safe road conditions *during* a winter storm. To be successful, the timing of the operations must be consistent with the objective of preventing the formation or development of bonded ice and snow. It requires the use of judgement in decision-making; climate and pavement surface information; and prompt, timely action. It is the most effective and efficient way to achieve a "bare pavement" level of service condition.

- The other approach is called *deicing*. It is a *reactive* response to road conditions. Its objective is to break the bond of already-bonded snow and ice. It is usually initiated after a minimum of 25 mm (10 in.) or more of snow has accumulated or bonded to the road. Because it is reactive, it cannot support the requirements for safe road conditions *during* a winter storm. It can be difficult to achieve bare pavement in a reasonable amount of time following a storm event by following a reactive deicing strategy only.

Removing the snow pack after it has bonded is more difficult than keeping it from forming in the first place.

Like body weight, which is easier to keep off than to lose, removing the snow pack after it has bonded to the pavement is more difficult than keeping it from forming in the first place. Even so, it is not always an either/or decision when it comes to deciding which approach is most suitable for your particular circumstances—there are times when there is no other option than to undertake deicing operations after the ice-pavement bond has formed.



If a sudden and/or unexpected change in weather occurs, or there are insufficient personnel or equipment to conduct initial and subsequent anti-icing treatments, there may be no way to prevent the bond from forming. In those instances, deicing is the only option available to break the bond before mechanical removal of the accumulated precipitation. Keep in mind, though, that this approach requires more time, chemicals, and equipment to achieve the level of service requirement.

### Quick Quiz

**Describe how your organization responds to winter storms. Is every response the same? If not, how do they differ? Would you characterize your response strategies as anti-icing or deicing?**

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## Time flies when you're fighting snow



As we have learned in previous lessons, the main role of road salt is to prevent or destroy a bond from occurring between the snow and the road surface. This enables you to more quickly achieve a bare pavement condition following the storm, or to destroy the bond that has already formed.



Temperature, moisture, and time are the variables involved in the process of salt melting ice.

We know that road salt requires TMT to dissolve into brine so that crossfall and traffic action can distribute it evenly across the road surface. Whether you've applied the road salt ahead of the storm, or after it's moved on to the neighbouring jurisdiction, once the resulting brine is in place, less expensive mechanical removal of the snow can proceed.

If you've acted proactively, that's called anti-icing, and it requires less road salt. If you're acting reactively, that's called deicing, and that strategy requires more road salt.

The key to effective road salt use is all in the timing. It is the *timing* of the application of either a solid, liquid, or pre-wetted mixture, rather than the *choice of material* that

It's the timing of the application, rather than the choice of material, that defines whether your strategy is anti-icing or deicing.

defines whether your strategy is anti-icing or deicing. While it is critical that you use the right material, and put it down in the right quantities at the right locations, the effectiveness is determined by the timing of the application.

Put it down too soon and it could be blown away or dispersed by traffic before it has a chance to go to work. Put it down too late, and you've missed the chance to prevent the ice-pavement bond from forming, and now you have to go into deicing mode and apply a greater amount of road salt.

To get the timing right, you need knowledge. To get knowledge you need information, experience, and training. There are a lot of variables to consider, and in order to make the right call, you have to know what they mean and how they interact.



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-THE ROAD SALT BILL OF RIGHTS-

**4 R's:** The most efficient way to use road salt is to apply the *Right* material in the *Right* quantities at the *Right* locations at the *Right* time.

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## It's your call

Several variables come into play in making the right call. You need to have a solid understanding of the complex interplay among climatic conditions, pavement condition and temperature, level of service, type of chemicals available, the properties of those chemicals and how they work, and their method of application.



As we learned in the previous lesson, chemicals can be applied to roads in one of three states:

- Liquid
- Dry solid
- Pre-wetted solid

The choice of material and the timing of the application will be determined by your level of service, maintenance strategy (anti-icing or deicing), weather conditions, road conditions, equipment availability, and public expectations.

The better your information and knowledge, the more likely you are to make the right call.

In many areas, the motoring public has come to expect that bare pavement conditions will be maintained throughout the storm period. Delivering this level of service requires more frequent road salt applications, and if you don't conduct snowfighting strategically, you could end up using more road salt. During storms with heavy snowfall, for example, frequent plowing is necessary to clear the snow from the road

surface. Road salt should be applied behind the plow blade to avoid wasting it. Otherwise, it'll be plowed to the sides of the road before it has had time to work.

Careful co-ordination with plowing is an integral aspect of anti-icing.

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-NOTE-



**Let it flow:** "Chemical plowing" is an approach that uses road salt to reduce the amount of snow that has to be removed by mechanical means. This approach is less efficient and less cost-effective, but may be necessary under certain circumstances in the interests of safety and other considerations, for example lack of snow storage space on the right-of-way. This practice is most common in urban areas. Keep in mind, though, that it results in more road salt entering the environment.

Besides in an anti-icing role, road salt is also used in a deicing role where snow pack has occurred on surfaces where bare pavement is the required level of service. If storm and temperature conditions did not allow the assigned resources to keep up with the accumulation, road salt is applied to melt through the compressed layer of snow, disperse brine at the interface with the road surface and allow mechanical removal to more easily be done.



As we learned in earlier lessons, this mode of road salt use requires TMT, with the time being dependent on the thickness of snow pack and the "staying power" of the dissolving road salt particles.

Deicing is a less efficient use of resources.

Deicing is a less efficient use of resources. Mechanical removal of snow pack can be very difficult and road salt is needed to break the bond to the pavement. This requires higher application rates of road salt. The more efficient approach is to use road salt to prevent the bond in order to achieve bare pavement as soon as possible after the storm has passed.

The bottom line in all of this is that there are consequences to these frequent applications of road salt in order to meet a level of service expectation. It is important that you—and the public—clearly understand the price that sometimes has to be paid in order to deliver the expected level of service.

You can make the right call if you have good information and strong knowledge.

After weighing all the information, the right call may simply be to do nothing or to send out the plows but not spread any chemicals at all during the storm event. The better the information, and the stronger your knowledge, the more likely you are to make the right call for the conditions.

## A systematic approach to maintenance

Anti-icing operations require a systematic approach based on continuous monitoring and assessment of information from a variety of sources. Here's a partial list of the questions that you need to ponder as you put together your plan of attack:



- What is the level of service for roads in the maintenance jurisdiction?
- What kind of weather event is on the way, and when is it expected to arrive?
- Will it contain precipitation, and if so how much and what kind?
- At what point in the storm will the precipitation fall?
- How long will it last?
- What is the current condition of the road, including pavement temperature?
- What is the current air temperature, wind speed, and humidity level?
- How many personnel and how much equipment is available to deal with the event?
- What kinds of chemicals are available for the anti-icing operation and how should they be spread?
- When should they be spread?
- When should they be re-applied?
- At what point should the plows be sent out?
- Should your contractors be called in or placed on standby?

Like snowflakes, no two storms are alike. There are simply too many variables for the exact conditions to occur twice.

The list seems endless. And if even one of the variables changes significantly, it can affect your assessment and may necessitate a change in strategy. Like snowflakes, no two storms are alike. There are simply too many variables for the exact conditions to occur twice.

Most often, you are making your decisions on the fly, adjusting your strategy as you get new information. You need to be able to make sense of it, put it into context, and know how to transform your knowledge into action.

Try your hand at transforming knowledge into action in the following Quick Quiz.

## Quick Quiz

Knowing the pavement temperature at a specific location is good information. But it doesn't really mean much unless you also know, for example, that the pavement temperature is on a downward trend, humidity levels are high, dew point temperatures are low, skies are clear, the end of the day is approaching, and the roads will soon be clogged with commuter traffic.

Taken together, what does this information tell you? What kind of action would you take?

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### Answer



If you consider all the variables, you can determine that you should be prepared to deal with the possibility of black ice forming on the road during rush hour. One plan of attack may be to apply a straight liquid to the bare pavement in advance of the storm to prevent the ice-pavement bond from forming.

What other strategies could you follow?

Throughout this learning guide, we'll be taking a close look at all of the variables mentioned above, and more. We're going to show you how to turn information into knowledge, and how to apply that knowledge so that you can make sound decisions on what course of action, if any, is best to take when weather events are on the way or in progress. In this lesson, we'll be looking specifically at the pros and cons of anti-icing and deicing.

## Your LOS is their gain

How do you decide which road will receive a particular treatment?

Underlying any winter maintenance strategy, whether it is anti-icing or deicing, is the rationale for taking that particular course of action. You could, for example, put a strategy in place to achieve bare pavement on every road in your jurisdiction; or you could leave the main highways covered with snow pack. After all, anti-icing will work anywhere if you follow the appropriate procedures. But how do you decide which road will receive a particular treatment?

The LOS standard is an objective for the winter road condition at a given time during and after the end of the storm.

The answer is provided in your level of service (LOS). This document is a prerequisite to providing snow and ice control. The LOS standard is a defined “primary objective” for the winter road condition at a given time during and after the conclusion of the storm. To meet the objective, you need to begin proactive operations at the onset of the storm, followed by continuous operations that “keep up” with the weather.

Think of the LOS as your grand strategy for snowfighting. The first thing you’ll want to do when planning a course of action is to check the LOS standard. After all, there’s no use putting together a strategy for a bare pavement end-of-storm condition when all that the LOS requires is centre-bare.

Usually the LOS dictates a window of time either directly in hours, or indirectly by a snow accumulation amount. In other words, it dictates maximum accumulation amounts allowable on a route at any point during the weather event; or it prescribes a condition that must be met within a certain time period following the end of the storm. The LOS standard is most often determined on the basis of traffic volumes, road classification, importance of the corridor for access (e.g. emergency route, truck route, economic corridor), or other factors.



The highest level of service standard usually has bare pavement as the desired outcome.

The highest level of service standard, normally for the highest priority roads, usually has “bare pavement” as the desired outcome. Bare pavement, which is free of contaminants (e.g. sand, slush, snow pack, ice, etc.), provides the best possible friction for vehicle tires to maintain control. On less traveled roads, a centre-bare LOS or snow pack condition may be appropriate. For centre-bare conditions, less road salt is used, whereas for snow pack conditions road salt would only be used where there are extreme icy conditions or where mechanical plowing, grading, or applying abrasives does not improve friction.





The goal is to use the optimal amount of road salt to achieve the LOS.

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-TIP-

**Prevent the ice-pavement pond:** The use of road salt on a snow pack road can cause pot holing in the snow pack, and water ponding on the road due to poor geometrics. This ponding can cause saturation and softening of the roadbed. These two factors can actually increase winter maintenance costs.

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A bare pavement standard for roadways requires both chemical and mechanical removal. Though mechanical removal is much more cost-effective at removing quantities of snow and slush accumulation, only a chemical, such as road salt, will ultimately provide bare pavement under continuing winter conditions. Your goal is to achieve the prescribed condition using the optimal amount of road salt necessary to do so.

For example, if the prescribed end-of-storm condition for a secondary road is solid snow pack within 24 hours after the event, then no chemicals are required, and you can send the plows there after you've dealt with the main routes that have higher service level requirements.

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-TIP-

**Getting good grades:** Road salt gradation is an important factor in helping you to achieve your LOS standard.

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However, if the LOS calls for "bare pavement", which is the highest maintenance standard, as soon as possible after the end of the storm event, then a systematic anti-icing approach is the preferred strategy. You can achieve bare pavement by following a reactive deicing approach, but it would require more equipment, more personnel, more chemicals, and more time.

### A gritty performance



Abrasives such as sand are important in winter maintenance when you need to improve traction rapidly at colder temperatures.

Some jurisdictions routinely blend up to 50% road salt in sand for deicing purposes. However, with a fixed high-ratio blend, if the objective is traction, then too much road salt will be spread. If the objective is deicing, then too much sand will be spread. And the more sand you spread, the more costs you'll incur in spring when it comes time to clean the sand from the streets and storm sewer grates.

Either way, materials are being wasted.

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–TIP–



**Mix-master:** When mixing abrasives and road salt to prevent freezing in piles for yard storage, only about 2% to 5% road salt is needed. Any more is wasteful. But these low levels can only be achieved in engineered piles.

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## By the book: Doing more with LOS

LOS standards can help you establish priorities and determine theoretical routes for equipment to follow.

As a playbook, the LOS document can help the operations manager assign resources. You can use it to establish priorities and to determine theoretical routes for equipment to follow. This way, you'll be sure to assign the necessary amount of equipment to cover all road sections during storm conditions.

The skilled road maintenance strategist will analyze LOS standards for theoretical routes with an eye to using combined plow and spreader units in areas where the cycle times for plowing and spreading are similar, and where the spreader capacity for the route is appropriate.

As an operator, your job is to deliver the prescribed LOS, not to establish what the level should be. However, you should be aware that LOS priorities are not always communicated to the traveling public. As a result, the public may have widely varying perceptions regarding the service they receive.

There are three LOS perspectives that may not always have the same objective:

1. The LOS prescribed by the road authority.
2. The service that is actually delivered by the road maintainer.
3. The service that the driving public expects.

The ideal situation is when the maintenance services that are provided and those that are expected by the public are the same as the LOS prescribed by the road authority. Public expectations should be heeded as much as possible. Where the public expects a higher LOS than prescribed, there will be pressure to increase it.

There should be a regular review of the road network, by the part of the organization that establishes the LOS, to ensure that the appropriate standard is established. If it is necessary to raise the standard, that should be done. If the standard is deemed appropriate, public expectations can be managed through information campaigns.



### Residents benefit from Burlington's LOS

In Burlington, Ont., snow plowing on primary and secondary roads begins when the accumulation of

to the salting and sanding of roads. Primary (or arterial roads) are the first roads to be plowed. Secondary (or collector roads) are plowed next. The balance of the residential streets known as locals will follow upon snow accumulation of 75 mm (3"). The level of service is to complete all city roads 24 hours after the snowfall stops.

Generally, after all residential streets are plowed, a re-plowing program is undertaken to clean up snow left on the travel portion of roads due to cars parked during the initial plowing, and to ensure that surface drainage can reach the catch basins during a thaw.

Plowing cul-de-sacs, where the majority of the frontage is taken up with driveway entrances, provides limited lawn frontage for snow storage. As a result, snow is unavoidably deposited on property frontages and driveway entrances following a major snowstorm.

(Source: <http://www.burlington.ca>)

There are three components to the level of service standard. Together they provide the basis on which you will make your strategic decisions:

1. **Initial Response Time.** This determines how you time the callout of your crews and equipment at the start of a storm. Here are some of the questions that you'll need to consider at this stage:
  - ✓ Are you following an anti-icing policy that requires you to put the chemical down before the start of the storm so that you can get the brine forming immediately?
  - ✓ Or is yours a deicing strategy that doesn't require action until early on in the storm?
  - ✓ Are abrasives needed, and if so, when?
  - ✓ What about calling out the plows? If you're following an anti-icing strategy, you'll have to make sure you co-ordinate spreading and plowing so that you don't push solid road salt or brine off the road prematurely.
  - ✓ Or does the LOS specify a maximum accumulation? If so, that will determine when the plows hit the streets.

If your answer to any of these questions is unclear then you need to review your policies, if you have them; if not, you need to establish them clearly and as soon as possible.

2. **Service Delivery or Cycle Time.** This dictates how quickly the operators need to get around their routes. This cycle time will help you to allocate equipment and labour, as well as determine the optimal spacing of your service facilities. For



high standard roads it may be an hour and 20 minutes, whereas for lower standard roads you may have a cycle time of eight hours.

Whatever your policy on service delivery, it is important to have it documented and communicated to staff and the public.

- 3. **End of Storm Performance.** What is it that you expect to have occurred at the end of the storm? For example, how soon after the storm do you want to achieve bare pavement. Is it as soon as possible, or within a specific time frame?

One of your jobs is to ensure that all personnel understand what is required in the LOS.

As a supervisor, one of your jobs is to ensure that all personnel in your organization understand what is required in the LOS. Another task is to manage public expectations by keeping motorists informed about the services that you will be providing.

Quite often, roads have been over-serviced either because the operators didn't know that some lower level of service had been prescribed for a specific road and they ended up servicing it to the highest standard. This may have satisfied public expectations, but it also resulted in more road salt being used than might otherwise be necessary. It's all about balancing competing priorities.



The success of your winter maintenance program depends upon having the right people, materials, and equipment deployed at the right time and location in support of the right objectives.

Sometimes it's tough to keep all the balls in the air, but when you succeed, everyone gains from the LOS.

### Quick Quiz

**Are you aware of the LOS standards for the roads on your route? Explain how different standards affect the strategies that you employ to maintain the roads.**

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# High tech, low salt: A modern approach



We learned earlier in this lesson that anti-icing is a systematic, managed road salt application strategy. In an earlier era, when cost and environmental protection did not have the profile that they now enjoy, winter road maintenance strategies could be summed up in a phrase: “when in doubt, put it out.” In other words, it was felt best to err on the side of caution. Too much road salt was better than not enough.

Today, due to cost and environmental considerations, just the right amount of road salt is better than not enough. Too much is simply too much.

There have been significant advances and improvements in recent years in winter maintenance equipment, road and weather monitoring technology, and knowledge about the science of salt and ice. It is now possible to use this new knowledge, technology, and equipment to fight snow and ice more effectively and at lower costs.

Anti-icing has emerged as the preferred approach to winter road maintenance because it relies on the latest tools and technologies, combined with human knowledge, skills, and experience, to achieve prescribed LOS requirements using the optimum amount of road salt. The objective is to use road salt in a smarter way; the result is cost-savings and a healthier environment.

Ideally, we could remove all snow and ice through mechanical means such as plows and blowers. But in reality, chemicals such as road salt are usually necessary to prevent the formation of the ice-pavement bond (anti-icing), or to break the bond once it has formed (deicing) to allow effective plowing.

For chemical application, equipment advancements such as electronic ground speed spreader controls help to more precisely control the application rate. This equipment helps to ensure that the right amount of material is placed in the right location to do the job. It reduces costly waste and can provide useful records of material use for future planning.

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–TIP–

**Keeping up with the storm:** If changes during the storm event result in strongly bonded snow or ice, use deicing techniques to break the bond and return the road to acceptable conditions. Apply abrasives only if necessary. Once acceptable conditions are recovered, return to preventive anti-icing operations.

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Other tools that help road maintainers to provide safe roads with an optimal amount of road salt include pre-wetting equipment that adds brine to solid chemical to initiate the dissolving action, fixed and mobile brine dispensers for anti-icing operations, and pavement sensors to provide real time information on road conditions.

Anti-icing relies on the latest tools and technologies combined with human knowledge, skills, and experience.

Equipment is constantly improving, becoming more sophisticated, durable and easier to use, but the potential benefits can only be realized if maintenance staff are thoroughly trained and material use is closely monitored. We'll take a closer look at the latest technologies and equipment in Module 3, "Equipment and technologies."

## You're among trends

The highest LOS standard is bare pavement as soon as possible after the end of the storm. The most efficient way to achieve this policy objective is through an aggressive, well-managed, systematic anti-icing strategy.

There is a great deal of research on improving the way in which salt is placed on roads.

In an anti-icing strategy, road salt is "placed" rather than "spread." There is currently a great deal of research and development activity aimed at improving the way in which road salt is placed. The goal is to continually improve cost-effectiveness by staying abreast of new developments and ongoing research. The more you know, the better positioned you'll be to either support or dismiss the methods endorsed by other jurisdictions.

The latest trends in sand and road salt application that have been identified in the *TAC Salt Management Guide* confirm the emergence of anti-icing as the most effective way to achieve high LOS standards using an optimal amount of road salt.

Let's take a look at some of the reviews.

**Here's what they're saying about anti-icing trends across Canada...**

"Sand just doesn't cut it when it comes to providing bare pavement. Only road salt can meet this objective, if it's used strategically. Two thumbs up for sodium chloride."

--*Grit Weekly*

"This is the final frontier: technology is now being used to reduce road salt usage."

--*Spreaders Illustrated*

"This trend could walk away with all the awards this year: controlled road salt placement rather than a haphazard spreading approach."

--*On the Road*

"Here's a trend that's turning the old world upside down—say goodbye to high ratios of sand/salt blends."

--*Mix Monthly Digest*

"Never mind drawing a line in the sand. Now they're drawing lines with road salt. The new spreading mantra is "windrow, don't broadcast."

--*Broadcast News*

"Better late than never? Hardly. Better early when it comes to getting the road salt down before the storm."

--*The Salt Times*

"Less is more. More or less. The trend is to lower application rates on higher standard roads, while continuing to provide safe roads."

--*Blade and Plow Report*



## Salt, plows, and brains: A powerful mix

Your experience, training, and ability to interpret data constitute knowledge.

We've talked a lot about technologies, equipment, and chemicals. These are essential ingredients in any anti-icing strategy, but there's one element missing in that list: *knowledge*. You could have access to the most advanced, state-of-the-art tools, but if you didn't know how to use them, you wouldn't achieve your objective, which is to provide the prescribed LOS standard using the optimal amount of road salt. Your experience, training, and ability to interpret data are what constitute knowledge, and you need it in order to develop a complete and successful maintenance strategy.



People and their collective knowledge are the most important element of the winter maintenance resource mix. Just as the best equipment in the world is useless without the knowledge of how to use it properly, the best knowledge in the world can't be put to good use without proper equipment and

training. But when you've got it all, you've got a powerful ice- and snow-fighting weapon at your disposal.

The skillful blending of knowledge and technology will result in a successful anti-icing strategy.

If you're the operations manager, your responsibility is to use your dedicated staff resources most effectively by assigning them to their routes with the proper equipment; scheduling them effectively; deploying them at the appropriate time; and ensuring that there is ongoing training.

If you're the operator, your responsibility is to know your route, know where and when to salt and sand, and know spread patterns. You've got a lot of technology riding with you in the cab, but you still need to understand how to read, interpret, and then act upon the data that's presented to you.

Much of the inappropriate use of road salt has come from a lack of understanding of how much is enough or a philosophy of "when in doubt, put it out". Considerable savings in road salt use can be achieved, without sacrificing safety, through better training of winter maintenance staff. The skillful blending of knowledge and technology will result in a successful anti-icing strategy.

Let's take a look at how to put knowledge and technology to work as we break down the anti-icing strategy into its component parts.

## Anti-icing strategy components

Anti-icing is a strategy that calls upon all of your knowledge and resources at every phase of the storm.

Anti-icing is a systematic approach to preventing the formation of the ice-pavement bond. It calls upon all of your knowledge and resources at every phase of the storm.

It involves a complex interplay among tools, technologies, personnel, and numerous decision-making variables. If it's done well, you can "keep up" with the weather and achieve your LOS standards using the optimal amount of road salt.

We've already examined some of the following decision-making variables in previous lessons. In Module 3 we'll be looking more closely at tools and technologies. In this lesson we'll focus on the strategic operations of anti-icing, from the initial activities in the beginning phase, to ongoing actions throughout the storm, and finishing up with post-event evaluations and analysis.

The complete picture is provided in Table 1.



Operations	Tools & Technologies	Decision-making variables
<p><b>Beginning</b></p> <ul style="list-style-type: none"> <li>● information gathering, monitoring, analysis</li> <li>● decision</li> <li>● action (apply chemical; plow; do nothing)</li> <li>● initial operation</li> </ul>	<p><b>Materials and equipment</b></p> <ul style="list-style-type: none"> <li>● solid chemicals</li> <li>● chemical solutions</li> <li>● pre-wetted solid chemicals</li> <li>● plows and spreaders</li> <li>● abrasives</li> </ul>	<p><b>Conditions</b></p> <ul style="list-style-type: none"> <li>● wind</li> <li>● pavement temperature</li> <li>● relative humidity</li> <li>● traffic frequency changes (rush hour)</li> <li>● mixed precipitation</li> <li>● storm within a storm</li> <li>● sudden change in weather conditions</li> <li>● development of snow pack or bond</li> <li>● availability of personnel and equipment</li> </ul>
<p><b>Ongoing</b></p> <ul style="list-style-type: none"> <li>● monitoring of road and weather conditions</li> <li>● assessment of incoming information and data</li> <li>● actions (co-ordination with plowing is very important)</li> </ul>	<p><b>Road and weather information</b></p> <ul style="list-style-type: none"> <li>● weather forecast</li> <li>● current weather conditions</li> <li>● road climate</li> <li>● real-time data</li> <li>● traffic conditions</li> <li>● on-site patrols</li> </ul>	<p><b>Level of Service</b></p> <ul style="list-style-type: none"> <li>● end-of-storm road condition</li> <li>● timeframe within which to achieve end-of-storm condition</li> <li>● acceptable intermediate conditions while obtaining end-of-storm road condition</li> <li>● frequency of snow and ice control maintenance operations</li> </ul>
<p><b>Post-event evaluation</b></p> <ul style="list-style-type: none"> <li>● lessons learned from successes and failures</li> <li>● improvements in operations and equipment identified through post-storm evaluation of practices and effectiveness of treatments used</li> </ul>	<p><b>Personnel</b></p> <ul style="list-style-type: none"> <li>● trained personnel for anti-icing decision-making and operations</li> </ul>	<p><b>Public expectations</b></p> <ul style="list-style-type: none"> <li>● intermediate and end-of-storm conditions to which public has become accustomed</li> </ul>

**Table 1: Anti-icing strategy components**

## In the beginning: Buying time

Initial treatments buy time until subsequent applications become effective.

The main objective of the initial treatment is to “buy time” until subsequent applications of chemicals can become effective. In this period, the goal is to prevent the ice-pavement bond from forming or, if it does form, to ensure that the bond is so weak that it can be removed more easily later in the storm. Applying the chemical before the storm, or in its early stages, ensures that the chemical can reach the pavement before too much snow has accumulated on the surface.

An important part of the initial operations phase is the gathering and analysis of information. To make a good decision, you need good information. It's as simple as that. The more information that you have—and the higher its reliability—the better the likelihood that you'll make the right call.

## Harvest time: Gathering the facts

When a storm is on the way, you could have information coming in from one or more of the following sources:

- weather forecasts
- weather radar data
- satellite data
- local road conditions
- RWIS data for immediate maintenance jurisdiction
- RWIS data from areas outside immediate maintenance jurisdiction that might have already been affected by the approaching storm
- pavement temperature forecasts



We'll be taking a closer look at these monitoring and tracking instruments in Module 3, Lesson 2, “Using tracking and forecasting technology.” For now, we'll discuss how you make sense of all the data at your fingertips.

## In the balance: Making the decision



After analyzing this collection of data, you should have a pretty good picture of what's coming:

- the type and amount of precipitation, and at what point in the storm it will fall
- the anticipated air and pavement temperature trends
- whether or not there will be wind, and if so at what speeds and from which direction
- the volume of traffic you can expect at the peak of the storm
- what conditions are behind the storm

Based on what you know, what you've learned, and what you've experienced in the past, you're in a position to make a decision. If your decision is to initiate a treatment, you can start assembling your resources for action.

## Go for it: Putting the plan into action



While a set of meteorological and pavement condition data is critical information, it doesn't tell you what course of action you need to follow. Your understanding of the complex interaction among the many variables is what enables you to make a decision based on the data.

This process is how information becomes knowledge. And the more experienced you become at working through this process, the better and more efficient your operations will become.

If you decide that action is necessary, then you must determine what type of treatment is required, and when it should start. You really have three options open to you at this point:

1. Apply chemicals
2. Plow
3. Do nothing

Once you've made your decision, it's time to start the initial operation.

## Apply chemicals: Stop the bond

The choice of material and timing of application should be consistent with the LOS standard.

Chemicals can be applied as liquid, dry solid, or pre-wetted solid. The choice of material and the timing of the application should be consistent with the underlying objective as defined in the level of service.

### Liquids

Generally, liquid chemicals are most effective as pre-treatments in advance of a storm or when applied in the early stages of a storm, soon after the snowfall has begun and/or when the pavement temperature is dropping toward freezing. In anti-icing operations, the objective is to prevent the formation of the ice-pavement bond. Even when an ice-pavement bond does form despite pre-treatments, it will be a weaker bond and will require less effort and fewer resources to remove later in the storm.

#### –TIP–

**Physical a-traction:** Apply liquid “on the go” for pre-wetting at the spinner. If the goal is to increase traction in a hurry, wet the salt at the spinner so that it freezes onto the road, creating a “sandpaper” effect. This approach provides traction now, and brine later as it melts from traffic action.

The liquid should be applied ahead of the expected time of ice formation.

Liquid chemicals are very effective in the fight against frost or black ice, which is caused by radiative cooling of the pavement in the presence of high humidity. The chemical should be applied ahead of the expected time of ice formation. In this scenario, the water component of the brine will either evaporate or be removed by traffic action, leaving behind only the chemical. This will result in the greatest concentration when the frost or black ice conditions occur.

Liquid applications can be made onto dry, wet, light slush, or lightly snow covered pavement. If applied too late in the storm, there is a risk that the chemical solution will become excessively diluted and lose its effectiveness. Liquids should not be applied on top of solid ice or snow pack.

Therefore, late applications should be coordinated with plowing—as much of the snow accumulation as possible should be removed before applying the chemical.

### Dry or pre-wetted solid chemicals

Late applications should be carefully coordinated with plowing operations.

Like liquids, solid or pre-wetted solid chemicals can be applied ahead of a storm or as an early-storm treatment. In the latter capacity, the application should be completed before the accumulation or snow pack bonds to the pavement. The pre-wetting technique is recommended when there is not enough moisture or accumulation on the road to initiate the brine process. Dry solid chemicals should not be applied to dry pavement and is therefore not recommended as a pre-treatment agent.

Late applications should be carefully coordinated with plowing operations to ensure that as much of the accumulation as possible has been removed in order to avoid excessive dilution and to ensure that the appropriate amount of chemical reaches the pavement surface before it loses its effectiveness.

### Plow: For the grader good

Under certain conditions, you may not need to apply chemicals. In fact, they could exacerbate the situation. If the pavement and snow are cold and dry and tire tracks are not adhering to the pavement, plowing is all that is necessary.

Applying a chemical under these conditions could cause the snow to stick to the road, leading to either snow drifting or the development of an ice-pavement bond.

### Do nothing: Stand pat and stand by

Standing by and monitoring the situation is an option.

Sometimes, doing nothing is the right course of action. However, we're not talking about ignoring the situation, turning on the television and watching the hockey game while the storm rages outside.

But when the pavement is cold (below  $-9.5\text{ C}$ ) and new or blowing snow is light, traffic and wind speeds (25 km/hr or higher) may be sufficient to prevent accumulation or compaction in tracks. Under these conditions, the application of any chemical may create, rather than cure, a problem: once a wet surface develops where before it was cold and dry, the dry snow can adhere and begin to build up.

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#### -TIP-



**Listen to the wind:** Crosswinds in excess of about 24 km/hr may cause local drifting across the pavement and retention of snow if the pavement is wet. The threshold wind speed at which this becomes a problem will vary widely with road siting and other conditions.

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If the weather forecast is for rising temperatures, however, chemicals should be applied before the snow becomes wet with the potential of forming a pack. The application should be made when the temperature rises high enough for the chemical to act rapidly, usually above  $-5\text{ C}$ .

The "do nothing" strategy doesn't mean that you do nothing.

The "do nothing" strategy doesn't mean that *you* do nothing. It means that you *do nothing to the roads* until conditions warrant. In some ways, this strategy requires more monitoring than any other. You have to be ready to react in a hurry if conditions suddenly change.

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### Traffic woes



Vehicles can affect the pavement surface in several ways:

- tires compact, abrade, displace, and disperse snow
  - heat from tire friction, engines, and exhaust systems can add measurable heat to pavement surface
  - they can cause chemicals to be thrown from the pavement
  - they can influence, both positively and negatively, the effectiveness of anti-icing treatments
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## Ongoing operations: Keeping up with the storm

Often, initial operations are not the end of the story. As mentioned earlier, they buy time until subsequent applications can be made. During subsequent ongoing operations it is crucial that you carefully co-ordinate plowing with applications.

The timing of subsequent applications should be consistent with the underlying objective of preventing the formation or development of bonded snow or ice, and should reflect an operational readiness consistent with a preventive strategy.

When it comes to plowing, too early can be as detrimental as too late.

During a storm, the snow cover should be removed as completely as possible before the chemical is reapplied, ensuring that the necessary amount of chemical reaches the pavement. Subsequent plowing operations must also be timed carefully to ensure that the chemical is not removed from the surface prematurely. This impairs its effectiveness and results in high concentrations of chemicals ending up on the roadside or in ditches and surrounding waterways. When it comes to plowing, too early can be as detrimental as too late.

Ongoing operations during the course of a storm may have to be adjusted in response to changing conditions, or the expectation of changing conditions. This is why it is critical to have as much real-time information as possible on the state of the pavement surface, current and forecast weather conditions, and traffic conditions.

Above all, the decision to send out the plows or chemical spreaders must take into account the timing of the last treatment:

- Plow too soon after the last application of chemical and you risk losing it to the environment.

- Apply a chemical before sending the plows out first and you end up with a diluted solution that may not reach the pavement.

It's all about timing and co-ordination, based on good information from every available source.

## Post-event evaluation: Lessons learned

Learn from your successes as well as your failures.

What you've learned from a storm when it's over is as important as what you did before and during the event. It may not always be possible to conduct post-mortems immediately after every storm. Some winters are like that. But when you do get some breathing space, try to review your operations. Look at what went right and what could be done better next time. Learn from your successes as well as your failures.

When you get into the habit of reviewing your actions, you can learn to improve your operations and equipment. Evaluate your practices and assess the effectiveness of the treatments that you used.

The more you know about what works the better equipped you'll be to succeed next time. Your continuous learning is all about making a difference for the environment and its human and animal inhabitants; and improving your personal confidence and marketability.

## Quick Quiz

There may not really be such a thing as a perfect storm, but your response to each individual storm can be perfectly suited to the conditions. Let's consider five different storm scenarios. Based on what you already know, combined with what you have learned in this guide so far, describe briefly how you would respond to the following storm events.

1. Short duration snowfall

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2. Continuing snowfall

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3. Snow storm with steady precipitation and steady pavement temperature conditions

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4. Snow storm with significant changes in precipitation and pavement temperature

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5. Storm within a storm

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**Answer**

1. **Short duration snowfall.** Initial anti-icing treatment may be enough for short duration events.
2. **Continuing snowfall.** When snowfall continues and pavement temperature is  $-9.5^{\circ}\text{C}$  or higher, subsequent treatments may be required to prevent the formation or development of pack or bonded pack. The snow should be plowed off as completely as possible before chemicals are reapplied, allowing necessary small amounts of chemical to reach the pavement surface.
3. **Snow storms with steady precipitation and pavement temperature conditions.** Subsequent chemical operations at regular intervals.
4. **Snow storms with significant changes in precipitation and pavement temperature.** Conditions will require operations at irregular intervals. Subsequent applications made in prompt response to changing conditions can improve friction and pavement conditions. Applications made in anticipation of changing conditions can prevent deteriorating conditions or mitigate their effects.
5. **Storm within a storm.** Treat it as a separate storm event. Chemical application just before, monitoring, irregular operations as required in response to changing conditions.

**Quick Quiz**

## The three T's

Anti-icing is based on new technologies and guided by best practices.

Anti-icing is a systematic approach to winter road maintenance based on new technologies and guided by best practices. If you're the operations manager and you want to continue to optimize road salt use, you need to pay attention to the three T's:

- Technologies
- Techniques
- Training

It's important to monitor Technological developments and to stay abreast of new and emerging Techniques as they become available. But the third T could be the most important one of all: if you don't let your crew know what you know by keeping them in the information loop through Training and communications, your maintenance strategies will be less successful.

Everyone has to understand their role, and why they are being asked to perform tasks that may be different from the way things were done in the past. You need to manage change as carefully as you manage the application of chemicals to roads.



## Maintenance strategy checklist

Got a storm on the way? Here's a checklist that can help guide your thinking process as you put together your plan of attack. These are the variables that you need to consider, and this is roughly the order in which you should address them. The first three items on the list will help you decide on the maintenance strategy. The last two items on the list will be determined by the option that you select in item #4.

### 1. Level of service

- ✓ prescribed end-of-storm road condition
- ✓ acceptable intermediate conditions until final objective is obtained
- ✓ frequency of snow and ice control maintenance operations

### 2. Climatic conditions

- ✓ probable air temperatures
- ✓ air temperatures during and after storm
- ✓ humidity levels
- ✓ dew point temperatures
- ✓ precipitation (when it is expected to start; what form it will be)
- ✓ wind direction and speed

### 3. Pavement condition and temperature

- ✓ pavement temperatures usually follow air temperatures within a few hours
- ✓ be aware of climatic characteristics of pavement environment

### 4. Maintenance strategy

- ✓ preventive anti-icing (supports high "bare pavement" service level)
- ✓ reactive deicing

### 5. Type of chemical

- ✓ sodium chloride
- ✓ calcium chloride
- ✓ magnesium chloride
- ✓ calcium magnesium acetate
- ✓ potassium acetate

### 6. Chemical application method

- ✓ solid
- ✓ liquid
- ✓ pre-wetted solid

# Optimizing road salt use: Best practices








The goal of an anti-icing strategy is to achieve the LOS standard by using available resources cost-effectively while minimizing the use of road salt. In order to meet this objective, you need three types of information:

1. **Forecast information** (what will happen), for predicting upcoming storms and potential icing events;
2. **Current information** (what is happening), providing road surface temperatures and conditions; and
3. **Status information** (what did happen), recording what was done and the level of service achieved.

TAC has identified best practices that can help you optimize road salt use.

TAC has identified several best practices that can help you optimize road salt use in winter road maintenance activities. Various strategies in providing the safest winter road surface possible are in use across the country. Given the variation in climate, road classification and evolution of maintenance standards, it is understandable that the rationale in using road salt also varies greatly.

Let's browse the **Road Salt Optimization Best Practices Hall of Fame** and see which practices are getting all the attention.

 <p>Improved information and decision-making tools will allow equipment, personnel, and salt to be used more efficiently and salt applications to be better timed.</p>	 <p>Efficient mechanical control of snow and ice will minimize the amount of snow and ice that needs to be controlled by chemicals.</p>	 <p>Whenever possible, chemical applications should occur at a time that prevents bonding of snow or ice to the surface.</p>
 <p>Proper equipment choices will help operators to place the exact amount of salt required at the precise location where it is needed, at the right time.</p>	 <p>Keeping good records of snow and ice control actions taken, along with material usage and a record of changing road conditions, will improve planning and budgeting and limit an organization's liability.</p>	 <p>The safe and effective use of any equipment requires operators to be properly trained. This is particularly important when introducing new equipment and techniques.</p>
 <p>Solid road salt should be placed on the crown or high side of the driving surface where a good crossfall and traffic will distribute the resulting brine over the road.</p>	 <p>Use wider spread patterns on deteriorated pavements where an undulating surface or poor crossfall will not ensure adequate chemical migration across the entire road or when treating frost or black ice conditions.</p>	 <p>Liquids or pre-wetted salt can prevent or clear frost more quickly than solid salt. Straight liquid will avoid the endothermic cooling effect that solid salt can have on pavements.</p>

You can find more best practices listed in the *TAC Salt Management Guide* as well as in the *TAC Road Salt Management Best Practices Syntheses*.

## Where have you been?



In this lesson, we drew upon what you learned in previous lessons about ice formation, how road salt works, and the interaction between pavement and weather conditions.

It all comes together in a pro-active winter road maintenance strategy called anti-icing. It's catching on across the country and around the world in jurisdictions that have to grapple with the challenges of keeping roads safe and the environment clean.

The objective of anti-icing is to meet the prescribed level of service and provide safe roads for motorists. One of the benefits of this approach is that you may end up using less road salt. It involves a strategic targeting of treatments to conditions, all with the objective of keeping the ice-pavement bond from forming and achieving the highest level of service standard: bare pavement as soon as possible after the storm event.

## Where are you going?



An important aspect of anti-icing is the co-ordination of plowing with the use of chemicals. Timing is everything. If you plow too soon after applying the chemical, you'll remove it from the road before it's had its full effect. If you wait too long, the solution can become diluted and may re-freeze, causing the very problem that you are trying to prevent with the anti-icing strategy. In the next lesson we'll take a look at some of the equipment that will help you to keep your roads clean and safe using the optimal amount of road salt.

Let's plow ahead.



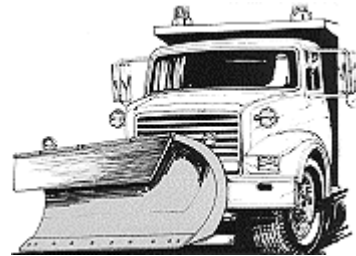
Transportation Association of Canada



## **Salt SMART**

**Spreading, Management, Application Rates and Timing**

# Learning Guide



**Module 3, Lesson 1  
Tools of the trade:  
Plows and spreaders**

*June 2004*

## ***Transportation Association of Canada***

The Transportation Association of Canada is a national association with a mission to promote the provision of safe, efficient, effective and environmentally and financially sustainable transportation services in support of Canada's social and economic goals. The association is a neutral forum for gathering or exchanging ideas, information and knowledge on technical guidelines and best practices. In Canada as a whole, TAC has a primary focus on roadways and their strategic linkages and inter-relationships with other components of the transportation system. In urban areas, TAC's primary focus is on the movement of people, goods and services and its relationship with land use patterns.

## ***Wellspring Consulting Inc.***

Wellspring Consulting is an instructional design company, specializing in adapting reference information into self-contained learning guides through the application of proven adult learning principles. With the Wellspring methodology, learners are first engaged through an enjoyable, easy to follow and entertaining writing style, then challenged using interactive techniques like problem-solving and role-playing. This fresh and stimulating approach enables learners to effectively transform dry technical information into vital, practical knowledge.

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***June 2004***

## Salt SMART Train-The-Trainer Program

TAC offers trainer workshops to accompany the Salt SMART Learning Guide in support of the best practices for the environmental management of road salts. They range from one-day overview sessions to two-day all-inclusive sessions.

*Make a SMART investment today and book your “at-home”  
trainer workshop or attend one in Ottawa!*

### Overview session

This one-day session is for trainers with formal training and experience. It is designed to walk through the *Salt SMART Learning Guide* to highlight key messages and to discuss potential areas of resistance and how to handle them.

**Member price at a member-selected location:** \$5,000 flat fee for up to 10 participants plus expenses (e.g. training room and AV equipment, catering, TAC trainer’s travel and accommodation).

**Member price in TAC-Ottawa training room:** \$899 per participant. A minimum class size is required and dates will depend on attendee preferences and trainer’s availability.

### All-inclusive session

This two-day session is for those who have little or no training experience. It offers the one-day overview combined with an extra day devoted to soft skills training (trainer techniques, adult learning principles, lesson planning).

**Member price at a member-selected location:** \$6,500 flat fee for up to 10 participants plus expenses (e.g. training room and AV equipment, catering, TAC trainer’s travel and accommodation).

**Member price in TAC-Ottawa training room:** \$1099 per participant. A minimum class size is required and dates will depend on attendee preferences and trainer’s availability.

*TAC non-members pay a 20% premium on all sessions.*

To book your trainer workshop, or for further information, contact the TAC Training Manager, Diane Jodouin at (613) 736-1350, ext. 261 or [djodouin@tac-atc.ca](mailto:djodouin@tac-atc.ca)



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The project team for this Learning Guide consisted of the following individuals:

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TAC gratefully acknowledges the dedication, guidance and input of the Subject Matter Reviewers; and the quality of work performed by the Instructional Designer.

This Learning Guide is truly a team effort by all those who have contributed financially and/or technically.

# Preface

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## TAC Learning Guide

There are some things that should be taken with a grain of salt. The information in this learning guide is not one of them.

When you consider that the nation's extensive transportation network supports a wide range of economic and social activities, it's not putting too a fine point on it to state that safe and efficient road traffic throughout the year is essential to our way of life. We rely on the road network for transport to the workplace and other economic uses, for recreation and leisure activities, and for emergency and security services.

Road salt is the deicer of choice for winter road maintenance.

There's something else that we rely on: road salt. It's the deicer of choice for keeping roads passable throughout the winter.

The benefits of using road salt to keep the thoroughfares open don't come without costs, both economic and environmental. Recognizing this, and concerned about the environmental implications of road salt applications, the Transportation Association of Canada's (TAC) Chief Engineers' Council, the Road Salt Working Group (a subcommittee of the Maintenance and Construction Standing Committee), and the Environment Council launched an initiative to identify and document new ways of handling and using road salt. Transportation professionals from across the country worked together through the 20-member project steering committee and 17-member project team to produce three important documents:

- *Road Salt and Snow and Ice Control Primer*: An executive summary of the project, written for the general public, that provides information on the importance of road salt use to maintaining a safe and efficient transportation system that sustains Canada's economy.
- *Road Salt Management Guide*: A comprehensive reference guide which addresses transportation and Canada's economy and quality of life, road salt and the environment and road salt management practices.
- *Syntheses of Best Practices for Road Salt Management*: A series of syntheses of best practices related to the effective management of road salt use in winter maintenance operations.

## This guide's for you

This learning guide is based on the best practices in the *Road Salt Management Guide* and the *Syntheses of Best Practices for Road Salt Management*. If you're an operator or supervisor, then this guide is for you.

As a winter road maintainer, you're on the front lines in the battle against snow and ice on roads. In fact, the only thing that gets out there ahead of you is your plow blade. You probably already know that road salt is the most effective, cheapest, and easily handled de-icing material. There may be alternatives out there, but they usually cost a lot more, require special care when handling, and are only effective under certain weather conditions. Road salt is still the most reliable de-icing chemical available.

## The "4 R's" of winter road maintenance

There was a time when winter road maintainers lived by a simple rule of thumb: "when in doubt, put it out." In other words, it was better to err on the side of caution and put down a lot of road salt—and put it everywhere—just to make sure. But those days are long gone.

The modern winter road maintainer has a new mantra: "put the **R**ight amount of the **R**ight material in the **R**ight place at the **R**ight time." In other words, use road salt more wisely and effectively. The benefit of this approach is that road salt usage is *optimized*. This translates into savings for the organization, and minimizes the impact of road salt on the environment. This guide is designed to teach you how to optimize road salt usage while continuing to keep winter roads safe for commercial, passenger, and emergency vehicles.

