



# SNOW & ICE CONTROL GUIDEBOOK

June 2016

LRRB Report #2016RIC11



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## Technical Advisory Panel

The following members comprise the project's Technical Advisory Panel (TAP) that contributed to this project:

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# INTRODUCTION

This Snow and Ice Control Guidebook summarizes common snow and ice control tools and serves as an introduction to the field of winter maintenance for operators and managers.

Minnesota local agencies perform winter maintenance to keep roads clear for the traveling public. However, agencies must balance public safety, cost, and environmental concerns to effectively manage their winter maintenance policy.

Minnesota cities and counties should retain an up-to-date policy for winter maintenance that specifies desired pavement conditions.

## Winter Pavement Condition Definitions\*



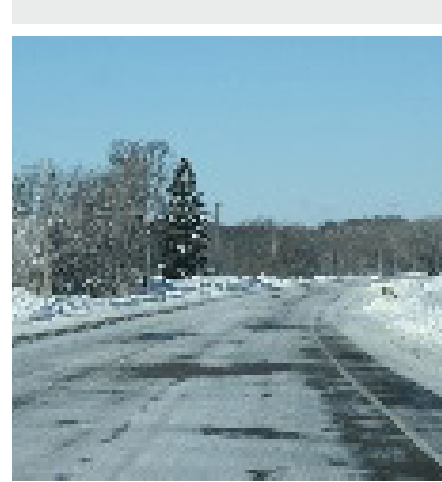
### Bare Pavement

May be wet. Accurate and precise plowing and chemical use may be needed to achieve this condition and maintain normal travel speeds.



### Bare Wheel Paths

Some slush may remain. Plowing and chemical applications have been made. The roadway is open to near-normal travel.



### Plowed and Treated

Wheel paths may or may not be visible, some snowpack remaining, plowing and chemical use performed.



### Plowed to Snowpack

Maintenance is being performed, but snowpack remains across the roadway.

\*Final winter pavement conditions are defined by each agency based on their own service goals, budgets, and policies.

# SECTION 1: SNOW AND ICE CONTROL STRATEGIES

## Before the Storm (Anti-icing/Pretreatment)

Anti-icing is the application of liquid chemicals to the roadway before a winter storm.

- Prevents ice from bonding to the pavement.
- May reduce the amount of time required to restore the roads to bare pavement.
- Can be performed before the storm, during a regular shift.
- May offer cost savings over de-icing (material, personnel, and equipment).
- Pretreatment may be performed with solid materials as well.
- Material may be washed away if rain comes first, or wasted if forecasts are wrong.



## During and After the Storm (De-icing)

De-icing is the application of chemicals during or after a storm.

- Improves ability for plows to clear ice and snow from the road by loosening compacted snow and ice.
- Aids in getting to bare pavement goals.
- Plowing and de-icing can be performed independently or to complement each other.
- *Prewetting* de-icers may improve effectiveness.



**Effectiveness of material application can be improved with prewetting.**



Prewetting is adding brine or other liquids to granular material to help jump start the melting process. Prewetting can be done at the spinner, in the pile, or by adding brine in the spreader box.

### Benefits of Prewetting

- Achieve faster melt
- Reduce material use
- Prevents material scatter

# SECTION 2: SNOW PLOWS AND EQUIPMENT

## SNOW PLOWING

Snow plowing is the removal of snow and ice from the roadway by mechanical means.

Final winter pavement condition expected varies depending on precipitation type, snow moisture content, temperatures, and conditions. Agencies may only be able to achieve “plowed and treated” or “plowed to snowpack” conditions with plowing alone. It may take time and repeated efforts to reach final goals.

Plowing snow is typically complemented with applying de-icing chemicals. For some conditions it may be necessary to plow and treat the roadway with sand or other abrasives.

Plowing alone may have no environmental impacts from chemical use, but the trade-off is less effective snow removal, lower levels of service, and potentially a higher risk to public safety.

Tandem plowing, echelon plowing (commonly called “gang plowing”), or tow plows may be used to clear multiple lanes in one pass.



# TYPES OF SNOW PLOWS



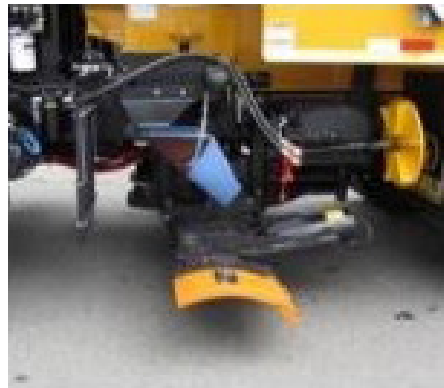
## Front End Plow

Front end plows are the most common, basic type of plow. Front plows come in many variants including left/right (reversible) plows, fixed, V-plow and high-speed plows.



## Wing Plow

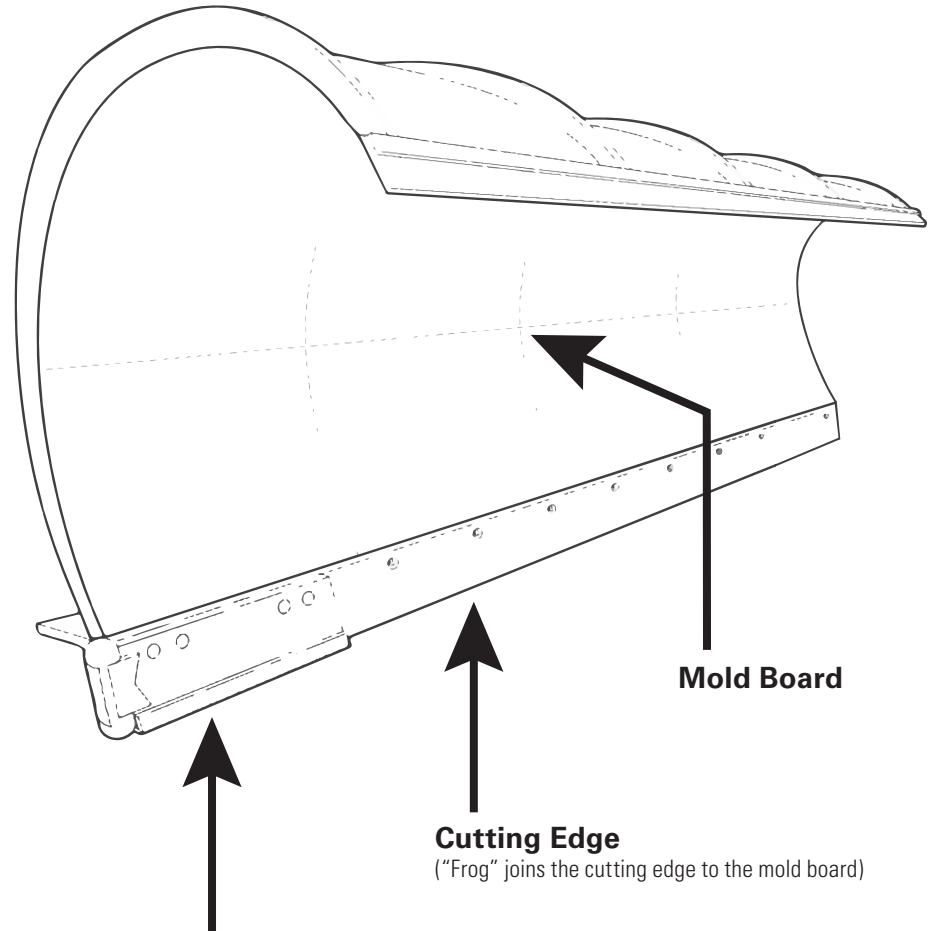
Wing plows are used in conjunction with other plows. They push snow behind the front wheels, and can exert down-pressure. They may be used by themselves, or in conjunction with a front plow in deeper snows for optimal clearing.



## Underbody Plow

Underbody plows are located behind the front wheels, and can exert down-pressure. They may be used by themselves, or in conjunction with a front plow in deeper snows for optimal clearing.

# PLOW DIAGRAM



## A Shoe

(additional cutting edge mounted on the end of the mold board used primarily by municipalities to protect the plow from the curb and gutter)

# SNOW PLOW VEHICLES

A variety of construction equipment can be used for plowing and other winter maintenance operations, either as-is, or by fitting the equipment with appropriate apparatus or attachments.



Dump Truck with underbody and front plows as well as a material spreader



Motor Grader with wing plow attachment (currently in the raised position)



Loader with reversible front plow, which allows snow to be thrown to the left and right, as needed

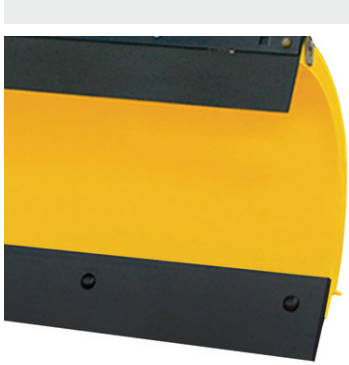


Snow removal using trucks and loader with blower



# SNOW PLOW CUTTING EDGES

## Commonly Used Cutting Edges



Source: Northern Tool

### Steel

- Wears faster than carbide.
- Often used by cities that plow roads with metal hardware in the pavement (manholes, water valves).
- Can be stacked in front of a carbide blade to protect the carbide edge.