## Your guide to road salt optimization

Optimizing salt use means being smarter about you how put it down.

Optimizing road salt usage means being smarter about how you apply the material. In most cases it will mean that you use less road salt, but that is a result rather than an objective. In order to use road salt more wisely, you'll need to become a better decision-maker, and in order to do that, you need to improve your knowledge. That's where this learning guide comes in.

The guide consists of six modules:

- **Module 1** sets the stage by looking at the importance of transportation to our economy and way of life; the economic implications of winter maintenance; and the cost-benefits of winter maintenance.

- **Module 2** explores the science of road salt and ice. In Lesson 1 we look at the principles of ice formation. Lesson 2 examines the concept of freeze point depressants and how they work to prevent or break the bond between pavement and ice. In Lesson 3 we consider alternative de-icing chemicals and their role in winter road maintenance. Lesson 4 looks at application strategies, in particular anti-icing, a modern preventive approach that aims to keep the ice-pavement bond from forming.
- **Module 3** looks at equipment and technologies used by modern winter road maintainers. In Lesson 1 we survey plows and spreaders and how they can be put to work to optimize road salt usage. Lesson 2 examines pavement condition tracking and forecasting techniques and technologies, including road weather information systems.
- **Module 4** deals with road salt and the environment. In this module we look at the pathways by which road salt can make its way into soil and groundwater, and the effects it can have on vegetation and wildlife.
- **Module 5** looks at snow and road salt handling. In Lesson 1 we look at road salt handling and storage at the road maintenance yard. In Lesson 2 we examine disposal strategies and techniques at snow disposal sites.
- **Module 6** considers the importance of monitoring and record keeping in winter road maintenance.

The objective throughout these modules and lessons is to help you, as an operator or supervisor, to understand how it is possible to use road salt more effectively while continuing to provide safe roads during winter and minimizing the impact on the environment.

## The same, but different

You have a lot in common with winter road maintainers across the country.

As a winter road maintainer, you have a lot in common with operators and supervisors in other jurisdictions across the country. At the same time, your job is very unique. Every road jurisdiction has a different transportation infrastructure to service. No two agencies face the same weather conditions. Each organization has a different mix of human resources and equipment available to keep the roads open during winter. Levels of service differ from one jurisdiction to the next, winter maintenance strategies are designed to meet specific local challenges, and public expectations change from one jurisdiction to the next.

In other words, while all winter road maintainers may be out on the front lines keeping the roads open, they could be using very different means to achieve similar ends.

This learning guide deals with general principles of winter road maintenance that can be applied in every jurisdiction, but it is beyond the scope of this document to prescribe practices that apply to specific road authorities. The best practices upon which this guide is based have been carefully researched and prepared and are endorsed by the Transportation Association of Canada's (TAC) Chief Engineers' Council, the Road Salt Working Group (a subcommittee of the Maintenance and Construction Standing Committee), and the Environment Council.

This material is provided as advice to winter road maintainers for consideration when developing their own policies, practices, and procedures. Keep in mind that the best practices are to be used in concert with the legislation, manuals, directives, and procedures of your individual road agency.

The material in this learning guide will be incorporated into your agency's current or planned training programs.

## A word about what's inside

Before we dive into the learning guide, let's take a look at what you'll see inside. We know that your time is valuable, and that the technical nature of this subject-matter may not be the most exciting thing you've read lately. So we've tried to make the learning experience as easy and enjoyable as possible.

We want you to learn, and to enjoy doing it.

The first thing you'll notice is that, unlike a lot of those technical reference manuals and user guides you may have seen and tried to read, our tone is conversational. We talk directly to you in a casual voice that's free of jargon and technical terminology. We even throw in a bit of humour every now and then. Unlike those other documents, we want you to learn, and to enjoy doing it.

Each lesson begins with a summary of the topics that we'll be discussing. This is followed by a conversation among fictional characters in a fictional maintenance yard: Pine Junction. Any resemblance between these characters and anyone you may actually work with is entirely coincidental. This dialogue sets the stage for the material covered in the lesson. Once you've read the list of topics to be covered and the dialogue, you'll have a pretty good idea of what you're going to discover in the lesson.

## Getting around: Navigation aids

The margin along the left side of each page is an area that we call the “fast track.” This serves three purposes:

We call this area the “fast track.”

1. Document designers tell us that “white space” on the page is visually pleasing to the eye, making it easier for you to read what’s on the rest of the page.
2. We can provide a capsule summary of the important points on the page. If you don’t have time to read the whole thing, at least you’ll know what you’re missing, and you can come back to it later if you’re interested.
3. The capsule summaries serve as “navigation aids”, which means that they provide a reference point if you need to come back to a section of a lesson and find a particular piece of information.

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### -TIPS, NOTES, and WARNINGS-

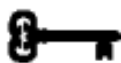
Although we feel that all of the information in the learning guide is important, some items need to have special attention drawn to them. We present these in the form of “Tips”, “Notes”, and “Warnings”. Information presented in this format is related to, but not part of, the discussion at hand.

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On the other hand, when we want to emphasize an important point *in* the discussion, we highlight it in this fashion.

If you only had time to skim a lesson, you could quickly grasp the essence of it by reading just the list of topics covered, the dialogue, the fast track items, the highlights, the tips/notes/warnings, and the summaries at the end, which we’ll discuss in a moment.

Our approach is based on the concept of self-assessment and instant feedback to confirm what you’ve just learned. Throughout this guide you’ll find “Quick Quizzes” that are designed to make you reflect on concepts that have been presented in the lesson. Once you’ve taken your best shot at answering the questions or offering solutions, you can check the answers that we provide following the quizzes. Look for the key to find out how you did. Sometimes there is no right or wrong answer, a reflection of the fact that operators in different jurisdictions might do things differently. We offer possible solutions, but our word isn’t always the final one.



When you reach the end of the lesson, we offer you a quick summary of where you’ve been. This is usually a restatement of the key points of the lesson that you should have picked up along the way. You’ll find it in the section entitled “Where have you been?”.



Knowing where you've been is useful, but knowing where you're going can be just as helpful. We'll let you know what's in store in the next lesson, in the context of what you've just learned. You'll find it in the section entitled "Where are you going?"

This guide can be used in different ways:

- You can use it at your desk, working and learning at your own pace.

-OR-

- You can use it in a classroom setting as a participant manual.

If you will be participating in a classroom training session, you will gain the maximum benefit by reading this guide in its entirety, if possible, before attending.

We hope that whatever you take from this guide will confirm the importance of the role you play as a winter road maintainer, and will generate discussions among your peers. Winter road maintenance is not a new profession, but there are always new techniques, technologies, and equipment coming along that change the way you operate. Keeping up with the changes, or staying ahead of the game, is a continuous learning process.

Let's start learning.

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# Module 3, Lesson 1

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## Tools of the trade: Plows and spreaders

As a result of research and development into winter maintenance technologies, equipment is available that can help you reduce salt use, control its impact on the environment, improve winter driving conditions, and reduce costs

### *Well, what shall we talk about?*

- Tools of the trade: Types and characteristics of plows and spreaders
- Work horses: Vehicles for mechanical removal of snow and ice
- Making the grade: Plows and plow blades
- All about spreaders: Controls, spread patterns, and calibration
- Brew your own: Brine-making equipment
- What the future holds: Equipment innovations

## Equipment depot. Pine Junction maintenance yard. December.



“Hey, Rusty,” called Roch Salterelli from the back of the depot. “Can you bring truck #12 in? That spreader hasn’t been calibrated yet.”

“Will do, boss,” replied Rusty Steele. “It seemed to be throwing out a good stream of salt last time I used it, though. It may not need it.”

“Well, I don’t necessarily want it to be spitting out a good stream of salt. I mean, it depends on where we’re putting it down. Every road is different, and every storm has different conditions that we need to address. We may be putting down more than we need to and our goal is to use only enough road salt to keep the roads safe this winter.”

“You been reading that learning guide again, Roch?” asked John Rhodes from the other side of the room. “Why do you want to put the public at risk by cutting back on salt? It’s not worth it.”

“Johnny, sometimes I think you don’t hear a word I say. Now listen carefully: it’s not about putting drivers at risk. It’s about being smarter about how we use salt. If we don’t waste it, we save money and trees. Got it?”

“Well, if you want to really save money, why not just plow till the cows come home and forget about using salt altogether? If we can keep the roads clean with plows, we won’t need chemicals.”

“I realize that that was an attempt at sarcasm, Johnny, but you know what? That’s not a bad way to think. Our first line of defense is mechanical removal. The more we can get rid of with plow blades, the less we’ll need to remove with salt. Maybe you have been listening to me, after all,” laughed Roch.

“And according to what I read in the learning guide,” added Crystal Ion, “we could be a whole lot smarter in the way we use our plows.”

Roch smiled. “I’m glad to hear you say that. Now I won’t be alone in trying to convince Johnny to join us in the 21<sup>st</sup> century. Crystal’s right,” Roch continued, turning to Rhodes. “Not all trucks and plows are ideal for all roads. You wouldn’t use a front-end loader to clear the main highway any more than you would use a high-speed rig to clean out the urban cul-de-sacs.”

“You had to take training to learn that?” asked Rhodes.

“No, Johnny. We all know that instinctively. But we have to start changing the way we do things so that everything comes to us more instinctively. Like when to use road salt. How much to use. When not to use it. We need to integrate all of this into a big

picture and then we need to know, instinctively, how to respond. Every storm is different, Johnny, and we have to get smarter at knowing how to respond to them.”

“The Zen of storms? Is that what you’re preaching now?”

Brine Watters entered the shop. “Are you getting religious on us, now, Johnny? What are you talking about?”

“I’m not sure what Roch’s talking about,” Rhodes shot back.

“It’s all about becoming smarter in the way we do things. Not that we’ve been doing things in a way that wasn’t smart, but there’s a lot of new technology and knowledge and we need to get up to speed or we’ll be left behind.”

“He’s right,” agreed Watters. “They’re doing a lot of research and development. There’s new equipment that can make our job easier if we care to take the time to learn how to use it. I’m always open to anything that will help to make my job easier. I’m surprised that that doesn’t appeal to you, Johnny.”

“In the meantime, people, let’s carry on,” Roch urged. “We need to get all the rigs serviced by the end of the week. The long-range forecast is for a pretty significant snowfall by the weekend. I want everything ready to roll.”

“Everything was serviced last spring, Roch,” reminded Rhodes.

“Absolutely right, Johnny,” Roch replied. “That’s part of our standard operating procedure here. That’s why this final, pre-winter check isn’t going to take long. My main concern is to get all the spreaders calibrated. I want to try out a new procedure from the learning guide.”

“Is that becoming your bible?” asked Rhodes.

“There you go again, Johnny,” interjected Watters. “Bringing religion into it. Let’s keep that out of the workplace, shall we?”

## Tools of the trade



So far in this learning guide we've discussed things that you can do to optimize the amount of salt and other chemicals that are applied to roads in winter. We've talked about strategies, such as anti-icing, that will enable you to make more effective use of lesser amounts of salt to achieve even better results than you have by following traditional snow and ice fighting tactics. Up to this point we've shown how *behavioural* changes can result in more effective use of salt—and the way you change your behaviour is by acquiring knowledge and learning how to apply it on the job.

Let's recap what you've learned so far in this guide:

- ✓ You know how ice forms on the road, and how hard it is to break the ice-pavement bond once it's fixed itself in place.
- ✓ You know how road salt and other chemicals work either to prevent or break the ice-pavement bond.
- ✓ You know when *not* to use chemicals during conditions that can lead to re-freeze and create problems that you are working to avoid.
- ✓ You understand the significance of the phase diagram and the importance of tracking air and pavement temperatures.

All of this knowledge will help you to change the way that you use salt to fight ice and snow on roads.

The best-laid plans look good on paper, but that's where they'll stay unless you have a fleet of equipment to turn theory into action.

Now we shift our attention to the *tools and equipment* that will help you to achieve your goals. The best-laid plans based on accurate data and sound analysis look good on paper, but that's where they'll stay unless you have a fleet of equipment to turn theory into action.

There's a wide variety of vehicles, plows, spreaders, weather tracking devices, and other equipment that you can mobilize against winter storms. In this lesson, we'll review the vehicles and their accessories that you may already have at your disposal, or that you may want to consider acquiring when the time comes to upgrade your maintenance fleet.

As a result of research and development into winter maintenance technologies, new equipment is available that can help you make more effective use of road, control its impact on the environment, improve winter driving conditions, and reduce costs.

If you know what's available, and you understand the capabilities and limitations, you'll be in a position to make the right decision when it comes time to acquire or deploy equipment.

What road maintenance authorities are looking for when implementing new maintenance procedures is equipment that will:

- minimize the amount of snow that needs to be dissolved; and
- place the right amount of salt in the right location at the right time.

Snow, ice, and slush that can be removed by mechanical means don't have to be melted by chemical means.

We're talking plows and spreaders here. The more snow you can remove by mechanical means from the road surface, the less you'll have to melt using chemical means. And when you do have to place salt on the road, the more accurately and strategically you place it, the more effective it'll be, and the less you'll need.



Financial constraints may prevent you from thinking about upgrading or replacing your winter maintenance fleet. Or you may not be willing to deal with the risks involved in bringing in untried or unproven equipment. There are also additional expenses involved in training operators on the proper use of the new tools. But these risks and constraints must be measured against the benefits that can be realized with the equipment that is now available, including the opportunity to optimize your use of road salt. Snow, ice, and slush that can be removed from the roadway by mechanical means don't have to be melted by chemical means.

Therefore, every effort should be made to remove as much snow and ice as possible before salt is applied. Much of the new equipment allows you to achieve this more effectively than in the past.



As we discussed in earlier lessons, reacting to a snow and ice event by applying salt after a bond has formed requires more salt than does proactively treating the road surface just prior to the event, or just as it begins. This approach can prevent a bond, simplify the mechanical removal, and speed up the process of achieving bare pavement.

All weather events—and your reactions to them—are unique.

Unless you can get the salt out early in an anti-icing preventive application, the cheapest, most efficient, and most environmentally-friendly approach is to physically remove as much snow as possible, and then use salt to melt any remaining snow or ice. As we know, all weather events are unique in terms of temperature, intensity, duration, and type of precipitation. Your response, in turn, will also be unique in each case.

There is a trigger point at which plowing, rather than anti-icing, becomes the primary focus. Each authority has its own threshold in this regard. Make sure that you are aware of the policies in your organization.

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-TIP-



**Out with the old, in with the new:** Some road authorities leave a small amount of snow on the road before salt is applied to keep the salt from being blown away by wind or passing traffic. This can increase the amount of salt required to “de-ice” or melt the snow packed on the road, and is not as efficient in retaining salt on the road as other methods, such as slower spreading speeds, pre-wetting, or zero-velocity spreading. Optimal timing of the salt application along with new methods and procedures, supported by the latest developments in equipment and technology, are providing new solutions to minimize wasted salt.

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## Scraping by: Removing it mechanically

Snow, ice, or slush that has accumulated on the roadway can be controlled mechanically by removing it with plows mounted on trucks, motor graders, or loaders.. Snow blowers are also used in some areas. Salt is applied using various spreading tools and techniques. The objective of mechanical removal is to reduce friction. The following provides an equipment overview, including advantages and disadvantages of each.

Vehicles	Plows	Plow blades	Spreaders	Other
Trucks	Front mounted	Rubber	Hopper	Spreader controls
Motor graders	Front mounted one-way	Plastic	Tailgate	Pre-wetting equipment
Loaders	Front mounted reversible	Sliding blade segments	New multipurpose	Brine-making equipment
Snow blowers	Underbody all-way	Steel with tungsten carbide inserts	Zero velocity	Brine-making equipment
Mobile conveyors	Wing/wing-plow	Shoes and tripping mechanisms	Reverse dumping	Liquid-only equipment
Snow melters		Castors	Dual dump	Loader-mounted electronic weighing equipment
		Wear edges		Salt handling by loaders

## Vehicles: Workhorses of the fleet

The goal is to have a balanced fleet based on your road inventory and street configuration.

There was a time when equipment fleets consisted of a limited range of equipment. That time may still be now in your shop, but you have more options today than you did in the past. The range of trucks, for example, is broader than it's ever been. now come equipped with heavy-duty single, or tri-axles and have enough horsepower to the demands of rural snow and ice control.



They tandem, handle

They come in a variety of capacities and dimensions. If you're operating in an urban environment, you may prefer the smaller, maneuverable vehicles, but if you're working on rural roads or urban freeways, you'll want the larger, more powerful trucks.

Each organization has its own unique requirements. The goal is to have a balanced fleet based on your road inventory and street configuration. How the city's transportation infrastructure is built will be the most important determining factor in what equipment you need to buy.

### Western versatility



Road maintainers in the City of Edmonton, Alberta are continually finding new and innovative ways to modify their equipment fleet for year-round use. Most of the modifications are designed and developed in-house at relatively low cost.

Being innovative doesn't mean being expensive. But the savings can be substantial. Road authorities can realize a substantial return on investment by looking inside for improvements in efficiency.

Clever modifications involving hoist pins, for example, enable operators in Edmonton to turn tandem trucks into multi-purpose vehicles.

(Photo courtesy City of Edmonton)



High-speed plowing provides several benefits, but the trucks require larger engines.

On inter-city, rural, and high-speed roads, truck-mounted plows provide the best solution as they can operate at much higher speeds than other equipment. To sustain these speeds, however, the trucks require larger engines than would normally be fitted. There are several benefits to high-speed plowing:

- the roads can be cleared sooner, before traffic has packed the snow into a slippery surface;
- plows operating at close to the speeds of other traffic are less of a safety hazard; and
- high-speed plows can throw snow a sufficient distance back from the edge of the shoulder to minimize snow bank build up, thereby eliminating an impediment that could trap blowing snow, and minimizing the need for subsequent plowing and salting.

## Tread carefully

To maintain adequate traction during winter storms, traction tires must be selected carefully to ensure the tread pattern and tread material are suitable. Trucks require locking differentials or electronic traction control to prevent traction loss due to a spinning wheel. All-wheel drive trucks were commonly used in the past, but improved trucks and roads have eliminated the need for this expensive option.



Selection of the appropriate plow type, and proper adjustment, reduces costs and minimizes the need to use salt.

Truck manufacturers have developed special specifications for snow plow trucks, and the American Association of State Highway and Transportation Officials (AASHTO) has published a compendium of special requirements for its members. Equipment manufacturers provide different types of snowplows that have advantages and disadvantages for various operations. Selection of the appropriate type of plow, and proper adjustment of the plow, will reduce costs and minimize the need to use salt to clear the roadway.



Later in this lesson we'll be looking at how trucks can be adapted to specific winter operations. For example, underbody plows can be mounted on trucks and used with down pressure to scrape bonded ice from the pavement on urban streets.

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### –THE WINTER MAINTENANCE BILL OF RIGHTS–



**The 5 R's:** A successful winter maintenance program depends on having the *right* people, the *right* materials, and the *right* equipment deployed at the *right* time and in the *right* location.

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## Heading for perfection: Cleaning up our mess



Cleaning up the roads isn't the only activity that requires your attention. We need your help in cleaning up a problem in this learning guide. During production, we ran into some difficulties and we seem to have lost track of the section headings for the discussion on types of winter snow maintenance vehicles. When we found them later, they were out of order and out of context. We'd like you to help us put them back where they belong.

In the table below are six of the most commonly used types of vehicles or machinery used to clear snow and ice from roads. Following the table are descriptions of these units. What we'd like you to do is to match the description with the appropriate heading.

We should mention that the descriptions themselves got mixed up as well. In fact, each of the following sections contains a statement that belongs in a different section. See if you can identify it and indicate where it belongs. And thanks for helping.

<b>Snow melters</b>
<b>Snow blowers</b>
<b>Trucks</b>
<b>Loaders</b>
<b>Motor graders</b>
<b>Mobile conveyors</b>



Heading: \_\_\_\_\_

1. With front mounted plows and wings they can operate at speeds close to that of other traffic, presenting less of a safety hazard and allowing roads to be cleared sooner. Operating at higher speeds they can effectively "throw" snow a sufficient distance back from the edge of the shoulder to minimize snow build-up. However, higher operating speeds may not be appropriate in urban areas where snow thrown beyond the edge of the pavement could damage roadside features.
2. They are useful when working in tight quarters on urban streets with cul-de-sacs, elbows, bus bays, and varying road widths (particularly articulated ones). They

are used to pick up and remove snow in inaccessible areas with limited snow storage.

3. To ensure adequate traction and load-bearing capacity, both front and rear tires must be selected carefully to ensure suitable tread pattern, material and sufficient load rating to handle both the material load and plows. Front axle capacity is a consideration, and the vehicle should meet legal weight requirements as necessary. They require locking differentials or electronic traction control to prevent traction loss due to a spinning wheel.

**Misplaced statement** \_\_\_\_\_

**Under which heading does it belong?** \_\_\_\_\_



**Heading:** \_\_\_\_\_

1. They have been extensively fitted with plows and wings to remove snow.
2. With their large glass areas on the sides and front, and a high mounted operator's position, they provide the operator with excellent vision of the area immediately around it. This is useful when working in tight quarters on urban streets with cul-de-sacs and varying road widths. They also allow the operator to do a thorough job of removing all snow, minimizing the amount left to be removed with chemicals.
3. The excellent visibility that they afford also promotes a safer operation when working in the presence of pedestrians and heavy traffic.
4. They can be fitted with front plows, including one way and reversible plows, "V" plows, and side wings. They can also be mounted with a tooth or stacked-disc ice blade to scarify hard ice pack and provide improved, temporary friction. The standard blade can also be used to clear snow.
5. They can be configured with a hopper or tank to serve the dual-duty role of spreading materials as well as plowing, but careful attention must be paid to its specification to configure it as a frame-stiffened winter vehicle of suitable horsepower and hydraulics, rather than simply a generic cab-and-chassis off the production line.
6. They are often readily available for winter road maintenance as they are widely used by municipalities and contractors during the summer for road construction and maintenance, and are little used otherwise during the winter. Its heavy construction results in a durable machine for snow plow operations.

**Misplaced statement** \_\_\_\_\_

\_\_\_\_\_

**Under which heading does it belong?** \_\_\_\_\_



**Heading:** \_\_\_\_\_

1. Its operation usually requires a dump truck for hauling to an appropriate snow dumpsite. They are also occasionally fitted with plows, wings, and snow blowers for snow removal. Modern ones, with large glass areas on the sides and front, and a high-mounted operator position, provide the operator with excellent vision of the immediate area around it.
2. They are used to open roads in areas with very high snowfall rates. They are also used to load trucks for snow removal in urban areas along roads with limited snow storage space.
3. They are readily available for winter road maintenance as they are widely used by municipalities and contractors during the summer for road construction and maintenance and are used extensively to load sand and salt onto spreader trucks at the maintenance yards.

**Misplaced statement** \_\_\_\_\_

\_\_\_\_\_

**Under which heading does it belong?** \_\_\_\_\_



**Heading:** \_\_\_\_\_

1. They are available with hydraulic controls on the chutes to accurately direct the snow into the trucks used for haulage. They are mounted on dedicated trucks, tractors, or are attached to large front-end loaders.
2. Modern ones can operate at much higher speeds than older models but are limited to 30 to 35 km/hr (20 mph).
3. They often leave some snow on the road that must be treated with abrasives or de-icing chemicals to maintain safe driving conditions.

**Misplaced statement** \_\_\_\_\_

\_\_\_\_\_

**Under which heading does it belong?** \_\_\_\_\_



**Heading:** \_\_\_\_\_

1. These units can operate entirely on the shoulder with the unit and the truck being loaded both lined up on the shoulder and not disrupting traffic.
2. They are effective during fall freeze-up and spring thaw when roads are soft and susceptible to digging-in by truck-mounted plows.

**Misplaced statement** \_\_\_\_\_

\_\_\_\_\_

**Under which heading does it belong?** \_\_\_\_\_



**Heading:** \_\_\_\_\_

1. They were developed before energy costs escalated. Their operation became expensive due to rising fuel costs, but they may provide a solution for unique problem areas.
2. They are used to load snow from the shoulders onto trucks for removal in areas with high traffic volumes.

**Misplaced statement** \_\_\_\_\_

\_\_\_\_\_

**Under which heading does it belong?** \_\_\_\_\_

*Please see the next page for the correct responses.*



## Answers to “Heading for perfection”

(Misplaced statements are indicated in italics)

### Trucks

- With front mounted plows and wings they can operate at speeds close to that of other traffic, presenting less of a safety hazard and allowing roads to be cleared sooner. Operating at higher speeds they can effectively “throw” snow a sufficient distance back from the edge of the shoulder to minimize snow build-up. However, higher operating speeds may not be appropriate in urban areas where snow thrown beyond the edge of the pavement could damage roadside features.
- *They are useful when working in tight quarters on urban streets with cul-de-sacs, elbows, bus bays, and varying road widths (particularly articulated ones). They are used to pick up and remove snow in inaccessible areas with limited snow storage. (This statement belongs under “Loaders”).*
- To ensure adequate traction and load-bearing capacity, both front and rear tires must be selected carefully to ensure suitable tread pattern, material and sufficient load rating to handle both the material load and plows. Front axle capacity is a consideration, and the vehicle should meet legal weight requirements as necessary. They require locking differentials or electronic traction control to prevent traction loss due to a spinning wheel.

### Motor graders

- They have been extensively fitted with plows and wings to remove snow.
- With their large glass areas on the sides and front, and a high mounted operator’s position, they provide the operator with excellent vision of the area immediately around it. This is useful when working in tight quarters on urban streets with cul-de-sacs and varying road widths. They also allow the operator to do a thorough job of removing all snow, minimizing the amount left to be removed with chemicals.
- The excellent visibility that they afford also promotes a safer operation when working in the presence of pedestrians and heavy traffic.
- They can be fitted with front plows, including one way and reversible plows, “V” plows, and side wings. They can also be mounted with a tooth or stacked-disc ice blade to scarify hard ice pack and provide improved, temporary friction. The standard blade can also be used to clear snow.
- *They can be configured with a hopper or tank to serve the dual-duty role of spreading materials as well as plowing, but careful attention must be paid to its specification to configure it as a frame-stiffened winter vehicle of suitable*

*horsepower and hydraulics, rather than simply a generic cab-and-chassis off the production line. (This statement belongs under “Trucks”.)*

- They are often readily available for winter road maintenance as they are widely used by municipalities and contractors during the summer for road construction and maintenance, and are little used otherwise during the winter. Its heavy construction results in a durable machine for snow plow operations.

### **Loaders**

- Its operation usually requires a dump truck for hauling to an appropriate snow dumpsite. They are also occasionally fitted with plows, wings, and snow blowers for snow removal. Modern ones, with large glass areas on the sides and front, and a high mounted operator position, provide the operator with excellent vision of the immediate area around it.
- *They are used to open roads in areas with very high snowfall rates. They are also used to load trucks for snow removal in urban areas along roads with limited snow storage space. (This statement belongs under “Snow blowers”.)*
- They are readily available for winter road maintenance as they are widely used by municipalities and contractors during the summer for road construction and maintenance and are used extensively to load sand and salt onto spreader trucks at the maintenance yards.

### **Snow blowers**

- They are available with hydraulic controls on the chutes to accurately direct the snow into the trucks used for haulage. They are mounted on dedicated trucks, tractors, or are attached to large front-end loaders.
- *Modern ones can operate at much higher speeds than older models but are limited to thirty to thirty-five kilometers per hour. (This statement belongs under “Motor graders”.)*
- They often leave some snow on the road that must be treated with abrasives or de-icing chemicals to maintain safe driving conditions.

### **Mobile conveyors**

- These units can operate entirely on the shoulder with the unit and the truck being loaded both lined up on the shoulder and not disrupting traffic.
- *They are effective during fall freeze-up and spring thaw when roads are soft and susceptible to digging-in by truck-mounted plows. (This statement belongs under “Motor graders”.)*

### Snow melters

- They were developed before energy costs escalated. Their operation became expensive due to rising fuel costs, but they may provide a solution for unique problem areas.
- *They are used to load snow from the shoulders onto trucks for removal in areas with high traffic volumes. (This statement belongs under “Mobile conveyors”.)*

### Co-operative effort pays big dividends

In 1995, Otterburn Park, a small Quebec municipality, implemented pre-wetting techniques and began a strategy of targeting their road salt applications. It also added new, more efficient plows to its salt trucks. With less snow on the pavement, less salt is needed to melt it. These initiatives resulted in a 50% reduction in salt use over five years, while continuing to achieve a high level of service standard.

The Otterburn Park superintendent attributes the success to collaborative efforts from citizens who have increased their winter safety awareness; municipal employees who have learned the new techniques; and city council, which allowed the purchase of new equipment and the implementation of new methods.

**Moral of the story:** When you want to implement change, just do it. When you want to implement change successfully, involve all the stakeholders.

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-TIP-

**All plugged up:** If you apply a lot of sand to your streets, you may want to think twice about using a snow melter. Experience has shown that sand and other abrasive material can clog up a melter in short order.  
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## Plows: Scraping by

Vehicles and machinery aren't the only things that have evolved over the years. Developments in plow design have resulted in a wide range of blades, shoes, and mould boards that can help remove snow from virtually any road surface. You may not need or want to make use of all of these improved tools, but it's important to assess the applicability of new designs to the road and climate characteristics in your jurisdiction.



## If the shoe fits...

The plow shoes or castor wheels should be close enough to the pavement to absorb the weight of the plow if it strikes



Castor wheel on front-mounted plow

All plows for both low- and high-speed operations should be fitted with shoes or castor wheels to prevent the blade from dropping into holes or catching on obstructions such as manhole covers or bridge expansion joints.

Plows should have enough weight on the blade to effectively cut through packed snow and ice in order to minimize the amount of salt required to bare the pavement. This will often require almost all of the weight of the plow to be carried on the plow blade, rather than on the shoes or castor wheels. In these situations, the plows should be adjusted to minimize the amount of weight carried on the shoes, but the shoes or castors should be close enough to the pavement to absorb the weight of the plow if it strikes an obstruction.

Castors are very useful on municipal roads with obstructions, and tend to be less costly than shoes. Some authorities have found that using castors results in less damage to their trucks than using shoes.

---

### -TIP-

**Buckle up:** Always wear your seat belt when operating your plow. This is particularly important on urban roads with obstructions. Even though your plow may be equipped with shoes, castors, or tripping mechanisms, your vehicle can be deflected. Any unsecured objects, such as yourself, risk being tossed around inside the truck cab.

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Plows should also be fitted with a tripping mechanism that will reduce damage to the plow if it strikes catch basin covers or other obstructions. The trip mechanism will also prevent your truck from being violently deflected from its traffic lane.

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### -BELIEVE IT OR NOT-

One enterprising company collected old daggers, melted them down, and re-used the metal to make snow plow shoes. Their slogan? "Turning swords into plow shoes."

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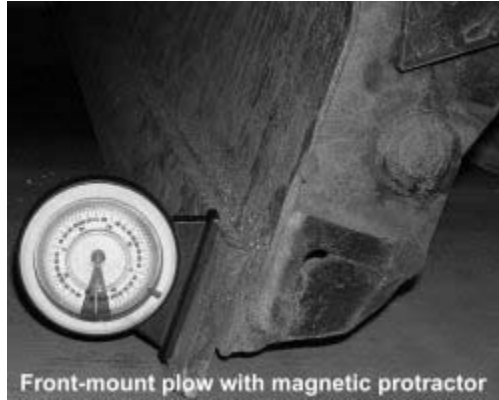
Wear edges provide a good return on relatively small investment.

Wear edges are simply flat pieces of iron bolted to the bottom of plow blades. They provide protection from the wear and tear on blades caused by municipal curbs and gutters. These aren't sophisticated pieces of equipment, but they can extend the life of your plow blade significantly. There is a good return on a relatively small investment of time and money, whether you buy wear edges, or make your own.

## Making snow angles

Tests have shown that 55 degrees is the optimum angle between the blade and the road.

When it comes to efficiently moving large quantities of snow with the least amount of snow being blown up at the front of the vehicle, there's nothing like a 55-degree angle between the blade and the road.



Front-mount plow with magnetic protractor

Extensive tests have shown that this seems to be the optimum angle.

However, if your objective is to cut heavily packed snow and ice, then a 75-degree angle will provide more effective results. A recent SHRP project tried to achieve the best of both worlds by developing a combination plow with blades at both angles. It sounded good in theory, but operators encountered problems with slush build up between the

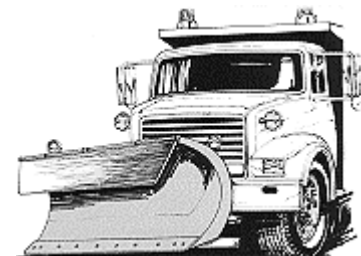
two blades. One road jurisdiction has used a 40-degree angle to improve snow pickup.

The bottom line is that there seems to be an optimum angle, but it isn't carved in ice. You may want to experiment to find out what works best for the road conditions in your jurisdiction and for the machinery that you have available. A magnetic protractor is a handy, inexpensive device to help you set your blade angle.

## Keeping your head out of the clouds

When the snow cloud settles, it has the potential to create an icy road surface.

As an operator, you have experienced the challenge of keeping your eye on the road while driving through snow clouds. The most effective way to trap some of the snow kicked up by the cutting edge is to fit rubber extensions to the tops of front-mounted plows. They should extend well beyond the cutting edge in order to effectively improve your visibility.



There is currently a great deal of testing underway to develop more aerodynamic airfoils to trap the snow cloud created at the front of the snowplow. These devices could greatly improve visibility for both plow operators and motorists. The added benefit of this type of airfoil is that there would be less snow in the cloud to settle on the pavement behind the plow with the potential to create an icy surface.

-----  
-TIP-

**See and be seen:** Some authorities use airfoils on the rear of their vehicles to help improve visibility for both operators and motorists.  
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## Different strokes for different folks

Plows have different blades or cutting edges for different tasks.

Plows are fitted with different blades, or cutting edges, for different tasks. The plow type and cutting edge must be selected carefully to ensure that it can be mounted properly on the vehicle, operate in the required area, and achieve the desired snow-clearing performance.

The selection of the appropriate plow type, and its proper adjustment, will reduce costs and lessen the need to use salt to clear the roadway.

### Front mounted “V” plows



These plows are designed to lift snow over adjacent windrows and to balance side loading by pushing snow to both sides. They were widely used on trucks to effectively handle deeper accumulations of snow.

The use of “V” plows is now restricted mainly to areas with high snowfall rates and as backup units to open roads closed during severe storms.

### Wing-plows

Wings are smaller side-mounted plows that can be mounted on a tower or mast near the front of the plow truck, or further to the rear at the back of the cab. They can be mounted on either or both sides of the plow vehicle, and effectively increase the width of the plowed path. Wings can be mounted on graders as well.



One disadvantage of wings is that operator visibility can be impaired. Wings improve efficiency and allow for increased snow removal, being especially useful in multi-lane clearing and when operating in an echelon formation since they help prevent leaving a windrow of snow on the traveled surface.

Wings may be inappropriate in some urban settings.

Wings may be inappropriate in some urban settings where they can throw snow beyond the edge of pavement and damage roadside features. Usually the vertical angle of the plow can be adjusted by a cable/chain or hydraulically, allowing the wing to be used for clearing shoulders or for cutting side banks of snow.

## Underbody plows

Underbody plows are popular on crowded urban streets where parked cars are a problem.

These plows are popular for use on crowded urban streets where parked cars are a problem, for square-blading in urban laneways and back alleys with limited or no storage space, and for municipal roads in general. These units are the workhorses of urban plowing operations. In theory, they are limited to clearing snow accumulations up to 30 cm, which is the depth of snow that will pass under the front axle, unless an



Underbody plow with ice blade and end bit

all-wheel drive vehicle is used. In reality, these plows can push more than that by virtue of the weight that can be applied to the plow.

These plows have also been used effectively to clear highly compacted snow and ice, an application that otherwise often requires the use of ice blades or high

salt application rates. A variable down pressure, using the truck's compressed air system, is required to maximize effectiveness of underbody plows for this application.

Underbody plows have not been used with side snow wings so the cutting path was limited. A rear-mounted snow wing is now available for trucks with underbody plows but the cutting width is less than that of a front mounted wing. The vehicle may be less stable than front-mounted wings as the side thrust from the wing is located further from the center of gravity of the truck.

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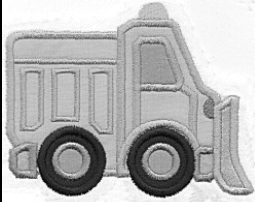
### –NOTE–



**Baked Alaska:** The state of Alaska has used permanently mounted solar heaters as an innovative solution to keep culverts from freezing in remote areas.

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We now turn to our feature plows, the front-mounted one-way and reversible models. Read what the reviewers had to say in the most recent issue of a popular plowing trade journal.



# Plowboy Magazine



*review*

\*\*\*\*\*

*review*

## Everything about this plow is right

by Axle McCloud

with the **front-mounted one-way plow**.



This is simply the most efficient plow available for the high-speed removal of snow, slush, and packed snow. Need to clear a minor amount? Or maybe a half-metre of snow? This plow handles it all.

The front-mounted one-way plow can clear a swath 2.75 meters wide. Your driving safety is improved considerably by the minimal amount of snow that escapes into the snow cloud at the point of impact. And you won't have to worry about the plow catching on bridge expansion joints and cross-cracks with the newly designed noise points.

The truck has a high-capacity front axle and heavy-duty wheels and tires to accommodate the weight of the plow, which extends a good distance out in front. This vehicle wasn't designed for clearing snow in congested urban areas and subdivisions with cul-de-sacs. Extend your cutting width to 4.25 meters on rural roads by fitting this rig with snow wings. This unit comes equipped with frame reinforcements and heavy-duty wheels, springs, and axles to accommodate high side loading.

More information: *TAC Salt Management Guide*

## Which way you plowing, Billy?

by Lefty LaRue

Can't decide where to put the snow? Get a **front-mounted reversible plow** and you'll be able to move it to either the left or the right. It's hard to beat this blade for clearing medians and ramps during low-speed urban operations. Leave it in the yard if you're heading out on the highway, though--it wasn't made for high-speed operations.



plow design specialist Lane Windrow.

But it's got reach: you can clear a swath from 4.25 meters wide when the blade is set perpendicular to the direction of travel to 3 meters when fully angled in either direction.

If there's one complaint, it's the low outlet height. Because of the reduced capacity to hold snow on the mouldboard, snow is re-handled more often as it is moved to the side of the road, and more loose snow escapes from the plow. This reduces visibility for the operator and adjacent motorists. Because this rig operates at lower speeds, snow is not thrown as far at the outlet end of the plow and remains on the shoulder. Keep this in mind when planning your strategy.

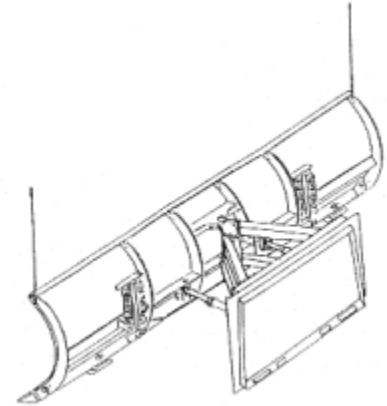
Critics complain that these plows can't be fitted with noise points, but manufacturers now offer mouldboards that can be reshaped to match the shape of one-way plows when it is angled in either direction. "This works well," explains Windrow, "but it costs a lot more."

Watch for a unique variation: a center-hinged reversible plow that can push left or right, or effectively become a V-plow. It can be fitted with noise points to protect against catching on minor roadway obstructions.

## On the cutting edge: Snow plow blades

Plows for high-speed operations are fitted with high-strength steel blades with tungsten carbide inserts.

Snowplow blades, or cutting edges, are available in various designs and configurations for specific operations. Regular blades are made of heat-treated steel or fitted with tungsten carbide inserts to improve durability. Plows used in high-speed operations are usually fitted with high-strength steel blades with tungsten carbide inserts. These inserts increase the durability by a factor of up to 80 times in high-speed operations, and eliminate the need to discontinue operations to change blades during a storm.



As these blades wear slowly, they take much longer to reach the point where the bottom of the blades lies flat on the pavement. So the shape of the blade bottom and insert should be designed to effectively remove snow and simultaneously minimize the amount of snow being blown up into the cloud of snow in front of the plow. Using a blade that provides a streamlined flow of snow over the face can minimize the snow cloud.

## Rubber and polymer/plastic blades

Rubber and polymer/plastic blades can help to minimize damage to catch basins, bridge expansion joints, centerline pavement markings and raised reflective markers. These types of blades can be used to effectively “squeegee” the surface to remove slush in areas where the ambient temperatures usually rise above the freezing point during daylight hours after a storm.

In areas with colder temperatures the use of these blades has not been as successful as they cannot remove heavily compacted snow or ice. Excessive amounts of salt are then required to remove the buildup.

## Ice blades

Ice blades cut into hard-packed snow and ice that can't be removed by conventional blades.

Ice blades are used to cut into hard-packed snow and ice that cannot be removed with conventional blades. They are particularly effective when mounted on underbody trucks and motor graders where high down pressure can be used on the main mould board. In many instances, underbody-mounted, serrated ice blades are the only way to remove compacted snow and ice from urban roadways.

The first versions of these blades featured three-centimeter fingers with three-centimeter gaps between the fingers to increase the pressure on packed snow and ice.

Variations of this design are now available with replaceable, revolving tungsten carbide inserts on a similar spacing.

## Sliding blades

In Europe special plows with sliding blade segments facilitate thorough clearing of rough or distorted pavement, reducing the amount of salt required to bare off the pavement. The manufacturers also claim that these blades minimize damage to the plow and truck from hitting obstructions such as catch basin covers as less force is required to retract one segment clear of the obstruction.



### Running things back in Saskatoon

To maintain snow-clearing operations, the City of Saskatoon uses 900 grader blades per winter at an average cost of \$46.00 per blade. Blades normally last one shift.

Under normal winter conditions, the city has 20 motor grader operators that provide 17-hour coverage five days a week. When bad weather strikes, the operators are called on to keep the equipment working continuously until the priority roadways

are back to good winter driving conditions. The sander operators provide 24-hour coverage seven days a week.

8,000 metres of snow fence are erected each year to help deflect drifting in critical areas. On average, crews remove 10,600 tandem loads of snow from city streets every year.

Saskatoon mixes sand/salt at a 19:1 ratio. Salt is only 5% of the material placed on the road.

(Source: <http://www.city.saskatoon.sk.ca>)

## Spreaders: Putting it down right

Equipment of your own design will be the least expensive and most serviceable.

When it comes to spreading chemicals on winter roads, a variety of equipment has been tried and tested: some homemade and some purchased; some inexpensive and some expensive. Equipment of your own design will probably be the least expensive and most serviceable.

If it's simple you can replace or repair it, maybe even during a storm event when, true to Murphy's Law, so much equipment seems to fail. Simple designs also usually require fewer inventories of spare parts.

Various types of truck-mounted spreaders are used to apply salt, sand, and other winter maintenance materials on winter roads. They should have the necessary capacity to spread either substance along the pre-determined route to avoid deadheading.

## Spread green

Spreading equipment must be able to deliver several precise application rates.



The efficiency of a spreader is a function of both its design and use. Spreaders must meet many requirements to avoid wasting salt, but even the most well designed units can be used improperly. When that happens, salt is wasted. The last thing you want to be doing is wastefully spreading your winter maintenance dollars all over the road.

Spreading equipment must be capable of delivering several precise application rates. Once the application rate is set, it shouldn't vary due to minor material variations or temperature changes as the hopper empties. Just as improper use of well-designed equipment can lead to salt wastage, so can proper usage of poorly functioning equipment.

When you purchase new equipment, you should require test results from suppliers to confirm precise application rates *under all conditions*.

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-NOTE-



**Weight for it:** One-quarter inch of ice on a mile of pavement weighs 71.1 tonnes (70 tons). To melt that much ice in an hour at 25 degrees F (-4 C) could take as much as 17.2 tonnes (17 tons) of salt. But you could do the job with less salt if you timed the application correctly and spread it right.

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## Built tough

By their nature, spreaders must operate in severe environments.

By their very nature, spreaders must operate in severe environments. In fact, they operate almost exclusively under conditions of low temperatures, high moisture, poor visibility, and corrosion—and they must be capable of maintaining the required application rates in this environment with little maintenance. If only our automobiles could be built to such specifications.



**Here's what to consider when looking for the ideal spreader for your operations.**

- ✓ Constructed so that all material can be easily removed from the body. Material remaining in the spreader can leach and contribute to local contamination. Hydraulic and electric vibrators and Teflon coatings have been used to promote free flow of material.
- ✓ Must be easy to load and simple to use in inclement weather. Cab shields should be fitted to assist in loading to ensure that all loaded salt enters box and is not spilled over truck.
- ✓ Fitted with screens to ensure that frozen clumps of material or other contaminating material that would jam the mechanism are not loaded into the spreaders.
- ✓ Coated with special chlorinated rubber primers and epoxy-based primers. High-strength, low alloy self-coating steel used with good surface preparation and special primers can extend body life up to 15 years.
- ✓ Fiberglass and stainless/galvanized steel bodies are available but are expensive. Fiberglass does not corrode but bodies are damaged more easily during loading and cost more to repair than steel bodies.
- ✓ Wiring must be enclosed in vapor-proof or sealed systems. Hydraulic components must be sealed to prevent seizing.
- ✓ Neoprene spinners improve durability and spreading efficiency.

Since spreaders are only required during winter storms, they should be adaptable for other tasks, or the box should be easily removable so the trucks can be used for other operations during the summer. Spreading the work around is always more efficient.

## Finding a better spreader

Your job is all about making decisions: when to call out the crews, what to put down on the roads, and when. It's no different when it comes to equipment: what type of truck, what sort of plow, and what kind of spreader. There's a wide variety of everything, and they all serve specific purposes.

What you have to decide is which tools and technologies will help you to meet your objectives most efficiently and cost-effectively, given your particular conditions and requirements.