### Carbide

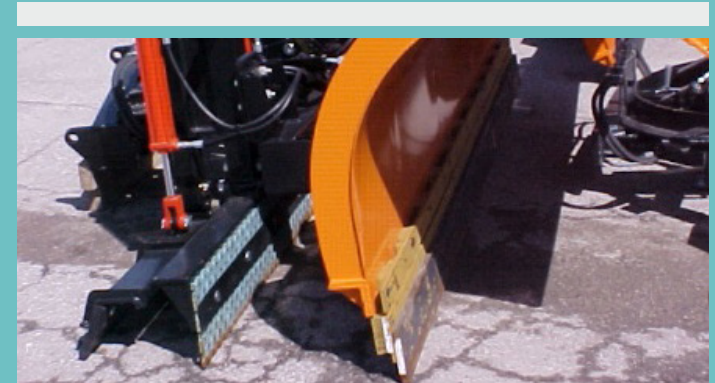
- More expensive than steel, but long-lasting.
- More resistant to wear than steel, but also more susceptible to breaking.



### Combination

- Segmented blade that is a combination of steel, carbide, and rubber.
- Long-lasting.
- Blade segments conform to the profile of the road (for example, rutted roadways).
- Reduced noise and vibration.
- Clears roadway better than standard cutting edges.

## Newer Cutting Edge Options



### Multi-Blade System

- Consists of two to three cutting edges.
- Relatively high cost.
- Each cutting edge has a separate function.
- Removes slush, cuts snow/ice, and removes snow.



Ceramic Cutting Edge



Rubber Cutting Edge

### Other Materials

- Ceramic, composite, and rubber-encased cutting edges have also been used, but these have high cost and are typically used for specific applications such as brick roadways.

# SOLID MATERIAL SPREADERS

Solid material spreaders are used to distribute granular material on the roadway in a consistent and measured way.

Various solid material spreaders are available for trucks:

- V-box, slide-in or permanent mount
- Pan
- Single or dual spinner
- Center or side discharge

Different spreader configurations provide various options for how the solid chemical is applied to the roadway, such as a spinner in the back, or deposited in front of the rear wheels.

Basic spreaders have the least amount of control over how effectively and efficiently the material is spread, or rates of application. Modern technology, such as ground speed controllers and prewetting equipment, can greatly enhance performance and material control.

Calibration of all types of spreaders is essential for optimal and effective use.



Truck with V-box insert

Source: Lindco Equipment Sales, Inc.



Truck with a spinner

Source: New Jersey DOT

# LIQUID MATERIAL APPLICATORS

Liquid material applicators are used to consistently apply liquid chemicals to the roadway in a deliberate and controlled spray pattern.

Liquids in anti-icing are typically applied using a "pencil-line" stream.

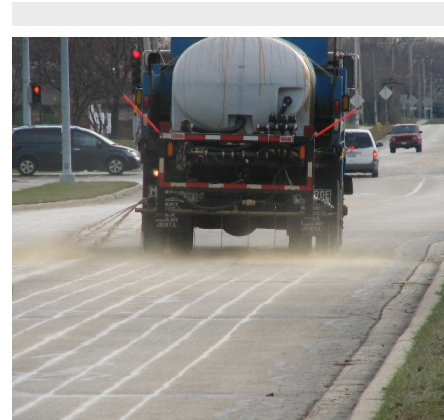
Liquid may be dispensed by gravity or by pressurized depending on the available equipment.

Side sprayers on pressurized units may be added for multi-lane applications.

Various types of tanks are used to hold liquids on trucks depending upon the intended use. For instance, saddle tanks are generally used for prewetting material at the spinner, and bladder or standard tanks for anti-icing.

Liquids are the most common and effective way to apply anti-icing chemical. Applying as lines rather than a spray pattern has been found to be most effective.

Calibration of the applicator is essential for effective use.



"Pencil-lines" application for anti-icing with pressurized liquid being applied from the left side of the truck.