Manufacturers provide different spreader types to meet various requirements. The various designs have different characteristics that you need to consider when you're making a decision on a spreader for a particular application. The available options

include hopper spreaders, tailgate spreaders, reverse dumping spreaders, and some new variations of these types.

We've compiled a compendium of the most popular types of spreaders. You may already have some of them in your fleet, or you may be considering acquiring them.

## What's What?

### A compendium of winter maintenance equipment

#### *Spreaders*

##### **Type:** Hopper

**Nickname:** "Dennis"

**Size:** Available in six-cubic-metre size for mounting on tandem axle trucks, and four-cubic-metre size for single rear-axle trucks.

**Distinguishing features:** Steeply sloping sides to eliminate material hanging up or bridging in body. Conveyor chain moves material to discharge location. (Augers have shown high wear and offer poor accuracy in material discharge control.)

**Modus operandi:** Material is conveyed for discharge to locations at the front of the wheels on the driver's side, or to the rear of the hopper for discharge on the centerline of the vehicle. Some models have additional distribution points on the passenger side, either in front of or behind the wheels, to cover four-lane roads and truck climbing lanes.

Material can be spun onto the road surface using a variable speed, hydraulically driven spinner, or deposited in a narrow windrow along the crown of the road using an adjustable chute. The application rate of the material being spread is controlled by adjusting the speed of the chain used to convey the material to the chute or spinner and the gate opening on the body.

**Power source:** A constant source of power to drive the hydraulic pump was once provided by an integral small gasoline or diesel engine. But these engines were a constant source of downtime and maintenance. Reliable hydraulic pumps driven from the truck engine are now the preferred power source.

**Pros and cons:** On the one hand, hopper spreaders provide the best control of material application and the most dependable service. On the other hand, they are the least versatile for other operations during the off-season. They are restricted almost entirely to applying winter maintenance materials, although they have been used to a limited extent to fill washouts and treat hazardous material spills during the summer. As a result, the bodies are usually installed on contractor or municipal trucks during the winter and removed and replaced by standard dump bodies for the summer.

**Assessment:** It's a tradeoff, and only you can make the decision for your organization based on its particular needs.

## What's What?

A compendium of winter maintenance equipment

### *Spreaders*

**Type:** Tailgate reverse dumping or dual dump

**Nickname:** "Two-timer"

**Distinguishing features:** Tailgate multi-purpose spreader that can be used year round. Functions as regular rear dumping body when not being used to apply winter maintenance materials.

**Modus operandi:** When required, the pivot pins are repositioned so the standard hoist can be used to raise the rear of the body. This moves the salt or sand to the chain conveyor at the front of the body that moves the material to the distribution point ahead of the rear wheels. These spreaders have the advantage of providing year round service and can be switched from hauling construction materials to winter maintenance use with no adjustments required.

**Pros and cons:** On the one hand, these units distribute the material in front of the rear wheels so they have the same resulting advantages as front discharge hopper spreaders. All material can be discharged from the body. On the other hand, this type of spreader weighs a lot more than a regular dump truck. Furthermore, the need to raise the body while driving to move the material to the front of the truck reduces the truck's stability. Care is required by the operator to ensure that sufficient material covers the cross conveyor at the front to maintain a precise application rate. The pivots have been a source of failure and replacement is expensive.

**Horse of a different color:** A variation of the reversing dump body is the side-tipping floor. The floor and passenger side of the box are raised to move sand or salt to the driver's side of the truck where a longitudinal conveyor moves the material to the front of the box for distribution ahead of the rear wheels.

**Pros and cons:** On the one hand, this type of unit eliminates the strong weight shift to the front of the vehicle and the material is distributed ahead of the rear wheels where the operator can easily monitor the application. On the other hand, the complexity involved in ensuring that the box is tipped far enough to cover the conveyor can be a problem. Difficulties have also been encountered with body integrity, as the full support of the contractor's dump box is not available. The vehicle is also more heavily loaded on the driver's side and braking on slippery roads could be affected.

**Assessment:** An economical alternative to maintaining separate fleets of winter and summer maintenance vehicles in areas where storms are less frequent. You'll need to compare the costs of converting trucks for winter use to the cost of purchasing new equipment dedicated to seasonal use only.

## What's What?

A compendium of winter maintenance equipment

### *Spreaders*

**Type:** Zero velocity

**Nickname:** "Velocity-raptor"

**Background:** A high percentage of salt applied to the road bounces off due to the combination of the impact of the granules hitting the pavement, and the speed of the spreading vehicle. This wastage can be reduced significantly by spreading it in a way that will keep it on the road, and in the right location. Most road authorities now theoretically constrain their spreaders to a speed of about 30 km/h (20 mph) to avoid wasting salt due to the scatter effect at higher speeds. In practice, speeds of 40 km/h (25 mph) are not uncommon. If salt could be applied at higher speeds, combination units would be much more productive as the unit could apply salt at plowing speeds. Many authorities report that plow speeds approach 70km/h (40 mph) in rural areas.

**Modus operandi:** Zero velocity refers to a concept by which the salt is discharged rearward at exactly the same speed as the spreading vehicle is traveling ahead. The two velocity components cancel each other causing the salt to drop on the road as if the spreading vehicle were standing still.

**Pros and cons:** On the one hand, faster spreading speeds would result in faster treatment of hazardous conditions and reduce the number of expensive maintenance vehicles required. On the other hand, the available zero velocity products have experienced problems, such as material caking, uneven discharge, and mechanical complications, under certain conditions. One manufacturer of these units uses a high-speed blower to discharge the salt rearward, but this results in a large cloud of salt that is hard to control and is easily affected by side winds.

**Assessment:** These spreaders may lower the amount of salt spread by allowing it to be spread at fairly high speeds in a narrow band at or near the centerline. However, they don't broadcast the material, which is often a requirement on multi-lane roads.

So far, there is no ideal way to spread sand with these spreaders. Modifications are being developed and it is anticipated that further refinements will enable road authorities to reduce application rates and increase application speeds using this concept. Stay tuned.

## What's What?

A compendium of winter maintenance equipment

### *Spreaders*

**Type:** Multipurpose

**Nickname:** "Jack of all trades"

**Distinguishing features:** The new multipurpose spreaders incorporate most of the benefits of the other spreaders. These units are available in various sizes starting at a nine-cubic-meter capacity. They provide precise application rates and all the advantages of distribution in front of the rear wheels. The units are lightweight and provide year round use. The cross conveyors are easily removable during the summer so that there is no tare weight penalty.

A recent design makes use of a U-shaped box to ensure that no material hangs up in the box and that all material can be easily removed from the box at the end of the shift. These units can carry substantial loads so care must be exercised to ensure that adequate truck components, axles, springs, and wheels, are specified to carry the load. This is particularly important on combination units that are also equipped with snow plows.

**Modus operandi:** They use a longitudinal conveyor, which is similar to, but wider than, the longitudinal conveyors on hopper spreaders, to transport salt or sand to the front of a large modern contractor's dump box. At the front, a lateral conveyor transports the material to the left or right side of the body for distribution ahead of the rear wheels. At this point the material is either discharged in a windrow using a chute for concentrated action, or spun across the lane using spinners.

**Assessment:** The bodies of these units can be easily switched to carrying construction materials. Good for efficient, year-round vehicle use.

## At the controls

Spreader controllers have come a long way since the days of full manual operation. Research and development efforts have produced a new generation of electronic controllers with the ability to change distribution rates and record the chronology of operator actions for later analysis.

Ground-speed controllers have demonstrated a positive cost-benefit relationship.

There should be little doubt that ground-speed spreader controls are worth their cost. Controllers that are now available have demonstrated a positive benefit-cost relationship.



The latest models not only allow you to spread the precise amount you want, but they provide accurate information as to what was spread. They help determine effectiveness of operations, with whatever material used, and provide some information necessary to modify action to continue to provide safe highways.

All spreaders require an accurate electronic controller to ensure that the appropriate application rate is achieved at any speed and during all conditions. The most basic unit is a simple hydraulic circuit to maintain a steady application rate. This type of controller is still in use in many municipalities. One of the biggest disadvantages of the hydraulic circuit units is that it starts to exceed the desired application rate as soon as the truck speed drops below the design speed and an unnecessarily rich salt mixture is dumped on the road.

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**-NOTE-**

**What does it take?** Fourteen kilograms (31 lbs) of salt is required to keep snow and ice from bonding to a kilometre (0.6 mile) of two-lane pavement.  
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Modern spreaders use electronic ground-speed controls to provide consistent application rates.

The modern generation of spreaders uses electronic ground-speed controls to provide consistent, accurate application rates. The truck speed is monitored from the truck's speedometer drive, and the spreader output is adjusted to maintain a steady output at the set rate per kilometre or mile. Both open and closed loop systems provide increased accuracy of the spread rate. These "smart" controllers also automatically increase the output rate if a second spinner is actuated to treat truck climbing and turning lanes.

New spreaders have infrared controls that can provide calibration settings electronically.

Early models of the electronic controllers were not dependable and required extensive maintenance. The new, improved models provide additional benefits, such as calibration settings that can be applied electronically using infrared controls.

There are also units that record the information about the amount of salt used, the time it was used, and the associated application rate, for analysis and control by the road authority. Some of the really high-tech units even incorporate global positioning to identify where the material was discharged. Unfortunately there is no standard format for the information and it is difficult to compare and combine the information from the units supplied by the various manufacturers.

Here's an opportunity for anyone who dabbles in computer programming on the side: we need a standard that would enable automatic downloading of the information from the controllers of various manufacturers to a standard program.

## Spread patterns

There's more to winter road maintenance than knowing when to salt, where to salt, how much to salt, and which type of spreader to use. You also have to know *how* to spread it. Customizing your application methods to your maintenance requirements is the best way to make the most efficient use of salt.

Using salt strategically allows you to use less of it.

Extensive testing in North American and Europe has shown that using salt strategically allows you to use less. Targeted applications in concentrated locations is often more effective—and is almost always more cost-effective—than simply spreading the chemical uniformly across the entire width. As we discussed in an earlier lesson, the “when in doubt, put it out” school is no longer in vogue.

## A windrow of opportunity

An example of a targeted application is a continuous windrow along the centerline.

One example of a targeted application is a continuous windrow along the centerline of the road. The concentrated mass of material minimizes its tendency to bounce or be blown off the road by passing traffic. As it goes into solution, the salt drains down the crown of the road under packed ice and snow so that some ice or slush is blown off the roadway by passing traffic, and does not have to be melted.

A uniform section along the center of the road is bared off initially to provide two-wheel stability for traffic. Application in the windrow is achieved without using the spinner by dropping the material from a chute.



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**–BELIEVE IT OR NOT–**

Several years ago, a large software company in the United States developed a prototype computer program to calculate the optimum spread pattern for a given set of road conditions. Although it showed promise, the company eventually terminated the development project before bringing it to market. They were going to call the program “Windrows 98.”

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Centerline windrows are not always the answer. For example, they are not appropriate if the road surface is treacherous and immediate de-icing is required. Another example is banked curves where salt should be placed on the high side of the pavement. In these situations, you may have no other choice than to apply more salt across the traffic lanes.

## Wheel-time spreading

Salt and sand can be discharged on either side of the spreader vehicle ahead of the drive wheels, on either side at the rear, or on the centerline of the vehicle at the rear. Application ahead of the drive wheels provides two significant advantages:

1. When traction is limited, the application of sand ahead of the truck wheels provides improved traction for the spreader vehicle.
2. Application close to the driver’s cab enables the driver to monitor the application to ensure that material flow has not been impeded. This is a serious problem that is encountered due to the adverse weather conditions in which the equipment operates, the large amount of material discharged, and the existence of frozen chunks of material.

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**–TIP–**

**A sound approach:** Equipment operators have expressed dissatisfaction with the need to use rear discharge spreaders in place of the front discharge units normally used because of an inability to see if the discharge was working properly. One European manufacturer addressed this problem on rear discharge spreaders by mounting a metal plate in the stream of salt discharged off the spinner, and using a microphone and a speaker mounted in the cab to monitor for continuous flow of material.

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Spreaders with discharge at the rear are less expensive. Slide-in spreaders can be mounted and dismounted quickly if discharge at the front is not required. Discharge on the centerline of the vehicle at the rear is simple but restricts the vehicle to treating the lane in which the vehicle operates, on two-lane roads, or skewed application on other roads. These spreaders are often used on combination snow plow/spreader units. Some manufacturers provide units with adjustable chutes to change the location where salt is applied to the spinner. This allows operators to modify the location and concentration of the application on the road.



## Salt and sand in the shadow of the Rockies



In the City of Calgary, Alberta, salt is used when the temperature is  $-5$  degrees C (20 F) with a good forecast and rising temperatures. When the temperature is 0 degrees C (32 F) and dropping below  $-5$  degrees C, the city uses calcium chloride-treated sand and salt on high-speed roadways, and 9.5 mm sanding chips on all other roadways. On high-speed roadways, a mixture of 75% fine sand and 25% salt wetted with liquid calcium chloride is used.

When bridge decks are wet or slushy with a temperature of  $+1$  degree C (34 F) and falling, they are checked regularly and appropriate action is taken to eliminate slippery conditions.

(Source: <http://www.calgary.ca>)

## Spreading it properly

### Tips and tricks

- ✓ For light traffic, spread the salt in a narrow strip along the centerline. A four-foot windrow is OK.
- ✓ If you drive too fast for a control setting you'll spread too little. If you drive too slowly, you'll spread too much. Automatic controls solve this problem.
- ✓ Brines run downhill, so spread on the high side of the pavement whenever possible.
- ✓ On the straightaway and on super-elevated right-hand curves, crowd the centerline...but be careful not to cross the line and endanger oncoming traffic.
- ✓ On super-elevated left-hand curves, crowd the high right side.
- ✓ For streets and multi-lane roads with high traffic volume, use the spinner to spread salt the full width of the road.
- ✓ Keep the spinner speed slow to avoid spreading salt where it's not needed.
- ✓ Use shields or flaps to control the spread width. Calibration controls how much material is released, while shields and flaps control how far it is broadcast.
- ✓ When slush begins to stiffen and kicks to the rear from vehicle tires, it's time to plow and spread more salt.
- ✓ Check your gear before winter and re-check it before going out in a storm.

# For good measure: Getting the right amount



You'll recall the Salt Bill of Rights from an earlier lesson: the right material in the right amounts at the right time in the right location. The focus of this section is on getting the "right amount" of material on the road. The way to ensure that you do is to make sure your spreader has been properly calibrated.

The way to ensure that you get the right amount on the road is to properly calibrate your spreader.

Calibration of spreaders is simply calculating the pounds per mile discharged at various spreader control settings and truck speeds by first counting the number of auger or conveyor shaft revolutions per minute, measuring the material discharged in one revolution, then multiplying the two and finally multiplying the discharge rate by the minutes it takes to travel one mile.

Keep in mind that different dry and liquid materials will spread at different rates at the same setting, so spreaders must be calibrated with the material that will be used. You can use the Salt Institute Calibration Chart for easy record keeping. The chart is available as a spreadsheet that does all the calculations automatically. To get your free copy, in either metric or imperial, visit the Salt Institute web site at <http://www.saltinstitute.org/snowfighting/6-calib.html>.

## Calibrating the spread

Many road authorities don't regularly calibrate their spreaders.

Road authorities are beginning to realize the value of calibration as an inexpensive technique to reduce salt use. The calibration process is very simple and doesn't take a lot of time to complete. But there are many agencies that have not made the process part of their standard operating procedures.

It is important to know what amount of material you are using for the varying storm conditions, for your own benefit as well as that of the public, who may mistakenly assume that because you are using less salt, then the level of service standards have been lowered.

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### –CAUTION–

**Hands free:** Before beginning calibration procedures, make sure the spinner is turned off, out of the way, or otherwise disengaged. Don't place hands or other body parts near the spinner during calibration.

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With hopper-type spreaders, specific gate openings must be calibrated. Measure from the floor of the conveyor to the bottom edge of the gate. Below are calibration procedures for spreaders and automatic controls. Columns A, B, and C are references to the Salt Institute calibration chart.

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–TIP–

**Different strokes for different folks:** Each spreader must be calibrated individually. Even the same models can vary widely at the same setting. Also, you must calibrate differently for each type of material that you'll be spreading.

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## What you'll need

1. Scale for weighing.
2. Canvas or bucket/collection device.
3. Chalk, crayon, or other marker.
4. Watch with second hand.

### To calibrate a spreader:

1. Warm the truck's hydraulic oil to normal operating temperature with spreader system running.
2. Put partial load of salt on truck.
3. Mark shaft end of auger or conveyor.
4. Dump salt on auger or conveyor.
5. Rev truck engine to operating RPM (at least 2000 RPM).
6. Count number of shaft revolutions per minute at each spreader control setting, and record.
7. Collect salt for one revolution and weigh, deducting weight of container.

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–TIP–

**The best weigh to do it:** For greater accuracy, collect salt for several revolutions and divide by the number of turns to get the weight for one revolution. This can be accomplished at idle or very low engine RPM.

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8. Multiply shaft RPM (Column A) by discharge per revolution (Column B) to get discharge rate in pounds per minute (Column C), then multiply discharge rate by minutes to travel one mile at various speeds to get pounds discharged per mile.

For example:

- **Metric:** At 20 km/hr with 30 shaft RPM and 3.1 kilograms discharge:  
 $30 \times 3.1 = 93 \times 3.00 = 279 \text{ kilograms per kilometre.}$

- **Imperial:** At 20 mph with 30 shaft RPM and 7 pounds discharge:  
 $30 \times 7 = 210 \times 3.00 = 630$  pounds per mile.

## Calibrating automatic controls

Automatic controls come with factory calibration cards that indicate the proper rate of spread for each setting. However, when there is a need to calibrate, use the following steps:

### To calibrate automatic controls:

1. Remove or turn off spinner.
2. Set auger on given number, such as No. 2.
3. Tie sack or heavy canvas under discharge chute.
4. Mark specific distance, such as 100 or 1,000 feet, then drive that distance with spreader operating.
5. Weigh salt collected in sack or canvas.
6. Multiply weight of salt by 5.2 (in case of 1,000 feet) or 52.8 (in case of 100 feet).

This will be the amount of salt discharged per mile, which remains constant regardless of speed, but calibration must be done for each control setting.

Continuous calibration lets you score a big win and save money.

Calibration should be an ongoing process. You need to continually calibrate your spreaders, then conduct audits to verify the application rates. This is one of the most important means of controlling your sand and salt inventory, with the expenditure of relatively little time and money. By making this part of your normal operating procedures, and letting all staff know about it, you can score a big win and save money in the process.

## Pre-wetting redux



Getting the salt down in the right place at the right time using the right spread pattern is critical, but if the salt doesn't stay where it's put, all of your efforts are for naught. This is where pre-wetting comes in. As we discussed in Module 2, pre-wetting is an approach that has been used extensively for several years to keep salt on the road. It's done by using salt brine or liquid calcium chloride to wet the salt as it is spread on the road.

Adjustment of spray nozzles used in pre-wetting is critical.

Spraying stockpiles and truck loads has been tried, but was not practical as the granules were not uniformly coated and the liquid tended to drain out of the solid material. The most practical alternative is to spray the salt as it is discharged from the chute, or at the spinner. Extensive testing is currently being carried out to identify optimum liquid application rates.

The adjustment of the spray nozzles used in pre-wetting is critical. Tests by one state department of transportation showed that they never achieved more than 60% coverage of the salt with the remaining 40% of the brine or calcium chloride wasted. This is certainly more than enough to offset the benefits of using less salt on the roads.

## Turning water into brine: Equipment requirements

Pre-wetting provides significant potential reductions in salt use but greatly increases the complexity of the equipment that you'll need to make it happen.

Here's what you'll need:

- a storage tank for the liquids
- brine-making equipment
- pumps to load the spreaders



Wetting agents are corrosive, so use stainless steel nozzles and non-contact pumps.

The application pumps on the spreaders themselves should be regulated by ground speed controllers to ensure the correct liquid application rate is maintained under all conditions and at all speeds. Additional maintenance is required to ensure that the lines and nozzles are purged and the equipment cleaned at the end of the storm to prevent clogged line and seized equipment. Wetting agents are corrosive materials, so it's important to use stainless steel nozzles and non-contact pumps to ensure dependable performance.



Several manufacturers offer equipment to manufacture salt brine for pre-wetting and anti-icing applications. Both batch plants and higher capacity continuous flow plants are available. The continuous flow tanks are more common.

You can make brine using either a batch or continuous flow plant. The latter is more common.

In the brine-making batch plants, water is added by gravity to rock salt to produce a saturated brine solution. Be sure to check the concentration with a hydrometer to measure the specific gravity of the solution.

The percent of saturation is determined by reference to specific gravity charts for the specific solution temperature. In the continuous flow plants water is forced through salt under pressure. The solution strength is metered and controlled automatically, but

you should still check it periodically with a hydrometer to ensure that you're getting the right concentration.

The resulting salt brine can be pumped directly into tanks mounted on the spreaders or transferred to holding tanks at the maintenance depots.

### **How it's being done**

One road authority in Iowa worked with a manufacturer to design a brine-making system that produces 600 gallons of liquid brine at 23.3% solution in less than an hour.

Here's how it works:

1. Dry salt is loaded into the top of the tank and water is pumped through the salt from below.
2. Once the loading area has filled, water will begin overflowing the tank through four-inch diameter screened holes into the main storage tank below. At this point the brine is tested with a hydrometer to determine the salinity level of the solution.
3. If the brine needs adjustment, a separate fresh water valve can be opened to mix fresh water with the brine bringing the solution to the 23.3 percent optimum. The system is also equipped with an internal float that shuts off incoming water once the lower tank is full.
4. At this point the brine is ready to be pumped to the tailgate spreaders through a 55-gallon-per-minute pump system and one-inch discharge hose equipped with a quick disconnect coupling. The system also comes equipped with a remote control for pumping the brine into the tanks, which makes filling quick and easy.

Since the minimum purity of rock salt is 95 percent, the brine makers have to be cleaned out four or five times each year. It is also important to make sure all screens are in place, as the impurities will plug up the system.

## Liquid-only equipment

Salt brine applications can be done at higher speeds as the brine adheres well to the road surface.



The Scandinavian countries have reported substantial salt reductions by using light applications of straight salt brine at the start of the storm to prevent roads from becoming slippery. They have been able to eliminate subsequent regular salt applications as long as this treatment remains effective.

Many North American road authorities have used solid salt applications at the start of the storm to achieve similar results, but at higher total salt loads. The salt brine application has the added advantage that it can be done at much higher speeds, approaching the speed of other traffic, as the brine adheres well to the road surface.

Several manufacturers are producing equipment for anti-icing, which is being tried by a number of jurisdictions in North America. This equipment normally includes 4,000 to 6,000 liter stainless steel holding tanks with non-contact pressure pumps. A distribution manifold fitted with stainless steel nozzles is mounted at the rear to cover the required section of the road. The application rate is controlled with an accurate ground speed control system. These units show considerable promise but their benefits can only be achieved in a narrow temperature range.

## Orifice nozzles

Maintain a consistent spray pattern at low speeds with variable orifice nozzles.

The liquid distribution system must be designed to apply very low application rates as the vehicle starts from rest, and high-speed application rates at full operating speed. This requires the use of variable orifice nozzles or a separate set of nozzles for low speed operation to maintain a consistent spray pattern. It may take a considerable amount of trial and error testing before you find the right setting.

Your knowledge of the phase diagram (Module 2, Lesson 2) will come in handy here. As an operator, you need to take into consideration the pavement conditions and to fully understand the potential risks involved in brine dilution, falling temperatures and the possibility of re-freeze.

## How much salt is enough?

Weighing devices can record the amount loaded. This valuable data can be analyzed later to refine loading precision.



In the good old days—and perhaps even today—you probably tended to load a little extra sand or sand/road salt into the hopper just to make sure you didn't run out half a mile from the end of your route. Better to have a little too much than not enough. But in the age of electronic ground speed systems that can precisely apply the right amount of material, you can load the exact amount needed for your route with the confidence that you won't run out before the job's done.

To eliminate the overloading problem, there are inexpensive, durable, and accurate weighing devices available for installation on the loaders used to load the salt spreaders. These devices can measure a predetermined load size for the scheduled route. An audible warning is provided to the loader operator when the planned load is achieved.

Some models can record the amount loaded with the loader in motion so that the loader operation is not impeded. This is valuable data that can be analyzed later and used to further refine the precision in loading the correct amounts for each route. This equipment provides the operators with a mechanism to accurately measure and control the amount of material loaded on the spreaders.



-----  
-TIP-

**Under control:** Don't monitor load sizes by counting the number of buckets per load. Weigh each load using available weighing devices. The digital readouts and hard copy printouts are essential components of inventory control. They also let operators know exactly how much they are putting down. The inventory control benefits of these weighing devices far outweigh the costs. This is a good return on investment.  
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## Quick Quiz

**You may ask what's wrong with having a little extra material on board. Good question. And we're going to give you a chance to provide the answer. We can think of at least three good reasons why you shouldn't overload. How many can you think of?**

1.

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2.

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3.

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### Answer

1. Loading extra material onto a spreader can lead to overloading or the temptation to over-apply the salt.
2. Extra material left on the truck, rather than being properly off-loaded and piled in the storage building, can be dissolved by the next rainstorm if the truck is parked outdoors.
3. Overloaded trucks contribute to contamination in the area of the salt storage facilities. Salt heaped above the sideboards is thrown off the trucks as they negotiate curves to exit the yards.



## Safer by the yard: Salt handling tips

Conveyors allow salt trailers to dump directly for transfer into the storage facility.

Salt yards are potential sources of extensive salt contamination resulting from poor handling practices. For example, salt does not have to be dumped on a paved surface when it is being loaded into storage buildings. Conveyors are available which are designed to allow salt trailers to dump directly for transfer into the storage facility. This is a practical approach at high salt use locations.

Loaders used to fill spreader vehicles are often fitted with buckets that are too large for the spreader bodies. This results in spillage. Smaller buckets are available for most loaders, or side-dumping bucket attachments can be used which provide quick precise loading.



We'll be taking a closer look at these and other measures and practices to avoid salt contamination at storage yards in Module 5, Lesson 1, "Road maintenance yards."

## Chemical removal of snow and ice



When all else fails, it's time to bring out the chemicals. As we have already learned, snow and ice that cannot be physically removed from the roadway must be chemically removed by applying the right amount of the right material in the right location at the right time. Chemical removal of snow and ice involves a calibrated application of liquid and/or solid chemical, which will lower the freeze point of water and allow melt water to shed from the surface.

Apply the chemical proactively to prevent the ice-pavement bond from forming.

If you're able to act proactively, you can apply the chemical before the storm event to prevent the ice-pavement bond from forming, easing later mechanical removal. At low temperatures, after the precipitation stops and the moisture evaporate, the final result may be a "freeze-dry" condition with only a salt residue remaining.

Liquid chemicals are becoming increasingly popular due to technological developments in metering equipment, which make it possible to apply just the right amount for the conditions.

## Future Watch: What's in it for you?



**In this issue of *Future Watch* we take a look at the wide variety of innovative equipment that has been developed, or is in development, to help make your job easier and enable you to use less salt.**

A lot of research and development effort has gone into the search for more efficient ways to remove snow and ice from roads with an eye to minimizing, or even eliminating, the use of salt. *Future Watch* recently spoke with Aaron Dee, also known as “Research and Development Guy”, about technological innovations that could be coming to your road authority soon.

**Future Watch:** We’ve heard a lot about automatic sprayers. Where are they at in terms of development?

**Aaron Dee:** Of all the innovative technology that is being developed or tested, this is probably the one that will emerge as the next important advancement in winter road maintenance technology. Already, solar-powered, battery-operated automatic equipment has been permanently mounted at some critical locations to spray brine solution or liquid calcium chloride when sensors installed in the pavement detect icing.

**FW:** In what critical locations would you see these being used?

**AD:** They’re going to be very useful on high traffic volume bridges or critical areas at the end of spreader routes. Tests are continuing to determine if the equipment is sufficiently dependable to operate unattended at remote sites.

**FW:** We’ve heard about something similar to this being tested in Japan.

**AD:** Yes, but in that case what they are looking at is a device that exudes de-icer onto the road surface under time control from ejection devices embedded in the road surface. Tests are continuing to determine if the process is practical when used in winter highway operations. But it is a very interesting concept.

**FW:** What’s the most radical idea that’s being explored right now?

**AD:** I would have to say the microencapsulated de-icing materials. It’s more theory than reality at the moment, but the idea is that ultraviolet, visible light, or microwave radiation could be used to rupture microencapsulated de-icing materials placed on the pavement before a storm. The Strategic Highway Research Program in the U.S. has evaluated this concept. They determined that the equipment to activate or rupture the encapsulated de-icing material is readily available, so we may see more developments in this area in the near future.

**FW:** Very interesting.

**AD:** Yes, but not as interesting as the attempts to use high-pressure abrasive jets and acoustic waves for winter road de-icing. So far, they have been found to be impractical, but some work has been done with abrasive air jets. Although this work is preliminary, the researchers concluded that this could be a practical method of removing ice from the

roadway but many problems have to be addressed before the process could be used on highways.

**FW:** We've heard about experiments with equipment that measures the available traction on winter roads. Is this going to be feasible?

**AD:** Oh, yes, very much so. Several U.S. states, the province of Ontario, and the Scandinavian countries in Europe are experimenting with this equipment. In some cases, it's mounted on the spreader vehicles and used in conjunction with onboard mounted pavement temperature measurement equipment to automatically control the application rate of de-icing chemicals. A survey of maintenance administrators determined that the equipment would have to be considerably less expensive than at present to be considered for future use, but technically the equipment has proven to be accurate and dependable. This certainly has the potential to eliminate the unnecessary use of salt on roads with adequate traction.

**FW:** It looks like we've got a lot to look forward to. Thanks for bringing our readers up to date.

## Know where to plow...get the drift?

You need to know which areas on your route are potential trouble spots during high winds.



Knowing what equipment is available, how it works, and how to use it is obviously very important. But knowing *where* and *when* to use it is even more important. One of the most challenging conditions that you face as an operator is drifting snow. There are several measures that you can take to deal with drifting conditions, but perhaps the most important one is to know which areas on your route are the potential trouble spots during high winds.

Road authorities should have a comprehensive inventory of drifting areas, as well as a plan on how to treat them. Many authorities have established drifting routes that receive priority attention during high wind conditions.

Proactive, preventive measures include the erection of snow fences and the creation of snow windrows to act as windbreaks against drifting. Once the high-risk drift areas have been identified, operators can be deployed to put up snow fences in the period leading up to winter.

Windrowing snow into a "fence" creates an effective windbreak.

Snow fences can be expensive to purchase, install, and maintain. The expenditure of money and resources should be considered carefully. Often, simply windrowing the snow into a "fence" is as effective as installing expensive fencing that is vulnerable to damage from the elements and vandals.

## Where have you been?



Despite all the technological advances and innovations, the equipment traditionally used to clear winter roads, including snow plows and de-icing spreaders, continues to provide the most effective and practical solution to ensure safe travel during the winter. Modern developments in the design and deployment of this equipment enable road authorities and contractors to substantially reduce salt use. As a result of extensive research and testing, there is equipment available to precisely control the application of material at reduced rates. This equipment is much more sophisticated, durable, and easier to use, but the potential benefits can only be realized if maintenance staff is thoroughly trained and material use is closely monitored.

Although many of the developments aren't here yet, we can confidently anticipate the time, in the not-too-distant future, when application rates may be tied into sensor-based information systems including real time data, forecasts, road friction measurements, road surface temperature measurements, and global positioning equipment. As the use of this technology evolves, considerable planning, organization, and evaluation are required to ensure the best use of the available equipment.

As equipment technology continues to improve, it is important for agencies to monitor changes and evaluate, select, acquire, and implement the appropriate technological changes to help them to become more effective and efficient.

## Where are you going?



Spreading and plowing equipment isn't the only area receiving research and development attention. There is a growing array of sophisticated equipment either available or in development to help you to track and forecast the weather. As a winter road maintainer, no information is more critical to you than accurate weather data. You need to know what's on the way, when it will arrive, how long it will stay, and what kind of conditions it will leave behind. The more you know ahead of time, and the more accurate the information is, the better equipped you'll be to develop and implement a plan of attack.

In the next lesson we'll look at weather tracking and forecasting equipment and how you can use the information it provides to strategic advantage.



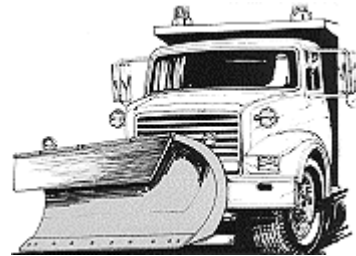
Transportation Association of Canada



# Salt SMART

Spreading, Management, Application Rates and Timing

## Learning Guide



Module 3, Lesson 2  
Using tracking and  
forecasting technology

*June 2004*

## ***Transportation Association of Canada***

The Transportation Association of Canada is a national association with a mission to promote the provision of safe, efficient, effective and environmentally and financially sustainable transportation services in support of Canada's social and economic goals. The association is a neutral forum for gathering or exchanging ideas, information and knowledge on technical guidelines and best practices. In Canada as a whole, TAC has a primary focus on roadways and their strategic linkages and inter-relationships with other components of the transportation system. In urban areas, TAC's primary focus is on the movement of people, goods and services and its relationship with land use patterns.

## ***Wellspring Consulting Inc.***

Wellspring Consulting is an instructional design company, specializing in adapting reference information into self-contained learning guides through the application of proven adult learning principles. With the Wellspring methodology, learners are first engaged through an enjoyable, easy to follow and entertaining writing style, then challenged using interactive techniques like problem-solving and role-playing. This fresh and stimulating approach enables learners to effectively transform dry technical information into vital, practical knowledge.

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***June 2004***

## Salt SMART Train-The-Trainer Program

TAC offers trainer workshops to accompany the Salt SMART Learning Guide in support of the best practices for the environmental management of road salts. They range from one-day overview sessions to two-day all-inclusive sessions.

*Make a SMART investment today and book your “at-home”  
trainer workshop or attend one in Ottawa!*

### Overview session

This one-day session is for trainers with formal training and experience. It is designed to walk through the *Salt SMART Learning Guide* to highlight key messages and to discuss potential areas of resistance and how to handle them.

**Member price at a member-selected location:** \$5,000 flat fee for up to 10 participants plus expenses (e.g. training room and AV equipment, catering, TAC trainer’s travel and accommodation).

**Member price in TAC-Ottawa training room:** \$899 per participant. A minimum class size is required and dates will depend on attendee preferences and trainer’s availability.

### All-inclusive session

This two-day session is for those who have little or no training experience. It offers the one-day overview combined with an extra day devoted to soft skills training (trainer techniques, adult learning principles, lesson planning).

**Member price at a member-selected location:** \$6,500 flat fee for up to 10 participants plus expenses (e.g. training room and AV equipment, catering, TAC trainer’s travel and accommodation).

**Member price in TAC-Ottawa training room:** \$1099 per participant. A minimum class size is required and dates will depend on attendee preferences and trainer’s availability.

*TAC non-members pay a 20% premium on all sessions.*

To book your trainer workshop, or for further information, contact the TAC Training Manager, Diane Jodouin at (613) 736-1350, ext. 261 or [djodouin@tac-atc.ca](mailto:djodouin@tac-atc.ca)



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The project team for this Learning Guide consisted of the following individuals:

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TAC gratefully acknowledges the dedication, guidance and input of the Subject Matter Reviewers; and the quality of work performed by the Instructional Designer.

This Learning Guide is truly a team effort by all those who have contributed financially and/or technically.

# Preface

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## TAC Learning Guide

There are some things that should be taken with a grain of salt. The information in this learning guide is not one of them.

When you consider that the nation's extensive transportation network supports a wide range of economic and social activities, it's not putting too a fine point on it to state that safe and efficient road traffic throughout the year is essential to our way of life. We rely on the road network for transport to the workplace and other economic uses, for recreation and leisure activities, and for emergency and security services.

Road salt is the deicer of choice for winter road maintenance.

There's something else that we rely on: road salt. It's the deicer of choice for keeping roads passable throughout the winter.

The benefits of using road salt to keep the thoroughfares open don't come without costs, both economic and environmental. Recognizing this, and concerned about the environmental implications of road salt applications, the Transportation Association of Canada's (TAC) Chief Engineers' Council, the Road Salt Working Group (a subcommittee of the Maintenance and Construction Standing Committee), and the Environment Council launched an initiative to identify and document new ways of handling and using road salt. Transportation professionals from across the country worked together through the 20-member project steering committee and 17-member project team to produce three important documents:

- *Road Salt and Snow and Ice Control Primer*: An executive summary of the project, written for the general public, that provides information on the importance of road salt use to maintaining a safe and efficient transportation system that sustains Canada's economy.
- *Road Salt Management Guide*: A comprehensive reference guide which addresses transportation and Canada's economy and quality of life, road salt and the environment and road salt management practices.
- *Syntheses of Best Practices for Road Salt Management*: A series of syntheses of best practices related to the effective management of road salt use in winter maintenance operations.

## This guide's for you

This learning guide is based on the best practices in the *Road Salt Management Guide* and the *Syntheses of Best Practices for Road Salt Management*. If you're an operator or supervisor, then this guide is for you.

As a winter road maintainer, you're on the front lines in the battle against snow and ice on roads. In fact, the only thing that gets out there ahead of you is your plow blade. You probably already know that road salt is the most effective, cheapest, and easily handled de-icing material. There may be alternatives out there, but they usually cost a lot more, require special care when handling, and are only effective under certain weather conditions. Road salt is still the most reliable de-icing chemical available.

## The "4 R's" of winter road maintenance

There was a time when winter road maintainers lived by a simple rule of thumb: "when in doubt, put it out." In other words, it was better to err on the side of caution and put down a lot of road salt—and put it everywhere—just to make sure. But those days are long gone.

The modern winter road maintainer has a new mantra: "put the **R**ight amount of the **R**ight material in the **R**ight place at the **R**ight time." In other words, use road salt more wisely and effectively. The benefit of this approach is that road salt usage is *optimized*. This translates into savings for the organization, and minimizes the impact of road salt on the environment. This guide is designed to teach you how to optimize road salt usage while continuing to keep winter roads safe for commercial, passenger, and emergency vehicles.

## Your guide to road salt optimization

Optimizing salt use means being smarter about you how put it down.

Optimizing road salt usage means being smarter about how you apply the material. In most cases it will mean that you use less road salt, but that is a result rather than an objective. In order to use road salt more wisely, you'll need to become a better decision-maker, and in order to do that, you need to improve your knowledge. That's where this learning guide comes in.

The guide consists of six modules:

- **Module 1** sets the stage by looking at the importance of transportation to our economy and way of life; the economic implications of winter maintenance; and the cost-benefits of winter maintenance.

- **Module 2** explores the science of road salt and ice. In Lesson 1 we look at the principles of ice formation. Lesson 2 examines the concept of freeze point depressants and how they work to prevent or break the bond between pavement and ice. In Lesson 3 we consider alternative de-icing chemicals and their role in winter road maintenance. Lesson 4 looks at application strategies, in particular anti-icing, a modern preventive approach that aims to keep the ice-pavement bond from forming.
- **Module 3** looks at equipment and technologies used by modern winter road maintainers. In Lesson 1 we survey plows and spreaders and how they can be put to work to optimize road salt usage. Lesson 2 examines pavement condition tracking and forecasting techniques and technologies, including road weather information systems.
- **Module 4** deals with road salt and the environment. In this module we look at the pathways by which road salt can make its way into soil and groundwater, and the effects it can have on vegetation and wildlife.
- **Module 5** looks at snow and road salt handling. In Lesson 1 we look at road salt handling and storage at the road maintenance yard. In Lesson 2 we examine disposal strategies and techniques at snow disposal sites.
- **Module 6** considers the importance of monitoring and record keeping in winter road maintenance.

The objective throughout these modules and lessons is to help you, as an operator or supervisor, to understand how it is possible to use road salt more effectively while continuing to provide safe roads during winter and minimizing the impact on the environment.

## The same, but different

You have a lot in common with winter road maintainers across the country.

As a winter road maintainer, you have a lot in common with operators and supervisors in other jurisdictions across the country. At the same time, your job is very unique. Every road jurisdiction has a different transportation infrastructure to service. No two agencies face the same weather conditions. Each organization has a different mix of human resources and equipment available to keep the roads open during winter. Levels of service differ from one jurisdiction to the next, winter maintenance strategies are designed to meet specific local challenges, and public expectations change from one jurisdiction to the next.

In other words, while all winter road maintainers may be out on the front lines keeping the roads open, they could be using very different means to achieve similar ends.

This learning guide deals with general principles of winter road maintenance that can be applied in every jurisdiction, but it is beyond the scope of this document to prescribe practices that apply to specific road authorities. The best practices upon which this guide is based have been carefully researched and prepared and are endorsed by the Transportation Association of Canada's (TAC) Chief Engineers' Council, the Road Salt Working Group (a subcommittee of the Maintenance and Construction Standing Committee), and the Environment Council.

This material is provided as advice to winter road maintainers for consideration when developing their own policies, practices, and procedures. Keep in mind that the best practices are to be used in concert with the legislation, manuals, directives, and procedures of your individual road agency.

The material in this learning guide will be incorporated into your agency's current or planned training programs.

## A word about what's inside

Before we dive into the learning guide, let's take a look at what you'll see inside. We know that your time is valuable, and that the technical nature of this subject-matter may not be the most exciting thing you've read lately. So we've tried to make the learning experience as easy and enjoyable as possible.

We want you to learn, and to enjoy doing it.

The first thing you'll notice is that, unlike a lot of those technical reference manuals and user guides you may have seen and tried to read, our tone is conversational. We talk directly to you in a casual voice that's free of jargon and technical terminology. We even throw in a bit of humour every now and then. Unlike those other documents, we want you to learn, and to enjoy doing it.

Each lesson begins with a summary of the topics that we'll be discussing. This is followed by a conversation among fictional characters in a fictional maintenance yard: Pine Junction. Any resemblance between these characters and anyone you may actually work with is entirely coincidental. This dialogue sets the stage for the material covered in the lesson. Once you've read the list of topics to be covered and the dialogue, you'll have a pretty good idea of what you're going to discover in the lesson.

## Getting around: Navigation aids

The margin along the left side of each page is an area that we call the “fast track.” This serves three purposes:

We call this area the “fast track.”

1. Document designers tell us that “white space” on the page is visually pleasing to the eye, making it easier for you to read what’s on the rest of the page.
2. We can provide a capsule summary of the important points on the page. If you don’t have time to read the whole thing, at least you’ll know what you’re missing, and you can come back to it later if you’re interested.
3. The capsule summaries serve as “navigation aids”, which means that they provide a reference point if you need to come back to a section of a lesson and find a particular piece of information.

---

### -TIPS, NOTES, and WARNINGS-

Although we feel that all of the information in the learning guide is important, some items need to have special attention drawn to them. We present these in the form of “Tips”, “Notes”, and “Warnings”. Information presented in this format is related to, but not part of, the discussion at hand.

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On the other hand, when we want to emphasize an important point *in* the discussion, we highlight it in this fashion.

If you only had time to skim a lesson, you could quickly grasp the essence of it by reading just the list of topics covered, the dialogue, the fast track items, the highlights, the tips/notes/warnings, and the summaries at the end, which we’ll discuss in a moment.

Our approach is based on the concept of self-assessment and instant feedback to confirm what you’ve just learned. Throughout this guide you’ll find “Quick Quizzes” that are designed to make you reflect on concepts that have been presented in the lesson. Once you’ve taken your best shot at answering the questions or offering solutions, you can check the answers that we provide following the quizzes. Look for the key to find out how you did. Sometimes there is no right or wrong answer, a reflection of the fact that operators in different jurisdictions might do things differently. We offer possible solutions, but our word isn’t always the final one.



When you reach the end of the lesson, we offer you a quick summary of where you’ve been. This is usually a restatement of the key points of the lesson that you should have picked up along the way. You’ll find it in the section entitled “Where have you been?”.

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# Module 3, Lesson 2

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## Using tracking and forecasting technology

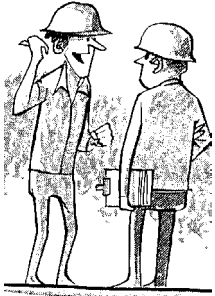
The crucial information that you need in order to make appropriate choices in winter road maintenance service delivery comes in many forms, but more and more of it is coming from technological innovations.

### *Well, what shall we talk about?*

- Tools of the trade: Winter road maintenance technologies
- Information as a tool
- Watching the weather and the road: The importance of looking up...and down
- Deconstructing RWIS
- RWIS in action: Case study
- Who needs RWIS?
- The importance of tracking pavement conditions
- Pavement condition tracking tools: IRTs, friction/chemical residue sensors



## Equipment depot. Pine Junction maintenance yard. December.



“I didn’t think you were into censorship, Roch,” joked John Rhodes as he surveyed the equipment on the table.

“I didn’t think you were into bad puns, Johnny,” Roch Salterelli fired back.

“You bring out the worst in me. I take it we’re about to get another lesson from that learning guide. I already know that these are sensors, so can I be excused from this session?”

“Sure, Johnny. If you can tell me what an RWIS is and why it’s important for winter road maintainers like us, you can be excused. I know you’re just dying to get the rest of the plows hooked up.”

“Well, it looks like a storm’s coming, Roch. Let’s not get caught.”

“Johnny been watching the Weather Channel again?” asked Brine Watters as he joined the group in the lunchroom.

“I don’t need to watch it. I’ve been in this business long enough to know when snow’s on the way.”

“Maybe so,” replied Watters, “but I bet you can’t tell me the temperature of the pavement out there.”

“And you can?” Rhodes shot back.

“Actually, I can, with this,” explained Watters, holding up an infrared thermometer. “Looks like they’re serious about bringing us into the 21<sup>st</sup> century.”

“Of course we’re serious,” Salterelli interjected. “I didn’t take all that training for nothing. We’re just waiting for Rusty and Crystal so we can get started. Johnny will be leading the session today, explaining to us what an RWIS is. Right, Johnny?”

“Very funny. I’m dying to learn how to go out and take the temperature of the pavement. Where do you aim that—in the asphalt?”

“Brine, do you want to give us a quick demo of that gizmo?” asked Salterelli as Rusty Steele and Crystal Ion joined the group.

“Sure. This is our new IRT, or infrared thermometer. It’ll give you the exact pavement temperature at a specific location on the road. Takes the guesswork out of trying to figure out what’s happening on the road surface. Whoever’s on patrol can take a series of readings and radio them back here. It’ll give us a good picture of the

temperature trend.”

“Do you use that on the fly, or do you have to stop for each reading?” asked Steele.

“With this one, you have to stop to take the reading. But we’re also going to equip a couple of the patrol trucks with mounted units. They can take readings as you drive down the road. They’re displayed on a screen in the cab.”

“Cool.”

“Can we get to the RWIS, Roch?” asked Rhodes. “I’ve got work to do this afternoon.”

“Sure, Johnny. Has anyone here ever heard of an RWIS?”

“I have,” Watters replied. “It’s a road weather information system. I’ve never actually seen one in operation, though.”

“Well, you’re going to get a chance pretty soon. We’re going to be hooking up to a network that will feed us all kinds of data, in real time, on air and surface temperatures, dew point, humidity levels, and all the rest.”

“Great,” said Rhodes sarcastically. “We’re about to be replaced by computers.”

“Hardly, Johnny,” assured Salterelli. “We may get a clearer picture of what’s coming, but someone’s still going to have to make the call on how we respond. Don’t worry—we still need your many years of experience.”

“Yeah, I don’t think we can get rid of you that easy, John,” laughed Watters.

“Well, the day you tell me that you’ve got remote control plows is the day I call it quits.”

“We’ll never get there, Johnny. This isn’t about replacing humans. It’s about using technology to improve your decision-making capabilities. No RWIS in the world could replace what you know about this business.”

## Tools of the trade



As you've progressed through this learning guide you've learned the value of the transportation infrastructure to our economy and way of life. You've seen how ice forms on roads and you know how to use chemical and mechanical means to prevent its formation or help in its removal.

You now know that it takes temperature, moisture and time (TMT) for salt to dissolve. The concentration of the brine, based on the phase diagram and eutectic point, determines the freeze temperature of the moisture. It is the temperature trend of pavement, rather than that of the surrounding atmosphere, that governs the behavior of the salt chemical.

You know the importance of an anti-icing strategy based on knowledge.

You've learned the importance of having an anti-icing strategy based on knowledge, experience, public expectations, and prescribed level of service standards. You understand that having the proper equipment can lessen the need for chemicals, and that properly calibrated spreading equipment can make sure that chemical applications are targeted effectively.

Winter maintenance operating and research personnel in many parts of the world have identified new methods and technologies that have the potential to improve snow fighting efficiency and significantly reduce the amount of road salts used to maintain roads and highways in the winter. Equipment is now available that incorporates these developments to reduce salt use, control the impact on the environment, improve winter driving conditions, safety and mobility, and reduce overall costs.

From the maintenance arsenal at your disposal, which includes spreading equipment, plows, trucks, and chemicals, you must be able to decide when, where, why, and how to deploy your resources. That requires knowledge, which comes from the combination of your experience and the information at your disposal.

# In the know: The critical importance of good information

Information is your most valuable commodity. It's the prerequisite to any action that you take.

Information is your most valuable commodity. It's the prerequisite to any action that you take. Everything you do as a snow fighter is based on forecast and actual weather and pavement conditions. Where you get that information is the focus of this lesson.

These days, most of the information and data that you need in order to make road maintenance strategy decisions comes from technological innovations. Road weather information systems (RWIS) provide a continuous flow of data on pavement and air temperatures and conditions. As sophisticated as this technology is, however, it can't replace your knowledge, skills, and experience.

Your role as a decision-maker is assisted—not replaced—by winter maintenance technology.

If you think that your role as a decision-maker can be replaced by technology, think again. If that were the case, then anyone could walk in off the street and run the winter road maintenance show. But to a complete outsider, with no knowledge of salt chemistry, ice formation, dew and eutectic points, and phase diagrams, what would the following information mean when it appeared on the computer screen?

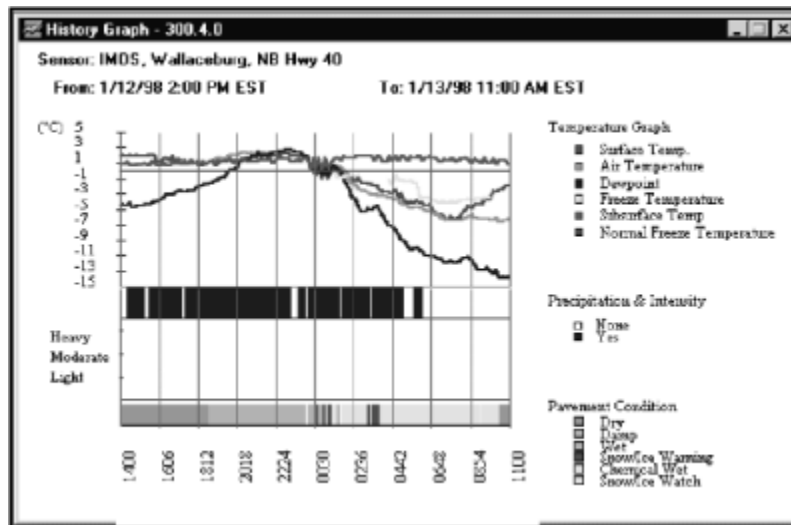


Figure 1. Historical RWIS graph

Think of road weather technology as a tool to help you make decisions, rather than as something that can replace your knowledge, experience, and training. Once you know how to read this kind of data, and interpret what it's telling you, you'll be able to make decisions on what action is required to address what's happening on the road.

## Building corporate memory

Outsiders may not realize the critical role of decision-making in winter maintenance operations.

We referred earlier to the outsiders' perspective. To them, the winter road maintainer's role is to clear the roads, and the most important tool to do that is the snowplow. What they may not realize is the critical role of decision-making, and the importance of information as a winter maintenance tool.

Heading out to the roads in the middle of a storm is really the execution phase of a strategy based on information and knowledge. You can't go out until you know where and when to go, and what to do when you get there.

Monitoring pavement condition forecast data from a road weather information system is part of a continuous learning process. The development of a database helps your organization to refine winter maintenance tactics. It also provides a recorded history of information and activity in the event that your liability is challenged. So from many perspectives it pays to do your due diligence and know what data is coming in and understand its implications for your organization.

The critical information that you need to support your judgment as a decision-maker can be divided into three categories:

1. *Forecast information* (what will happen): predicting upcoming storms and potential icing events;
2. *Current information* (what is happening): road surface temperatures and conditions; and
3. *Results information* (what did happen): record of what was done and the level of service achieved.

In this lesson we'll be looking at a number of tools that are available to help provide you with the required information.

**Yes, Virginia, there is a better way**

In an effort to improve its RWIS network,



performance, studied what other jurisdictions are doing, and concluded that it could do things better. Here's how VDOT plans to improve its RWIS:

- availability and accuracy, including detection of sensor malfunctions, timely repair, and routine maintenance and calibration.
- procedures and penalties for non-compliance in future contracts.
- once a maintenance contract is in place.
- quantifiable forecast measures and penalties for non-compliance.
- accurate forecasts of this type are possible.

Source: [www.virginiadot.org](http://www.virginiadot.org)

## Eye on the sky...and on the ground

Your storm preparation will improve if you know when it will arrive, how long it will last, and the nature of its special characteristics. You can use the U.S. Weather Bureau, Meteorological Service of Canada, local media forecasts, or private forecasting services to get complete, detailed reports during winter.

Some maintenance departments hire private forecasters to assure a balanced and more localized weather picture, as well as special advance notice. Some larger agencies combine this information with data from pavement sensors and local weather instruments to receive actual pavement and atmospheric conditions for more precise forecasts and operations. There are a number of free services available on the Internet. For example, check out:

- The Weather Channel: [www.weather.com](http://www.weather.com)
- Accuweather: [www.accuweather.com](http://www.accuweather.com)
- National Weather Service: [www.nws.noaa.gov](http://www.nws.noaa.gov)
- Environment Canada Weather Office: [weatheroffice.ec.gc.ca](http://weatheroffice.ec.gc.ca)

## Acting on the information

Communications is another important winter maintenance tool.

Communications is right behind information as a key winter maintenance tool. Knowing that weather conditions will change is critical information. Relaying this information to all personnel is the next step.

If late afternoon reports indicate the possibility of overnight snowfall, prepare your equipment by attaching snowplows and spreaders before the workday ends. If necessary, a certain portion of the work force should remain on duty to start fighting the storm when it arrives.



The preferred strategy, as discussed in an earlier lesson, is to anti-ice roadways with a protective brine spray before going home the night before a forecast storm to prevent bonding of the snow and ice to the pavement.

If the forecast indicates snow during the night, the work force should be sent home to get some rest, but alerted that they may be called back during the night. Arrange with the highway patrol, local police, sheriff's department or weather service to notify key personnel of storms that develop late at night. Ensure that your system identifies the person responsible for relaying the alert to the entire maintenance force, if and when the need arises.



### What you need to know...

When it comes to the weather, you don't have to be a skilled meteorologist. There are any number of weather services that can provide forecasts customized for your local region.

As an operator or field supervisor, what you need to know is what constitutes a "normal" winter. Once you know that, you'll be in a better position to track anomalies and respond accordingly. So, how do you decide what's normal? First of all, you need to know, in an average year, the following about your local region:

- ✓ Number of freeze-thaw cycles
- ✓ Number of winter storms
- ✓ Number of snow days
- ✓ Number of rain days

These are the four key pieces of weather information with which you need to become intimately familiar. Without this knowledge, you have no sound basis on which to plan your salt usage for the season. Only by tracking winter severity indicators over time can you come to an understanding of what's "normal" for your region. Trying to plan salt requirements without this type of information is like taking a shot in the dark. You may hit the target, but odds are that you'll be off the mark more often than not.

# Sensorship: Deconstructing RWIS

Sensor-based weather information systems have been in use for over 25 years.

Sensor-based road weather information systems have been in use for over 25 years by road and airport authorities around the world. They are used extensively in Europe and the U.S.

## The RWIS File

Besides improving road information and trends, RWIS networks support winter road operations in a number of other significant ways:

- ✓ They improve the accuracy of decision-making by providing an understanding of pavement temperature forecasts and trends.
- ✓ Sensors embedded flush in the pavement, as well as sub-surface, generate data that can be sent back to central locations, allowing the development of trends and forecasts.
- ✓ Pavement sensors can monitor pavement temperature, wet/dry status, freeze point of the solution on the road, presence of chemical and concentration (for some chemicals), as well as subsurface temperatures.
- ✓ Tower-based sensors can provide real-time, local information on typical atmospheric conditions such as precipitation, relative humidity, dew point, air temperature, and wind speed and direction.
- ✓ Weather forecasting services can use road-based information to provide “road weather” forecasts to help the road maintainer make better decisions regarding snow and ice control.
- ✓ Salt use is optimized by more accurate deployment of equipment and application of chemicals.
- ✓ Other types of sensors and systems can be added to RWIS to further support road maintainers, for example road-embedded devices to measure road friction and snow cover, automated liquid de-icer application systems, and Fixed Automated Spray Technology (FAST).



In 1998 there were less than 100 sites in Canada, but that is about to change in a significant way. In the summer of 2003, the Canadian Transport Minister announced the government’s intention to move forward on the development of a cross-country integrated network of road weather information systems. These RWIS installations will provide data on the national highway network. Municipal road authorities

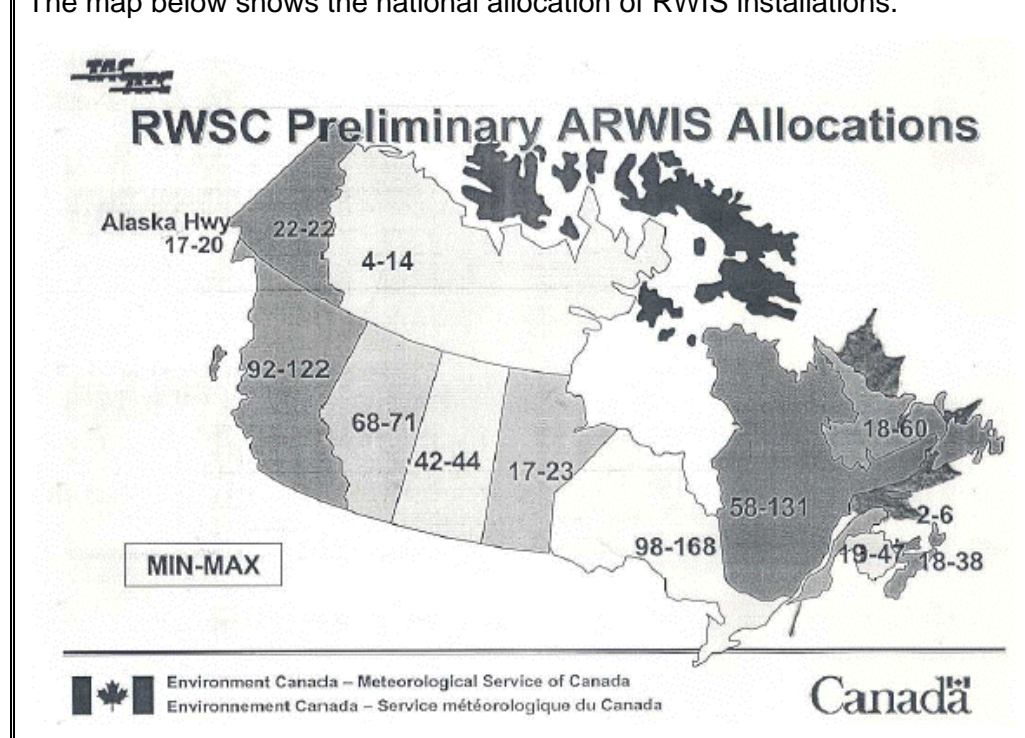


wishing to use technology to monitor their local road networks will need to implement their own RWIS installations.

### Canada moving to the forefront in road weather technology

In the summer of 2003, the Canadian government announced that it had started funding negotiations with the provinces and territories for the development of a cross-country integrated network of road weather information systems. Canada already has more than 150 roadside sensor sites installed by various jurisdictions. But since they were installed at different times using different technologies, jurisdictions cannot all share information.

An integrated system will provide consistent weather information for all jurisdictions. With the implementation of a national RWIS, Canada will become a world leader in large-scale, integrated road weather technology. The map below shows the national allocation of RWIS installations.



#### –NOTE–

**What's in a name?** The terms Advanced Road Weather Information System (ARWIS) and Road Weather Information System (RWIS) are used interchangeably. For the purposes of this learning guide we have chosen to use RWIS, which is the more common term.

Let's take a look at the what, how, where, and why of RWIS and see what makes it tick.

## RWIS: What

Road weather information has always been a critical component of winter maintenance decision-making. Traditionally, information has come from a limited number of sources:

- patrollers who radio in their observations to their home maintenance yard or dispatch center
- general weather reports and forecasts

RWIS site-specific information confirms what the road maintainers may already be thinking.

This information has usually been relayed within the jurisdiction involved and perhaps shared with adjacent patrols or even neighbouring municipalities. A logical evolution involved distributing this information by computer links so that real-time road condition information could be available to all maintainers in all areas to better watch the progression of weather patterns. This type of information has also proven valuable to transit authorities, trucking firms and recreational services.

For many years, we've been able to gather information through dedicated road and atmospheric sensors. This data is distributed and presented in detail specifically for the road maintainer. It can be modeled using a heat-balance equation to forecast road conditions.



Road weather information systems are based on road-related information gathered on a real-time basis and used to forecast pavement conditions. They provide site-specific information that confirms what road maintainers may already be thinking.

In other words, it supports their thinking. They may also contribute new data that enables fresh insights and changes to the strategy.

The benefits of RWIS often outweigh the upfront costs.

Though there is significant expense to the hardware and modeling effort required, and the system and network to support them, the benefits can be significant for those jurisdictions following a bare pavement policy in areas where the climate provides an appropriate winter season with numerous pavement freeze-thaw cycles. With the most significant routine maintenance cost related to the application of road salt, adequate information for its optimal use can generate sizable cost savings.

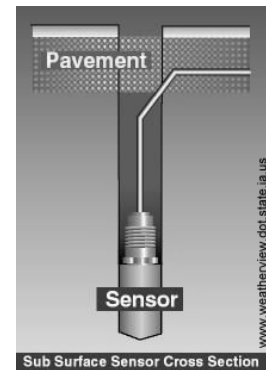
An RWIS typically consists of a number of components, including a network of pavement and atmospheric sensors that are powered by either electricity or battery and solar cells. Here's what makes up a typical RWIS:

- ✓ tower with atmospheric sensors
- ✓ pavement surface and sub-surface sensors that measure temperatures, presence of moisture on the road, and chemical concentrations
- ✓ a Remote Processing Unit (RPU)
- ✓ modems and telephone connections

There are several types of pavement sensors in use. What they have in common is that they are installed in the pavement and connected to a tower. Some of the more sophisticated units actually calculate the freezing point of the pavement. It takes into account factors such as residual chemicals, which will reduce the freezing point to below 0 C (32 F).

Sub-surface sensors can tell you when frost is present.

There are also sub-surface sensors that measure sub-grade temperatures. These can be useful in determining when frost is present for deciding when to impose load restrictions. More accurate timing of the start and end of load restrictions can have significant benefits for truck movements.



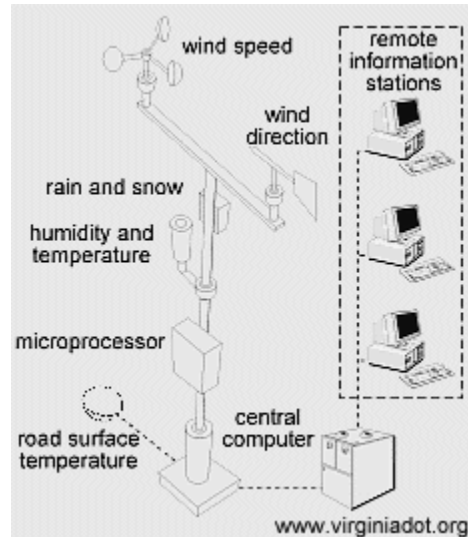
Pavement sensors are connected to a tower at the side of the road which collects information on:

- ✓ wind speed and direction
- ✓ solar radiation
- ✓ barometric (air) pressure
- ✓ presence or absence of precipitation, possibly including visibility measurements or identification of the type of precipitation
- ✓ relative humidity
- ✓ ambient temperature

The RWIS tower also has a data logger and a communications device for sending data to a pavement temperature forecasting service via a phone line. The information is analyzed by a weather service, such as Environment Canada or World Weather Watch, which is skilled in pavement temperature forecasting.

## RWIS: How

A typical RWIS includes pavement and atmospheric sensors connected through a communication link to a host server.



All of the various sensors and monitoring devices are connected to a local computer serving as a remote processing unit (RPU) or data logger that translates the signal from the sensors into a format that can be communicated to a central server computer. This may include a confirmation of the sensor readings as well.

For instance, if the pavement sensor reads “wet”, but the precipitation monitor reads “no”, the RPU will consider alternate possibilities, for example, dew point, blowing snow, or simply “unknown”, as may be caused by vehicle wheel-well slush falling on the sensor.

Typically a site includes pavement and atmospheric sensors connected through a communication link to a host server. The host server is accessed by a forecast service, which uses the data to forecast pavement temperatures in a manner similar to forecasting weather.

The forecaster can then combine available weather forecasts and pavement information to predict when the combination of weather conditions and pavement temperature will likely result in hazardous winter conditions.

## RWIS: Where

An RWIS network is usually made up of several individual sites. The information gathered is valid at the site from which it is being obtained, but it can also be interpolated between sites. The number and spacing of sites in the network is dependent upon factors such as:

- topography
- soil type
- land use
- microclimate zones
- proximity to utilities
- road classification



Generally, the greater the variability in these factors, the more sites will be required in the network. There are models available that assist in accurately interpolating information between sensor sites.

A network of RWIS pavement sensors can greatly improve the understanding of how salt will behave on the road.

A network of RWIS pavement sensors can greatly improve the understanding of how salt will behave on the road. And, combined with predicted forecasts of the atmospheric conditions, decision-makers can better understand how that salt brine will change knowing the precipitation and its given intensity.

As a supervisor, you have a significant tool in this information to better dispatch proper resources, both initially and for follow-up runs.

## RWIS: Why

By strategically timing applications, you can optimize material usage.

A road information weather system is the most effective decision-support tool available for winter road maintenance. Based on the current and forecast pavement condition information that it provides, you can determine the window of application for de-icing chemicals in a way that replaces the guesswork. By strategically timing initial, in-storm, and final applications, you can optimize material usage.

An RWIS helps you to achieve the prescribed LOS using the appropriate amount of salt.

Data from an RWIS allows you to predict specific times and locations of pavement freeze-up. By monitoring the road network condition on a continuous, real-time basis, you can achieve optimum road safety levels for the motoring public.

In short, an RWIS helps you to achieve the prescribed level of service standard using the appropriate amount of salt necessary to ensure driver safety. This is a significant return on whatever investment your organization makes in a monitoring system.

## RWIS: Not for everyone

RWIS are valuable for large highway networks, but less so for municipal road systems.

As useful as road weather information systems are, they are not necessarily the best solution for all situations. They are extremely valuable for large highway networks, for example, but less useful for monitoring municipal road systems. In urban environments, local conditions can vary considerably due to the presence of buildings and heavy traffic. In this environment, truck-mounted and hand-held sensors can be more effective in tracking localized variations in pavement conditions. RWIS is an expensive option for most municipalities, and the return on investment may not justify the allocation of resources required to install and maintain it.

There is no need for high tech when low tech will do the job.

# Anatomy of a storm: RWIS in action

Let's take a look at historical data from a storm event that occurred in Wallaceburg, New Brunswick in 1998. This data highlights the potential of an RWIS. You'll recall earlier that we looked at this data from the perspective of an outsider. Now let's look at it from your perspective.

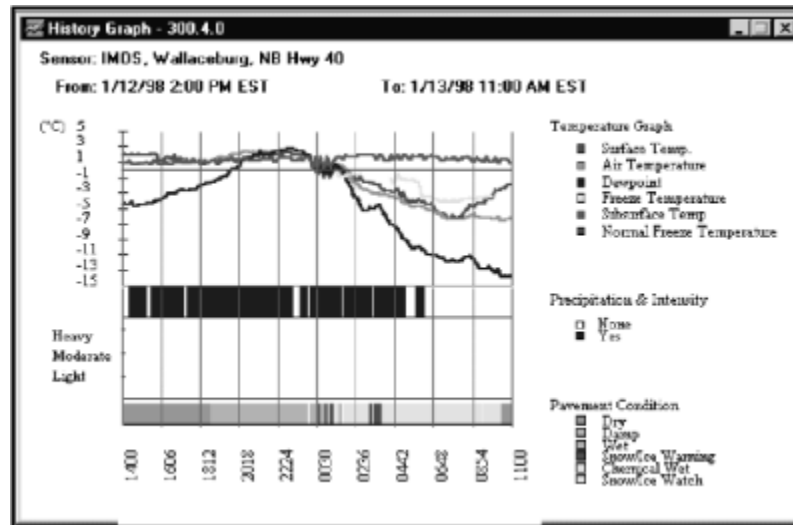


Figure 1. Historical RWIS graph

## Case study

**2:00 pm, January 12 to 11:00 am, January 13**

A winter weather event involved an above average air temperature initially, dropping to below zero at a time when the pavement surface temperature also started above zero and dropped below zero. Continuing precipitation diluted an applied salt application at midnight, requiring a second salt application later in the early morning.

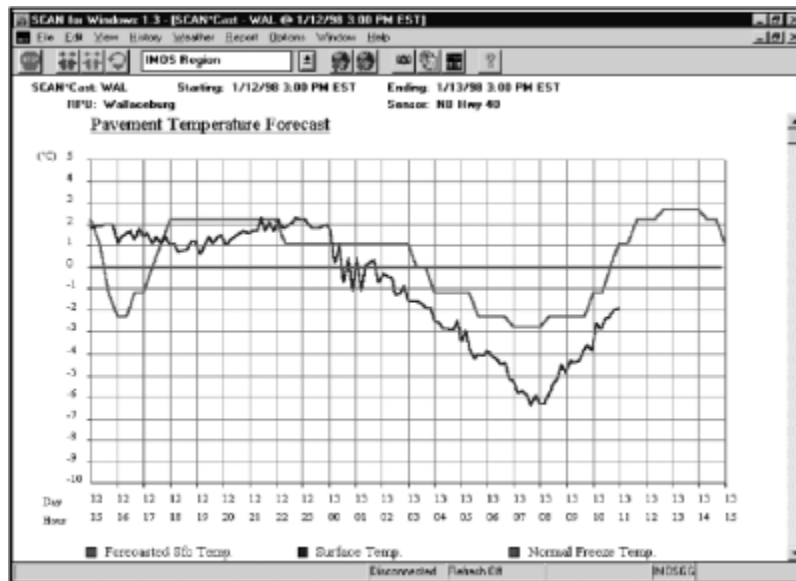
The information provided to the field operators at the time was both "real time" as well a modeled forecast of the pavement conditions. In advance of the storm event, field staff are provided with a 24-hour pavement temperature forecast.

Going back in time, the dispatch operation center knew, prior to the storm, that a forecast had predicted that:

1. the pavement temperature would drop sometime around 3:00 am;
2. rain would change to snow of a given intensity; and
3. the precipitation would stop in the middle of the night.

In Figure 2, we see the advance pavement temperature forecast (the stair-step line), overlaid by the actual pavement temperature. While atmospheric conditions are well predicted by

weather forecasters, the pavement condition cannot be predicted as accurately without a better understanding of pavement surface and subsurface temperatures.



**Figure 2. Forecast vs. Real time pavement temperatures**

As the evening progressed and the precipitation began, the dispatch center had real-time data from actual sensor readings. Two-way communications with the operators can relay information on both conditions and trends to the operators, who in turn can confirm that what is viewed on the computer screen, is in fact what is being observed.

The history graph shows the event progress as predicted. However, the onset of the cold front was more rapid than forecast, and the air and pavement temperatures dropped earlier by approximately an hour. Operational staff were conscious of this potential and were monitoring the real-time data. In fact, spreader trucks were dispatched early in the storm to effectively anti-ice and be cautious of potentially slippery conditions.

The pavement sensor showed “chemical wet” at 12:20 am, indicating that the first application of salt had reached the sensor location, which is roughly 20 minutes away from the patrol yard. This followed a “snow and ice warning” that there was potential ice crystal formation. This was a well-targeted application of salt.

Salt brine concentration and a freeze point temperature show up on the graph as well. The continued dilution due to the heavy, wet snow was fairly rapid, resulting in a further snow and ice warning two hours later. A second application of salt can be seen on the bar graph at the bottom of Figure 1 at approximately 3:30 am. After this, the road remained “wet”, or “chemical wet” until the precipitation stopped. The temperature remained cold, and the freeze point temperature remained lower than the pavement temperature.

The morning sunrise is indicated by the rise in pavement temperature shown on the graph starting about 8:30 am. Although the air temperature remained cold and below zero, the pavement condition changed from “chemical wet” to “dry”, indicating that it had effectively “freeze-dried”.

This examination of RWIS data for the duration of the Wallaceburg storm event demonstrates the types of information that are available through the use of this technology, and the importance of being able to interpret it and then act accordingly. It's clear that this technology is designed to assist—not replace—human beings.

Let's put your decision-making skills to the test.

## Quick Quiz

When you use a road weather information system, you have to call upon all of your knowledge, skills, experience, and intuition in order to interpret what you're reading, and then make the right call. Let's consider three hypothetical weather scenarios, and then you decide what the response should be.

At the end of this lesson we offer some guidelines on how you could respond, but the responses could vary according to local policies, conditions, and available resources. For purposes of this exercise, draw upon your own experiences and knowledge, including what you have learned so far in this guide.

**Scenario 1:** The current temperature is around  $-1$  C (30 F). There is snow, sleet, or freezing rain. The road surface is wet. What would you do?

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**Scenario 2:** The temperature is below  $-1$  C (30 F) or falling. There is snow, sleet, or freezing rain. The road surface is wet or sticky. What would you do?

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**Scenario 3:** The temperature is below  $-6$  C (20 F) and falling. There is dry snow falling. The road surface is dry. What would you do?


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**Answer**

**Scenario 1**

**Temperature:** Near -1 C (30 F)

**Precipitation:** Snow, sleet or freezing rain

**Road surface:** Wet

- If snow or sleet, apply salt at 140 kg per two-lane kilometre (500 lbs per two-lane mile). If snow or sleet continues and accumulates, plow and salt simultaneously.
- If freezing rain, apply salt at 56 kg per two-lane kilometres (200 lbs per two-lane mile). If rain continues to freeze, re-apply salt at same rate.

**Scenario 2**

**Temperature:** Below -1 C (30 f) or falling

**Precipitation:** Snow, sleet or freezing rain

**Road surface:** Wet or sticky

- Apply salt at 85-226 kg per two-lane kilometre (300-800 lbs per two-lane mile), depending on accumulation rate. As snowfall continues and accumulates, plow and repeat salt application.
- If freezing rain, apply salt at 56-113 kg per two-lane kilometre (200-400 lbs per two-lane mile).

**Scenario 3**

**Temperature:** Below -6 C (20 F) and falling

**Precipitation:** Dry snow

**Road surface:** Dry

- Plow as soon as possible. Do not apply salt. Continue to plow and patrol to check for wet, packed or icy spots; treat them with heavy salt applications.

### Strength in numbers

Automated RWIS stations have been used for many years as a highway winter maintenance tool to improve snow removal and ice prevention efficiency. They are now deployed in all western U.S. states as part of MesoWest.

MesoWest is a real-time cooperative data exchange network that provides access to weather observations from more than 180 government, educational, and commercial data providers at over 6000 surface stations around the U.S., with an emphasis upon the western states.

You can get real-time and archival data and information on the MesoWest web site at <http://www.met.utah.edu/mesowest>.

## RWIS: Who needs it?

Winter road maintenance technology has evolved, with the cost of computer hardware dropping.

The available winter road maintenance technology has evolved over the last 25 years, with the cost of computer hardware dropping steadily. There are an increasing number of applications across North America, as more jurisdictions understand the cost savings that can be realized by having more accurate, pavement-based information.

Still, RWIS systems are not for everyone. They are most useful where the following conditions exist:

✓ High number of pavement surface freeze/thaw cycles	✓ Need for proof of what treatment is required and what action was taken
✓ High enough traffic volume to create a positive benefit/cost ratio	✓ Need for more road-based information and not enough staff to gather the information by traditional means
✓ Need for continuity of information across the delivery system	✓ There are other sites nearby that complement your sites

Your organization doesn't need to meet all of these conditions to benefit from a RWIS, but you'll realize maximum advantage under these circumstances.

Road weather information systems aren't comprised solely of sensors embedded in the pavement or mounted on roadside towers. On a broader level, they can include any device that captures and transmits road weather information. For example, they can include available technology such as:

- mobile infrared thermometers which are handheld or mounted on the truck;
- electronic spreader controls which monitor the prescribed application rates, location and type of material;
- other useful equipment changes, which may also involve adjusting the type of material from a straight solid to a pre-wetted solid.

## Tracking pavement conditions

Everything that you've learned so far, from ice and salt science to road weather information systems, revolves around one central objective: *to determine the pavement condition now, and to forecast what it will be later.*

The pavement temperature trend is the most important piece of information you can have.

Moisture on the road only matters when the pavement temperature is expected to fall below freezing, unless you have a snow accumulation that in itself can create an unsafe road condition. Therefore understanding the expected change in pavement temperature over time is important.



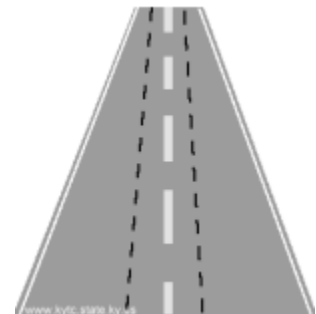
We know from the phase diagram, for example, that salt is not effective at temperatures below  $-18\text{ C}$  ( $0\text{ F}$ ). But even with a constant low air temperature, the pavement temperature can rise during the day to a range where salt application is effective.

This fluctuation and discrepancy between air and surface temperatures can be forecast with the assistance of pavement sensors and cloud cover models.

Conditions change as much throughout the year as they do during the course of a day.

Conditions change as much throughout the year as they do during the course of a day. At the onset of winter, for example, before the frost is in the ground, the ground is warmer than the air because it holds the heat. During this condition, the pavement temperature will often be warmer than the air temperature, and will likely be above freezing. Therefore, if there is precipitation, it is not likely to freeze unless the pavement temperatures drop below freezing.

Once the ground is frozen in winter, the pavement temperatures will not be warmed from below, but will instead be warmed by the sun.



In the spring, as the days warm up, the ground will still be cold until the frost comes out. During this condition, it is possible that even though the air temperature is slightly above freezing, the pavement temperature could be below freezing. If the pavement temperature is below the dew point, or there is rain, the result will likely be frost or black ice.

Once you have collected the information, what you do with it is even more important.

In this guide, we discuss the importance of tracking pavement condition trends, and we look at the tools and technologies that are available to help you gather the data. But this is only the preliminary step. Once you have collected the information, what you do with it is even more important.

It's your responsibility as an operator or field supervisor to be able to read the data, understand it, correlate it with weather data that's coming in from other sources, and then make decisions on courses of action to follow. Most of the time, you'll be doing this on the fly, changing your maintenance strategy as conditions change. Throughout it all, it's critical that the decisions that are being taken—and the rationale for them—are communicated to everyone in the organization.

When employees know *why* they are being asked to do something, they are more apt to stick to the plan and do *what* they are expected to do. Communication is a key component of any effective winter maintenance strategy.

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-TIP-

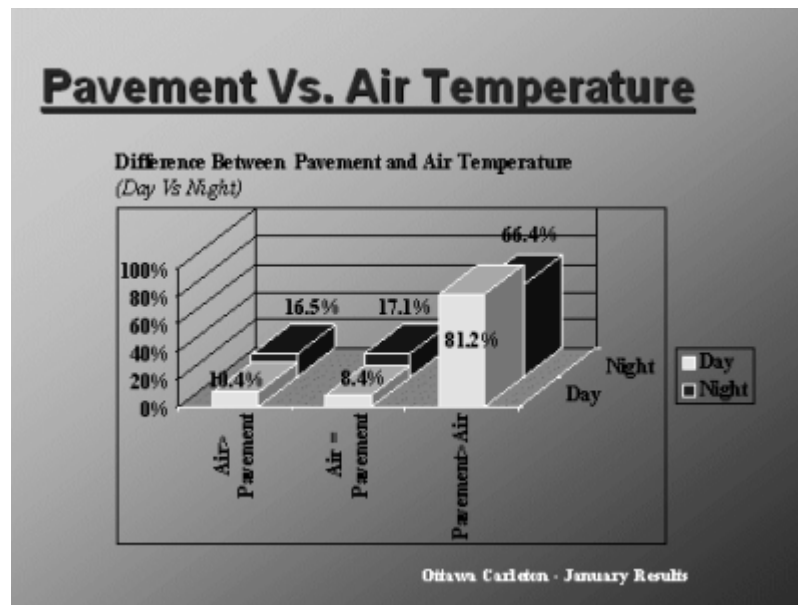
**All in good time:** When implementing new technology, allow plenty of time for monitoring, adjusting, training, and public education. According to Barry Belcourt, Director of Road Maintenance for the City of Edmonton, Alberta, it will take up to three years of tracking and monitoring before its newly installed FAST (fixed automated spray technology) system can be relied upon to run independently. During this period, the new technology will be carefully incorporated into the overall road maintenance program. A prime consideration was to ensure the compatibility of FAST chemical applications with those put down by spreaders.  
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## The lowdown on looking down

A study done in Ottawa, in the dead of a Canadian winter, compared the amount of time the pavement temperature was warmer or colder than the air temperature. The results showed that air temperature was greater than pavement temperature only about 10% of the time during the day and 16% of the time at night. The two temperatures were approximately equal 8% of the time during the day and 17% during the night.

Interestingly, the study also found that 81% of the time during the day, pavement temperatures were higher than air temperatures, and that during the night, pavement temperatures exceeded air temperatures 66% of the time.

This clearly shows the importance of looking down as well as up.



The logo for the 'Quick Quiz' section. The word 'Quick' is in orange and 'Quiz' is in black, with a checkmark symbol integrated into the letter 'i' of 'Quiz'.

Since the pavement condition trend is the most critical element in your decision-making process, we felt that it would be useful to review what you know and have learned so far in this guide. Indicate true (T) or false (F) next to each of the following statements.

- Pavement temperature has a greater effect on ice formation than does air temperature.
- Daytime pavement temperatures can be significantly higher than air temperatures, while at night, pavement temperatures can drop rapidly due to radiational cooling.
- Since pavement temperatures fluctuate due to radiation and not direct sunlight, cloud cover has no effect.
- Early in the season, heat is retained in the ground and warms the pavement surface, so the pavement may remain above freezing even with air temperatures below freezing.
- Late in the season, frost in the ground will cool the pavement surface, so the pavement temperature may remain below freezing even if the air temperature is above zero. In this situation, warm moist air moving across the pavement can condense and produce frost.



T	Late in the season, frost in the ground will cool the pavement surface, so the pavement temperature may remain below freezing even if the air temperature is above zero. In this situation, warm moist air moving across the pavement can condense and produce frost.
T	Early in the season, heat is retained in the ground and warms the pavement surface, so the pavement may remain above freezing even with air temperatures below freezing.
F	Since pavement temperatures fluctuate due to radiation and not direct sunlight, cloud cover has no effect. (Clouds trap heat and therefore do have an effect on radiational cooling of pavement.)
T	Daytime pavement temperatures can be significantly higher than air temperatures, while at night, pavement temperatures can drop rapidly due to radiational cooling.
T	Pavement temperature has a greater effect on ice formation than does air temperature.

**Answer**

**Quick Quiz**

## Putting technology to work

An RWIS is useful, but it isn't the only game in town.

It's clear from these discussions that you can never have too much information about pavement conditions. Road weather information systems provide a great deal of real-time and forecast information, but they aren't the only game in town. Not every jurisdiction has access to RWIS or the resources to put a system in place. But that doesn't mean that you can't use technology to help you track and forecast what's happening on the roads for which you're responsible.

### Seeing the heat: Infrared thermometers

The IRT is an essential tool for anyone involved in monitoring road conditions.

One of the most useful pieces of technology on the market is the infrared thermometer (IRT), a portable device that can be used to determine the current road surface temperatures while mobile along the road network. IRTs are available in both hand-held and truck-mounted versions. The mounted versions, which allow continuous monitoring of the road surface while the



**Handheld infrared thermometer**

vehicle is moving down the road, also measure ambient air temperature.

This tool is useful for anyone involved in monitoring road conditions, and because it is relatively inexpensive, there is no reason for not providing it to personnel whose job it is to patrol the roads and report on conditions.

Even if you have access to RWIS information, an IRT is still a valuable way to confirm what the remote sensors are telling you, and to spot local anomalies that need to be addressed immediately.

---

–TIP–

**Creating new records:** Pavement temperature trends should be recorded in daily logs, along with pavement conditions, weather conditions, and winter treatment strategy.

---



Truck-mounted  
infrared thermometer

Although infrared thermometers provide an instant reading of the pavement surface temperature, they can still be used to track temperature trends and support decision-making.

As we know, the current temperature, along with air moisture content and salt concentration, determines the melt effectiveness of the salt. If the IRT readings, which are accurate to within two degrees, indicate a rising or falling temperature, a decision can be taken on how the trend relates to the possibility of freezing or the effective operating temperature of the salt.

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–TIPS–

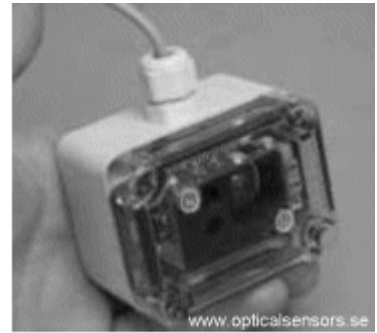
- Be careful where you mount an infrared thermometer on the truck. If it is mounted in a location where it will be exposed to wind or other weather elements, the reading may be distorted.
  - Pavement temperature monitoring equipment should be tested weekly—or more often if necessary—to ensure that it is operating correctly. Inaccurate equipment should be recalibrated, repaired, or replaced immediately.
- 

## Non-friction: Road surface traction measurement

Nothing degrades road surface friction and creates dangerously slippery conditions like freezing precipitation. You can fight these conditions by applying chemicals and abrasives to increase the coefficient of friction. Or, to put it into plain English, you can apply sand and salt in order to improve traction. Your decision about what to apply, and when, can be supported by information about the current friction level of the road surface.



There are technological devices available that can measure the degree of friction on the road surface. Perhaps the most important benefit of this kind of tool is its potential to eliminate the unnecessary use of materials on roads that already have adequate traction, since the presence of precipitation or applied winter materials such as sand and salt can provide inconsistent friction across the cross-section of the road surface.



**Laser friction sensor**

Friction sensors aren't new, having been used extensively on airport runways, but their high cost is currently restricting widespread use on roads. However, research and development efforts are showing promise of alternative designs at lower cost.

There are a variety of ways that these devices could be used. For example the Insurance Corporation of British Columbia has promoted the development of an automated in-road friction sensor that can also record the depth of snow cover.

Friction sensing devices could be mounted on a “smart” patrol truck, along with other winter maintenance tools. Alternatively, they could be mounted on the spreader vehicles and used in conjunction with on-board mounted pavement temperature measurement equipment to automatically control the application rate of snow and ice control chemicals.

Technically, this kind of equipment can be accurate and dependable, and has the potential to eliminate the unnecessary use of salt on roads with adequate traction.

## Leftovers: Measuring chemical residues

The legacy of your snow fighting strategy is chemical residue.

The end of the storm event is not the end of the story. After the snow and ice have been melted and plowed and the road has returned to bare and dry condition, the legacy of your snow fighting strategy remains behind in the form of a chemical residue on the road surface.

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### –NOTE–

**Working overtime:** Pavement will often “freeze dry” following a storm, if the last salt application is properly timed. Often, moisture on the pavement will turn to vapor and evaporate as it freezes, leaving behind a completely clean, dry surface.

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This chemical will be activated with the next precipitation event, so you need to know about it and take it into consideration when planning your next attack. An RWIS road sensor can provide this kind of valuable information. Portable salinity sensors are also available, but the information that they provide comes at a cost that may be prohibitive to most jurisdictions.

-----  
-NOTE-

**Coming soon:** An innovative piece of technology on the horizon is a chemical presence sensor that can measure the chloride concentration of road spray in a vehicle's wheel well.  
-----

### RWIS plus

Adverse weather conditions dramatically affect the nation's surface transportation system. Each



lost on America's highways because of adverse weather conditions.

The U.S. Department of Transportation's Federal Highway Administration (FHWA) responded by leading the development of the Maintenance Decision Support System (MDSS) to assist winter road maintenance managers in predicting the impact of adverse weather conditions and planning treatment.

The system combines standards of practice with the latest weather models and forecasting techniques. It uses advanced winter prediction capabilities to recommend courses of action. MDSS displays various maintenance alternatives and their resulting benefits, which will allow highway departments to deploy snowplows and improve road conditions more effectively while also reducing response costs. The system also will lead to more efficient use of chemicals, which will reduce the impact on the environment.

## Quick Quiz

When you use a road weather information system, you have to call upon all of your knowledge, skills, experience, and intuition in order to interpret what you're reading, and then make the right call. Let's consider two hypothetical weather scenarios, and then you decide what the response should be.

At the end of this lesson we offer some guidelines on how you could respond, but the responses could vary according to local policies, conditions, and available resources. For purposes of this exercise, draw upon your own experiences and knowledge, including what you have learned so far in this guide.

**Scenario 1:** The current temperature is below  $-6$  C (20 F). There is snow, sleet, or freezing rain. The road surface is wet. What would you do?

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**Scenario 2:** The temperature is below  $-12$  C (10 F). There is snow or freezing rain. There is an accumulation of packed snow or ice on the road surface. What would you do?

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**Answer**

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**Scenario 1**

**Temperature:** Below -6 C (20 F)

**Precipitation:** Snow, sleet or freezing rain

**Road surface:** Wet

- Apply salt at 170-226 kg per two-lane kilometre (600-800 lbs per two-lane mile), as required.
- If snow or sleet continues and accumulates, plow and salt simultaneously.
- If temperature starts to rise, apply salt at 141-170 kg per two-lane kilometre (500-600 lbs per two-lane mile). Wait for salt to react before plowing.
- Continue until safe pavement is obtained.

**Scenario 2**

**Temperature:** Below -12 C (10 F)

**Precipitation:** Snow or freezing rain

**Road surface:** Accumulation of packed snow or ice

- Apply salt at rate of 226 kg per two-lane kilometre (800 lbs per two-lane mile) or salt-treated abrasives at rate of 425-566 kg per two-lane kilometre (1500-2000 lbs per two-lane mile).
- When snow or ice becomes mealy or slushy, plow.
- Repeat application and plowing as necessary.

## Where have you been?



Successful winter road maintenance involves a skilful blend of experience, knowledge, equipment, and technology. Collectively, each of these components is essential to the successful execution of your snow fighting strategy.

In this lesson we looked at technologies that can help you formulate your strategy and target your actions. Tools such as RWIS, IRTs, and pavement sensors are decision-making support tools that replace a lot of the guesswork that used to go into deciding how to react to a storm event. This is not to discount the value of intuition—sometimes it's the best guide. But it can be helpful to have tools and technologies that can confirm what you may already know.

You can never have too much information in this business.

## Where are you going?



RWIS installations track weather and pavement conditions. Whether your organization has access to RWIS data or not, a critical part of your job is to know how to interpret weather forecasts. Knowing that a storm of a certain duration and intensity is on the way is critical, but knowing what to do in response is even more important.