Tailgate Liquid Tank

# SOLID SPREADER AND LIQUID APPLICATOR IN-CAB CONTROLS

Plow operators regulate material application rates using in-cab controls.

Good control systems are easy to operate, ergonomic, and provide adequate control.

Various types of in-cab controls allow the operator to adjust plows and chemical application:

- Joysticks
- Knobs or push buttons
- Dial control (set rate 1-10)

Operators set spread rates (pounds of solids per lane-mile or liquid application rates) or rates can be automatically set by onboard computer systems. Older-style manual controls (levers) are being phased out.

Computer-controlled systems can be set for “blast” mode to apply extra material in a targeted area, such as within an intersection. Be sure to use the calibrated application rate to avoid over use of material.

Ground speed control spreaders can automatically adjust application rates based on vehicle speed.

Control systems are often integrated with automatic vehicle location systems (AVL) for supervisors to remotely track maintenance activity.

# IMPORTANCE OF CALIBRATION

Calibration is an essential procedure to measure the amount of liquid and solid material applied to the roadway at various settings in relation to truck speed. No matter how sophisticated or simplified the operations, always calibrate or verify calibration annually.

The Minnesota Snow and Ice Control Field Handbook for Snowplow Operators provides additional guidance about calibration and offers the following calibration resources:

- Clear Roads has links to manufacturers’ calibration instructions and a comprehensive calibration guide: [clearroads.org/project/calibration-accuracy-of-manual-and-ground-speed-control-spreaders/](http://clearroads.org/project/calibration-accuracy-of-manual-and-ground-speed-control-spreaders/)
- MnDOT also has calibration instructions: [www.dot.state.mn.us/maintenance/training.html](http://www.dot.state.mn.us/maintenance/training.html).
- For sander calibration training, contact the Minnesota Circuit Training and Assistance Program (CTAP) instructor at [www.mnltap.umn.edu/about/programs/ctap/](http://www.mnltap.umn.edu/about/programs/ctap/).
- For liquid calibrations, see the MnDOT Anti-icing Guide at [www.dot.state.mn.us/maintenance/training.html](http://www.dot.state.mn.us/maintenance/training.html).



Source: Force America



Source: Varitech Industries



# SECTION 3: WINTER MAINTENANCE MATERIALS

## WINTER MAINTENANCE MATERIALS

A variety of winter maintenance materials are available for local agencies to use to manage snow and ice.

This table summarizes the commonly used materials, their uses, attributes and environmental impacts.



	Abrasives	Solid Rock Salt (NaCl)	Salt Brine	Magnesium Chloride (MgCl <sub>2</sub> )	Calcium Chloride (CaCl <sub>2</sub> )	Acetates	
						Calcium Magnesium Acetate	Potassium Acetate
<b>Usage</b>	Mix with salt to provide traction to slippery roads.	Deicing or anti-icing	Prewetting and anti-icing	Deicing, prewetting, and anti-icing	Deicing	Anti-icing	Anti-icing
<b>Typical Form</b>	Sand (paved roads) or gravel (unpaved roads). Mixed with salt (20% to 33% salt).	Solid granular	Liquid	Liquid or solid	Liquid	Liquid	Liquid
<b>Lowest Practical Melting Temperature</b>	Lowest practical melting temperature	15° F	15° F	-10° F	-20° F	20° F	-15° F
<b>Positive Attributes</b>	<ul style="list-style-type: none"> <li>- Provides temporary traction</li> <li>- More effective than chemicals at very low temperatures and for spot traction at targeted locations (hills, curves, bridges, intersections, shaded areas, windblown areas)</li> <li>- Useful alternative in environmental sensitive locations (no salt roads)</li> </ul>	<ul style="list-style-type: none"> <li>- Excellent melting capacity</li> <li>- Lower cost compared to other chemicals</li> <li>- Clear roads of snow and ice</li> </ul>	<ul style="list-style-type: none"> <li>- Prevents snow and ice from bonding to pavement (anti-icing)</li> <li>- Lower cost compared to other chemicals</li> <li>- Reduced granular scatter when used for prewetting</li> <li>- Low cost</li> </ul>	<ul style="list-style-type: none"> <li>- Reduced amount of product used, reduced salt and abrasive use over rock salt</li> <li>- Better cold temperature performance than rock salt</li> <li>- Persists on the road surface, aiding in longer black ice prevention than sodium chloride</li> </ul>	<ul style="list-style-type: none"> <li>- Better cold temperature performance than rock salt</li> <li>- Reduced amount of product used</li> </ul>	<ul style="list-style-type: none"> <li>- Non-corrosive</li> <li>- Often used on bridge anti-icing systems</li> </ul>	