In the next lesson, we'll take a look at weather tracking and forecasting and what you need to know to understand how to read a weather forecast.



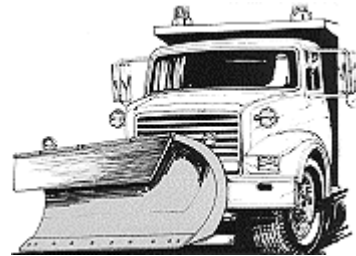
Transportation Association of Canada



# Salt SMART

Spreading, Management, Application Rates and Timing

## Learning Guide



Module 4  
Deicing chemicals  
and the environment

*June 2004*

## ***Transportation Association of Canada***

The Transportation Association of Canada is a national association with a mission to promote the provision of safe, efficient, effective and environmentally and financially sustainable transportation services in support of Canada's social and economic goals. The association is a neutral forum for gathering or exchanging ideas, information and knowledge on technical guidelines and best practices. In Canada as a whole, TAC has a primary focus on roadways and their strategic linkages and inter-relationships with other components of the transportation system. In urban areas, TAC's primary focus is on the movement of people, goods and services and its relationship with land use patterns.

## ***Wellspring Consulting Inc.***

Wellspring Consulting is an instructional design company, specializing in adapting reference information into self-contained learning guides through the application of proven adult learning principles. With the Wellspring methodology, learners are first engaged through an enjoyable, easy to follow and entertaining writing style, then challenged using interactive techniques like problem-solving and role-playing. This fresh and stimulating approach enables learners to effectively transform dry technical information into vital, practical knowledge.

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***June 2004***

## Salt SMART Train-The-Trainer Program

TAC offers trainer workshops to accompany the Salt SMART Learning Guide in support of the best practices for the environmental management of road salts. They range from one-day overview sessions to two-day all-inclusive sessions.

*Make a SMART investment today and book your “at-home”  
trainer workshop or attend one in Ottawa!*

### Overview session

This one-day session is for trainers with formal training and experience. It is designed to walk through the *Salt SMART Learning Guide* to highlight key messages and to discuss potential areas of resistance and how to handle them.

**Member price at a member-selected location:** \$5,000 flat fee for up to 10 participants plus expenses (e.g. training room and AV equipment, catering, TAC trainer’s travel and accommodation).

**Member price in TAC-Ottawa training room:** \$899 per participant. A minimum class size is required and dates will depend on attendee preferences and trainer’s availability.

### All-inclusive session

This two-day session is for those who have little or no training experience. It offers the one-day overview combined with an extra day devoted to soft skills training (trainer techniques, adult learning principles, lesson planning).

**Member price at a member-selected location:** \$6,500 flat fee for up to 10 participants plus expenses (e.g. training room and AV equipment, catering, TAC trainer’s travel and accommodation).

**Member price in TAC-Ottawa training room:** \$1099 per participant. A minimum class size is required and dates will depend on attendee preferences and trainer’s availability.

*TAC non-members pay a 20% premium on all sessions.*

To book your trainer workshop, or for further information, contact the TAC Training Manager, Diane Jodouin at (613) 736-1350, ext. 261 or [djodouin@tac-atc.ca](mailto:djodouin@tac-atc.ca)



# Acknowledgements

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TAC gratefully acknowledges the sponsors for their generous contributions to the development of this Learning Guide. Their contribution exemplifies national cooperation in pursuit of the effective management of road salt use in winter maintenance operations.

The project team for this Learning Guide consisted of the following individuals:

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<b>Project Management Instructional Review</b>	Diane Jodouin Manager, Training Program Transportation Association of Canada

TAC gratefully acknowledges the dedication, guidance and input of the Subject Matter Reviewers; and the quality of work performed by the Instructional Designer.

This Learning Guide is truly a team effort by all those who have contributed financially and/or technically.

# Preface

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## TAC Learning Guide

There are some things that should be taken with a grain of salt. The information in this learning guide is not one of them.

When you consider that the nation's extensive transportation network supports a wide range of economic and social activities, it's not putting too a fine point on it to state that safe and efficient road traffic throughout the year is essential to our way of life. We rely on the road network for transport to the workplace and other economic uses, for recreation and leisure activities, and for emergency and security services.

Road salt is the deicer of choice for winter road maintenance.

There's something else that we rely on: road salt. It's the deicer of choice for keeping roads passable throughout the winter.

The benefits of using road salt to keep the thoroughfares open don't come without costs, both economic and environmental. Recognizing this, and concerned about the environmental implications of road salt applications, the Transportation Association of Canada's (TAC) Chief Engineers' Council, the Road Salt Working Group (a subcommittee of the Maintenance and Construction Standing Committee), and the Environment Council launched an initiative to identify and document new ways of handling and using road salt. Transportation professionals from across the country worked together through the 20-member project steering committee and 17-member project team to produce three important documents:

- *Road Salt and Snow and Ice Control Primer*: An executive summary of the project, written for the general public, that provides information on the importance of road salt use to maintaining a safe and efficient transportation system that sustains Canada's economy.
- *Road Salt Management Guide*: A comprehensive reference guide which addresses transportation and Canada's economy and quality of life, road salt and the environment and road salt management practices.
- *Syntheses of Best Practices for Road Salt Management*: A series of syntheses of best practices related to the effective management of road salt use in winter maintenance operations.

## This guide's for you

This learning guide is based on the best practices in the *Road Salt Management Guide* and the *Syntheses of Best Practices for Road Salt Management*. If you're an operator or supervisor, then this guide is for you.

As a winter road maintainer, you're on the front lines in the battle against snow and ice on roads. In fact, the only thing that gets out there ahead of you is your plow blade. You probably already know that road salt is the most effective, cheapest, and easily handled de-icing material. There may be alternatives out there, but they usually cost a lot more, require special care when handling, and are only effective under certain weather conditions. Road salt is still the most reliable de-icing chemical available.

## The "4 R's" of winter road maintenance

There was a time when winter road maintainers lived by a simple rule of thumb: "when in doubt, put it out." In other words, it was better to err on the side of caution and put down a lot of road salt—and put it everywhere—just to make sure. But those days are long gone.

The modern winter road maintainer has a new mantra: "put the **R**ight amount of the **R**ight material in the **R**ight place at the **R**ight time." In other words, use road salt more wisely and effectively. The benefit of this approach is that road salt usage is *optimized*. This translates into savings for the organization, and minimizes the impact of road salt on the environment. This guide is designed to teach you how to optimize road salt usage while continuing to keep winter roads safe for commercial, passenger, and emergency vehicles.

## Your guide to road salt optimization

Optimizing salt use means being smarter about you how put it down.

Optimizing road salt usage means being smarter about how you apply the material. In most cases it will mean that you use less road salt, but that is a result rather than an objective. In order to use road salt more wisely, you'll need to become a better decision-maker, and in order to do that, you need to improve your knowledge. That's where this learning guide comes in.

The guide consists of six modules:

- **Module 1** sets the stage by looking at the importance of transportation to our economy and way of life; the economic implications of winter maintenance; and the cost-benefits of winter maintenance.

- **Module 2** explores the science of road salt and ice. In Lesson 1 we look at the principles of ice formation. Lesson 2 examines the concept of freeze point depressants and how they work to prevent or break the bond between pavement and ice. In Lesson 3 we consider alternative de-icing chemicals and their role in winter road maintenance. Lesson 4 looks at application strategies, in particular anti-icing, a modern preventive approach that aims to keep the ice-pavement bond from forming.
- **Module 3** looks at equipment and technologies used by modern winter road maintainers. In Lesson 1 we survey plows and spreaders and how they can be put to work to optimize road salt usage. Lesson 2 examines pavement condition tracking and forecasting techniques and technologies, including road weather information systems.
- **Module 4** deals with road salt and the environment. In this module we look at the pathways by which road salt can make its way into soil and groundwater, and the effects it can have on vegetation and wildlife.
- **Module 5** looks at snow and road salt handling. In Lesson 1 we look at road salt handling and storage at the road maintenance yard. In Lesson 2 we examine disposal strategies and techniques at snow disposal sites.
- **Module 6** considers the importance of monitoring and record keeping in winter road maintenance.

The objective throughout these modules and lessons is to help you, as an operator or supervisor, to understand how it is possible to use road salt more effectively while continuing to provide safe roads during winter and minimizing the impact on the environment.

## The same, but different

You have a lot in common with winter road maintainers across the country.

As a winter road maintainer, you have a lot in common with operators and supervisors in other jurisdictions across the country. At the same time, your job is very unique. Every road jurisdiction has a different transportation infrastructure to service. No two agencies face the same weather conditions. Each organization has a different mix of human resources and equipment available to keep the roads open during winter. Levels of service differ from one jurisdiction to the next, winter maintenance strategies are designed to meet specific local challenges, and public expectations change from one jurisdiction to the next.

In other words, while all winter road maintainers may be out on the front lines keeping the roads open, they could be using very different means to achieve similar ends.

This learning guide deals with general principles of winter road maintenance that can be applied in every jurisdiction, but it is beyond the scope of this document to prescribe practices that apply to specific road authorities. The best practices upon which this guide is based have been carefully researched and prepared and are endorsed by the Transportation Association of Canada's (TAC) Chief Engineers' Council, the Road Salt Working Group (a subcommittee of the Maintenance and Construction Standing Committee), and the Environment Council.

This material is provided as advice to winter road maintainers for consideration when developing their own policies, practices, and procedures. Keep in mind that the best practices are to be used in concert with the legislation, manuals, directives, and procedures of your individual road agency.

The material in this learning guide will be incorporated into your agency's current or planned training programs.

## A word about what's inside

Before we dive into the learning guide, let's take a look at what you'll see inside. We know that your time is valuable, and that the technical nature of this subject-matter may not be the most exciting thing you've read lately. So we've tried to make the learning experience as easy and enjoyable as possible.

We want you to learn, and to enjoy doing it.

The first thing you'll notice is that, unlike a lot of those technical reference manuals and user guides you may have seen and tried to read, our tone is conversational. We talk directly to you in a casual voice that's free of jargon and technical terminology. We even throw in a bit of humour every now and then. Unlike those other documents, we want you to learn, and to enjoy doing it.

Each lesson begins with a summary of the topics that we'll be discussing. This is followed by a conversation among fictional characters in a fictional maintenance yard: Pine Junction. Any resemblance between these characters and anyone you may actually work with is entirely coincidental. This dialogue sets the stage for the material covered in the lesson. Once you've read the list of topics to be covered and the dialogue, you'll have a pretty good idea of what you're going to discover in the lesson.

## Getting around: Navigation aids

The margin along the left side of each page is an area that we call the “fast track.” This serves three purposes:

We call this area the “fast track.”

1. Document designers tell us that “white space” on the page is visually pleasing to the eye, making it easier for you to read what’s on the rest of the page.
2. We can provide a capsule summary of the important points on the page. If you don’t have time to read the whole thing, at least you’ll know what you’re missing, and you can come back to it later if you’re interested.
3. The capsule summaries serve as “navigation aids”, which means that they provide a reference point if you need to come back to a section of a lesson and find a particular piece of information.

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### -TIPS, NOTES, and WARNINGS-

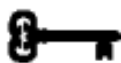
Although we feel that all of the information in the learning guide is important, some items need to have special attention drawn to them. We present these in the form of “Tips”, “Notes”, and “Warnings”. Information presented in this format is related to, but not part of, the discussion at hand.

---

On the other hand, when we want to emphasize an important point *in* the discussion, we highlight it in this fashion.

If you only had time to skim a lesson, you could quickly grasp the essence of it by reading just the list of topics covered, the dialogue, the fast track items, the highlights, the tips/notes/warnings, and the summaries at the end, which we’ll discuss in a moment.

Our approach is based on the concept of self-assessment and instant feedback to confirm what you’ve just learned. Throughout this guide you’ll find “Quick Quizzes” that are designed to make you reflect on concepts that have been presented in the lesson. Once you’ve taken your best shot at answering the questions or offering solutions, you can check the answers that we provide following the quizzes. Look for the key to find out how you did. Sometimes there is no right or wrong answer, a reflection of the fact that operators in different jurisdictions might do things differently. We offer possible solutions, but our word isn’t always the final one.



When you reach the end of the lesson, we offer you a quick summary of where you’ve been. This is usually a restatement of the key points of the lesson that you should have picked up along the way. You’ll find it in the section entitled “Where have you been?”.



Knowing where you've been is useful, but knowing where you're going can be just as helpful. We'll let you know what's in store in the next lesson, in the context of what you've just learned. You'll find it in the section entitled "Where are you going?"

This guide can be used in different ways:

- You can use it at your desk, working and learning at your own pace.

-OR-

- You can use it in a classroom setting as a participant manual.

If you will be participating in a classroom training session, you will gain the maximum benefit by reading this guide in its entirety, if possible, before attending.

We hope that whatever you take from this guide will confirm the importance of the role you play as a winter road maintainer, and will generate discussions among your peers. Winter road maintenance is not a new profession, but there are always new techniques, technologies, and equipment coming along that change the way you operate. Keeping up with the changes, or staying ahead of the game, is a continuous learning process.

Let's start learning.

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# Module 4

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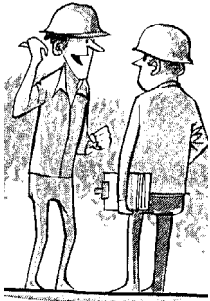
## Deicing chemicals and the environment

Implementation of the salt management practices discussed throughout this guide will go a long way towards reducing salt loadings to the environment while continuing to provide safe roads and achieving the prescribed levels of service.

### *Well, what shall we talk about?*

- Pros and cons of road salt
- Variables in determining environmental damage
- The hydrologic cycle and environmental pathways
- Effects of road salt on groundwater, vegetation, and aquatic habitats

## Cafeteria. Pine Junction maintenance yard. December.



“Every year it’s the same thing,” complained John Rhodes as he threw the newspaper down on the table. “Right before we’re about to get our first snowfall, they print an article about how bad road salt is for the environment. Wouldn’t they rather have salt than cars sliding off the road and going into the environment?”

“Relax, Johnny,” advised Roch Salterelli. “I can understand your frustration, but they do have a point, you know. We can’t be putting down salt all winter long and not expect there to be some consequences.”

“You agree with that stuff, Roch?” Rhodes asked. “I’m really surprised, but I guess I shouldn’t be. You’re probably going to tell me that you’ve learned something about this in that learning guide.”

“What’s eating John today?” asked Brine Watters as he joined the discussion.

“The environmentalists,” answered Lee Green. “It’s that salt article in today’s Tribune.”

“Hey, don’t worry about it, John. Just imagine what they’d write if we stopped putting salt down. They wouldn’t be able to deliver any of their newspapers,” Watters laughed.

“That’s right, Johnny. If you’d read the first module of the learning guide you’d have seen all the benefits of winter road maintenance written there in black and white,” explained Roch.

“Maybe we should send them a copy of that guide, Roch,” Rhodes said sarcastically.

“I wouldn’t go that far, Johnny, but you’re on the right track. We should try and find a way to educate the public. They might be surprised to find out how important our services are to their way of life. And they might also be surprised to find out that some of stuff that they write is a bit off the mark.”

“What do you mean by that, Roch?” asked Crystal Ion. “Are you referring to the information in Module 4? I read that last night. Do you mean that their perspective is off?”

“Exactly. I mean, road salt runoff is only one of a number of different sources of salt pollution entering the environment. And it’s not even the major one. But we’re the most visible. There we are, right in front of them as they drive down the highway, spreading it all over the road.”

“So that they can get to work and write articles about us,” continued Rhodes.

“They see us, but what they don’t see are all the other sources of pollution, most of them far worse than road salt. They don’t see things like the runoff from agricultural and industrial activities. They don’t see the naturally occurring salt deposits that contribute to salinity of ponds and small lakes. They only see what *we* do.”

“That’s the bad news,” Green explained. “But there’s good news in there too.”

“Good news?” asked Rhodes.

“Yeah, John. Think about it. There’s a long list of other sources of salt pollution entering the environment, right?”

“Right.”

“But we’re the most visible one, right?”

“Right.”

And the only source of pollution that we can control from that long list is road salt, right?”

“Three for three, kid,” answered Rhodes.

“So, if we can demonstrate to the public that what we do is vital to their way of life, and at the same time show them that we can continue to keep the roads safe while optimizing salt use, maybe they’ll cut us some slack next time they write one of those articles.”

“Good thinking, Lee,” said Salterelli. “We don’t necessarily have to go on a campaign to cut down on salt use. But we all know that there are ways to use it more effectively, or to ‘optimize’ its use, as you put it. The result of that will probably be that we put down less. Not to mention the money we’ll save in operating and material costs. The reduction in salt going into the environment almost seems like just a fringe benefit.”

“That’s right. But we could get some good press and public support for what we do, and do our part to keep the environment healthy. I mean, we can only control what’s in our power to control.”

“For once, it sounds like you guys are on my side,” observed Rhodes. “But I still think you’re coming at it from the wrong angle.”

“Hey, take what you can get, Johnny. And remember—we’re all on the same team.”

## In the balance: Pros and cons of salt



Effective salt management practices can reduce salt loadings to the environment while maintaining safe roads.

Any discussion about the effects of deicing chemicals on the environment should begin with a reiteration of their benefits to millions of residents in Canada and the northern portions of the United States. As we learned in Module 1, deicing chemicals are essential to the safe transportation of goods and people across both nations.

Road salt has the potential to negatively impact vegetation (including agricultural crops) and aquatic habitats. Sometimes these impacts can be quite serious. The only way to entirely eliminate these effects would be to discontinue the use of road salt. In the absence of an alternative deicer that works as effectively and cost-efficiently as road salt, however, discontinuation is not a viable option. But through effective salt management practices you can help to reduce the amount of road salt entering the environment.

Implementation of the salt management practices discussed throughout this guide will go a long way towards reducing salt loadings to the environment while continuing to provide safe roads and achieving the prescribed levels of service. In areas where road salt must continue to be used to maintain roadway safety and assured access, road authorities should identify salt vulnerable areas and implement appropriate best management practices and precautionary measures on roadways adjacent to these areas.

More details on these precautionary measures are available in the *TAC Road Salt Management Guide* and in the *Best Practices Synthesis on Vegetation*. Many of the measures discussed deal with road construction, infrastructure design, and landscaping considerations, and therefore are beyond the scope of this learning guide.

Our objective here is to show you the pathways by which road salt enters the environment and explain some of its effects on wildlife and vegetation. When you understand what's happening on and in the ground as the result of winter road maintenance activities, you'll be better equipped to carry out the best management practices and precautionary measures prescribed by your road authority for salt vulnerable areas.

## Bad or not? Getting the right perspective

There are a lot of variables to consider when determining the extent of environmental damage.

Ground water, surface water, and soil can become polluted as the result of heavy and frequent applications of deicing chemicals, but there are a lot of variables to consider when determining the extent of environmental damage. It is not accurate to state simply that putting salt on a road surface will invariably have a negative impact on the surrounding environment.

The degree of damage largely depends on the type and designated use of the receiving water, and on the drainage system used to discharge the runoff.

The turbulent actions of surface waters, for example, effectively blend and dilute many of the chemicals almost immediately after they enter. The absence of these turbulent actions in ground waters, however, renders them more vulnerable to pollution as undissolved chemicals percolate through the soil and enter the water table.



As you learned in the lesson on freeze point depressants, calcium magnesium acetate (CMA) and potassium acetate (KAc) are the most environmentally friendly deicing chemicals because they contain weak biodegradable acids. Sodium chloride (NaCl), calcium chloride ( $\text{CaCl}_2$ ), and magnesium chloride ( $\text{MgCl}_2$ ), on the other hand, leave residues of chloride ions on the highway surface that may not only contaminate surrounding ground waters, but that may also corrode motor vehicles and bridge structures.

The point is that not all deicing chemicals are created equally, nor do they all have the same effects on the environment: some present more problems than others. Corrosion inhibitor additives may contain phosphorus compounds that, in turn, stimulate the growth of undesirable aquatic plants, weeds and algae in fresh-water lakes.

Deicing chemicals in highway runoff are neither the only nor the major source of chloride contamination of the nation's waters—they are simply the most visible.

Contaminants come from a variety of point and non-point sources.

Contaminants come from a variety of point and non-point sources. Among the most significant point sources are industrial waste disposal sites, municipal landfills, leaking septic tanks, and occasional accidental spills of petroleum products and industrial liquids.

Non-point sources include agricultural runoff, mine drainage, urban and highway runoff, and runoff from lawns and natural areas. Even rain and snow can deposit as much as 16 to 18 kilograms of chloride per acre annually even without the presence of deicing chemicals. Areas that are geographically located along coastal waters also

Even rain and snow can deposit chloride without the presence of deicing chemicals.

experience high chloride concentrations since chloride occurs naturally in seawater, natural brines, and water that passes through salt-bearing strata. Overall, non-point sources accounts for as much as 80 percent of the degradation of water.

It would be fair to say that problems don't *necessarily* arise as the result of elevated salt concentrations in water bodies. It is only when the water is used to sustain human, animal, or plant life with low tolerance to salt that difficulties arise.

It is only when the contaminant becomes a pollutant that we have a problem. So, when does a contaminant become a pollutant and start causing problems?

The amount of chemicals in water is less important than the use and health of the water body.

The amount of chemicals present in water, whether it is in the ground or on the surface, is less important than the specific use and overall ecological health of the water body. For example, water with elevated concentrations of sodium may be suitable for some uses but undesirable for certain industrial purposes. High concentrations of salt in water may be harmful to a small percentage of the population with certain types of heart or kidney diseases, but the major concern of the public is what salt does to the taste of their drinking water.



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-NOTE-

**Clean Bill of Health:** Health Canada has concluded that road salts are not toxic to humans.  
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In the fish world, certain species can tolerate only very low salt levels, while others thrive with levels higher than those found in seawater. Fish farmers, in fact, routinely add salt to the water to protect their fish against disease.

Sanding and salting may leave chloride, sodium, and calcium on the road surface.

Salting and sanding practices may leave concentrations of chloride, sodium, and calcium on the road surface. Ordinary operations and the wear and tear of our vehicles also result in the dropping of oil, grease, rust, hydrocarbons, rubber particles, and other solid materials on the highway surface. These materials are often washed off the highway during rain or snowstorm events.

The most common contaminants in highway runoff are heavy metals, inorganic salts, aromatic hydrocarbons, and suspended solids that accumulate on the road surface as a result of regular highway operation and maintenance activities.

Highway runoff can have adverse effects if no measures are taken for the removal of excessive contaminants before the runoff reaches the receiving water, but if handled properly, it need not be a serious problem.

Highway runoff is generally cleaner than runoff from other non-point sources such as farms and mines.

Highway runoff is generally cleaner than runoff from buildings, farms, mines, harbours or other non-point sources. It is ironic, though, that despite the vast number of measures taken and resources invested to minimize its impact on receiving waters,

highway storm water runoff is still one of the most misunderstood and misrepresented contributors to water quality degradation.

Retention and detention basins effectively control excessive flows of highway runoff.

There are highly effective active and passive means to treat highway runoff before it actually causes any damage. Some of the most effective treatments are passively present even when no deliberate actions are taken for mitigation. Highway runoff that soaks into soil with or without the presence of any type of vegetation, channel, or basin is usually harmless to the environment.



Retention and detention basins, among other management practices, are highly effective means for controlling excessive flows of highway runoff. These devices capture

highway runoff and release it at very slow rates, allowing sufficient time for heavier particles to settle out, evaporate, infiltrate or be absorbed.

Given that a large number of preventive and corrective measures can be and are being taken to suppress potentially disturbing highway runoff effects on nearby receiving waters, it is important to recognize that runoff is not necessarily, and most often is not, a serious problem.

## In the know: Becoming salt savvy

A little knowledge is a good thing. There is an extensive amount of data and material dealing with the science involved in the processes by which deicing chemicals enter the environment. If you want to explore it in-depth, you can read about it in the *TAC Road Salt Management Guide* and in the many documents on the subject on the Salt Institute web site ([www.saltinstitute.org](http://www.saltinstitute.org)).

Our objective in this lesson is purely to provide an overview of how deicing chemicals can find their way into water and soil, and the resulting potential impacts on animal, aquatic, plant, and human life.

This guide is all about optimizing road salt use while continuing to provide safe roads.

This guide is all about optimizing road salt use while continuing to provide the safest roads possible for motorists. In the process, you may find opportunities to use less salt, but that is a result and not an objective. By putting less salt down, however, you are helping to reduce the total amount of material that enters the environment and poses potential problems in vulnerable areas.

If you're able to identify salt-sensitive areas on your route and apply the salt use optimization principles that you've learned in this guide, you can contribute to the mitigation of adverse environmental impacts without compromising road safety.

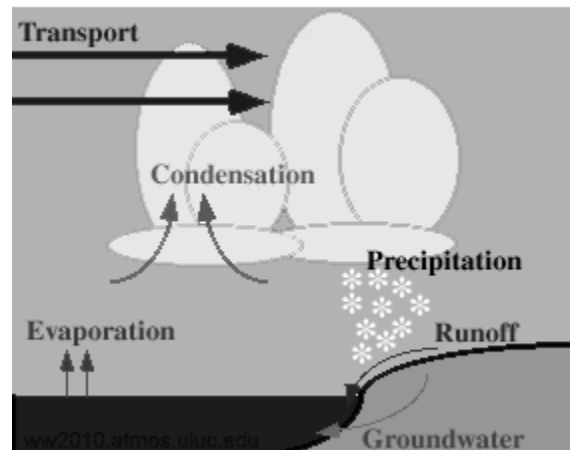
## Cycle-paths: How salt gets around

Road salt enters the environment through a variety of pathways that involve water.

Road salt can enter the environment through a variety of pathways, all of which involve water in one form or another. In order to understand the workings of these pathways, you need to know about the hydrologic cycle.

The earth's oceans, rivers, and clouds are in a constant state of change as surface water evaporates, cloud water precipitates, and rainfall infiltrates the ground. Water that falls from the sky as rain or snow either evaporates back into the air, runs off into wetlands, rivers and lakes, or goes into the ground.

When it goes into the ground, it's either taken up by plants or flows into underground lakes called aquifers. But through it all, the total amount of water does not change. This circulation and conservation of the earth's water supply, called the "hydrologic cycle," is what dictates how road salt enters and moves through the environment.



The hydrologic cycle dictates how road salt enters and moves through the environment.

**Figure 1. Hydrologic cycle**

Deicing salt that is applied to the road surface prior to, during, and following winter storm events forms a brine solution that eventually finds its way into roadside soils and onto vegetation through road runoff (drainage), vehicle spray, and plowing activity.

Salt-laden runoff can either follow drainage ditches and discharges to receiving watercourses, or infiltrate soil and groundwater where it can be taken up by plant roots. Salt that enters the groundwater through runoff will move through the soil where it may enter wells or eventually discharge as base flow to surface water.



Knowing the pathways of deicing salts will help you to understand the effects of winter maintenance activities.

Salt brine spray, consisting of finer droplets, can be deposited some distance from the road, depending on vehicle speeds, winds, and the landscape setting. Once it has settled, the spray can follow the same pathways described above.

Knowing the pathways by which deicing salt is transported to terrestrial and aquatic environments will help you to understand the effects of winter maintenance activities. Through these pathways, road salt can potentially affect, either directly or indirectly, soils, vegetation, groundwater, aquatic habitats, and wildlife.

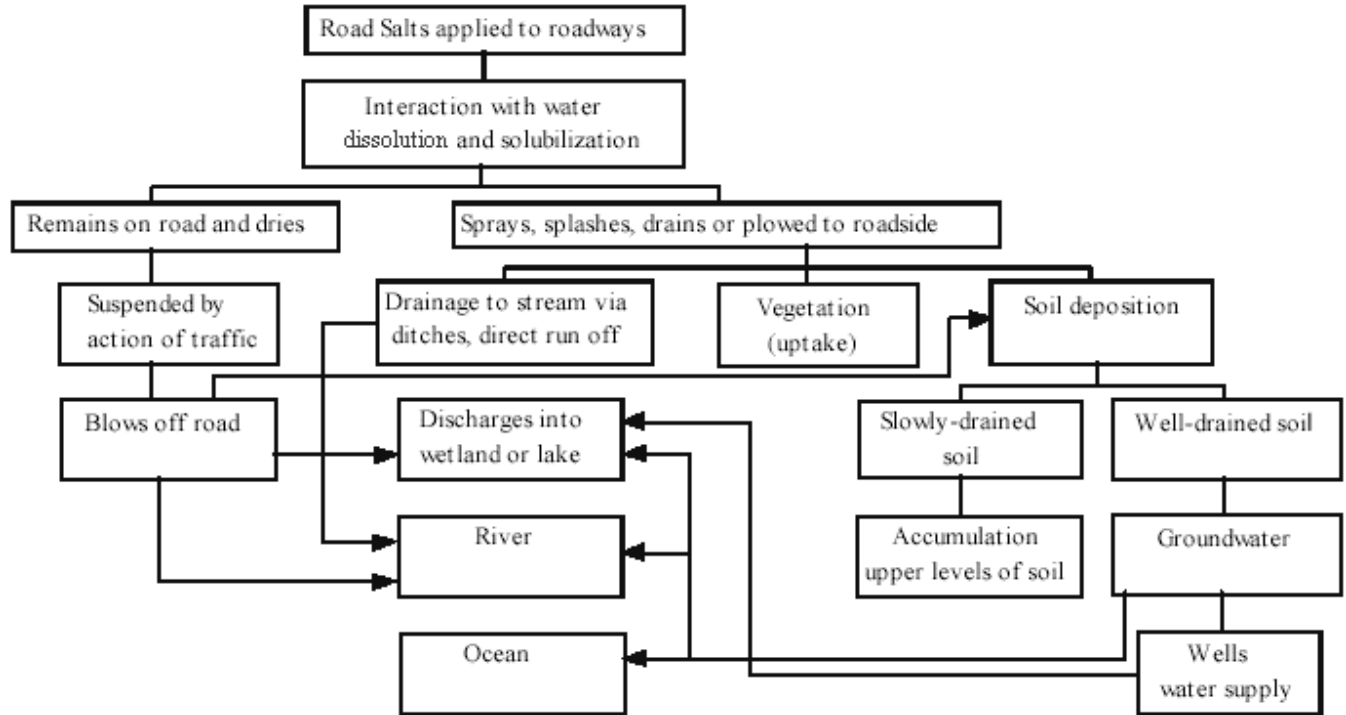


Figure 2: Road salt pathways to the environment

## Quick Quiz

Thinking of some of the roads and highways on your route, identify any areas that you would consider to be more vulnerable to road salt than others. What factors make them susceptible to the effects of salt-laden runoff? Provide your best answer now, and then come back to this quiz after you have finished reading through the lesson and see if you have anything more to add.

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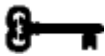
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### Answer

- Can you think of other signs that might indicate salt-vulnerable areas that could benefit from improved salt management practices?
- ponds, small lakes, or wetlands in close proximity to road
  - salt-vulnerable species such as white pine displaying brown needles, a possible sign of desiccation
  - plants located at bottom of steep runoff slopes

## The dirt on road salt and soil

Salt-laden water eventually moves into groundwater zones.

Most of the salt that you place on the roadway eventually ends up on the shoulders and in the ditches. From there, it drains into surface water, eventually returning to the ocean, or seeps into the ground through whatever pathways are most readily available.

Salt-laden water from winter roadway maintenance activities can infiltrate soil either directly through the melting of snow banks, salt stockpiles, and salt spray/splash, or indirectly through surface runoff in ditches. Regardless of the way in which it seeps into the soil, the salt-laden water eventually moves into groundwater zones.

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-NOTE-



**Let us spray:** Traffic and wind can carry road salt spray and splash as much as 50 metres. If there are road salt effects on the environment, they are most likely to occur within 30 metres of elevated and grade level roadway edges. Beyond this distance salt levels are relatively insignificant. Although salt spray can be carried some distance, the effects are not really significant beyond 2 metres from the road. The effects of splash from vehicles are only significant within 8 to 40 metres of the road.

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## Setting the ions free: Cation exchange process

The cation exchange process releases calcium and magnesium ions into the soil.

Road salt affects soil properties through a process known as cation exchange, whereby calcium and magnesium ions that are bound to the soil are displaced by sodium ions. This displacement, in certain soils, can decrease soil permeability, aeration and fertility. Scientists speculate that road salts may also mobilize heavy metals bound in the soil, though further studies are needed on this point.

It's important to keep in mind that these impacts are not necessarily permanent. The cation exchange process can become reversible as sodium concentrations are diluted during passage through the soil.

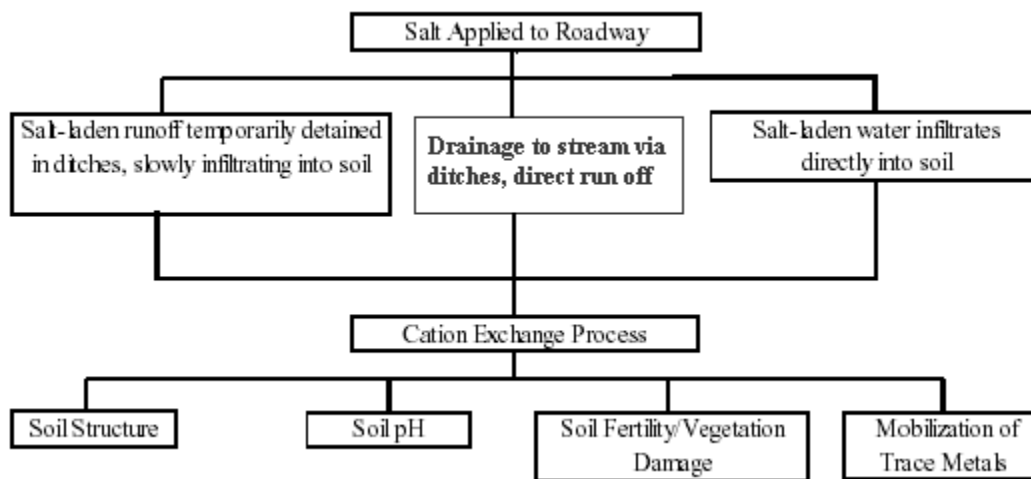


Figure 3. Road salt and soils pathways, processes, and impacts

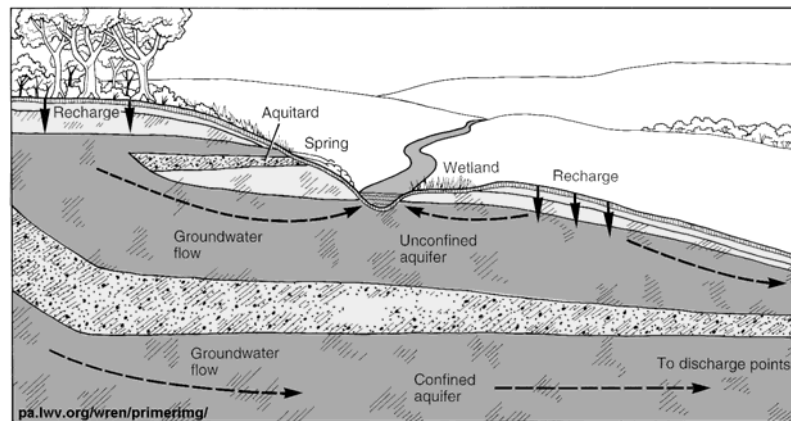
## Down under: Groundwater and road salt

Rain and snow form soil moisture and underground lakes called aquifers.

A lot of the water that falls as rain or snow goes into the ground and forms soil moisture and underground lakes called aquifers. The tops of these aquifers form the water table. There may be perched water tables as well as the deeper aquifers. Perched aquifers are pools of water that form above the main aquifer because of a localized confining layer.

Groundwater in aquifers flows from higher to lower areas, just like surface water. Where the surface of the ground dips down below the water table, the groundwater

will surface as springs to form rivers, wetlands, or lakes. The water in lakes evaporates and starts the hydrologic cycle over again.



Now let's look at how salt enters and moves through the groundwater. Because road salt is

Road salt is highly soluble in water and moves easily with the flow of either surface or groundwater.

highly soluble in water, it moves easily with the flow of either surface or groundwater. It can enter the environment from storage piles, spilled salt, or the salt spread on roads.

The calcium, magnesium, and heavy metals that are released through cation exchange are also carried in the water and eventually reach wells and surface water. Depending upon the soils, groundwater flow may be slow or fast: water moves quickly through sand, and very slowly through clays.

Studies have shown that, where the flow is slow, it can take hundreds of years for contaminants in groundwater to reach the surface water.

The combination of sodium and chloride from the road salt, and the release of calcium, magnesium—and, possibly, heavy metals—from the soils through the cation exchange process, can have several potential effects on groundwater. These include:

- *Increased hardness in the water due to the increased concentration of calcium and magnesium.* Hardness is an inconvenience in that it increases the soap neutralizing capacity of water (soap suds do not last as long). The increased hardness can also cause scaling in water pipes, and premature deterioration of plumbing and appliances that use hot water.

- *Elevated sodium and chloride levels.* Chlorides are naturally present in groundwater at minute concentrations, but higher levels can be the result of road salt operations. Because chloride ions are relatively small, and are negatively charged, they are highly mobile and travel through the overburden relatively quickly and into the groundwater even in finer grained soils.



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-NOTE-

**Sodium, naturally:** Natural concentrations of sodium occur in bedrock water formations and groundwater in small amounts, but higher levels can be the result of road salt operations. Because sodium ions are relatively large and are positively charged, they are not highly mobile and may be removed from solution by being absorbed onto soil surfaces with high cation exchange capacities.

However, if the exchange capacity of the soil is exceeded, sodium becomes more mobile and can enter drinking water. It is slowly released and subsequently infiltrates into the groundwater during precipitation events in the summer months. Those placed by their doctor on low sodium diets will want to inform their physician about elevated sodium levels in their drinking water.

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Estimates of the amount of salt applied to roads that enters groundwater systems range from 10% to 50%. The amount of chloride that travels through the groundwater system and re-enters surface water has been estimated at anywhere from 20% to 45%. In rural areas much of the salt may enter the subsurface adjacent to a roadway where no surface drains are present.

The various pathways, processes and impacts linking road salt and groundwater are shown in Figure 4.

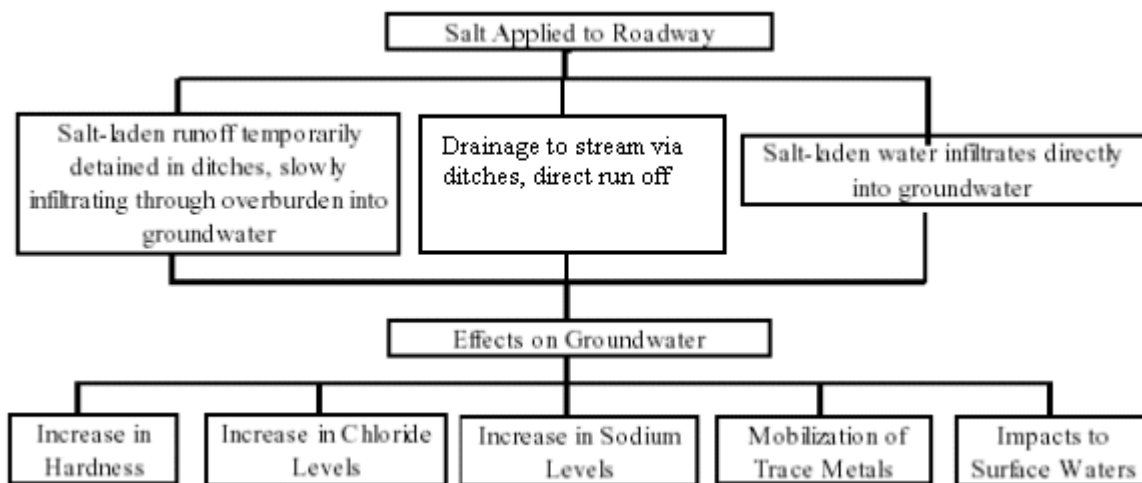


Figure 4. Road salt and groundwater pathways, process, and impacts

## Deicing chemicals: A-salting vegetation

Most of the vegetation impacts are close to the right of way and are not of a broad concern.

Deicing salts can affect vegetation through soil uptake and salt coating, causing a variety of injury symptoms that, in combination with other factors, can ultimately result in plant death. Tolerance and sensitivity to the ions deposited from road salts into the soil varies among the ions themselves and among plant species.

Most of the vegetation impacts are close to the right of way and are not of a broad concern. However if there is a sensitive, high valued plant community such as a salt-sensitive agricultural crop nearby, then there is a greater concern.

When damage occurs, it is usually through “desiccation,” a process that removes water from the roots, buds, or leaves of vegetation, causing them to dry out and, in extreme cases, to die. Evidence of desiccation shows up as needle damage and browning in conifers, and bud and twig damage in deciduous trees. It can also reduce the cold-hardiness of some vegetation, making it more susceptible to winter damage.

Deicing salt reaches roadside vegetation primarily through two pathways:

- 1) soil where salt concentrations have increased due to airborne salt spray deposition or surface runoff; and
- 2) direct salt splash, where brine is plowed or splashed directly onto nearby vegetation or soil, or airborne salt spray, where fine brine droplets are lifted by moving vehicles, blown to considerable heights and distances, and then deposited on aboveground vegetation.

Salt splash from roads typically extends from 8 to 40 metres from the road edge, with the extent of splash influenced by vehicle speeds. Concentrated salt levels in snow and soils typically are contained within 2 to 10 metres of the road edge. Vegetation in this zone is susceptible to the highest levels of salt spray.

Salt spray does not significantly contribute to increased soil salt levels.

The range of aerial salt drift is variable but it can travel up to 500 metres (1500 feet). However, salt spray does not significantly contribute to increased soil salt levels, unlike the direct salt splash and runoff from a highway.

The slope of the roadside is an important factor in determining the extent of salt damage upon adjacent vegetation. Steeper down slope areas typically have the highest percentages of salt-exposed trees. Road drainage, traffic levels, intensity and frequency of salt applications, prevailing winds, and weather conditions also affect exposure distances.

## Ontario keeping roads and environment safe

The top priority of the Ontario's Ministry of Transportation (MTO) winter maintenance program is to ensure safe highways in the winter while minimizing the impact on the environment. To achieve these objectives, MTO follows best practices consistent with those used across North America, and employs the latest winter maintenance technologies:

- All salt spreading trucks are equipped with Electronic Spreader Controls (ESC). These instruments allow the operator to control the amount and location of salt placed, ensuring the correct amount of salt is distributed without waste.
- Expanding use of 'pre-wetted' salt, with about 140 units now in place.
- Infrared thermometers are installed in over 200 winter maintenance vehicles to provide fast, accurate road and air temperatures. This information assists in planning where and when salt application will be most effective.
- Recently completed trials using high-speed spreaders that allow the maintenance vehicle to travel at highway speeds and place salt on the road with less scatter, bounce and waste.
- Expanding the use of snow hedge design innovations to reduce snow drifting on highways, which reduces the need for salt.
- Automated Vehicle Location (AVL) systems installed on 330 vehicles, using Global Positioning System (GPS) technology, to allow maintenance managers to monitor salt usage to ensure application rates conform to ministry standards.
- Uses Road Weather Information Systems (RWIS) to monitor and predict road and weather conditions to schedule winter maintenance operations and eliminate unnecessary salt applications. Owns or has access to over 100 RWIS stations.
- Has installed four automatic bridge anti-icing systems that automatically spray liquid anti-icing chemicals on the bridge surface when ice or snow is anticipated. Also, the ministry is expanding the use of mobile liquid anti-icing techniques to prevent black ice and snow from packing to the road surface.
- Maintenance Technology Project is a focus for demonstrating and piloting a variety of new winter maintenance technologies designed to ensure efficiency and enhanced environmental protection.
- Meets regularly with other highway agencies to exchange ideas on innovative winter maintenance materials, methods and practices. For example, MTO has been a long time participant of Environment Canada's study groups on the environmental impact of road salt materials and best practices.
- Actual salt usage is highly dependent upon weather conditions, varying from 500,000 to 600,000 tonnes of salt annually. Combining safe road salt use with new and existing MTO technologies is estimated to reduce road salt use by up to 20 per cent.



**Source:** [www.mto.gov.on.ca](http://www.mto.gov.on.ca)

## Water, water everywhere...and road salt

Eventually most water reaches wetlands, streams, lakes, and finally the ocean. It moves quickly through overland flow, such as spring runoff, or slowly through groundwater movements.

When it contains salt-laden runoff, it has the potential to affect aquatic systems, depending upon salt concentrations and the types of species living in the water body.

Road salt can interfere with the normal circulation of water in small lakes and ponds.

One of the most significant impacts that road salt can have is on the circulation of water in small lakes and ponds. As a lake cools in the fall, the surface water becomes denser and heavier, causing it to sink and push the warmer water on the bottom



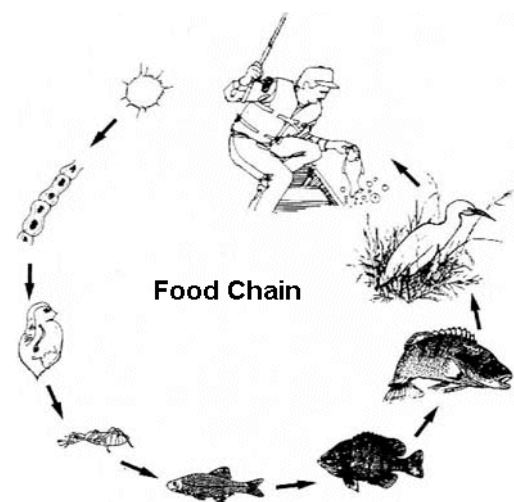
upwards. This turnover carries nutrients from the bottom up towards the surface, and oxygen-rich surface water down to the organisms living at the lower levels. This process is critical to the health of lake environments.

As we learned in the lesson on salt science, salt water is dense and heavy. When it enters a lake it sinks to the bottom and can interfere with normal circulation patterns. In addition, the high salt concentration at the bottom will start to interact with the soils. This is not usually a problem in larger lakes where the dilution factor minimizes the potential for this phenomenon to occur.

## Road salt and the food chain

In the environment there is a natural system whereby higher order animals feed on lower order species. This is called the food chain. The plants at the bottom of the food chain are food producers. They are eaten by micro-decomposers such as fungi and bacteria, which in turn are eaten by macro-decomposers such as nymphs, mosquito larvae, crayfish, and worms.

First-level carnivores, such as minnows and fish, feed on the macro-decomposers. Unfortunately they don't eat enough of them and we still end up with mosquitoes





and black flies. Finally, second-level carnivores such as larger fish, birds, and mammals, including humans, eat the first-level carnivores.

The food chain is weakened if one link is broken.

Part of the cycle involves organisms at all levels dying and sinking to the bottom of the lake or stream and decomposing to provide nutrients for the plants. So it goes. Like any chain, the food chain is weakened if one link is broken. The fish that you may have had for dinner depend on the plant producers and the bacteria and fungi that break them down. If the fungi aren't present to break down the plant producers, the higher-level species in the food chain are affected.



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**-NOTE-**

**Fill 'er up:** Abrasive sand can have a negative impact on aquatic habitats when it is deposited as sediment in the bottoms of rivers, streams, or ponds. In some cases, this represents a more significant impact than road salts.  
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### Salt contamination and aquatic life

**Overall, the harmful effects of salt contamination on aquatic life depend on a number of variables. Examine the list of variables below and check the ones you can control as an operator or field supervisor.**

<input type="checkbox"/> oxygen supply in the water	<input type="checkbox"/> water flows/circulation
<input type="checkbox"/> size of water body and drainage basin	<input type="checkbox"/> temperature
<input type="checkbox"/> rate of salt concentration increase	<input type="checkbox"/> chemical composition of water
<input type="checkbox"/> salting intensity	<input type="checkbox"/> precipitation
<input type="checkbox"/> topography	<input type="checkbox"/> type of highway drainage system



<p>It is obvious that there are a significant number of variables that contribute to the harmful effects of salt pollution on aquatic life. It is equally apparent that as an operator or field supervisor, you have no control over most of the factors. Where you can make a difference is in the amount of salt that enters the pathways from roadway runoff by optimizing road salt usage while maintaining road safety.</p>	
_____topography	_____type of highway drainage system
X _____salting intensity	_____precipitation
X _____rate of salt concentration increase	_____chemical composition of water
_____size of water body and drainage basin	_____temperature
_____oxygen supply in the water	_____water flows/circulation
<p><b>Answer</b></p>	

As salt is introduced to aquatic systems there is a decrease in the diversity of species.

Very high chloride pulses have been reported during spring thaws near large roadside snow banks, and emanating from leaking salt storage facilities and large snow disposal sites. High chloride exposures can have a significant impact on aquatic life, particularly in small water bodies where flow circulation and dilution is limited. Effects on larger water bodies are usually reduced by dilution, although there may be some residual effects from mixing in the bottom layers.

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-NOTE-  
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**Nothing fishy:** Highway deicing rarely generates chloride concentrations that are harmful to fish.

As salinity increases in fresh water, the number of species drops off quickly until it reaches a marine condition and then marine species start to take over and the number of species increases. It is rare that any pond would go from freshwater to a marine condition unless there was an incredibly high and sustained salt loading.

However, as salt is introduced to aquatic systems we see a decrease in the diversity of species present.



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-NOTE-

**Making light of anti-caking agents:** Sodium ferrocyanide and ferric ferrocyanide are anti-caking agents applied to road salt to minimize clumping and facilitate the efficient spread of the material on roadways. They are very stable and have low toxicity without sunlight. However, exposure to sunlight could conceivably break them down and release cyanide as a by-product. In sufficient concentrations this could be toxic to fish, but the volatile by-product disappears quickly, and is at sufficiently low concentrations by the time it reaches a stream or lake that it is not a major environmental concern.  
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## Keep the change: It's not a good thing

The magnitude of change in chloride levels may be more important than the actual levels.

Chloride levels in surface waters rarely reach levels where adverse impacts to aquatic life would occur, usually because of water flow and dilution. However, research in New York State suggests that the *magnitude of change* in chloride levels upstream and downstream of a salted highway may have more of an impact than *actual chloride levels*.

In addition, indirect effects of winter road maintenance, such as increased erosion due to salt-related mortality of roadside vegetation, and culvert erosion at stream crossings, may have as much effect on stream ecology as elevated chloride levels.

Rapid changes in stream chloride levels during and following the winter salting period, rather than high absolute levels of chloride, may act to stress fish and other aquatic life.

### Research project aims to save money and environment

In June 2002 Cargill donated technology developed by its Deicing Technology business to the University of Iowa Research Foundation for further study. The technology, a patented process designed to protect piles of deicing salt from snow or rain run-off, involves spraying salt piles with layers of liquid or foamed concrete.

The goal of the project is to help cities and small towns save money while protecting the environment.

Source: [www.cargill.com](http://www.cargill.com)

## Animal magnetism: Wildlife and road salt

Sodium hunger can attract wildlife to roadsides, increasing the risk of vehicle-animal collisions.

Sodium hunger is a contributing factor to the adverse effects of road salt on wildlife. Salt-deficient animals such as plant eaters increase their salt intake by drinking salty water or eating salty food. They'll often travel great distances to get salt. Some



animals have been observed licking roadside gravel in search of this needed salt.

Animals that are attracted to roadsides in search of salt, particularly moose, deer, elk, and big-horned sheep, create a high risk for animal-vehicle collisions

Smaller animals such as rabbits, foxes, and porcupines also experience sodium hunger in the spring. This hunger, along with their slow movement, contributes to a high spring mortality of porcupines.

Animals usually regulate salt intake by drinking water. Salt toxicity occurs when this self-regulation is interfered with. For example, if water is not available, salt is not eliminated as efficiently from the body.

Cardinals have been observed picking at salt piles in search of grit, not sodium.



Among bird species, cerulean finches are of particular concern. These species, which include cardinals, red crossbills, and pine siskins, are seed-eating birds. Seeds are very low in salt so the birds are salt hungry. In addition, they require grit to help with the digestion of the seeds.

Studies show that birds select grit on the basis of size, colour, and shape. It turns out that rock salt is similar in size, colour, and shape to the grit preferred by birds. The ingestion of grit may enhance toxicity if there is not a readily available source of water.



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-NOTE-

**Just fine with the birds:** Not all gradations of rock salt are a problem. Birds are not attracted to the fine salt gradations.  
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Deicing salt is made available to animals through three pathways:

1. roadside pools of salt-laden water in ditches, right-of-way margins, or road depressions;
2. salt residue on roadside dirt, gravel, or urban sidewalks; and

3. transport by surface runoff and/or groundwater to natural ponds and livestock drinking water supplies.

Where roadside salt ponding cannot be easily or practically prevented, deterrents are an option in high-risk areas. One inexpensive option, F2103, a mixture of egg solid, oil, and emulsifier, can be effective if applied to roadside pools during the peak periods of visitation by moose.

Managing the frequency and intensity of salting will benefit wildlife that might ingest excess salt residue.

While more research is required on salt loading of amphibian ponds in order to understand the relationship between physical and chemical parameters of ponds, salt effects, and



amphibian breeding success, it's clear that measures to manage the frequency and intensity of road salting consistent with providing safe driving conditions will benefit wildlife that might ingest excess salt residue.

## Quick Quiz

### Where does it come from?

From the following list, select the items that, in your opinion, are sources of salt in groundwater.

Natural brines and salt deposits

Agricultural and industrial chemicals

Road salt

Outflows from water treatment and softening processes



Road salt is only one potential source of salt in drinking water, and it is not the major one. It is the only one, however, over which operators and field supervisors have any form of control. Salt optimization practices can help reduce road salt loadings in surface and groundwater.

Outflows from water treatment and softening processes

Road salt

Agricultural and industrial chemicals

Natural brines and salt deposits

**Answer**

**Quick Quiz**

## Where have you been?



The *TAC Syntheses of Best Practices*, as well as the *Salt Management Guide*, identify many methods for optimizing salt use that will help to reduce the environmental impacts of winter operations. Some of them are aimed at engineers and road designers and are beyond the scope of this learning guide.

Throughout this guide we've focused on actions that you, as the operator or field supervisor, can take to optimize salt use while continuing to provide safe roads for motorists. Many of these activities will result in a reduction in salt use, which in turn will help to mitigate some of the environmental impacts of road salt that we've discussed in this lesson.

As long as salt remains the freeze point depressant of choice, there will always be a certain amount of road salt entering the environment through various pathways. But through effective salt management practices, such as those listed below, you can ensure that no more salt than necessary finds its way into the pathways:

- ✓ apply salt at optimal rates in a proactive manner to prevent ice from bonding with the pavement;
- ✓ use liquid anti-icing or pre-wetting to reduce the amount of salt lost to the ditch due to blowing or bouncing;
- ✓ use properly calibrated electronic controllers to ensure that material application rates are accurately regulated;
- ✓ monitor salt usage in salt vulnerable areas to ensure that only the desired amount is being used;
- ✓ use pavement temperature sensors and good road weather information to ensure that salt is applied only when needed;
- ✓ use effective plowing to optimize salt use;
- ✓ maintain records of salt usage to show due diligence; and
- ✓ learn to identify salt vulnerable areas and implement salt management best practices in these areas.

## Where are you going?



As we learned in this lesson, road salting operations are not the only, nor even the major, contributor of salt to the environment. Salt handling and snow storage facilities represent a much more significant environmental impact than the salt that you apply to winter roads. In the next module we'll take a look at best practices regarding road maintenance yards and snow storage/disposal facilities. While environmental protection is a serious concern, these best practices will also help you to control the costs of your operations.

Let's move on to "Road maintenance yards," the first lesson in Module 5.





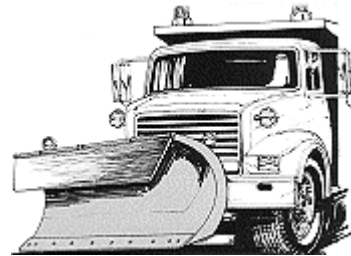
Transportation Association of Canada



# **Salt SMART**

**Spreading, Management, Application Rates and Timing**

## **Learning Guide**



**Module 5, Lesson 1**  
**Home base:**  
**Road maintenance yards**

*June 2004*

## ***Transportation Association of Canada***

The Transportation Association of Canada is a national association with a mission to promote the provision of safe, efficient, effective and environmentally and financially sustainable transportation services in support of Canada's social and economic goals. The association is a neutral forum for gathering or exchanging ideas, information and knowledge on technical guidelines and best practices. In Canada as a whole, TAC has a primary focus on roadways and their strategic linkages and inter-relationships with other components of the transportation system. In urban areas, TAC's primary focus is on the movement of people, goods and services and its relationship with land use patterns.

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***June 2004***

## Salt SMART Train-The-Trainer Program

TAC offers trainer workshops to accompany the Salt SMART Learning Guide in support of the best practices for the environmental management of road salts. They range from one-day overview sessions to two-day all-inclusive sessions.

*Make a SMART investment today and book your “at-home”  
trainer workshop or attend one in Ottawa!*

### Overview session

This one-day session is for trainers with formal training and experience. It is designed to walk through the *Salt SMART Learning Guide* to highlight key messages and to discuss potential areas of resistance and how to handle them.

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*TAC non-members pay a 20% premium on all sessions.*

To book your trainer workshop, or for further information, contact the TAC Training Manager, Diane Jodouin at (613) 736-1350, ext. 261 or [djodouin@tac-atc.ca](mailto:djodouin@tac-atc.ca)

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The project team for this Learning Guide consisted of the following individuals:

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TAC gratefully acknowledges the dedication, guidance and input of the Subject Matter Reviewers; and the quality of work performed by the Instructional Designer.

This Learning Guide is truly a team effort by all those who have contributed financially and/or technically.

# Preface

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## TAC Learning Guide

There are some things that should be taken with a grain of salt. The information in this learning guide is not one of them.

When you consider that the nation's extensive transportation network supports a wide range of economic and social activities, it's not putting too a fine point on it to state that safe and efficient road traffic throughout the year is essential to our way of life. We rely on the road network for transport to the workplace and other economic uses, for recreation and leisure activities, and for emergency and security services.

Road salt is the deicer of choice for winter road maintenance.

There's something else that we rely on: road salt. It's the deicer of choice for keeping roads passable throughout the winter.

The benefits of using road salt to keep the thoroughfares open don't come without costs, both economic and environmental. Recognizing this, and concerned about the environmental implications of road salt applications, the Transportation Association of Canada's (TAC) Chief Engineers' Council, the Road Salt Working Group (a subcommittee of the Maintenance and Construction Standing Committee), and the Environment Council launched an initiative to identify and document new ways of handling and using road salt. Transportation professionals from across the country worked together through the 20-member project steering committee and 17-member project team to produce three important documents:

- *Road Salt and Snow and Ice Control Primer*: An executive summary of the project, written for the general public, that provides information on the importance of road salt use to maintaining a safe and efficient transportation system that sustains Canada's economy.
- *Road Salt Management Guide*: A comprehensive reference guide which addresses transportation and Canada's economy and quality of life, road salt and the environment and road salt management practices.
- *Syntheses of Best Practices for Road Salt Management*: A series of syntheses of best practices related to the effective management of road salt use in winter maintenance operations.

## This guide's for you

This learning guide is based on the best practices in the *Road Salt Management Guide* and the *Syntheses of Best Practices for Road Salt Management*. If you're an operator or supervisor, then this guide is for you.

As a winter road maintainer, you're on the front lines in the battle against snow and ice on roads. In fact, the only thing that gets out there ahead of you is your plow blade. You probably already know that road salt is the most effective, cheapest, and easily handled de-icing material. There may be alternatives out there, but they usually cost a lot more, require special care when handling, and are only effective under certain weather conditions. Road salt is still the most reliable de-icing chemical available.

## The "4 R's" of winter road maintenance

There was a time when winter road maintainers lived by a simple rule of thumb: "when in doubt, put it out." In other words, it was better to err on the side of caution and put down a lot of road salt—and put it everywhere—just to make sure. But those days are long gone.

The modern winter road maintainer has a new mantra: "put the **R**ight amount of the **R**ight material in the **R**ight place at the **R**ight time." In other words, use road salt more wisely and effectively. The benefit of this approach is that road salt usage is *optimized*. This translates into savings for the organization, and minimizes the impact of road salt on the environment. This guide is designed to teach you how to optimize road salt usage while continuing to keep winter roads safe for commercial, passenger, and emergency vehicles.

## Your guide to road salt optimization

Optimizing salt use means being smarter about you how put it down.

Optimizing road salt usage means being smarter about how you apply the material. In most cases it will mean that you use less road salt, but that is a result rather than an objective. In order to use road salt more wisely, you'll need to become a better decision-maker, and in order to do that, you need to improve your knowledge. That's where this learning guide comes in.

The guide consists of six modules:

- **Module 1** sets the stage by looking at the importance of transportation to our economy and way of life; the economic implications of winter maintenance; and the cost-benefits of winter maintenance.

- **Module 2** explores the science of road salt and ice. In Lesson 1 we look at the principles of ice formation. Lesson 2 examines the concept of freeze point depressants and how they work to prevent or break the bond between pavement and ice. In Lesson 3 we consider alternative de-icing chemicals and their role in winter road maintenance. Lesson 4 looks at application strategies, in particular anti-icing, a modern preventive approach that aims to keep the ice-pavement bond from forming.
- **Module 3** looks at equipment and technologies used by modern winter road maintainers. In Lesson 1 we survey plows and spreaders and how they can be put to work to optimize road salt usage. Lesson 2 examines pavement condition tracking and forecasting techniques and technologies, including road weather information systems.
- **Module 4** deals with road salt and the environment. In this module we look at the pathways by which road salt can make its way into soil and groundwater, and the effects it can have on vegetation and wildlife.
- **Module 5** looks at snow and road salt handling. In Lesson 1 we look at road salt handling and storage at the road maintenance yard. In Lesson 2 we examine disposal strategies and techniques at snow disposal sites.
- **Module 6** considers the importance of monitoring and record keeping in winter road maintenance.

The objective throughout these modules and lessons is to help you, as an operator or supervisor, to understand how it is possible to use road salt more effectively while continuing to provide safe roads during winter and minimizing the impact on the environment.

## The same, but different

You have a lot in common with winter road maintainers across the country.

As a winter road maintainer, you have a lot in common with operators and supervisors in other jurisdictions across the country. At the same time, your job is very unique. Every road jurisdiction has a different transportation infrastructure to service. No two agencies face the same weather conditions. Each organization has a different mix of human resources and equipment available to keep the roads open during winter. Levels of service differ from one jurisdiction to the next, winter maintenance strategies are designed to meet specific local challenges, and public expectations change from one jurisdiction to the next.

In other words, while all winter road maintainers may be out on the front lines keeping the roads open, they could be using very different means to achieve similar ends.

This learning guide deals with general principles of winter road maintenance that can be applied in every jurisdiction, but it is beyond the scope of this document to prescribe practices that apply to specific road authorities. The best practices upon which this guide is based have been carefully researched and prepared and are endorsed by the Transportation Association of Canada's (TAC) Chief Engineers' Council, the Road Salt Working Group (a subcommittee of the Maintenance and Construction Standing Committee), and the Environment Council.

This material is provided as advice to winter road maintainers for consideration when developing their own policies, practices, and procedures. Keep in mind that the best practices are to be used in concert with the legislation, manuals, directives, and procedures of your individual road agency.

The material in this learning guide will be incorporated into your agency's current or planned training programs.

## A word about what's inside

Before we dive into the learning guide, let's take a look at what you'll see inside. We know that your time is valuable, and that the technical nature of this subject-matter may not be the most exciting thing you've read lately. So we've tried to make the learning experience as easy and enjoyable as possible.

We want you to learn, and to enjoy doing it.

The first thing you'll notice is that, unlike a lot of those technical reference manuals and user guides you may have seen and tried to read, our tone is conversational. We talk directly to you in a casual voice that's free of jargon and technical terminology. We even throw in a bit of humour every now and then. Unlike those other documents, we want you to learn, and to enjoy doing it.

Each lesson begins with a summary of the topics that we'll be discussing. This is followed by a conversation among fictional characters in a fictional maintenance yard: Pine Junction. Any resemblance between these characters and anyone you may actually work with is entirely coincidental. This dialogue sets the stage for the material covered in the lesson. Once you've read the list of topics to be covered and the dialogue, you'll have a pretty good idea of what you're going to discover in the lesson.



## Getting around: Navigation aids

The margin along the left side of each page is an area that we call the “fast track.” This serves three purposes:

We call this area the “fast track.”

1. Document designers tell us that “white space” on the page is visually pleasing to the eye, making it easier for you to read what’s on the rest of the page.
2. We can provide a capsule summary of the important points on the page. If you don’t have time to read the whole thing, at least you’ll know what you’re missing, and you can come back to it later if you’re interested.
3. The capsule summaries serve as “navigation aids”, which means that they provide a reference point if you need to come back to a section of a lesson and find a particular piece of information.

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### -TIPS, NOTES, and WARNINGS-

Although we feel that all of the information in the learning guide is important, some items need to have special attention drawn to them. We present these in the form of “Tips”, “Notes”, and “Warnings”. Information presented in this format is related to, but not part of, the discussion at hand.

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On the other hand, when we want to emphasize an important point *in* the discussion, we highlight it in this fashion.

If you only had time to skim a lesson, you could quickly grasp the essence of it by reading just the list of topics covered, the dialogue, the fast track items, the highlights, the tips/notes/warnings, and the summaries at the end, which we’ll discuss in a moment.

Our approach is based on the concept of self-assessment and instant feedback to confirm what you’ve just learned. Throughout this guide you’ll find “Quick Quizzes” that are designed to make you reflect on concepts that have been presented in the lesson. Once you’ve taken your best shot at answering the questions or offering solutions, you can check the answers that we provide following the quizzes. Look for the key to find out how you did. Sometimes there is no right or wrong answer, a reflection of the fact that operators in different jurisdictions might do things differently. We offer possible solutions, but our word isn’t always the final one.



When you reach the end of the lesson, we offer you a quick summary of where you’ve been. This is usually a restatement of the key points of the lesson that you should have picked up along the way. You’ll find it in the section entitled “Where have you been?”.



Knowing where you've been is useful, but knowing where you're going can be just as helpful. We'll let you know what's in store in the next lesson, in the context of what you've just learned. You'll find it in the section entitled "Where are you going?"

This guide can be used in different ways:

- You can use it at your desk, working and learning at your own pace.

-OR-

- You can use it in a classroom setting as a participant manual.

If you will be participating in a classroom training session, you will gain the maximum benefit by reading this guide in its entirety, if possible, before attending.

We hope that whatever you take from this guide will confirm the importance of the role you play as a winter road maintainer, and will generate discussions among your peers. Winter road maintenance is not a new profession, but there are always new techniques, technologies, and equipment coming along that change the way you operate. Keeping up with the changes, or staying ahead of the game, is a continuous learning process.

Let's start learning.

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# Module 5, Lesson 1

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## Home base: Road maintenance yards

This is salt science, not rocket science. There really isn't a lot to learn, but what there is to learn is critical. The fundamental principle to keep in the forefront of your mind is that *salt can be lost to precipitation and wind*. Everything else you're going to learn in this lesson is about how to prevent that from happening.

### *Well, what shall we talk about?*

- The role of the road maintenance yard
- Costs of salt loss
- Estimating salt requirements
- Salt handling cycle
- Storage structure types
- Outdoor storage techniques
- Salt handling best practices
- Yard location and design

## Equipment depot. Pine Junction maintenance yard. January.



“What are those consultants doing here, Roch?” asked John Rhodes, looking out into the yard from the cafeteria window. “Are they evaluating our work, or what?”

“I wouldn’t say ‘evaluating’, Johnny,” Roch Salterelli explained. “More like studying. They just want to see how we do things. Whether we’re efficient or not.”

“And if we’re not...?” Rhodes asked inquisitively.

“Don’t worry, Johnny, it’s not that kind of review. They’re designing the new yard. Next year at this time, we won’t be doing anything outdoors during the winter. They’re going to give us what we need to do all of our winter operations inside.”

“But they’re not doing this just because they like you so much, John,” Brine Watters laughed.

“I don’t mind working outdoors,” said Rhodes defensively. “We did everything outdoors when I first started in this business.”

“Well, times change, Johnny,” Roch said as he poured a cup of coffee. “We can’t afford to work outdoors in winter weather anymore.”

“Yeah, I know. They’re counting every cent these days.”

“True, but it’s not just money. It’s also about the environment, and your own safety. There’s a lot of activity going on out there. We’ve got to make sure that there’s a good flow to the activity. We need processes and procedures, and we need to make sure everyone knows them and follows them.”

“More rules,” Rhodes complained. “The more you read that learning guide, the more you try to regulate things. Did you ever notice that, Roch?”

“I’m glad you’re paying attention, Johnny. You’re absolutely right. But these aren’t just rules for the sake of rules. They’ll make your life around here easier, believe it or not. And we’ll be able to keep better control of the salt and sand.”

“Roch’s right.” Cal Ibrate joined the discussion. “We’ve got a lot of sophisticated equipment, a considerable amount of sand and salt, and a lot of traffic coming and going. The yard can’t run itself.”

“You’re not kidding,” laughed Watters. “Murphy’s Third Law would see to that.”

“What law is that?” asked Rhodes.

“It’s in the learning guide, Johnny,” advised Salterelli. “I invite you to see if you can find it. I’ll buy you a coffee if you can tell me what Murphy’s Third Law is.”

“And I’ll buy you a coffee if you can explain the Rule of Accuracy,” added Watters.

“You guys are hilarious,” complained Rhodes sarcastically.

“Seriously, Johnny,” explained Salterelli. “Think of all the activities that go on here: figuring out how much salt to order, ordering it on time, loading and unloading, making pickled sand, making brine, washing vehicles, keeping track of how much salt we use. It’s an endless list. You can’t have all that activity going on without some kind of a routine that everyone’s familiar with.”

“I know that, Roch. You think I’m a rookie? All that stuff’s been going on in maintenance yards for a long time. It’s just busier now, but it isn’t that much different.”

“He’s right,” agreed Ibration. “But you know what’s different now, Johnny? Now we have to do it more efficiently. So we don’t pollute the environment around the yard with salty runoff. And so we don’t waste salt—and time—by handling it more than we need to. I don’t know about you, but I don’t want to be doing something two or three times if I don’t have to.”

“Well, now you’re talking,” laughed Rhodes. “Brine, can you pass me that copy of the learning guide? I want that coffee from Roch. I need to look something up.”

## A yard by any other name

You may call it a patrol yard, a camp, or a depot. You may have worked in several of them over the course of your career.

Whatever you choose to call it, a road maintenance yard serves one main function: it's the location from which a road authority stages its road operations.

The role of a road maintenance yard can vary. The focus of this lesson is on winter operations.

The role of a maintenance yard can vary from being the central location for road operations, including administration functions, to simply serving winter operations only. The focus of this lesson is on winter operations, with an emphasis on salt handling best practices in the yard.



We'll look at salt management and environmental considerations that should be taken into account when operating and maintaining road maintenance yards. There are many other considerations that are unrelated to salt management that should be taken

into account when designing and operating maintenance yards, but they are beyond the scope of this learning guide. If you're interested, you can find information in TAC's *Salt Management Guide* and *Best Practices Synthesis on Design and Operation of Road Maintenance Yards*.

Maintenance yards can be sources of significant salt loss to the environment.

Maintenance yards can be sources of significant salt loss to the environment. Whether it is in the form of salt dust, brine runoff, or simple wastage of road salts through improper handling practices, lost salt will dissolve and can infiltrate into the soils below and adjacent to the site.



As we learned in Module 4, components of road salt entering the groundwater can travel great distances and affect wells, vegetation, and surface water where the groundwater emerges as springs or discharges into streams.

## Quick Quiz

The loss of road salt from maintenance yards is considered a significant impact because large volumes of concentrated salt are confined to a relatively small area. Salt can be lost to the environment through a number of activities. From your experience in the yard, list potential sources of salt loss to the environment.

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### Answer

- We've identified some of the potential sources of salt loss below. You may have identified others as well.
- runoff from exposed stockpiles
  - washing vehicles
  - blowing salt from exposed stockpiles
  - spillage of pure salt during delivery
  - stockpiling and loading



## The costs of salt loss

Salt loss and wastage is minimized in properly designed and well-run yards.

The good news is that there are actions that you can take to control salt losses. If the maintenance yard is well designed and established operating procedures are followed carefully, salt losses can be minimized, if not eliminated entirely.

There is almost certainly room for improvement in the operating procedures of any maintenance yard.

While the environmental impacts are serious, there can also be liability issues involved when road salt enters the environment. There have been cases where road authorities have had to replace salt-impacted wells and the resultant corroded appliances of affected homeowners.

In addition, salt-impacted runoff can affect vegetation and agricultural operations on and adjacent to the yard. Good yard design and salt handling practices are essential to prevent unnecessary salt loss and its environmental impacts.

Beyond environmental and liability considerations, there are three reasons why a road authority should construct and properly operate salt storage facilities:

1. Economy
2. Availability
3. Convenience

We've learned that salt is the most economical deicing material available. The initial cost is low compared to the alternatives; handling and storage are simple; and spreading is fast and easy.

Road salt has great staying power. It never loses its capability to deice, no matter how long it is stored. When you consider that rock salt is already between 210 and 320 million years old when it is mined, carrying it over on storage piles to the next year or even longer does nothing to diminish its melting power.

Salt has great staying power. All you have to do is make sure that it is properly protected from the elements.

All you have to do is make sure that it is properly protected from the elements. If it is, there is no loss to moisture from the air. Although salt begins to absorb moisture when the humidity reaches 75 percent, any absorbed moisture will evaporate when the humidity falls below that level.

## Maintenance yard salt handling

In this lesson we'll look at general principles of salt handling in maintenance yards based on well-established best practices.

These measures don't require huge investments in technology. As long as operating procedures have been established, communicated to everyone in the organization, and are followed diligently, salt losses can be reduced substantially.

This saves money, avoids liability, and protects the environment.



### Best practices

- ✓ Salt stockpiles *must* be stored indoors
- ✓ Load trucks indoor where possible
- ✓ Use low permeable surfaces to minimize infiltration
- ✓ Collect and reuse or properly manage salt impacted site drainage and vehicle wash water to comply with local water quality regulations and protect surface and groundwater resources
- ✓ Handle materials and clean up spilled salt to minimize salt loss
- ✓ Collect and dispose of onsite contaminants and wastes in accordance with local waste management legislation
- ✓ Control emissions (drainage, noise, dust, litter, fumes) to prevent off-site environmental impacts

## Estimating 101: How much is enough?

If you're the one responsible for estimating salt requirements for the coming winter, you need to be very aware of this:

**Murphy's Third Law:** Anything that can go wrong will go wrong.

If you keep that rule in mind, you won't make the mistake of ordering too little, thinking that you're going to have a mild winter. If you make that assumption, you can be almost certain that a severe winter is on the way.

Rather than trying to second-guess the weather, you would do well to follow these guidelines when estimating your salt requirements:

- ✓ Use the average over the last five years to arrive at a reasonable amount to order.
- ✓ Be sure to take into account new mileage added to your road or street system.
- ✓ Take into account improvements in winter maintenance, such as going to straight salt or adding more salt routes.
- ✓ When anticipating needs, make realistic estimates, but be sure to consider the possibility of unseasonable or prolonged cold spells, with more snow or ice events than usual.

All of these conditions, often unpredictable, can affect your use of salt.

You should also keep this in mind when trying to determine how much salt you'll need this winter:

***The Rule of Accuracy:*** When working toward the solution of a problem, it always helps if you know the answer.

Obviously, you can't know the answer, but you can make an educated guess based on experience and knowledge. In an earlier lesson, we discussed the importance of keeping close tabs on local weather conditions in your region. By keeping records of the number of freeze-thaw cycles, winter storms, and rain/snow days, you can get a good idea of what a "normal" winter looks like in your area.

At a minimum, you need this kind of baseline information before you can begin to estimate requirements for the coming winter.

You need to know what a "normal" winter looks like in your area before you can make an educated guess on salt requirements.

## Placing your order: You want it when?

Ordering salt early may be the most important part of the process.



As critical as it is to order an adequate amount of salt, it is also important to order it early—in fact, this may actually be *more* important. After all, ordering exactly the right amount won't help if it can't be delivered on time, or at all.

Order salt by mid-summer for summer and fall delivery. Then there is reasonable assurance of getting the material well ahead of winter.

Transport problems often become complicated once winter begins and the demand for salt increases:

- Numerous orders for salt all at one time place increased demands on the shippers and haulers that deliver salt from production points to stockpile sites and to users.

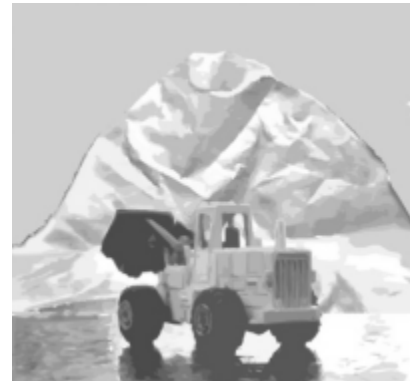
- Adverse winter weather can slow shipments that arrive by truck and rail. Much of the salt is shipped at least part of the way to the user by water, and freeze-ups can halt water shipments.

## Storing your order: You want it where?

Early ordering and stockpiling ensures a ready supply.

While estimating the amount of salt you'll need for the winter does involve a certain amount of guesswork—albeit educated guesswork—you can calculate with some precision the amount of space that you'll require to house all that salt. Early ordering and stockpiling of deicing salt ensures a ready supply, with the material delivered during good weather.

Plan your salt program early. Above all, make sure that you have adequate storage space for the salt when it arrives.



When deicing salt falls freely into a pile, it forms a cone with sides that slope at an angle of 32 degrees, its natural angle of repose.

We know enough about salt's physical characteristics to be able to determine in advance how much space a known amount will occupy. When deicing salt falls freely into a pile, it forms a cone with sides that slope at an angle of 32 degrees. This is salt's natural angle of repose.

The density of deicing salt ranges from 1152 kilos per cubic metre loose to 38 kilograms compacted. When calculating storage space requirements, use the figure 1280 kilos per cubic metre. Thus, a tonne of salt would require 0.78 cubic metre of storage space.

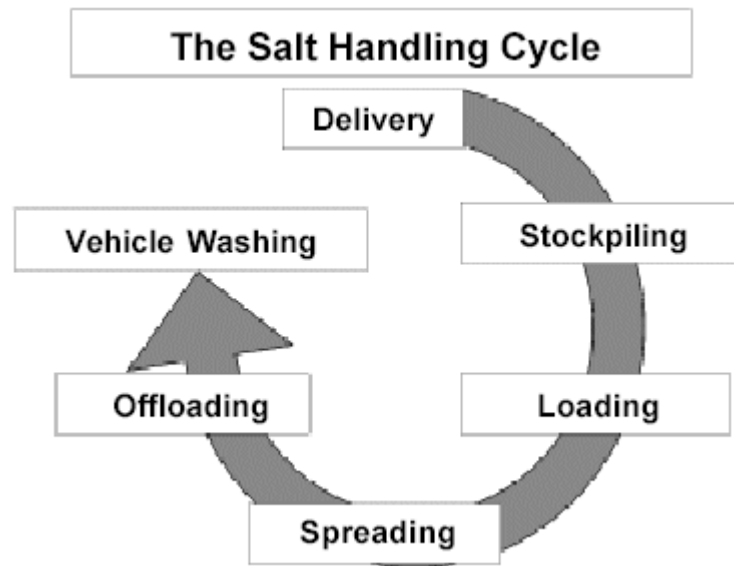
### Pre-season and post-season planning checklist

- ✓ Calculate sand/salt requirements and do not order more product than the yard can adequately store.
- ✓ Have the sand delivered during summer to ensure it is as dry as possible. Mixing of sand and salt should occur during dry summer months.
- ✓ In spring, sweep the pads and return excess salt and sand to stockpiles. Don't wash the pad before sweeping or you'll have extra wastewater to treat.
- ✓ Transfer as much as possible of the pickled sand indoors. Tarp pickled sand piles that are stored outdoors.
- ✓ Once the pad has been cleaned and washed, test and dispose of the pond water.
- ✓ Repair facilities that affect salt loss such as plugged ditches and damaged asphalt.

## Handling the salt: Do it once

There is room for both error and improvement at each step in the cycle.

The yard layout should be designed to be efficient in all activities. At each step in the salt handling cycle shown below, there is the potential for salt loss. At the same time, there is a chance to improve processes and procedures to make things run more efficiently and minimize potential salt losses.



The typical salt handling cycle flows from delivery, to stockpiling, to loading on the spreader and then to exiting the yard. Upon return, the spreader offloads unspent salt (preferably indoors), and the equipment is then washed to remove remaining salt residue.

**Each area affected by these activities can provide an opportunity for improvement.**

Typically, a delivery transport trailer end dumps or offloads the salt via a longitudinal conveyor. Preferably, the storage facility has been designed and constructed to allow the salt to be unloaded directly inside. If unloaded outside, the salt must be reloaded into a pile under cover.

Ideally, salt should never be “double handled.” The more it is handled, the greater the risk of salt loss.

Ideally, the salt should not be “double handled.” In some cases salt is blown into storage facilities using a closed pipe system to eliminate double handling. Whether mechanically piled or blown, each handling can cause particle breakdown, segregation, and loss.

The specification for salt at delivery generally limits the amounts of fines; double handling will create additional fines that can degrade the desired free-flowing characteristics of the salt

While handling can serve to break up any chunks that may be present, the gradation will usually vary and this effort is inefficient. It also allows for a greater wind-blown loss of salt and the loss of salt fines that are remaining on the outdoor surface.

### Quick Quiz

Think about the salt handling cycle in your maintenance yard. Are there steps that could be taken to minimize salt losses? Identify at least two activities, and explain how you would improve them.

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#### Answer

There is no "correct" answer to this quiz. Each maintenance yard is unique, and areas that could be improved will be different in each location. For guidance on how your processes could be improved, consult the checklists and best practices provided throughout this lesson. For more detailed information, refer to TAC's Best Practices Synthesis on *Design and Operation of Road Maintenance Yards*.

## Release no salt before it's time

When you're handling a substance that's already hundreds of millions of years old before it gets to your yard, it would be a shame to let it simply blow away or flow away. Especially when that can be so easily prevented just by establishing handling procedures and following them diligently.

This is salt science, not rocket science. There really isn't a lot to learn, but what there is to learn is critical. The fundamental principle to keep in the forefront of your mind is that *salt can be lost to precipitation and wind*. Everything else you're going to learn in this lesson is about how to prevent that from happening.

Once salt comes into contact with precipitation, it's the beginning of the end.

Whether it's in a nice conical but *uncovered* pile, or scattered about the yard as the result of spillage or careless handling, once salt comes into contact with precipitation, it's the beginning of the end for this ancient crystal. Your responsibility as an operator or a field supervisor is to ensure that you keep salt under wraps until it's time to load it into the spreader and apply it to winter roads.



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-TIP-

**Rule #1:** Storage piles, whether large or small, should never be left exposed to rain or snow.  
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A permanent under-roof storage facility is the ideal shelter for protecting salt, but if this isn't available, then outside piles should be built on impermeable bituminous pads and covered with one of the many types of temporary waterproof materials, such as tarpaulins and polyethylene.

Do whatever works best for your organization, as long as it keeps the salt in and the elements out.

## Avoiding the elements: Storage structures

In this section, we'll be taking a look at the most common types of salt storage structures. Storage facilities can be constructed of many different types of materials, including railroad ties, pressure-treated timbers, assorted lumber, old bridge timbers and decking, concrete blocks, corrugated sheet metal, steel, aluminium, fibreglass, or various other materials and fabrics.

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-TIP-

**Use protection:** Use pressure-treated posts and timbers in pole-type buildings, and make sure all hardware is galvanized. Concrete block buildings should be waterproofed inside. In case of open ends, covers should be supplied for exposed salt.  
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You can save money by using—or re-using—whatever is on hand. Keeping in mind the fundamental principle that salt can be lost to precipitation, all design considerations should be aimed at keeping precipitation out of the salt, or, if that is unsuccessful, containing any salt-laden water that may be created.

Whatever type of structure you choose, you should enclose the base of the pile, and support the structure, on a concrete wall, with or without a footing. These walls need to be designed to withstand the strain of materials and loaders pushing against them. They must also be free of gaps that would allow salt or salt-laden runoff to escape.

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–TIP–



**Mixing is a breeze:** When you're mixing sand and salt outdoors, pay attention to the wind. A significant amount of material can be blown away during the mixing process. It's worth waiting until the wind dies down.

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The roof and exterior of the storage structure should be constructed of waterproof material to keep precipitation and moisture from entering the building.

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–NOTE–



**No flow:** It's important to keep salt free flowing. To do this, salt producers add anticaking agents. However, if left exposed to precipitation, anticaking agents can be washed from the outer layer of salt.

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## Ins and outs of storage structures: Entranceway design

Well-designed entranceways on storage structures will take into consideration the prevailing winter wind direction to help keep out precipitation. Many road authorities like to have their salt at one end of the structure and their blended sand at the other end, with space to allow a pug mill and conveyor for creating the blend. In order to accommodate these types of requirements, structures may need side doors to allow spreaders to drive through and be loaded with different materials from either end.

Spillage during stockpiling and spreader loading is the main source of salt loss.

Some structures provide a more efficient capacity than others depending on the methods of putting up the piles and using the materials. Since spillage during stockpiling and spreader loading is the main source of salt loss, the more that these activities can be carried out under cover of a well-designed structure, the less salt will be lost to the environment.

Working indoors presents a whole set of other challenges, however. The two most significant considerations are ventilation and door/roof clearances. The door should be high enough to allow a transport trailer to end dump inside the structure. The entrance to the storage structure should have a door, curtain, or a sufficient overhang to minimize precipitation entering the structure.



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–TIP–

**Lighten up:** Areas around the building must be well lit to allow for safe night time operations. On the inside of buildings, place lights to the side and high enough to keep from covering wiring or light fixtures with salt when the building is full.

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## The bottom line: Floor design

Floors should have the lowest permeability and should slope away from the center of the storage area.

The floor of a salt storage structure provides both the operating surface and the barrier to infiltration of salt-impacted water into the ground. Since indoor operations will place significant stresses on the floor, it must be designed properly.

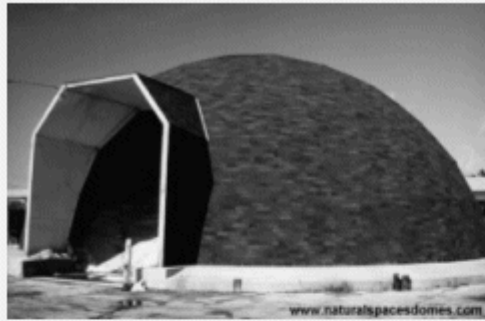
The floors of all structures should have the lowest possible permeability and be constructed of quality strength asphalt or concrete that is sloped away from the center of the storage area for drainage purposes. Both asphalt and concrete are somewhat permeable and should be sealed to minimize infiltration.

## Domes, barns and silos: Assessing the options

Structure designs range from domes to rectangular sheds or barns to high arch structures to elevated silos. There are variations on these themes, as road authorities have modified the designs—or come up with entirely new ones—to suit local conditions and requirements.

Let's look at the pros and cons of each of these structure types.

## Under the dome



### Scouting report

The most popular salt storage structures over the years. They have an efficient surface area to pile volume ratio.

#### Special considerations:

- roof covered with shingled plywood; re-shingling is expensive
- higher capital costs than other structures
- higher than average operating costs
- life-cycle costs can be high due to higher maintenance costs
- prone to damage by loaders because of arched roof and limited door width
- access door provides ventilation air (domes typically have no doors but can have sliding or swinging doors)
- ventilation inefficient through peak (often fitted with power ventilation systems or wall openings to improve ventilation)
- because of ventilation concerns, spreader loading is usually done outside, creating greater potential for salt loss
- spinning off excess salt after a run can be done inside once material volume is down
- putting up material requires double handling because transport trailers cannot dump inside
- because of their shape and size, domes cannot be expanded

## Under the framed single-peaked roof



### Scouting report

This rectangular structure is also known simply as a "barn." It is important that the salt is not permitted to come into contact with the steel cladding, which can lead to buckling of the walls and corrosion.

### Special considerations:

- has sliding doors at one or both ends, or on the sides
- has a ridge vent along the top to provide ventilation, which may be supplemented by a power vent (generally the natural ventilation is not good enough to permit loading inside)
- capital costs tend to be higher than for domes
- operating costs lower than for domes because of buttressed concrete walls on footings, wider door, greater loader clearance, steel cladding, and steel roof
- spinning off excess materials can occur inside the barn once the material volume is down
- putting up material may require double handling if the barn is not sufficiently large to permit a transport trailer to dump inside (some barns are large enough to permit inside dumping)
- costly to expand
- smaller versions (sheds) used for straight salt when salt delivery is frequent and reliable

## Under the gambrel arch



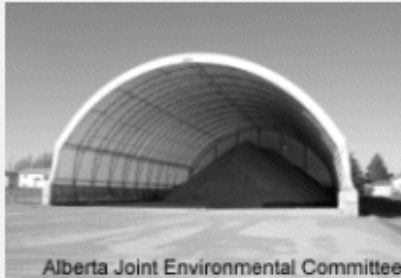
### Scouting report

The gambrel arch structure is usually constructed on a buttressed timber post foundation with wooden plank or plywood walls. The benefit is that the arched design allows for overhang at the top of wall, which gives good ventilation from the overhang through the roof ridge vent.

### Special considerations:

- roof can be steel or shingles
- capital costs can be higher than dome, but comparable to barn
- operating costs lower than for dome, but higher than for barn
- loader clearance is good, minimizing building damage from operations
- natural ventilation sufficient to permit inside loading
- spinning off excess materials can be done inside once material volume is down
- putting up material does not require double handling because transport trailer can dump inside
- easily expanded

## Under the fabric-roofed dome



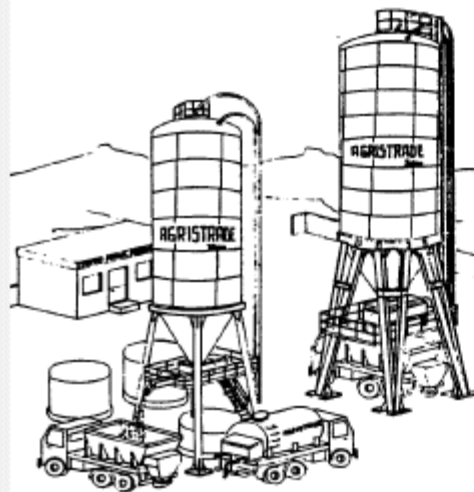
### Scouting report

Constructed of a fabric roof on aluminum trusses mounted on a concrete wall. Operating conditions similar to those of regular dome structures (see below).

#### Special considerations:

- have failed due to wind or snow loading, or fabric tears

## Under the salt silo



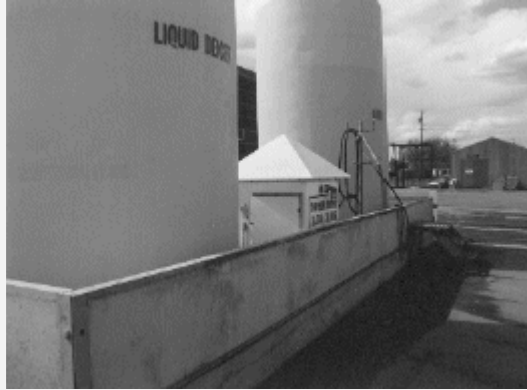
### Scouting report

A silo consists of a cylindrical hopper mounted on a tower under which a spreader can drive. A remote control gate opens to discharge the material directly into the spreader by gravity. The hopper is charged in preparation for a storm event by a salt conveyor from a storage pile.