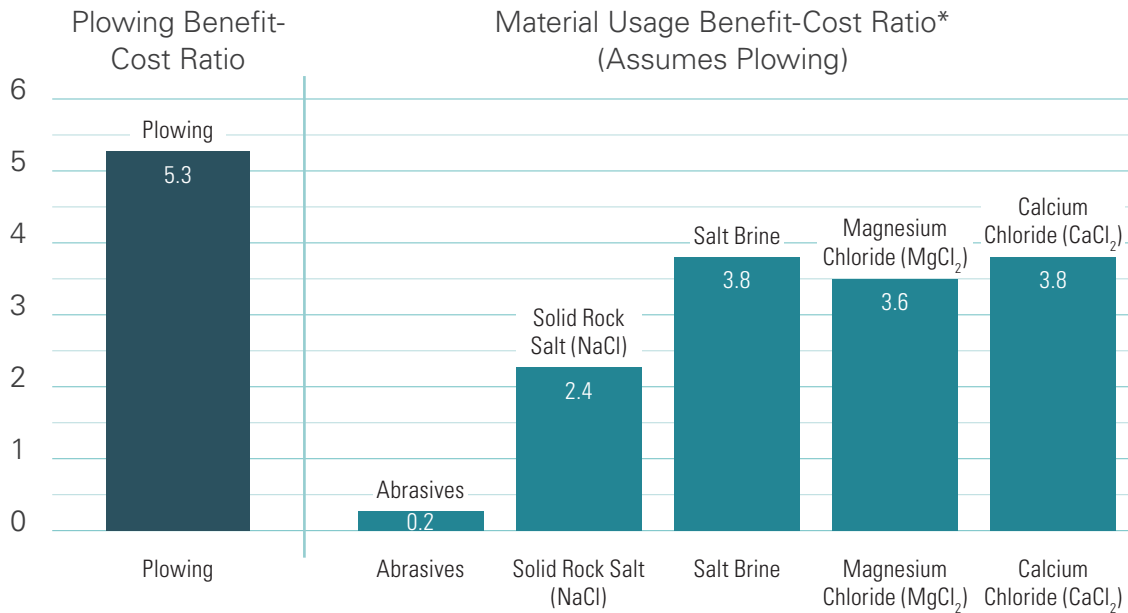
	Abrasives	Solid Rock Salt (NaCl)	Salt Brine	Magnesium Chloride (MgCl <sub>2</sub> )	Calcium Chloride (CaCl <sub>2</sub> )	Acetates	
						Calcium Magnesium Acetate	Potassium Acetate
<b>Negative Attributes</b>	<ul style="list-style-type: none"> <li>- Recovery from storms is slower than chemicals when used alone or in combination with only plowing</li> <li>- More plow passes and applications are required than if chemicals are used</li> <li>- Cannot achieve deicing</li> <li>- Requires clean up after winter season</li> </ul>	<ul style="list-style-type: none"> <li>- Corrosion</li> <li>- Impacts on roadside and waterways</li> <li>- Pavement deterioration</li> <li>- Corrosion to vehicles and infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>- Corrosion</li> <li>- Impacts on roadside and waterways</li> <li>- Corrosion to vehicles and infrastructure</li> </ul>	<ul style="list-style-type: none"> <li>- Pavement deterioration</li> <li>- Corrosion</li> <li>- Material cost is higher than rock salt</li> <li>- More corrosive than sodium chloride</li> </ul>	<ul style="list-style-type: none"> <li>- Pavement deterioration</li> <li>- Corrosion</li> <li>- Material cost is higher than rock salt</li> <li>- More corrosive than sodium chloride</li> </ul>	<ul style="list-style-type: none"> <li>- Expensive</li> </ul>	
<b>Environmental Impacts</b>	<ul style="list-style-type: none"> <li>- Abrasives can enter the waterways and clog streams, clog drains, can impact water quality and aquatic species</li> <li>- Straight abrasive use does not pose corrosion issues, but abrasive-salt mixes can cause this issue</li> </ul>	<ul style="list-style-type: none"> <li>- Entry into waterways</li> <li>- Impact to roadside soil, vegetation</li> </ul>	<ul style="list-style-type: none"> <li>- Entry into waterways</li> <li>- Impact to roadside soil, vegetation</li> </ul>	<ul style="list-style-type: none"> <li>- Entry into waterways</li> <li>- Impact to bridge infrastructure</li> <li>- Leaching/run-off from stockpiles</li> </ul>	<ul style="list-style-type: none"> <li>- Entry into waterways</li> <li>- Impact to roadside</li> <li>- May mobilize heavy metals in soil releasing them into the water</li> </ul>	<ul style="list-style-type: none"> <li>- Their decomposition consumes dissolved oxygen, resulting in lower oxygen levels in water.</li> </ul>	