#### Special considerations:

- allows for rapid and accurate filling of spreaders
- needs contingency system in case silo malfunctions
- difficult to service in event of material caking or jams

## Brine production and storage facilities



### Design checklist

- ✓ consult with local environmental regulatory authorities regarding site location and containment requirements (containment capacity should be 110-125% of capacity of largest tank)
- ✓ ensure adequate storage capacity for the season (depends on security of supply, production/delivery times, and rate of use)
- ✓ overflow protection and containment (walls, tank-in-tank)
- ✓ insulation against significant temperature drops and/or recirculation pumps to prevent ice crystals from forming at low temperatures
- ✓ use corrosion-resistant parts
- ✓ locate away from catch basins on impermeable loading pad
- ✓ where supplier-owned storage containers are used, arrange for delivery of full containers and removal of empties during yard operations
- ✓ have emergency power supplies to ensure liquid supplies available in event of power failure
- ✓ ensure sufficient water supply available to produce brine at required rate
- ✓ heat trace water supply lines to prevent them from freezing
- ✓ select pump and line sizes to ensure fill time is not prolonged unnecessarily
- ✓ production and storage tanks should have clean-out or flushing capability to remove settled impurities
- ✓ some liquids may require periodic recirculation to prevent settlement of impurities, additives, or product separation

## Quick Quiz

On balance, which type of salt storage structure do you think has the most efficient design? In your own maintenance yard, are there inefficiencies in your operations related to your type of storage facility? Suggest ways that they could be improved.

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### Answer

There are no "correct" answers to these questions. Each maintenance yard is unique, and areas that could be improved will be different in each location. Keep in mind the lists of special considerations for each of the structure types, for example, ventilation, door height, loading requirements, etc.

## External affairs: Keeping salt outside

Outdoor stockpiles provide maximum storage space and easy access. But these benefits come with an increased risk of salt loss.

Although permanent, covered storage is recommended, some agencies, whether through necessity or choice, still store salt in outdoor stockpiles on bituminous or concrete pads. This remains a low-cost method that provides maximum storage space and easy access. Along with these benefits, however, comes an increased risk of salt loss.

As is the case with indoor storage, salt must be placed on an impermeable pad or base. The pad site should be located away from wells, reservoirs, and groundwater sources and situated so that if any drainage inadvertently leaves the storage area it will not affect them.

The concrete pads should be constructed of air-entrained concrete and treated with a good quality concrete sealant to prevent spalling. While pads should be sloped to allow surface water to drain away, it is advisable to let local conditions control the



direction of slope to avoid excessive grading. The grade of the slope is also critical: a minimum slope of two percent is required to assure good drainage; a slope steeper than five percent may make front-end loaders unstable.

For good drainage, install ditches, pipes, and tile where necessary. In some cases, it may be necessary to channel water to a collection point, preferably a specially designed sump area.

## Piling and storage techniques

To minimize the loss of salt to the environment, and to avoid problems such as caking or clumping due to moisture or freezing, stockpiles of salt and pickled sand should be covered or have an equivalent system to reduce salt loss to wind or leaching.

If outdoor storage is used, the salt must be properly covered. Salt stored in bins or on pads must be covered with a suitable waterproof material. Old tires lashed together with rope or cable and placed uniformly over the flexible cover and tied down make a suitable weighting system. Poly-cord nets are also available for tying down covers. Be sure to weight down the base of covers to keep wind from peeling them off salt piles. Timbers, including railroad ties, may be used for that purpose.

The techniques for stockpiling sand/salt piles vary from one road authority to the next across the country. These techniques range from having no pad or cover, to uncovered piles placed on pads, to the use of covers such as spray-on surface sealant or tarps to shed water, to structures situated on a pad.

Stockpiling sand/salt piles without a pad or cover, or placing uncovered piles on pads, does not afford any protection against environmental impacts, and is not an acceptable method of storage. The only time that it is acceptable to leave a pile uncovered is when it is in use during the winter season.

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### Tips

- Exposed outdoor piles must be conical to minimize leaching.
  - Covered piles must be located in a contained area with drainage into a storage pond.
  - Drainage patterns should prevent uncontaminated precipitation from entering the sand/salt pile and contributing to increased runoff.
- 

Stockpiling techniques vary from one road authority to the next across the country.



**Cover your piles...****...here's why**

- ✓ reduces product loss from wind and water erosion;
- ✓ reduces caking and clumping of sand piles;
- ✓ reduces the volume of runoff that has to be managed; and
- ✓ improves water quality of surface runoff.

## Salt handling operations

Material wastage can be reduced through efficient yard layout and design.

Although yard layout and design are important factors in cutting down on salt loss, it is in the establishment and execution of good operating practices that material wastage can be reduced.

Earlier we had a look at the salt handling cycle. An environment audit of your operations at each step in the cycle will identify where salt loss is occurring. Putting in place documented operational procedures will help to minimize or eliminate the release of salt into the environment in the following areas:

- Salt delivery and handling
- Sand/salt mixing and storage
- Equipment washing
- Wastewater management

## Salt delivery and handling

The first step in the salt handling cycle is the delivery of the product. Salt is delivered to most storage sites by truck. There are a number of measures that you can take to make this process more efficient. These improvements will speed up the process and help to reduce potential salt loss.

### Tips to minimize salt loss during the delivery process

- ✓ delivery trucks entering the yard with salt should be covered
- ✓ deliveries should be done during good weather (low wind speed, no precipitation)
- ✓ salt should be offloaded and stored inside the covered storage as soon as possible
- ✓ before leaving the yard, excess salt should be removed from the spreader in the designated area
- ✓ salt should be loaded into the shed by a closed conveyor system
- ✓ delivery trucks and spreaders should be confined to paved access roads with speed bumps to dislodge salt

### Tips to speed up the salt delivery process

- ✓ allow enough room for maneuvering; some trailer trucks are 16 metres (55 feet) long; when dumping, trailers may rise 9 metres (30 feet) above the ground
- ✓ help truckers find salt storage points by posting signs and providing maps
- ✓ make sure someone is available to authorize deliveries and sign delivery tickets
- ✓ inspect and test the salt received for weight, gradation, and anticaking agent level
- ✓ inform trucker and salt supplier if you find foreign objects in salt load
- ✓ don't keep truckers waiting
- ✓ sweep or shovel spilled salt into shed

## Getting pickled: Mixing the sand and salt

If your operation includes use of sand, one of the main activities taking place in your yard is mixing sand and salt. Under ideal circumstances, creating pickled sand would take place inside the storage facility, but if that isn't possible, you should try to prepare the mixtures on a low permeable pad located as close to the storage area as possible. Remember, the more you have to handle salt, and the farther you have to move it, the greater the potential for loss.



If you're mixing outdoors, do it during good weather only. The two most significant weather conditions that contribute to salt loss are precipitation and wind. To eliminate salt loss through blowing and flowing, either do it inside the storage facility, or only when these two conditions aren't present.

The percentage salt you'll need is determined by the sand's moisture content.

Whether you're mixing inside or outdoors, you should use a pug mill or some other mechanical method to achieve a homogeneous engineered blend. It's possible to use as little as a 2% salt blend if you use mechanical means to mix the pile. The most you should need is a 5% blend. If the sand is as dry as possible before you begin mixing you can minimize the amount of salt required to prevent the pile from freezing.

The percentage salt that you'll need will be determined by the sand's moisture content. The two most important things you need to know about your sand pile is the moisture content and gradation.

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-TIP-



**Have a look:** It may not always be necessary to re-mix a sand/salt pile that has been in storage over the summer. Before re-mixing check the moisture content of the sand. If it is low enough, and your monitoring does not indicate excessive runoff from the pile over the summer, you may not have to re-mix. If you "check before you re-mix," you could save time and money.  
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Once the sand and salt have been mixed, the material should be moved into the storage facility as soon as possible. The mixing area should then be swept and the excess mixture returned to the pile inside the storage facility. This should be done as soon as possible, and above all before precipitation or wind have a chance to move the material into the surrounding environment.

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-TIP-

**Playing the percentages:** If you purchase pre-mixed material, check deliveries to validate that the percentage mix is as specified. Too high a percentage of salt is wasteful and too low a percentage may result in the pile freezing.  
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## Salt handling: Loading spreaders

Loading and offloading spreaders are potential sources of salt loss, primarily due to overloading.

Loading and offloading spreaders are the most frequent activities in a road maintenance yard during the winter season. They are also potential sources of significant salt loss, primarily due to overloading. In this section, we'll take a look at operating procedures designed to cut down on spillage during the loading process.



Spreaders are usually loaded using a front-end loader. Because ramps to facilitate loading by short loaders with small buckets are prone to tipping and spillage accidents, they are not as commonly used as they once were. Now, larger loaders and bucket sizes have increased the speed of the operation,

but the rate of spillage is often worse as a result of overloading. Spillage can occur either at the yard exit or before the spreader reaches the designated location.

Sometimes operators spread the entire load rather than return with a surplus.

Overloading results in another form of salt wastage: sometimes operators tend to spread the entire load rather than return with a surplus and spin it off. Knowing exactly how much material is needed to cover the route, and then loading *only* that amount, can avoid this problem. As we saw in the previous lesson, there are loader-mounted weighing devices that can help operators ensure that they have the appropriate amount of material on board.

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### -TIP-



**A clean sweep:** One of the most important things you can do to ensure that your yard remains environmentally friendly is to sweep up after every storm. This is an activity that requires relatively little effort, but the benefits are substantial.

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Like most maintenance yard activities, the more you can do indoors, away from the elements, the less chance there is that you'll lose salt to the environment.

Don't forget that salt lost to the environment is also a loss to your bottom line. A primary source of salt entering the groundwater is salt spillage that is either plowed or washed from the maintenance yard. Care to minimize spillage and practices to clean up spilled salt can reduce costly losses.



If you can't load spreaders inside, make sure you have procedures in place to recover spilled salt.

Where possible and practical to do so, you should load spreaders inside the storage structure. If this is not possible, then make sure that you have procedures and systems in place to recover salt that spills during the loading process.

Whether you're loading spreaders inside or out, it's hard to avoid spillage if you overload. As a general operating principle, spreaders shouldn't be loaded beyond

their capacity. The load should be no more than 30 centimeters (12 inches) above the grate to avoid general spillage and lumps falling off into traffic where it can damage windshields and paint jobs and expose your organization to possible compensation claims.

Where feasible, the load should be covered with a tarp when loaded with salt or sand. This also applies to incoming salt: all deliveries should be covered when being transported to the yard.

-----  
-TIP-

**Chock-a-block:** Stockpiles frequently have portions that have become frozen. These frozen blocks need to be properly managed and should not be placed into spreaders. These blocks should be pushed into the corner of the storage facility and allowed to thaw and dry. Once they have thawed and dried, the material should be broken up and reintroduced to the pile. Where brine production is ongoing, blocks of pure salt can be put into the brine production tank.  
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## All washed up: Equipment cleaning

Once the spreader is empty, it should be washed as soon as possible in order to minimize corrosion.

As previously discussed, overloading the spreader can result in salt loss through spillage as well as the practice of spreading the entire load to avoid returning to the yard and spinning off the surplus. As an operator, you should spread *only* what is needed to achieve the prescribed level of service. Return unused material to the storage facility for spinning off.



Once the spreader is empty, it should be washed as soon as possible following the storm in order to minimize corrosion. The wash water will likely be contaminated with dirt, oil, grease, and salt (chlorides). If not handled properly, this wash water can harm groundwater quality, receiving streams, ponds and lakes, and adjacent vegetation or agricultural operations.

Maintenance yards should have designated locations for vehicle washing where the wash water can be properly diluted, disposed, or treated.

It's easier to contain the wash water if you wash the vehicle indoors.

In order to reduce the potential toxicity of the wash water, sweep the spreader before washing to remove as much of the residual solids as possible. This surplus material should be returned to the pile inside the storage facility as soon as possible. Like most other yard activities, vehicle washing should be done indoors, if possible. This makes it easier to contain the wash water.

If outdoor washing is the only option, ensure that all wash water can be contained and directed through positive drainage to a water management system. It is preferable to direct wash water to a storage facility where it can be reused for brine production or sent for disposal. Careful consideration must be given to the ultimate receiver of the wash water. All vehicle wash water should be directed through an oil/grit separator.

## Liquidation: Salt brine production and storage

Where liquid melting agents are used, spillage can occur during production, delivery and transfer to spreaders. While these activities represent potential sources of environmental contamination due to spillage, they also provide opportunities to make use of wash water, salt-laden drainage, and salt clumps that would otherwise be unusable in spreaders.

Where regulations permit, equipment wash water or salt-laden drainage water should be considered for use in brine production. Clumps of salt or wet salt can also be placed into the brine production plant, rather than leaving them in the storage facility.

Tanks should be placed above ground, protected from potential collisions, and be inspected regularly for leaks.

If there are salt brine storage tanks in your yard, they should be placed above ground, protected from potential collisions by vehicles, and periodically inspected for leaks. Keeping in mind *Murphy's Third Law*, discussed earlier in this lesson, you should ensure that there is a provision for secondary containment where a tank failure could result in environmental damage. Containment is often achieved by double-walled tanks or dyking systems. Consult your local environmental regulatory agencies to determine the containment and handling requirements.

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-TIP-

**Sedimental journey:** You may need to flush brine production and storage facilities periodically to remove sediments. The materials produced from this flushing activity are mostly sand and gravel and can be mixed with the abrasive pile.  
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## Finding the spot: Yardsticks for yard sites

As an operator who uses the road maintenance yard, or a field supervisor who is responsible for its smooth and efficient functioning, you may wonder why a section discussing yard site selection and design is included in this learning guide. It's a valid question.

No one knows the yard better than you. You know best how it can be improved.

The TAC *Salt Management Guide* and *Best Practices Synthesis on the Design and Operation of Road Maintenance Yards* discuss design and site location considerations that are beyond the scope of this learning guide. The Salt Institute also offers a lot of technical material on this topic. Our focus here is to look at this subject from your perspective. After all, you're there every day. No one knows the yard better than you—and no one is in a better position to know how it can be improved so that it functions efficiently with as little salt loss and wastage as possible.

If you know some of the factors to consider when locating a yard site and designing its layout, you'll have a better understanding of why you're expected to follow certain operating procedures, and you'll be able to offer suggestions for improvement when the opportunity arises.

### Selecting a yard site: Getting SALTED

There are six key factors to consider when selecting a site for a road maintenance yard:

- Safety
- Accessibility
- Legality
  
- Economy
- Drainage



**Safety** means good visibility for operators, no direct access onto heavily traveled roads, warning signs at entrances, security fencing, and safety for the surrounding environment.

**Accessibility** means easy access for equipment and delivery trucks, big enough for front-end loaders to manoeuvre, room for a 6 metre (20 foot) extension of the pad in front of storage buildings, and doors large enough to accommodate equipment.

**Legality** means complying with local zoning ordinances and any required discharge permits.

**Tidiness** means making buildings as attractive as possible, keeping buildings well maintained, good housekeeping around the storage site, and screening the storage site with fencing or plantings.

**Economics** means permanent covered storage and locating the storage site to avoid long distance hauling.

**Drainage** means good drainage away from the stockpile, sloping bituminous pads (2 millimetres per metre downward from the center), containing runoff, installing retention curbs if necessary, and disposing of salt brine in conformance with applicable federal, state, and provincial regulations, as well as local ordinances.

Source: Salt Institute



## Laying it out: Yard design

Hopefully, the designers will consult people who will work at the facility.

As we've seen, maintenance yards are multi-functional facilities. From delivery to offloading to loading to mixing to equipment washing, the range of activities is wide. All functions must be considered in designing the most suitable layout and features for the yard. Hopefully, the designers will consult people like you who will work at the facility when laying out the flow of the yard.



The prime consideration in yard layout is to come up with a design that permits vehicles involved in the salt handling cycle to move efficiently and safely about the site. The design should also be flexible enough to allow for expansion as service delivery areas increase, or to be retrofitted to satisfy the latest method or policy change.

The ideal yard is safe to operate from, cost-effective to use, and facilitates the management of site drainage and vehicle wash water. It protects salt vulnerable areas, and generates limited liability. Yards that don't meet these criteria have room for improvement.

Yards should be located away from salt vulnerable areas.

To the extent possible, maintenance yards should be planned and located away from salt vulnerable areas. This requires sufficient investigations of potential sites to identify salt vulnerable areas and to factor them into the site evaluation process. Where salt vulnerable areas cannot be avoided, special design measures must be taken to prevent salt impacts.

We've discussed a number of measures in this lesson aimed at reducing spillage and salt loss, and containing salt-laden runoff when it occurs despite these preventive measures.

## Salt Institute *Excellence in Storage Award*

Proper storage of highway salt has been an integral part of the Salt Institute's "Sensible Salting Program" since it began in 1972.

Investing in good winter storage is no "frill." To encourage proper storage practices, the Salt Institute annually confers its *Excellence in Storage Award* to recognize agencies with outstanding storage facilities and programs.

The competition is to encourage the construction and operation of sound storage facilities that exemplify operating practices to minimize environmental concerns, promote worker safety, and assure uninterrupted winter maintenance service.

Principles of proper storage are outlined in the Institute's *Salt Storage Handbook*. If you feel you have an excellent storage facility, download the application form from the Salt Institute web site (<http://www.saltinstitute.org/40.html>) and submit it before the deadline. Canadians should use the separate *Canadian Excellence in Storage* application form, available in either English or French.



## Yard operations and maintenance checklist

### STORAGE FACILITIES

- Inspect the roof for leaks and repair
- Inspect the floor for cracks and repair
- Inspect the walls for leaks and repair

### SOLID SALT HANDLING

- Store salt under cover
- Deliver salt during dry weather
- Delivery trucks are tarped
- Deliver salt directly to the storage facility or place into storage immediately
- Load spreaders inside where possible
- Minimize spillage during spreader loading
- Spreaders are not overloaded
- Spilled salt is cleaned up quickly
- Excess salt is returned to storage

### LIQUID STORAGE AND HANDLING

- Liquid storage facilities have secondary containment
- Inspect storage tanks, pumps, pipes, and hoses for leaks and repair
- Train personnel in proper handling of liquids

### BLENDED ABRASIVE HANDLING

- Store blended abrasives under cover
- Deliver abrasives during dry weather
- Mix salt and abrasives inside where possible
- Outdoor mixing only occurs during good weather
- Mix only enough salt to keep the pile from freezing
- Load spreaders inside where possible
- Minimize spillage during spreader loading
- Spreaders are not overloaded
- Spilled blended abrasives are cleaned up quickly
- Excess blended abrasives are returned to storage

### SITE DRAINAGE

- Clean drainage is directed away from storage areas
- Salt impacted drainage is collected, treated, and/or sent to proper disposal
- Where collection and treatment is not practical, salt impacted drainage is directed away from salt vulnerable areas

### VEHICLE WASHWATER

- Vehicle wash water is collected, treated, and sent for proper disposal
- Vehicles are swept prior to being washed

## Where have you been?



In this lesson, we've stuck close to home. The road maintenance yard is your base of operations. We've discussed a wide range of activities related to salt handling that take place at the yard. These activities, if not conducted efficiently and according to established procedures and processes, represent potential sources of salt loss to the environment, as well as to the bottom line of the organization. It is in everyone's interest to have a smoothly functioning road maintenance yard.

The recommendations, tips, and checklists provided in this lesson are based on well-established best practices in salt management. Your organization may already be following several of them, but if there is room for improvement, let this lesson be your guide to more efficient salt handling operations.

## Where are you going?



In the next lesson we move from the road maintenance yard to the snow dump. This is where salt-laden snow that is collected from urban streets is stored. It represents a potential environmental hazard of significant proportions if precautions aren't taken to contain and control runoff as the snow pile melts during the spring and, occasionally, into the summer. We'll take a look at best practices for managing the snow disposal system cost-effectively, and with an eye to reducing environmental and social impacts.



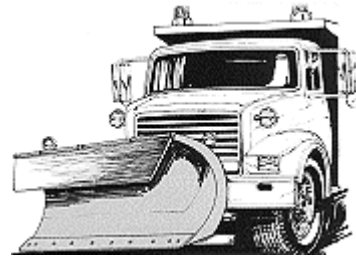
Transportation Association of Canada



# Salt SMART

Spreading, Management, Application Rates and Timing

## Learning Guide



Module 5, Lesson 2  
Snow storage and disposal

*June 2004*

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The Transportation Association of Canada is a national association with a mission to promote the provision of safe, efficient, effective and environmentally and financially sustainable transportation services in support of Canada's social and economic goals. The association is a neutral forum for gathering or exchanging ideas, information and knowledge on technical guidelines and best practices. In Canada as a whole, TAC has a primary focus on roadways and their strategic linkages and inter-relationships with other components of the transportation system. In urban areas, TAC's primary focus is on the movement of people, goods and services and its relationship with land use patterns.

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***June 2004***

## Salt SMART Train-The-Trainer Program

TAC offers trainer workshops to accompany the Salt SMART Learning Guide in support of the best practices for the environmental management of road salts. They range from one-day overview sessions to two-day all-inclusive sessions.

*Make a SMART investment today and book your “at-home”  
trainer workshop or attend one in Ottawa!*

### Overview session

This one-day session is for trainers with formal training and experience. It is designed to walk through the *Salt SMART Learning Guide* to highlight key messages and to discuss potential areas of resistance and how to handle them.

**Member price at a member-selected location:** \$5,000 flat fee for up to 10 participants plus expenses (e.g. training room and AV equipment, catering, TAC trainer’s travel and accommodation).

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### All-inclusive session

This two-day session is for those who have little or no training experience. It offers the one-day overview combined with an extra day devoted to soft skills training (trainer techniques, adult learning principles, lesson planning).

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**Member price in TAC-Ottawa training room:** \$1099 per participant. A minimum class size is required and dates will depend on attendee preferences and trainer’s availability.

*TAC non-members pay a 20% premium on all sessions.*

To book your trainer workshop, or for further information, contact the TAC Training Manager, Diane Jodouin at (613) 736-1350, ext. 261 or [djodouin@tac-atc.ca](mailto:djodouin@tac-atc.ca)

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The project team for this Learning Guide consisted of the following individuals:

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This Learning Guide is truly a team effort by all those who have contributed financially and/or technically.



# Preface

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## TAC Learning Guide

There are some things that should be taken with a grain of salt. The information in this learning guide is not one of them.

When you consider that the nation's extensive transportation network supports a wide range of economic and social activities, it's not putting too a fine point on it to state that safe and efficient road traffic throughout the year is essential to our way of life. We rely on the road network for transport to the workplace and other economic uses, for recreation and leisure activities, and for emergency and security services.

Road salt is the deicer of choice for winter road maintenance.

There's something else that we rely on: road salt. It's the deicer of choice for keeping roads passable throughout the winter.

The benefits of using road salt to keep the thoroughfares open don't come without costs, both economic and environmental. Recognizing this, and concerned about the environmental implications of road salt applications, the Transportation Association of Canada's (TAC) Chief Engineers' Council, the Road Salt Working Group (a subcommittee of the Maintenance and Construction Standing Committee), and the Environment Council launched an initiative to identify and document new ways of handling and using road salt. Transportation professionals from across the country worked together through the 20-member project steering committee and 17-member project team to produce three important documents:

- *Road Salt and Snow and Ice Control Primer*: An executive summary of the project, written for the general public, that provides information on the importance of road salt use to maintaining a safe and efficient transportation system that sustains Canada's economy.
- *Road Salt Management Guide*: A comprehensive reference guide which addresses transportation and Canada's economy and quality of life, road salt and the environment and road salt management practices.
- *Syntheses of Best Practices for Road Salt Management*: A series of syntheses of best practices related to the effective management of road salt use in winter maintenance operations.

## This guide's for you

This learning guide is based on the best practices in the *Road Salt Management Guide* and the *Syntheses of Best Practices for Road Salt Management*. If you're an operator or supervisor, then this guide is for you.

As a winter road maintainer, you're on the front lines in the battle against snow and ice on roads. In fact, the only thing that gets out there ahead of you is your plow blade. You probably already know that road salt is the most effective, cheapest, and easily handled de-icing material. There may be alternatives out there, but they usually cost a lot more, require special care when handling, and are only effective under certain weather conditions. Road salt is still the most reliable de-icing chemical available.

## The "4 R's" of winter road maintenance

There was a time when winter road maintainers lived by a simple rule of thumb: "when in doubt, put it out." In other words, it was better to err on the side of caution and put down a lot of road salt—and put it everywhere—just to make sure. But those days are long gone.

The modern winter road maintainer has a new mantra: "put the **R**ight amount of the **R**ight material in the **R**ight place at the **R**ight time." In other words, use road salt more wisely and effectively. The benefit of this approach is that road salt usage is *optimized*. This translates into savings for the organization, and minimizes the impact of road salt on the environment. This guide is designed to teach you how to optimize road salt usage while continuing to keep winter roads safe for commercial, passenger, and emergency vehicles.

## Your guide to road salt optimization

Optimizing salt use means being smarter about you how put it down.

Optimizing road salt usage means being smarter about how you apply the material. In most cases it will mean that you use less road salt, but that is a result rather than an objective. In order to use road salt more wisely, you'll need to become a better decision-maker, and in order to do that, you need to improve your knowledge. That's where this learning guide comes in.

The guide consists of six modules:

- **Module 1** sets the stage by looking at the importance of transportation to our economy and way of life; the economic implications of winter maintenance; and the cost-benefits of winter maintenance.

- **Module 2** explores the science of road salt and ice. In Lesson 1 we look at the principles of ice formation. Lesson 2 examines the concept of freeze point depressants and how they work to prevent or break the bond between pavement and ice. In Lesson 3 we consider alternative de-icing chemicals and their role in winter road maintenance. Lesson 4 looks at application strategies, in particular anti-icing, a modern preventive approach that aims to keep the ice-pavement bond from forming.
- **Module 3** looks at equipment and technologies used by modern winter road maintainers. In Lesson 1 we survey plows and spreaders and how they can be put to work to optimize road salt usage. Lesson 2 examines pavement condition tracking and forecasting techniques and technologies, including road weather information systems.
- **Module 4** deals with road salt and the environment. In this module we look at the pathways by which road salt can make its way into soil and groundwater, and the effects it can have on vegetation and wildlife.
- **Module 5** looks at snow and road salt handling. In Lesson 1 we look at road salt handling and storage at the road maintenance yard. In Lesson 2 we examine disposal strategies and techniques at snow disposal sites.
- **Module 6** considers the importance of monitoring and record keeping in winter road maintenance.

The objective throughout these modules and lessons is to help you, as an operator or supervisor, to understand how it is possible to use road salt more effectively while continuing to provide safe roads during winter and minimizing the impact on the environment.

## The same, but different

You have a lot in common with winter road maintainers across the country.

As a winter road maintainer, you have a lot in common with operators and supervisors in other jurisdictions across the country. At the same time, your job is very unique. Every road jurisdiction has a different transportation infrastructure to service. No two agencies face the same weather conditions. Each organization has a different mix of human resources and equipment available to keep the roads open during winter. Levels of service differ from one jurisdiction to the next, winter maintenance strategies are designed to meet specific local challenges, and public expectations change from one jurisdiction to the next.

In other words, while all winter road maintainers may be out on the front lines keeping the roads open, they could be using very different means to achieve similar ends.

This learning guide deals with general principles of winter road maintenance that can be applied in every jurisdiction, but it is beyond the scope of this document to prescribe practices that apply to specific road authorities. The best practices upon which this guide is based have been carefully researched and prepared and are endorsed by the Transportation Association of Canada's (TAC) Chief Engineers' Council, the Road Salt Working Group (a subcommittee of the Maintenance and Construction Standing Committee), and the Environment Council.

This material is provided as advice to winter road maintainers for consideration when developing their own policies, practices, and procedures. Keep in mind that the best practices are to be used in concert with the legislation, manuals, directives, and procedures of your individual road agency.

The material in this learning guide will be incorporated into your agency's current or planned training programs.

## A word about what's inside

Before we dive into the learning guide, let's take a look at what you'll see inside. We know that your time is valuable, and that the technical nature of this subject-matter may not be the most exciting thing you've read lately. So we've tried to make the learning experience as easy and enjoyable as possible.

We want you to learn, and to enjoy doing it.

The first thing you'll notice is that, unlike a lot of those technical reference manuals and user guides you may have seen and tried to read, our tone is conversational. We talk directly to you in a casual voice that's free of jargon and technical terminology. We even throw in a bit of humour every now and then. Unlike those other documents, we want you to learn, and to enjoy doing it.

Each lesson begins with a summary of the topics that we'll be discussing. This is followed by a conversation among fictional characters in a fictional maintenance yard: Pine Junction. Any resemblance between these characters and anyone you may actually work with is entirely coincidental. This dialogue sets the stage for the material covered in the lesson. Once you've read the list of topics to be covered and the dialogue, you'll have a pretty good idea of what you're going to discover in the lesson.

## Getting around: Navigation aids

The margin along the left side of each page is an area that we call the “fast track.” This serves three purposes:

We call this area the “fast track.”

1. Document designers tell us that “white space” on the page is visually pleasing to the eye, making it easier for you to read what’s on the rest of the page.
2. We can provide a capsule summary of the important points on the page. If you don’t have time to read the whole thing, at least you’ll know what you’re missing, and you can come back to it later if you’re interested.
3. The capsule summaries serve as “navigation aids”, which means that they provide a reference point if you need to come back to a section of a lesson and find a particular piece of information.

---

### -TIPS, NOTES, and WARNINGS-

Although we feel that all of the information in the learning guide is important, some items need to have special attention drawn to them. We present these in the form of “Tips”, “Notes”, and “Warnings”. Information presented in this format is related to, but not part of, the discussion at hand.

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On the other hand, when we want to emphasize an important point *in* the discussion, we highlight it in this fashion.

If you only had time to skim a lesson, you could quickly grasp the essence of it by reading just the list of topics covered, the dialogue, the fast track items, the highlights, the tips/notes/warnings, and the summaries at the end, which we’ll discuss in a moment.

Our approach is based on the concept of self-assessment and instant feedback to confirm what you’ve just learned. Throughout this guide you’ll find “Quick Quizzes” that are designed to make you reflect on concepts that have been presented in the lesson. Once you’ve taken your best shot at answering the questions or offering solutions, you can check the answers that we provide following the quizzes. Look for the key to find out how you did. Sometimes there is no right or wrong answer, a reflection of the fact that operators in different jurisdictions might do things differently. We offer possible solutions, but our word isn’t always the final one.



When you reach the end of the lesson, we offer you a quick summary of where you’ve been. This is usually a restatement of the key points of the lesson that you should have picked up along the way. You’ll find it in the section entitled “Where have you been?”.



Knowing where you've been is useful, but knowing where you're going can be just as helpful. We'll let you know what's in store in the next lesson, in the context of what you've just learned. You'll find it in the section entitled "Where are you going?"

This guide can be used in different ways:

- You can use it at your desk, working and learning at your own pace.

-OR-

- You can use it in a classroom setting as a participant manual.

If you will be participating in a classroom training session, you will gain the maximum benefit by reading this guide in its entirety, if possible, before attending.

We hope that whatever you take from this guide will confirm the importance of the role you play as a winter road maintainer, and will generate discussions among your peers. Winter road maintenance is not a new profession, but there are always new techniques, technologies, and equipment coming along that change the way you operate. Keeping up with the changes, or staying ahead of the game, is a continuous learning process.

Let's start learning.

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# Module 5, Lesson 2

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## Snow storage and disposal

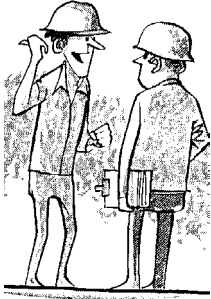
Proper management of a melting snow pile is all about control. You follow procedures and practice techniques to speed up the melting process; at the same time, you take measures to make sure that the melt water doesn't drain away too quickly or in the wrong direction.

### *Well, what shall we talk about?*

- Snow handling and removal methods
- Site operations management
- Objectives of managing a melting snow pile
- Importance of site drainage
- Monitoring and record-keeping
- Off-season maintenance activities



## Equipment depot. Pine Junction maintenance yard. February.



“Hey, Roch, you’re a celebrity,” laughed John Rhodes, holding up the morning copy of the *Tribune*. “You’re a ‘city official’, it says here,” continued Rhodes, pointing to an article on page 4. “Sounds pretty official.”

“Well, I’m sure they would have interviewed you as the expert, Johnny, but you weren’t available,” Roch Salterelli shot back with a smile.

“But why’d they interview you? I thought they had a consulting company working on designing the new snow disposal site in that part of town. No offense, Roch, but how many of these things have you designed?”

“Read the article, Johnny. They did interview some guys from that company, but they wanted to hear from someone with hands-on experience. They went over to the Glendale site and I just happened to be there, so they asked me a few questions. Right place, right time, that’s all.”

“I didn’t realize how much organized activity happens at these sites, Roch,” observed Crystal Ion. “But after reading that article, and looking through the lesson on snow disposal in the learning guide, there’s a lot more to it than I realized. There’s a method to the madness.”

“Yeah, there’s a lot of misconceptions on that score. Remember that public consultation meeting last month? It ended up being a public education meeting. But I think they have a better understanding now of what’s involved in running one of these sites. No one wants it in their back yard, but at least they know that we’re taking steps to protect their environment,” Salterelli explained.

“Well, if we left the snow on the street, they’d complain about the size of the drifts,” Rhodes replied. “We have to do something with it. What do they expect?”

“They expect us to know what we’re doing, Johnny,” advised Salterelli, “and to do it properly. Things weren’t always done the right way in the past. There’s a lot wrong with that old snow dump, but we’re not going to repeat those mistakes.”

“There’s been a lot of different methods and techniques tried by different jurisdictions around the country over the past several years,” explained Brine Watters, joining the discussion. “Some didn’t work, others worked really well. We now have a collection of best practices that can guide us when we operate snow disposal sites today.”

“I don’t know why everything has to be turned into some big scientific undertaking,” complained Rhodes. “Look, snow is going to melt during the spring. It’s as simple as that. Why do we have to put so much effort into managing everything?”

“The snow is not really the problem, John,” Watters explained. “It’s what’s in the snow. That stuff contains a lot of different debris and chemical compounds, and when you get a huge pile of it in a relatively small area, you can get a big concentration of these materials. Even you should know that we can’t let that get into the groundwater, or the river.”

“I know that, but it isn’t up to us to figure that one out, is it? We’re not the ones designing the site. We’re not engineers.”

“But it’s us who’ll be running the site, and we have to know how to control the melt and control the runoff. There are procedures and techniques that we need to know and follow. Read the learning guide, Johnny,” advised Salterelli.

“How did I know you were going to mention that guide, Roch?” asked Rhodes.

“Well, I don’t know about you, John, but I’ve found it pretty helpful,” said Ion. “But I haven’t been at this as long as you have.”

“No one’s been at it as long as Johnny,” laughed Salterelli. “He knows more about this business than anyone. The thing is, I don’t think he realizes how much he knows.”

“I know one thing, Roch,” Rhodes replied. “This business has changed a lot over the years. New technology. New methods. New procedures. But you know what hasn’t changed?”

“What’s that, Johnny?” asked Salterelli.

“The end result. No matter how fancy we get, we’re still trying to do the same thing. Keep the roads safe for motorists. Period.”

“No one can argue with that, John,” agreed Watters. “We’re also trying to keep the environment safe. If there’s technology out there that can help, why not use it?”

“Especially if it makes our job easier,” added Ion.

“Now you’re talking Johnny’s language,” laughed Salterelli.

## Down in the dumps

Snowdrifts, like this one in Newfoundland, obstruct the line of sight for drivers, reduce lane size, and eat up valuable parking space.



By mid-winter, or perhaps sooner if there has been an unusual amount of snowfall early in the season, snow banks can begin to grow out of control.

They obstruct the line of sight for drivers. They encroach on the roadway, reduce lane size, and cut into valuable parking space. They're a hazard to pedestrians trying to cross the street. When they get high enough, they form barriers that can cause drifts to

form across roads. Eventually, there's nowhere else to put the snow that's going to arrive with the next storm.

There are a number of different ways to deal with these conditions, but the most common solution—and the one that's the focus of this lesson—is to load the snow into trucks and haul it to a snow storage site for disposal.

When you move snow to a disposal site, you're trading one set of challenges for another.

It seems like a convenient solution, but what you're really doing is trading one set of challenges for another. When you move all that snow from the urban streets to the snow storage sites, you're bringing along a lot of environmental contaminants that



must be contained and disposed of as the snow pile melts.

Snow removed from roadways often contains chloride, sodium, and calcium from salting operations. But this is hardly the only source of snow contamination: it also contains heavy metals, aromatic hydrocarbons, oil, grease, rust, rubber particles and other solid materials deposited

by vehicles. Large and small debris are also collected during snow removal operations.

---

### —NOTE—



**As impure as the driven snow:** More than 30% of the snow that ends up in snow storage sites comes from small, medium, and large private parking areas, such as grocery stores, strip malls, gas stations, and condominium associations, to name a few. Most of the heavy metals and hydrocarbons found in snow storage sites originates from these sources, where vehicles sit and drip, rather than from highways, where traffic moves steadily.

---

# Snow job: Handling and removal methods

The least expensive way to handle and remove snow is to dispose of it close to where it accumulates.



The collection and removal of snow may pose a risk to the environment if it is not handled, stored and disposed of in an appropriate manner.

A number of methods have been developed to handle and remove snow, but the least expensive way is to dispose of it close to where it accumulates.

The method that works best depends upon the amount of storage space available along the right of way.

## On a wing back and a prayer

The simplest technique is simply to wing back the windrows as needed. The snow banks are pushed back about one metre or more onto the adjacent boulevard areas to enable crews to work around street obstructions such as fire hydrants and mailboxes. This works well in rural areas where there is enough roadside snow storage capacity, but in most urban areas it's usually not an option.

## Casting about for a solution

Snow accumulated in snow banks is cast, using a snow blower, onto adjacent wide public boulevards or other public vacant areas. This is usually confined to the newer residential streets that do not have sidewalks.

## Pulling for an early melt

Snow banks are spread onto the traveled portion of the road in order to hasten snow melting. Pulling snow works best when temperatures are high enough to ensure that the spread snow melts and drains away. Some jurisdictions have tried spreading snow banks back onto the roadway in the spring and broadcasting salt over it to accelerate the melting process. This practice is not recommended, as it can create a driving hazard, as well as increase the amount of chlorides released into the environment.

## A haul of a way to get rid of the snow



This method is the best option where there are no adjacent storage areas next to the snow bank. The snow is loaded onto trucks and hauled to disposal sites. The establishment, operation, and maintenance of these sites are usually governed by a number of zoning and environmental regulations.

---

### -TIP-



**Meltdown:** Mobile snow melters are used to melt the accumulated snow at the roadside. Melt water is disposed of through the storm sewer system. This method is expensive, but may be worth considering in areas where haul distances are long or snow disposal site capacity is limited. The ability of the storm sewer system and discharge site to handle the additional capacity and contaminants are important factors to consider before implementation.

Using melters is not recommended on roads where sand or gravel has been applied, as abrasives can clog or damage the machinery.

---

## Site management insights

The primary purpose of snow storage and disposal sites is to manage snow that would otherwise be a hazard to the public or impair winter road maintenance operations.

A melting pile of contaminated snow is not necessarily an environmental threat if proper disposal practices are followed.

The snow that is stored at these areas contains contaminants that are deposited on the ground or carried away with the melt water as the snow melts. This melt water and debris must be managed and should not be discharged back into the environment until properly treated.



A melting pile of contaminated snow is not necessarily an environmental threat. Proper snow disposal practices dilute contaminants, reducing the possibility of their being excessive when they reach streams and lakes.



As we learned in the previous lesson on the environment, chloride moves easily through soil and can be carried through to the groundwater. However, because the ground will probably be frozen as the snow melts, a significant proportion of it will flow overland. Some of the chemicals will be carried off the site with the flowing water diluting them, and some will be left at the site. Following thaws and rain events, the concentration of chemicals washed into the ground will be diluted and the impact to groundwater will be lessened.



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–NOTE–

**Staying power:** There is currently no practical or economical way to remove chlorides from snow.

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## Enhance the melt and slow the flow

Proper management of a melting snow pile is all about control. You follow procedures and practice techniques to speed up the melting process; at the same time, you take measures to make sure that the melt water doesn't drain away too quickly or in the wrong direction. It may seem that these two objectives are contradictory. The challenges can be managed by following proper procedures to attain the desired objectives:

Pile management has two objectives: enhancing the rate of melting, and minimizing the runoff flow.

1. Enhance the rate of melting so that it occurs during the spring period when receiving water bodies are at their highest levels to ensure maximum dilution of potential pollutants; and
2. Keep the runoff flow rate to a minimum to avoid erosion.

You can achieve both objectives by following the removal, storage, and disposal procedures discussed in this lesson, and described in more detail in TAC's *Synthesis of Best Practices for Snow Storage and Disposal*.

Keep in mind, though, that you must also respect local regulations, policies, or guidelines for the protection of water quality and the environment, as well as for the disposal of contaminated waste and snow. Together, these policies and procedures will form the basis of your snow handling, storage, and disposal strategy.

The best plan is to *have* a plan. The selection of a site for snow storage and disposal requires a lot of upfront legwork and preparation. But that's only the first step, and it's beyond the scope of this learning guide. Our focus is on the day-to-day operation of the site once it has been approved and commissioned for use.

### The best laid plans...

A snow handling, storage and disposal design should be practical and should not involve excessive maintenance requirements. When operating a snow disposal site, draw on the experiences of others. There are well-established principles and best practices that can guide you every step of the way:



- ✓ Roadway safety is the priority. A road authority must ensure that the hazards caused by accumulated snow are efficiently and safely addressed.
- ✓ Ensure that drivers use *only* designated truck routes.
- ✓ Locate and operate snow disposal sites to minimize impacts to the natural environment and control nuisance effects, including noise, dust, litter and visual intrusion on adjacent landowners.
- ✓ Clearly delineate the actual snow disposal area, in a manner that is clearly identifiable under adverse winter conditions, to ensure that the snow is placed in the proper location on the site.
- ✓ Manage the discharge of melt water to comply with local water quality regulations and protect surface and groundwater resources.
- ✓ Collect and dispose of onsite litter, debris and sediment from the melt water settling area in accordance with local waste management legislation.
- ✓ Control emissions (drainage, noise, dust, litter, fumes) to prevent offsite environmental impacts.

## Managing the melt: Site operations

There's a good chance that you'll be called upon to work at the snow disposal site during winter operations, and an even better chance that you'll be assigned to do off-season maintenance. The objectives of site management are to keep traffic moving, melt water flowing, snow thawing, and contaminants contained until sufficiently diluted.

### Vehicle management: Keep the traffic flowing

When snow removal operations are underway, time is the most critical element.

Managing the flow of traffic to and from the site is one of the most critical factors in the smooth, safe, and efficient operation of the snow disposal site. The site should be laid out in a way that makes it easy for incoming and outgoing trucks to move around without getting in each other's way, or in the way of on-site snow handling equipment.

When snow removal operations are underway, time is the most critical element. No one can afford to have trucks sitting idle, waiting for their turn to unload: trucks hauling snow cost a lot of money; trucks *not* hauling snow cost even more.

Make good use of on-site and entrance signage so that it is obvious where drivers are expected to go. Because a lot snow dumping occurs at night, on-site vehicle management is critical to avoid accidents and to control pile formation. Poles or moveable concrete barriers could be used to clearly mark the travel areas and actual snow disposal areas.

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-TIPS-

- Discourage “tailgate banging” and, where possible, trucks backing up to reduce the nuisance noise levels from “vehicle reversing warning beepers”. The layout of the site should attempt to minimize the requirements for trucks to back-up.
- All dump trucks should lower the truck box prior to leaving the site to avoid contact with overhead power lines.
- Determine the “safe fall radius” by measuring the distance from the ground to the top of an end-dump box in the raised position. Trucks in the snow disposal site should remain apart at least the distance of the safe fall radius in the event that a truck tips over while dumping.

Vehicle management is important later in the season as the site fills up with snow and maneuverability becomes an issue.



Increased vehicle management may be required later in the season to limit the number of trucks on site as the area fills up with snow and maneuverability becomes an issue. Accessibility and on-site vehicle management are important so that large trucks can continue to access the site, maneuver, and not get stuck, even when the frost begins to come out of the ground near the end of the season.

## Large debris management: Separate the piles

If clean snow were the only commodity delivered to a disposal site, this lesson would be a lot shorter, and your job at the disposal site would be a lot easier. But because the snow that arrives is laden with chemical contaminants and other assorted debris, you need to learn, and follow, procedures to ensure that the litter and toxins are contained and disposed of safely.

When a fleet of snow blowers, graders, and plows moves down an urban street in the middle of night gobbling up snow banks and spitting them into dump trucks, it's unavoidable that some extra passengers will be picked up accidentally. We're

In any snow removal and disposal operation, large debris will be collected along with the snow.



referring here to mailboxes, newspaper boxes, parking meters, recycling boxes, garbage pails, and just about anything else that gets forgotten at the curb before the last snowstorm rolled into town. This hidden debris emerges like spring crocuses when the pile melts at the disposal site during the warmer weather.

Keep an inventory of large debris so you can take steps to avoid collecting it next year.

The site management plan should include provision for periodic collection and onsite storage of the large debris. Eventually, it will have to be moved to an appropriate offsite disposal area.

If possible, try to keep an inventory of the types of large debris that show up so that you can take steps to avoid collecting them next winter. Some jurisdictions flag mailbox and newspaper box locations in an effort to reduce the number that are inadvertently hauled away during snow removal operations.

## Small debris management: Contain and collect

Collect litter regularly to prevent it from blowing onto adjacent properties.

Small, lightweight debris, or litter, is an unavoidable component of snow removed from urban roadways. This litter can be blown around by the wind, creating problems both on and off the site. As there is a very good chance that residents living in the vicinity of the snow disposal site would rather not have your operations in their back yards, it is important not to antagonize them by letting litter blow from your site onto their properties.



### —JUST A LITTER BIT—

Lightweight debris is most commonly found near elementary schools. It is also known as “kiddy litter.”