## Chemical Application Rates

Detailed provisions about material application rates are given in the Minnesota Snow and Ice Control Handbook [www.mnltap.umn.edu/publications/handbooks/documents/snowice.pdf](http://www.mnltap.umn.edu/publications/handbooks/documents/snowice.pdf)

# BENEFIT-COST OF PLOWING AND MATERIAL USAGE

The Clear Roads pooled fund commissioned an analysis of the costs and benefits of various winter maintenance strategies. This analysis found that plowing is the most effective and basic form of winter maintenance and material usage can supplement plowing at various rates. The analysis included safety benefits, agency resources, corrosion to infrastructure and vehicles, and environmental impacts.



\*When applied with typical methods

Read more about this study here:

Fay, Laura, et al. "Benefit-Cost of Various Winter Maintenance Strategies." 2015. [clearroads.org/wp-content/uploads/dlm\\_uploads/FR\\_CR.13-03\\_Final.pdf](http://clearroads.org/wp-content/uploads/dlm_uploads/FR_CR.13-03_Final.pdf)

# BLENDED PRODUCTS AND CORROSION INHIBITORS

## Blended Products

- Blended products can combine benefits of various chemicals, such as the low cost of rock salt with the low freezing point of calcium chloride as well as a corrosion inhibitor.
- Can be blended on site or purchased pre-blended.

## Corrosion Inhibitors

- Corrosion inhibitors are generally additives that reduce the corrosiveness of a chemical.
- Premixed chemicals with corrosion inhibitors can be purchased under trade names or are organics, such as beet juice or molasses.
- Typically used in spot locations.

More information about corrosion inhibitor effectiveness can be found here:

Shi, X. "Identification and Laboratory Assessment of Best Practices to Protect DOT Equipment from the Corrosive Effect of Chemical Deicers." 2013. [www.wsdot.wa.gov/research/reports/fullreports/796.1.pdf](http://www.wsdot.wa.gov/research/reports/fullreports/796.1.pdf)

# SECTION 4: WINTER MAINTENANCE TECHNOLOGIES

## ROAD WEATHER INFORMATION SYSTEM (RWIS)

### Overview

A Road Weather Information System (RWIS) is a combination of field hardware and software that provides detailed and timely road-weather information that is used to support operations and maintenance decisions.

RWIS's are comprised of a network of field Environmental Sensor Stations (ESS) that measure atmospheric and pavement conditions.

- Atmospheric data
  - Air temperature
  - Humidity
  - Visibility distance
  - Wind speed and direction
  - Precipitation type and rate
- Pavement data
  - Pavement temperature
  - Pavement condition (dry, wet, ice, frost)
  - Subsurface temperature



Environmental Sensor Station

## MNDOT'S RWIS SYSTEM

MnDOT maintains a RWIS system for the state roadways.

[rwis.dot.state.mn.us/](http://rwis.dot.state.mn.us/)

Local agencies can benefit from this system and use it to determine weather conditions of nearby roads.

**VAISALA / SCAN Web**

- ▶ Home
- ▶ Cameras
- ▶ Bridge Sprayers
- Maps**
- ▶ District 1
- ▶ District 2
- ▶ District 3
- ▶ District 4
- ▶ Metro District
- ▶ District 6
- ▶ District 7
- ▶ District 8
- Summaries**
- ▶ Statewide Summary
- ▶ RWIS Sites
- ▶ District 1 Sites
- ▶ District 2 Sites
- ▶ District 3 Sites
- ▶ District 4 Sites
- ▶ Metro Sites
- ▶ District 6 Sites
- ▶ District 7 Sites
- ▶ District 8 Sites
- ▶ Duluth Sites
- ▶ Vaisala Sites
- ▶ AWOS Sites
- ▶ ASOS Sites
- Related Links**
- ▶ User's Guide
- ▶ Glossary
- ▶ SCAN PDA
- ▶ Disable Java Links
- ▶ Administration

Click on an area to view the available RWIS data.