You should try to collect litter regularly to prevent it from blowing onto adjacent properties. It would be a good idea to install a net or fence around the perimeter of the facility to help contain the litter within the site. Where possible, try to make arrangements to adjust or re-schedule garbage collection to avoid snow removal locations and times.

The more you can do to reduce the amount of litter coming into the site, the less you’ll have to do to ensure that it doesn’t leave the site with the next wind.

### —CAUTION—

**Safety first:** All sites, whether permanent or temporary, should have some form of controlled gate access for safety purposes. This will prevent accidents such as children drowning in collection ponds.

## Pile management: Thaw and flow

Managing the pile is Job 1 at the snow disposal site. Proper and efficient pile management is essential to the smooth operation and long-term stability of the site.

Properly managing the pile ensures that site operations are safe, space is efficiently used, the bulk of the melting occurs during spring runoff, and melt water flow does not cause erosion.

Ensure that the pile melts as early in the spring as possible, when receiving water bodies are at their highest levels.

In the good old days, snow was simply dumped and allowed to melt virtually undisturbed. After all, who would have thought that you had to manage something that Mother Nature does for free? However, we now realize the importance of speeding up the melting process so that the pile melts as early in spring as possible when the receiving water bodies are at their highest levels. This ensures maximum dilution of any contaminants remaining in the melt water.



### —JUST FOR FUN—

Hold a community lottery in which residents must correctly guess the date on which the snow pile will be completely melted. Funds raised could be used to upgrade road maintenance equipment, or to compensate residents whose mailboxes were given an unscheduled trip to the snow dump.

Trapped contaminated melt water can seep into the groundwater.

When they get a chance to sleep during winter, dedicated site supervisors dream about the “perfect” pile melt scenario: a *sheet flow* under and near the pile. This can be achieved by skillfully controlling the melt process as well as the flow of melt water.

Water that flows either too quickly from the site, or not all, can cause problems. Fast flowing, high volume channels of melt water can cause erosion and rutting of the driving and snow pile surface. On the other hand, contaminated melt water that becomes trapped or allowed to pond in the receiving area of the site can seep into the groundwater. Rutting caused by heavy trucks can trap melt water and must be kept to a minimum or repaired quickly.



To achieve the perfect melt, slope the snow piles down from south to north.

To achieve that perfect melt, slope the snow piles down from south to north so that the snow on the high end melts first and runs under or around the pile to the melt water collection facility. This way contaminants such as sand, salt, and small debris will remain upstream of the pile and the melt water will not continuously flow across the materials previously released from the pile.

As the pile melts, a contaminated crust forms on the top. Through efficient pile management, you can minimize the number of times that the crust has to be handled. You can remove it, but a new crust will usually form soon after. This process is known as the “resurrection of the crust.” It can be broken up for good when the pile is spread in the spring to increase the melting surface and maintain the volume of melt water for early spring runoff.



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-TIP-

**Looking ahead:** Weather data and long-range forecasts can help you to predict current and future melt water volumes and discharge rates.  
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The pile can be managed using loaders, dozers or blowers to move, pile and break up snow. Blowers can be used onsite if you’re sure that the snow is free of large debris such as wood. If all the snow delivered to the site was blown into the trucks, then there’s a good chance that large, dangerous pieces of debris have already been removed, or reduced enough in size that they won’t cause problems. Otherwise, use a bulldozer or loader.



## Drainage management: Pollution dilution solution

Melt water should be directed away from the snow piles and into the collection pond.

Although the snow pile is the most prominent feature of a snow disposal site, the most important one—the collection pond—has a much lower profile. Site drainage and melt water should be directed away from the snow piles and dumping and into the collection pond to reduce ponding and rutting.



The melt water collection pond should be large enough to handle not only the expected volume from the snow pile and other site drainage, but also precipitation. It should be designed with an impermeable base, a forebay to collect litter and settle coarse sediments and a larger secondary area to settle finer particles. An absorbent boom can be placed in the forebay to capture any oil and grease in the site drainage. The outlet should be controlled to regulate the release to the receiving water body.



–NOTE–

**Solitary confinement:** If your jurisdiction permits dilution to meet regulated contaminant levels, uncontaminated site drainage and precipitation may be directed to the collection pond. Otherwise, you'll have to make sure that uncontaminated drainage is isolated from the melt water.

### Snow dump gets dumped

The Bayview Snow Dump in Ottawa's Hintonburg neighbourhood has been an ongoing source of discontent to the nearby neighbours for many years. Following a public consultation process to find solutions to minimize the impact of the dump on the community as it is being phased out, it will no longer operate at night.



With operation at the site now cut to nearly half, the adverse effects, which include noise, litter blowing, and odour, will be greatly reduced. But there is still great concern for the environmental impacts of this site. The dump is located on extremely contaminated soil and the catch basins on the site drain directly into the Ottawa River. Residents are looking to the city for reassurance that the site is being properly monitored and tested and that they will have access to this information.

This "temporary" site is on its way out of the community. The snow will be diverted to existing engineered sites which are designed to accept snow in an

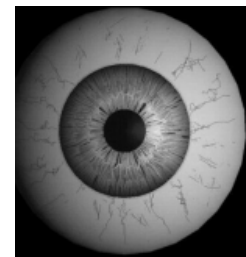


environmentally safe manner. As for future sites, the new City of Ottawa Official Plan will not allow snow disposal sites to be set up so close to residents or a river. No other communities will have to endure the adverse impact that this snow dump has imposed on Hintonburg residents.

## Monitoring: Keeping an eye on the snowball

Site monitoring is the most neglected aspect of snow disposal operations.

When you're managing the disposal of a small mountain of contaminated snow, you probably aren't thinking too much about administration and paperwork. This isn't surprising, given the nature of the work involved, and it's why site monitoring is often the most neglected aspect of the snow disposal site operation.



You're more concerned with the up front, visible costs of hauling and dumping snow than with what's happening in the piles and to the melt water.

As with yards and road maintenance, however, good data leads to good information, which leads to sound decision-making and smooth operations. You know that there's more to keeping roads safe during winter than simply spreading salt haphazardly during storms; you also need to know that there's more to snow disposal site operations than simply dumping snow. If it were that simple, we wouldn't need this lesson.

You can significantly extend the life span of the ponds by removing material that has settled out.

You need to be continuously monitoring all aspects of the snow disposal site, including the condition and remaining capacity of the melt water collection, retention, and discharge system, particularly as the seasons change and the ground becomes less stable. If the surface deteriorates significantly, a site may become unusable until major repairs are done. Over time, the collection and treatment ponds will silt up,

reducing their capacity to handle the melt water. You can significantly extend the life span of the ponds by regularly removing material that has settled out.



Some sites will need 24-hour security to control unauthorized access and dumping.

If your site allows both public and private snow dumping, you'll have to monitor it even more closely—some jurisdictions have had problems with

mixed load dumping (snow piled on top of waste fill or construction material). Mixed loads may not appear until melting slowly exposes the foreign material.

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-TIP-



**What goes around comes around:** Snow storage sites are the best places to collect recycled sand. More than 20% of the sand applied to streets is picked up and delivered to the snow storage site. This can be harvested and reprocessed for use in your street operations next winter.  
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Methods have been developed using transponders and weigh-in-motion sensors that can automatically track private dumping volumes and associated fees. Some sites will need 24-hour security to control unauthorized access and dumping, even during the off-season.

In order to ensure the smooth and efficient operation of the snow disposal site, here's what you need to keep a continuous eye on:

1. **Inputs** (what's brought into the site)
2. **Outputs** (what's being discharged from the site)
3. **Environmental impacts** (potential on-site and downstream contamination)

## Site inputs: Know the snow

Keep separate records for both public and private dumping volumes.

There's really only one thing that you need to track in this category: the volume of snow dumped on the site. If your site is used for both public and private snow



dumping, you'll need to keep separate records for both public and private volumes, as well as any fees collected.

As you compile this data over a number of years and create historical records, you'll begin to develop a sense of space requirements for a "normal" winter. This will be useful information for those planning new sites.

Throughout the season, on a regular basis, make an estimate of the volume of snow remaining on the site. It's useful to be able to estimate the melt rate if there's a timing restriction on discharging melt water into the receiving water body.

## Site outputs: Know where it goes

Keep track of the volume of melt water flowing into the receiving area.

If you've managed the pile properly, contaminated snow entering the disposal site will leave in the form of appropriately diluted melt water. For monitoring purposes, you need to keep track of the volume of melt water flowing into the receiving area. Your main concern is that it provides sufficient dilution of the chlorides and other contaminants in the discharge.

You should also keep track of the volume and type of large debris collected and disposed of, for reasons discussed earlier: if you know what kind of materials and objects are being inadvertently collected, you can take measures to avoid them in future.

## Environmental impacts: Know what it's doing

Following best practices can help minimize or mitigate environmental effects of polluted melt water.

There's no denying the obvious: if you dump a large amount of contaminated snow into a small, confined area, there's going to be an impact on the surrounding environment. But if you follow best practices in pile management, you can minimize or mitigate the environmental impacts of polluted melt water entering adjacent water bodies. The key to success in this undertaking is monitoring the impacts as well as the effectiveness of mitigation measures.



–TIP–

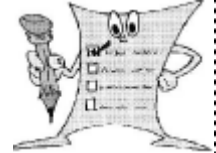
**What do you know?** Before you can effectively measure the environmental impact of the snow disposal site, you need to know what shape it was in before it was commissioned. Hopefully this benchmark information was captured during the commissioning process, well before the first truckload of snow was dumped.

## Where to monitor: Under, over, and around

Once the site is operational, you should monitor contamination levels at various points, and then compare the levels to those prior to the site opening.

In order to get an accurate picture of the effects of the melting snow on the immediate and surrounding areas, you need to monitor conditions in a number of key locations:

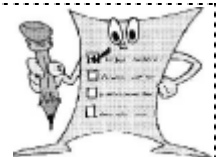
- ✓ beneath the site (groundwater and soil)
- ✓ above and around the site (where air quality is an issue)
- ✓ in the snow being dumped
- ✓ in the melting snow piles
- ✓ in the collected melt water
- ✓ at the discharge site and in the discharged melt water
- ✓ upstream (for comparison) and downstream of the discharge site (in the receiving area or mixing zone)
- ✓ in the groundwater downstream or down-flow of the discharge site



## What to monitor: Sodium, chlorides, and other stuff

There are several potential contaminant levels that should be monitored. Some of them are important from a salt management perspective; others may be required by local, provincial, state, or federal regulations. In addition, some land lease arrangements may require you to monitor for specific contaminants. Here are the most likely contaminants that you'll need to monitor:

- ✓ chlorides
- ✓ sodium
- ✓ pH
- ✓ metals
- ✓ total petroleum hydrocarbons (TPH)
- ✓ suspended solids





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-NOTE-

**Keeping tabs on chemicals:** Depending upon the nature of road operations some road authorities may monitor levels of such deicing chemicals as potassium acetate and CMA.

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## For the record: Creating a paper trail

The more complete your historical record, the more meaningful the information will be.

Monitoring without keeping records would be like taking pictures without any film in your camera. Through the viewfinder it might look like you've got great photos, but there'd be nothing to look at later.



Keeping records of what you monitor is as important as capturing the data in the first place. You need an historical record of what happened, and the more history you have, the more meaningful the information will be. Each agency has its own cycle of inspection, whether it is weekly, daily, or monthly. Whatever the frequency, make sure that you know

what it is. You may be called upon to explain it in court or in front of a decommissioning committee.

If you know how much snow was removed from the streets every winter for the past decade, you'll have a pretty good idea of what to expect in an average winter. If your records only go back two years, however, you'll be doing more guessing than estimating what you're up against in the coming winter.

## Why record?

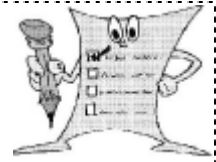
The records that you keep are important to demonstrate due diligence.

You need to keep records of activities at the snow disposal site for purposes other than simply being able to gauge the amount of resources you'll need to devote to the site. There are a number of other activities for which you aren't responsible and in which you won't be a direct participant, but for which the information that you compile is important.



Site records should be kept for:

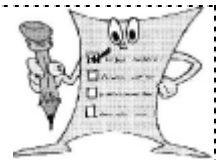
- ✓ dealing with public and private complaints
- ✓ litigation and showing due diligence
- ✓ showing compliance with regulations and licensing
- ✓ providing information to regulatory agencies
- ✓ determining fees and payments
- ✓ decommissioning and future sale of site



## What to record?

As we saw in the previous list, one of the major reasons for keeping records is to be able to show due diligence in the operation of the site. In order to demonstrate due diligence and improve the efficiency of the site operation, a wide variety of data must be captured and recorded:

- ✓ number of snow disposal sites and their capacities
- ✓ percentage of snow disposal sites with run-off collection and/or treatment systems
- ✓ percentage of snow disposal sites with monitoring programs (groundwater, surface water, etc.)
- ✓ volume of snow dumped and when it was dumped
- ✓ volume of snow left to flow into melt water collection and treatment system
- ✓ record of basic atmospheric data (to help determine melting rates)
- ✓ type and volume of debris
- ✓ contaminant monitoring records (point data, trends, levels, etc.)
- ✓ maintenance and operation records



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-TIP-

**Giving back to the community:** Set up a “lost and found” so residents and businesses can retrieve items such as mailboxes, garbage cans, signs, etc.

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Site operations records provide a valuable source of information. Review them regularly for ways to improve efficiency of dumping and pile management, and reduce debris and litter by tracking type and source. The records also provide an

important body of knowledge for training new staff and passing on lessons learned and best practices.

## Decommissioning: Wrapping things up

The type of decommissioning required will be determined by the monitoring records that you've kept.

All good things must come to end—even snow disposal sites. But when it's all said and done, you can't simply turn your back and walk away. Depending upon the level of contamination at the site and surrounding area, there will be some measure of remediation and decontamination required to bring the site back to the condition it was in before it became a dumping ground. The formal term for closing a snow dump and cleaning up the mess is "decommissioning."

The type and extent of decommissioning required will be determined in large part by the monitoring records that you've kept. Most likely there will be local regulations with criteria for decommissioning contaminated sites.

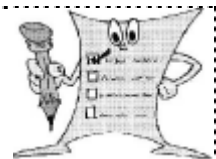
The gap between what is required, and the current conditions based on your records, will determine the amount and type of cleanup work that is required.

## Carrying on in the off-season

Monitoring and clean up continues until the pile has completely melted.

The end of winter may mean that you're not plowing or sanding any more, and you're enjoying more regular sleeping patterns. But it doesn't mean that the job is finished at the snow disposal site. Regular monitoring and clean-up operations continue throughout the spring for as long as it takes for the pile to completely melt. Even then, the work at the site isn't over. Here's a checklist of activities to do once the snow has completely melted:

- ✓ collect and dispose of any accumulated contaminants
- ✓ check for and repair any damage to the access and haul routes
- ✓ check for and repair any damage to the site surface and base and check the drainage channels for erosion
- ✓ grass cutting on berms and around collection and treatment areas
- ✓ tree trimming
- ✓ equipment check (lighting, monitoring, security) and general site repairs
- ✓ animal control (may damage pond and discharge area)
- ✓ repair discharge area
- ✓ clean out collection pond if capacity is reduced below volume needed to handle worst-case year



## Quick Quiz

**1. List three types of contaminants that may be found in snow delivered to a snow disposal site.**

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**2. What are the objectives of snow disposal site management?**

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**3. What are the objectives of snow pile management?**

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**4. Why is it important to ensure that the pile melts as early as possible in the spring?**

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**5. List three reasons why you should keep good records.**

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1. **List three types of contaminants that may be found in snow delivered to a snow disposal site.**  
 Chloride, sodium, calcium, heavy metals, aromatic hydrocarbons, oil, grease, rust, rubber particles and other solid materials.
2. **What are the objectives of snow disposal site management?**  
 The objectives of site management are to keep traffic moving, melt water flowing, snow thawing, and contaminants contained until sufficiently diluted.
3. **What are the objectives of snow pile management?**  
 Enhance the rate of melting so that it occurs during the spring period when receiving water bodies are at their highest levels to ensure maximum dilution of potential pollutants; and  
 Keep the runoff flow rate to a minimum to avoid erosion.
4. **Why is it important to ensure that the pile melts as early as possible in the spring?**  
 It is important that the pile melts as early in spring as possible when the receiving water bodies are at their highest levels. This ensures maximum dilution of any contaminants remaining in the melt water.
5. **List three reasons why you should keep good records.**
  - dealing with public and private complaints
  - litigation and showing due diligence
  - showing compliance with regulations and licensing
  - providing information to regulatory agencies
  - determining fees and payments
  - decommissioning and future sale of site

**Answer**


## Where have you been?



Snow storage and disposal sites are used to manage snow that must be removed from roadsides in an environmentally responsible way. There is always going to be a risk to the environment when large amounts of contaminated snow are stored in concentrated areas. However, by following best practices in disposal site management, you can help to mitigate and minimize the environmental impacts.

In this lesson we looked at ways to manage site operations and keep records of all activities that take place during snow removal operations and in the off-season as well.

## Where are you going?



In the final module of this learning guide, we'll be reviewing the importance of understanding your organization's operating policies and their application to winter operations. You need to know your route, the level of service that's required on each of the roads, and what you need to do to meet those requirements.

In Module 6, we'll also look at the importance of keeping timely and accurate records of all your activities. There are many reasons why this is important, and we'll review them in the next lesson.



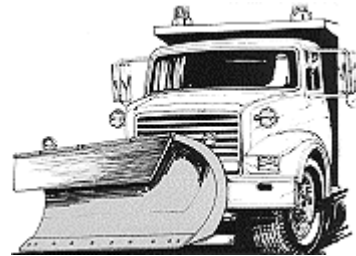
Transportation Association of Canada



# Salt SMART

Spreading, **M**anagement, **A**pplication **R**ates and **T**iming

## Learning Guide



### Module 6 Monitoring and record-keeping

*June 2004*

## ***Transportation Association of Canada***

The Transportation Association of Canada is a national association with a mission to promote the provision of safe, efficient, effective and environmentally and financially sustainable transportation services in support of Canada's social and economic goals. The association is a neutral forum for gathering or exchanging ideas, information and knowledge on technical guidelines and best practices. In Canada as a whole, TAC has a primary focus on roadways and their strategic linkages and inter-relationships with other components of the transportation system. In urban areas, TAC's primary focus is on the movement of people, goods and services and its relationship with land use patterns.

## ***Wellspring Consulting Inc.***

Wellspring Consulting is an instructional design company, specializing in adapting reference information into self-contained learning guides through the application of proven adult learning principles. With the Wellspring methodology, learners are first engaged through an enjoyable, easy to follow and entertaining writing style, then challenged using interactive techniques like problem-solving and role-playing. This fresh and stimulating approach enables learners to effectively transform dry technical information into vital, practical knowledge.

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***June 2004***

## Salt SMART Train-The-Trainer Program

TAC offers trainer workshops to accompany the Salt SMART Learning Guide in support of the best practices for the environmental management of road salts. They range from one-day overview sessions to two-day all-inclusive sessions.

*Make a SMART investment today and book your “at-home”  
trainer workshop or attend one in Ottawa!*

### Overview session

This one-day session is for trainers with formal training and experience. It is designed to walk through the *Salt SMART Learning Guide* to highlight key messages and to discuss potential areas of resistance and how to handle them.

**Member price at a member-selected location:** \$5,000 flat fee for up to 10 participants plus expenses (e.g. training room and AV equipment, catering, TAC trainer’s travel and accommodation).

**Member price in TAC-Ottawa training room:** \$899 per participant. A minimum class size is required and dates will depend on attendee preferences and trainer’s availability.

### All-inclusive session

This two-day session is for those who have little or no training experience. It offers the one-day overview combined with an extra day devoted to soft skills training (trainer techniques, adult learning principles, lesson planning).

**Member price at a member-selected location:** \$6,500 flat fee for up to 10 participants plus expenses (e.g. training room and AV equipment, catering, TAC trainer’s travel and accommodation).

**Member price in TAC-Ottawa training room:** \$1099 per participant. A minimum class size is required and dates will depend on attendee preferences and trainer’s availability.

*TAC non-members pay a 20% premium on all sessions.*

To book your trainer workshop, or for further information, contact the TAC Training Manager, Diane Jodouin at (613) 736-1350, ext. 261 or [djodouin@tac-atc.ca](mailto:djodouin@tac-atc.ca)



# Acknowledgements

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**Saskatchewan Highways & Transportation**  
**Salt Institute**  
**Yukon Highways & Public Works**

TAC gratefully acknowledges the sponsors for their generous contributions to the development of this Learning Guide. Their contribution exemplifies national cooperation in pursuit of the effective management of road salt use in winter maintenance operations.

The project team for this Learning Guide consisted of the following individuals:

<b>Subject Matter Review</b>	Barry Belcourt, R.E.T. Director, Roadway Maintenance City of Edmonton, Alberta, Canada  Richard L. Hanneman President Salt Institute, Alexandria, Virginia, USA
<b>Instructional Design Content Adaptation</b>	Tim Scapillato Technical Writer & Content Designer Wellspring Consulting Inc.
<b>Project Management Instructional Review</b>	Diane Jodouin Manager, Training Program Transportation Association of Canada

TAC gratefully acknowledges the dedication, guidance and input of the Subject Matter Reviewers; and the quality of work performed by the Instructional Designer.

This Learning Guide is truly a team effort by all those who have contributed financially and/or technically.

# Preface

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## TAC Learning Guide

There are some things that should be taken with a grain of salt. The information in this learning guide is not one of them.

When you consider that the nation's extensive transportation network supports a wide range of economic and social activities, it's not putting too a fine point on it to state that safe and efficient road traffic throughout the year is essential to our way of life. We rely on the road network for transport to the workplace and other economic uses, for recreation and leisure activities, and for emergency and security services.

Road salt is the deicer of choice for winter road maintenance.

There's something else that we rely on: road salt. It's the deicer of choice for keeping roads passable throughout the winter.

The benefits of using road salt to keep the thoroughfares open don't come without costs, both economic and environmental. Recognizing this, and concerned about the environmental implications of road salt applications, the Transportation Association of Canada's (TAC) Chief Engineers' Council, the Road Salt Working Group (a subcommittee of the Maintenance and Construction Standing Committee), and the Environment Council launched an initiative to identify and document new ways of handling and using road salt. Transportation professionals from across the country worked together through the 20-member project steering committee and 17-member project team to produce three important documents:

- *Road Salt and Snow and Ice Control Primer*: An executive summary of the project, written for the general public, that provides information on the importance of road salt use to maintaining a safe and efficient transportation system that sustains Canada's economy.
- *Road Salt Management Guide*: A comprehensive reference guide which addresses transportation and Canada's economy and quality of life, road salt and the environment and road salt management practices.
- *Syntheses of Best Practices for Road Salt Management*: A series of syntheses of best practices related to the effective management of road salt use in winter maintenance operations.

## This guide's for you

This learning guide is based on the best practices in the *Road Salt Management Guide* and the *Syntheses of Best Practices for Road Salt Management*. If you're an operator or supervisor, then this guide is for you.

As a winter road maintainer, you're on the front lines in the battle against snow and ice on roads. In fact, the only thing that gets out there ahead of you is your plow blade. You probably already know that road salt is the most effective, cheapest, and easily handled de-icing material. There may be alternatives out there, but they usually cost a lot more, require special care when handling, and are only effective under certain weather conditions. Road salt is still the most reliable de-icing chemical available.

## The "4 R's" of winter road maintenance

There was a time when winter road maintainers lived by a simple rule of thumb: "when in doubt, put it out." In other words, it was better to err on the side of caution and put down a lot of road salt—and put it everywhere—just to make sure. But those days are long gone.

The modern winter road maintainer has a new mantra: "put the **R**ight amount of the **R**ight material in the **R**ight place at the **R**ight time." In other words, use road salt more wisely and effectively. The benefit of this approach is that road salt usage is *optimized*. This translates into savings for the organization, and minimizes the impact of road salt on the environment. This guide is designed to teach you how to optimize road salt usage while continuing to keep winter roads safe for commercial, passenger, and emergency vehicles.

## Your guide to road salt optimization

Optimizing salt use means being smarter about you how put it down.

Optimizing road salt usage means being smarter about how you apply the material. In most cases it will mean that you use less road salt, but that is a result rather than an objective. In order to use road salt more wisely, you'll need to become a better decision-maker, and in order to do that, you need to improve your knowledge. That's where this learning guide comes in.

The guide consists of six modules:

- **Module 1** sets the stage by looking at the importance of transportation to our economy and way of life; the economic implications of winter maintenance; and the cost-benefits of winter maintenance.

- **Module 2** explores the science of road salt and ice. In Lesson 1 we look at the principles of ice formation. Lesson 2 examines the concept of freeze point depressants and how they work to prevent or break the bond between pavement and ice. In Lesson 3 we consider alternative de-icing chemicals and their role in winter road maintenance. Lesson 4 looks at application strategies, in particular anti-icing, a modern preventive approach that aims to keep the ice-pavement bond from forming.
- **Module 3** looks at equipment and technologies used by modern winter road maintainers. In Lesson 1 we survey plows and spreaders and how they can be put to work to optimize road salt usage. Lesson 2 examines pavement condition tracking and forecasting techniques and technologies, including road weather information systems.
- **Module 4** deals with road salt and the environment. In this module we look at the pathways by which road salt can make its way into soil and groundwater, and the effects it can have on vegetation and wildlife.
- **Module 5** looks at snow and road salt handling. In Lesson 1 we look at road salt handling and storage at the road maintenance yard. In Lesson 2 we examine disposal strategies and techniques at snow disposal sites.
- **Module 6** considers the importance of monitoring and record keeping in winter road maintenance.

The objective throughout these modules and lessons is to help you, as an operator or supervisor, to understand how it is possible to use road salt more effectively while continuing to provide safe roads during winter and minimizing the impact on the environment.

## The same, but different

You have a lot in common with winter road maintainers across the country.

As a winter road maintainer, you have a lot in common with operators and supervisors in other jurisdictions across the country. At the same time, your job is very unique. Every road jurisdiction has a different transportation infrastructure to service. No two agencies face the same weather conditions. Each organization has a different mix of human resources and equipment available to keep the roads open during winter. Levels of service differ from one jurisdiction to the next, winter maintenance strategies are designed to meet specific local challenges, and public expectations change from one jurisdiction to the next.

In other words, while all winter road maintainers may be out on the front lines keeping the roads open, they could be using very different means to achieve similar ends.

This learning guide deals with general principles of winter road maintenance that can be applied in every jurisdiction, but it is beyond the scope of this document to prescribe practices that apply to specific road authorities. The best practices upon which this guide is based have been carefully researched and prepared and are endorsed by the Transportation Association of Canada's (TAC) Chief Engineers' Council, the Road Salt Working Group (a subcommittee of the Maintenance and Construction Standing Committee), and the Environment Council.

This material is provided as advice to winter road maintainers for consideration when developing their own policies, practices, and procedures. Keep in mind that the best practices are to be used in concert with the legislation, manuals, directives, and procedures of your individual road agency.

The material in this learning guide will be incorporated into your agency's current or planned training programs.

## A word about what's inside

Before we dive into the learning guide, let's take a look at what you'll see inside. We know that your time is valuable, and that the technical nature of this subject-matter may not be the most exciting thing you've read lately. So we've tried to make the learning experience as easy and enjoyable as possible.

We want you to learn, and to enjoy doing it.

The first thing you'll notice is that, unlike a lot of those technical reference manuals and user guides you may have seen and tried to read, our tone is conversational. We talk directly to you in a casual voice that's free of jargon and technical terminology. We even throw in a bit of humour every now and then. Unlike those other documents, we want you to learn, and to enjoy doing it.

Each lesson begins with a summary of the topics that we'll be discussing. This is followed by a conversation among fictional characters in a fictional maintenance yard: Pine Junction. Any resemblance between these characters and anyone you may actually work with is entirely coincidental. This dialogue sets the stage for the material covered in the lesson. Once you've read the list of topics to be covered and the dialogue, you'll have a pretty good idea of what you're going to discover in the lesson.

## Getting around: Navigation aids

The margin along the left side of each page is an area that we call the “fast track.” This serves three purposes:

We call this area the “fast track.”

1. Document designers tell us that “white space” on the page is visually pleasing to the eye, making it easier for you to read what’s on the rest of the page.
2. We can provide a capsule summary of the important points on the page. If you don’t have time to read the whole thing, at least you’ll know what you’re missing, and you can come back to it later if you’re interested.
3. The capsule summaries serve as “navigation aids”, which means that they provide a reference point if you need to come back to a section of a lesson and find a particular piece of information.

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### -TIPS, NOTES, and WARNINGS-

Although we feel that all of the information in the learning guide is important, some items need to have special attention drawn to them. We present these in the form of “Tips”, “Notes”, and “Warnings”. Information presented in this format is related to, but not part of, the discussion at hand.

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On the other hand, when we want to emphasize an important point *in* the discussion, we highlight it in this fashion.

If you only had time to skim a lesson, you could quickly grasp the essence of it by reading just the list of topics covered, the dialogue, the fast track items, the highlights, the tips/notes/warnings, and the summaries at the end, which we’ll discuss in a moment.

Our approach is based on the concept of self-assessment and instant feedback to confirm what you’ve just learned. Throughout this guide you’ll find “Quick Quizzes” that are designed to make you reflect on concepts that have been presented in the lesson. Once you’ve taken your best shot at answering the questions or offering solutions, you can check the answers that we provide following the quizzes. Look for the key to find out how you did. Sometimes there is no right or wrong answer, a reflection of the fact that operators in different jurisdictions might do things differently. We offer possible solutions, but our word isn’t always the final one.



When you reach the end of the lesson, we offer you a quick summary of where you’ve been. This is usually a restatement of the key points of the lesson that you should have picked up along the way. You’ll find it in the section entitled “Where have you been?”.



Knowing where you've been is useful, but knowing where you're going can be just as helpful. We'll let you know what's in store in the next lesson, in the context of what you've just learned. You'll find it in the section entitled "Where are you going?"

This guide can be used in different ways:

- You can use it at your desk, working and learning at your own pace.

-OR-

- You can use it in a classroom setting as a participant manual.

If you will be participating in a classroom training session, you will gain the maximum benefit by reading this guide in its entirety, if possible, before attending.

We hope that whatever you take from this guide will confirm the importance of the role you play as a winter road maintainer, and will generate discussions among your peers. Winter road maintenance is not a new profession, but there are always new techniques, technologies, and equipment coming along that change the way you operate. Keeping up with the changes, or staying ahead of the game, is a continuous learning process.

Let's start learning.

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# Module 6

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## Monitoring and record-keeping

As an operator, one of your most important responsibilities is to provide the data that supports the decision-making process in your organization.

*Well, what shall we talk about?*

- The importance of monitoring and record-keeping
- Salt Management Plans

## Cafeteria. Pine Junction maintenance yard. March.



“It’s all in here, Roch,” said John Rhodes, pointing to his head. “Everything I know about this job is right in here. I don’t know why we have to spend time writing it all down and recording everything we do.”

“Johnny, what are we going to do with you?” asked Roch Salterelli. “You’re one of the best operators we’ve got. You know more than all of us combined. So why don’t you want to share all that knowledge with us?”

“I’m no genius, Roch,” explained Rhodes. “I just know what I know, and I try to do a good job.”

“And no one does it better, Johnny. Believe me. But things change. We have more workers now. More equipment in the fleet. We handle more salt and have more roads on our routes. Salt costs money. It can affect the environment. Everyone wants us to use it as efficiently as possible. We have to start getting a better handle on what we’re doing.”

“It mentions salt management plans in the learning guide, Roch,” said Crystal Ion. “I guess we’ll have to have one, according to the criteria listed in the last module. When is that going to happen?”

“Very good point, Crystal,” Salterelli replied. “We’re working on that right now, and we should have it ready by fall. And that’s another reason why we need to start keeping better records of what we do around here. We’ll be required to provide reports under the salt management plan. And we won’t be able to produce them unless we have data. Without crucial information provided by operators, the salt management plan is meaningless. That’s how important it is.”

“Another layer of bureaucracy, as far as I’m concerned,” complained Rhodes.

“You could look at it that way, I suppose,” replied Brine Watters. “Or you could just look at it as an important part of your job. As important as making sure your rig is in good working order, that the plows are on the right angle, that the spreader is calibrated properly. It’s part of your job, John. Not something that you have to do *in addition* to your job.”

“So this is now more important than actually getting out there and keeping the roads clear?” asked Rhodes sarcastically.

“As important, Johnny,” explained Salterelli, “but not *more* important. Look, if we’re going to be held accountable for the way we do things around here, I want to have facts and figures on hand to justify our actions. Who knows—someone may decide to haul us into court someday because they think that we didn’t do our job and it

affected them in some way. People sue at the drop of a hat these days.”

“But it’s not just lawsuits, either,” added Watters. “Sure, we may be required under the salt management plan to collect data. But we can also use it to keep our operations running smoothly. Once you’ve got a good collection of data, you can use it to identify discrepancies and solve problems. By keeping close tabs on every ounce of salt that comes into and goes out of the yard, we’ll know exactly where we’re at at any point in the winter. The last thing we want to do is run out of salt in the middle of the season, or wait too long to re-order when the stocks are running down. It’s just good business sense to keep track of things.”

“I can tell you when to re-order,” advised Rhodes. “I don’t need pages of numbers to tell me that.”

“That might have been true at one time, Johnny,” explained Salterelli. “But this operation’s become too big to rely on gut feelings. That’s not to say that your instincts are wrong—in fact, they’re probably bang on. But we need more than that now. This is a modern operation that uses a lot of technology to maintain roads during the winter. It just doesn’t make sense to not use technology and modern methods when it comes to managing things.”

“Everyone will benefit, John,” added Watters. “Even you.”

“How will this benefit me?” asked Rhodes.

“You won’t need to use up all your gut instincts on trying to figure out when the salt pile will run out. You can save them for trying to pick the winning lottery numbers instead.”

“Sure, and then I can retire and leave you guys to run things with your technology and your learning guides.”

“Hopefully not before we capture all the knowledge that’s in your head, Johnny,” said Salterelli. “We need to write it all down so that when new people like Crystal come on board, they can benefit from all your years of experience.”

“Flattery will get you everywhere,” smiled Rhodes.

## For the record

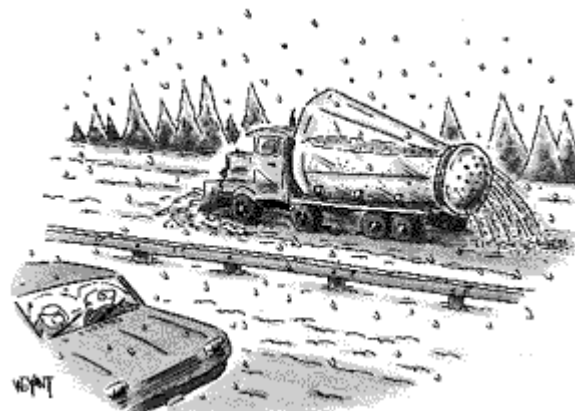
Imagine what would happen if the local fire department were called out to fight a fire at every house in the city simultaneously.

Or picture the challenge facing the police force if it were called upon to investigate a robbery at every corner store in town at the same time.

The drain on resources would be overwhelming: every piece of equipment and all personnel would be pressed into service immediately and for the duration of the events. Think of the logistics: knowing what resources are available and how to use them in the most efficient manner; being able to respond to rapidly changing conditions on the fly.

When a snowstorm hits, everyone is affected.

If you are involved in any aspect of winter road maintenance, this probably sounds very familiar. But no other service faces these unique kinds of challenges. When a



snowstorm hits, everyone is affected: every piece of equipment in the fleet is called into action; all personnel must be available to keep the roads open and the traffic moving safely.

Without a process in place to track equipment and material usage, a road authority could quickly find itself running out of sand or salt unexpectedly and unable to meet the required level of service.



Think back to Module 1, in which we discussed the importance of the transportation infrastructure to our economy and way of life. If even one main road were shut down during a blizzard, the consequences would be drastic and felt immediately.

Efficient maintenance operations depend upon good information.

Efficient management of winter road maintenance operations depends on reliable information. As an operator, one of your most important responsibilities is to provide the data that supports the decision-making process in your organization. Whether it is collected from your time card, gang sheet, or some other type of log, this data is the most important information that your organization can capture. It is the basis for the entire management plan of the fleet and inventory of materials.

As a supervisor, your responsibility is to use the data collected by your operators to support your salt management plan, control your inventory, and manage your fleet.

Any management system, whether electronic and sophisticated or manual and simple, is only as reliable and effective as the data that is fed into it.

With good data you can make good decisions. Without it, you can only make guesses.

Throughout this guide, we've stressed the importance of monitoring and record keeping, whether it is for salt usage, weather patterns, or pavement conditions. With good data, you can make sound decisions. Without it, you can only make good guesses.

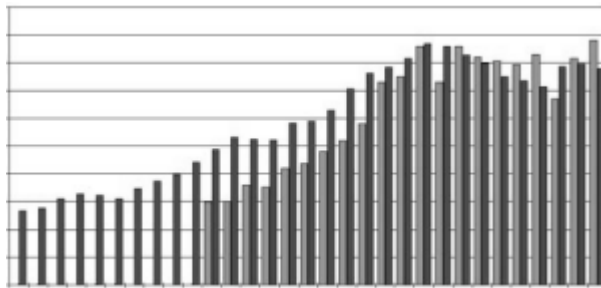
The farther back your historical records stretch, the more useful the information becomes. For example, if you have been keeping accurate salt usage records for 15 years, you know with some degree of certainty how much you'll need to get through the average winter. If your records only go back two years, however, you'll be doing some guesswork to determine how much you'll need.



Tracking usage on a daily, weekly, or monthly basis is essential. Once you know how much salt you'll need for the winter, you can compare ongoing usage against this benchmark. When you reach a trigger point, it's time to re-order. This requires careful and continuous monitoring, accurate record keeping, and lots of practice.

You can optimize salt usage by carefully recording how much salt goes into the spreader and controlling how much comes out of the spinner.

You can optimize salt usage by carefully recording how much salt goes into the spreader, and controlling how much comes out of the spinner. Historical records will tell you how much salt you'll need for your route. Careful calibration of the spinner will ensure that you put down the right amount. Proper spread patterns will ensure that you put it in the right place. And if there's anything left over, bring it back to the yard, spin it off, and make sure you record the surplus.



Tracking and recording usage to this degree on a shift-by-shift basis can provide an accurate picture of how much you've used, and when you have to re-order. The success of your organization's operations depends entirely upon the information that you feed into the management system.



## Monitor, track, record: All in a day's work

Every organization has its own unique monitoring and record-keeping system and requirements. It is beyond the scope of this guide to try and describe in detail all of the activities that could be tracked or monitored. Our objective is to make you aware of the importance of whatever records you are being asked to keep. Make sure you understand what you are being asked to monitor and record, and then do so diligently.

Here's a sample of some of the types of activities and conditions that you might be expected to monitor and record.

### On the road

- ✓ pavement temperatures and temperature trends (IRT; RWIS)
- ✓ pavement conditions, weather conditions, winter treatment strategy
- ✓ pavement temperature monitoring equipment (test, then recalibrate, repair, or replace if necessary)

### At the yard

- ✓ percentage of sand/salt blends stored under cover
- ✓ percentage of salt stored under cover
- ✓ percentage of storage sites with collection and treatment of wash water and drainage
- ✓ inspection and repair records
- ✓ stockpiling records
- ✓ quality control records for brine concentrations
- ✓ levels of environmental indicators (e.g. chloride levels)
- ✓ amount of material used during year (should be reconciled at year-end)

### At the disposal site

- ✓ number of snow disposal sites and their capacity
- ✓ percentage of snow disposal sites with run-off collection and/or treatment system(s)
- ✓ percentage of snow disposal sites with monitoring programs (e.g. groundwater, surface soil)
- ✓ volume of snow dumped and when it was dumped
- ✓ estimate of the melt rate
- ✓ record of basic atmospheric data (useful in helping to determine the melting rates)
- ✓ debris volume and type
- ✓ contaminant monitoring records (e.g. point data, trends, levels)
- ✓ maintenance and operation records
- ✓ type and amount of winter materials being placed

### In the fleet

- ✓ percentage of fleet equipped with electronic spreader controllers
- ✓ percentage of fleet equipped with pre-wetting
- ✓ percentage of fleet equipped with direct liquid application
- ✓ percentage of fleet calibrated annually
- ✓ percentage of staff trained in equipment use

# Planning the salt management plan

As we've learned throughout this guide, proper spreading, improved equipment, calibration of spreaders, automatic spreader controls, road weather information systems, and adequate covered storage and relocation of some stockpiles have combined to make salting of roads the most effective and safest method for snow and ice control.

Salt is a necessary and accepted part of our winter environment to assure safety and mobility.

Salt is a necessary and accepted part of our winter environment to assure safety and mobility for the individual motorists, school buses, commercial vehicles and, especially, ambulances, fire engines and other emergency equipment. Delays in reaching victims or getting them to hospitals often are the critical difference between life and death.

But while providing safety and essential mobility, the modern winter road maintainer must be concerned as well with safeguarding our environment. Environmental problems related to the use and storage of salt can be mitigated or minimized if there is a balanced approach to the use of salt for snow and ice control—one that demonstrates care for the environment as well as for the safety and mobility of people.



In Canada, over \$1 billion is spent annually on winter maintenance activities.

In Canada, over \$1 billion is spent annually on winter maintenance to keep roads safe and passable. Snow and ice control is a key part of winter maintenance operations. Road salts, particularly sodium chloride, are the preferred deicing/anti-icing chemicals for maintaining winter roadway safety because of their cost, effectiveness, and ease of handling. However, excessive use of salt can lead to environmental problems.

Recognizing their responsibility to the environment, many road authorities across Canada are taking positive actions towards implementing salt best management practices. The goal is to find ways to more effectively manage road salt used in winter maintenance and provide the public with the safe and efficient road systems they expect, while minimizing effects on the environment.

The amount of salt used is a function of local policies, practices, roadway systems, funding constraints, and weather conditions. Because of the variability of conditions across Canada, salt management initiatives, including salt management plans, need to be developed and implemented locally by each road authority.



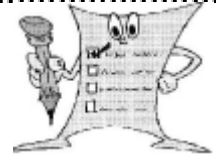
If your organization uses more than 500 tonnes of road salt annually and you have salt vulnerable areas in your road authority district, you will be required by Environment Canada to implement a salt management plan. In order to meet the

Record keeping is critical to the success of the salt management plan.

requirements of the salt management plan, road authorities—meaning *you*—will need to monitor and keep records on a wide variety of activities in order to meet annual reporting requirements. If record keeping was an important activity in the past, it is about to become even more important in the future.

The salt management plan is the vehicle through which your agency commits to implementing salt best management practices to fulfill its obligation to provide safe, efficient, and cost-effective roadway systems. It should contain best management practices to protect the environment from the negative impacts of road salts.

**These are just some of the activities and conditions on which your authority will be required to report through its salt management plan:**



- ✓ total length of road on which road salt is applied in the jurisdiction
- ✓ winter severity rating (municipal organizations only)
- ✓ total number of events requiring road salt application during the winter
- ✓ materials use, including total quantity of road salts used
- ✓ description of non-chloride materials used for winter road maintenance
- ✓ state of calibration of equipment
- ✓ average chloride concentration and frequency of sampling at each sampling location, if available

In order to meet its reporting requirements, your organization will depend upon the accuracy and timeliness of the data that you collect on a daily basis. When it comes to record keeping, be diligent and thorough.



## Quick Quiz

**Complete and accurate records can be used for both monitoring and problem-solving purposes.**

**Suppose that four operators using the same spreader on different shifts recorded significantly different salt usage totals. Think of possible reasons why this could happen, and indicate which records you'd consult to try and solve the problem.**

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Here's a sample of the types of records you could analyze to determine discrepancies in salt usage:

- ✓ **Calibration records.** Regular spreader calibration is one of the easiest ways to save a significant amount of salt. Even slight variations in application rates can represent substantial differences in the amount put down over the course of an entire shift of spreading.
- ✓ **Loading records.** If one operator loads to the fill line, which is usually about a foot below the top of the hopper, while another tops up the load to avoid having to deadhead back to the yard for more material, there will be a discrepancy. Don't count the number of loads during a shift—check the weight of the material leaving the yard by examining the loading records.
- ✓ **Weather records.** Check weather records to see if conditions deteriorated during a shift, requiring a heavier application than an earlier or later shift.
- ✓ **Number of kilometres covered.** Examine the log to determine the exact distance covered by the spreader during the shift.
- ✓ **Amount spun off.** One operator may try to use up an entire load, while another may return to the yard and spin-off the surplus. This should be recorded. Check the records to see how much was brought back, then subtract it from the amount that left the yard, to get an accurate picture of total salt used during the shift.

There are a number of factors, and combinations of circumstances, that can affect the amount of salt used by an operator during a shift. You need to look at the big picture in order to get the true picture. Are there other records not mentioned here that you think would be helpful?

**ANSWER**



## Where have you been?



As an operator or supervisor, you've got a hand in almost every activity that happens in the yard, on the road, or at the snow disposal site. What you do is important. Recording what you do is equally important. In this lesson, we've looked at what types of information you may be asked to monitor and record in your organization.

We've also looked at how important this data is in supporting the salt management plans which many organizations will be required to implement in the near future. The timeliness and accuracy of the data that you capture during your day-to-day activities is critical to the success of salt management plan reporting.

## Where are you going?



From here, you're going forward. Out onto the roads, armed with knowledge and renewed confidence: knowledge that will help you make good decisions and confidence that they will be the right decisions. This learning guide has been all about helping you learn to optimize salt use in order to minimize its impact on the environment, while continuing to provide safe roads for motorists in all kinds of winter weather.

Hopefully, what you've learned here will have reaffirmed the importance of your role on the front line of winter road maintenance operations; and will have made you salt SMART (Spreading, Maintenance, Application Rates, and Timing), which is all about using the "right amount" at the "right place" at the "right time" and recording it.

Congratulations on working through this learning guide! Feel free to come back any time you need to refresh your knowledge.