- [Iteris Forecast Web Site](#)
- [Metro Traffic Cameras](#)
- [The Weather Channel Radar](#)
- [AccuWeather Radar](#)
- [SSEC Goes-8 Infrared](#)
- [NCAR/RAP Visible](#)
- [NWS Radar](#)
- [Snow Control](#)

MnDOT's RWIS website

# MAINTENANCE DECISION SUPPORT SOFTWARE (MDSS)

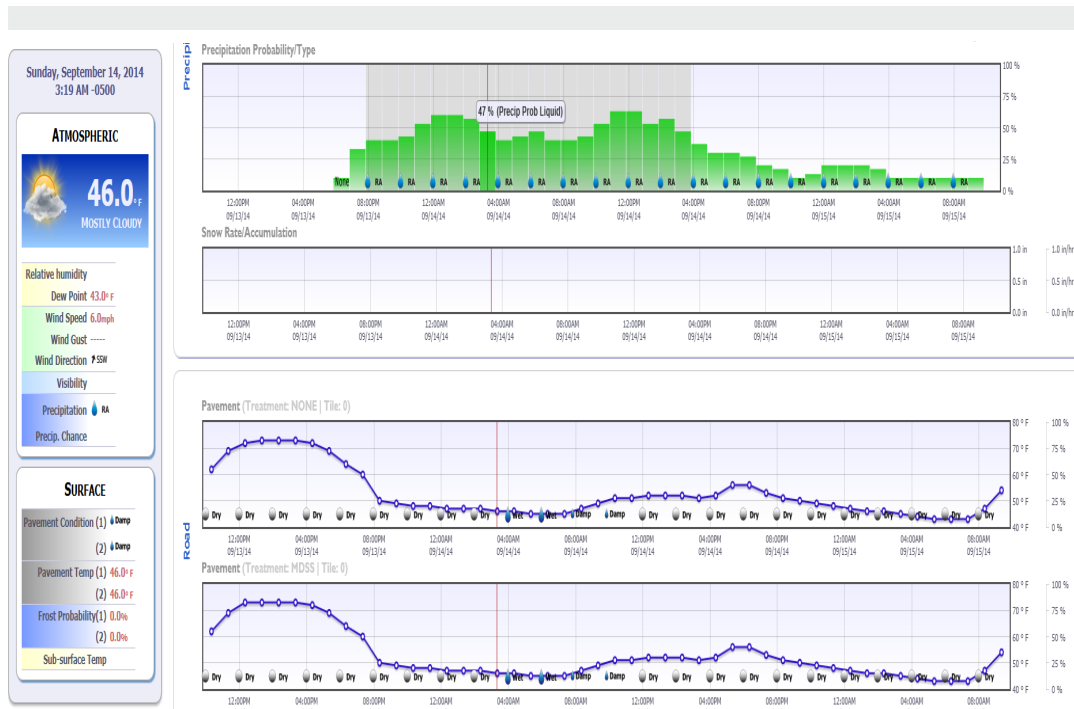
The MDSS provides reliable weather, road condition, and maintenance information enabling transportation agencies to accomplish their winter maintenance missions.

Current road conditions are supplemented with RWIS and entries from operators/supervisors in trucks to determine the near to medium term weather forecast and recommend sound winter maintenance strategies:

- Treatment type
- Application rates
- Application timing
- Predict the resulting road conditions

MDSS Deployment Guide, FHWA

[ntl.bts.gov/lib/30000/30400/30467/14439.pdf](http://ntl.bts.gov/lib/30000/30400/30467/14439.pdf)



Example Software Screenshot

Weather Radar/Satellite Risk Maps Forecast Sites/Routes Text Forecasts MET															
TP6B1391 (MN139, IOWA STATE LINE - JCT US52 (HARMONY))															
MN139 -- IOWA STATE LINE - JCT US52 (HARMONY)															
Time (CDT)	Roadway: Treatment None				Roadway: Treatment MDSS				Wind						
	Temp (° F)	Pvnt Cond	Frost Prob (%)	Maintenance Rate	Temp (° F)	Pvnt Cond	Frost Prob (%)	Maintenance Rate	Air Temp (° F)	Dew Pt (° F)	Humidity (%)	Direction	Speed (mph)	Gust (mph)	Wind Chill
3am															
Tue 4am	34	Wet	15	---	34	Wet	15	---	32	31	98	NW	15	30	FR 60
Tue 5am	33	Wet	15	---	33	Wet	15	---	32	31	94	NW	17	35	FR 60
Tue 6am	32	Wet	20	---	32	Wet	20	---	32	30	92	NW	18	37	FR 50
Tue 7am	33	Wet	15	---	33	Wet	15	---	33	30	88	NNW	19	38	FR 20
Tue 8am	34	Wet	5	---	34	Wet	5	---	Patrol for Ice Accumulation (precautionary)						
Tue 9am	35	Damp	0	---	35	Damp	0	---	33	27	80	NNW	20	36	RA 20
Tue 10am	37	Dry	0	---	37	Dry	0	---	34	27	76	NNW	19	34	RA 30
Tue 11am	39	Dry	0	---	38	Dry	0	---	35	27	70	NNW	20	33	RA 20

Example Software Screenshot



# AUTOMATIC VEHICLE LOCATION (AVL)

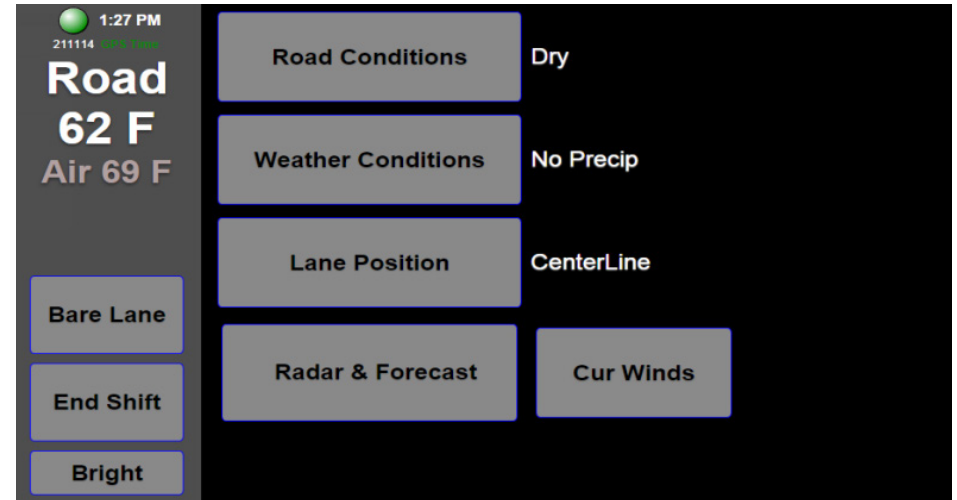
## Overview

Automatic Vehicle Location (AVL) systems are used to automatically determine and transmit the location of a vehicle.

AVL systems provide a dispatch center the capability to monitor the location of all vehicles continuously in real time to monitor progress of snow removal operations during the event and re-deploy equipment to meet changing weather conditions.

AVL is usually integrated with digital communications and Geographic Information System (GIS) mapping systems to streamline instructions from the dispatcher who is able to view vehicle itineraries and locations graphically.

AVL systems can automatically generate “end-of-shift” reports that determine the amount of material used rather than the operator manually filling out a worksheet.



Automated End-of-Shift Reports



AVL hardware



Some AVL systems have a mobile data terminal operator interface

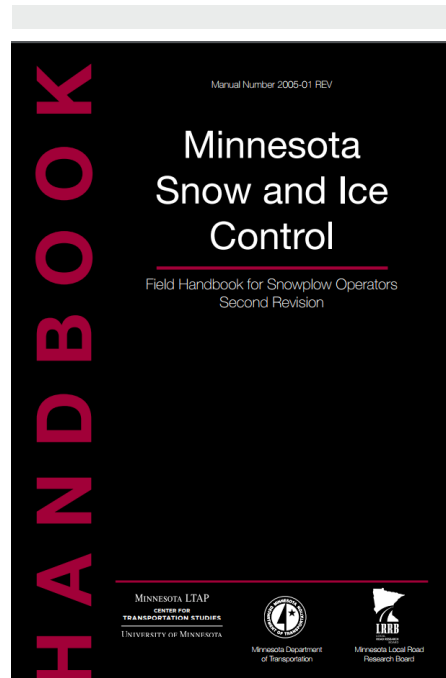
# SECTION 5: WINTER MAINTENANCE POLICIES AND BEST PRACTICES

## MINNESOTA SNOW AND ICE CONTROL HANDBOOK

- Promotes “the understanding of the tools, best practices, and limitations for snow and ice control.”
- “...encourages progressive changes in snow and ice control practices that will help you reduce salt/sand use and environmental impacts while meeting the safety and mobility needs of roadway users.”

Offers “standard best practices expected in a quality snow and ice control program.”

Minnesota Snow and Ice Control Field Handbook for Snowplow Operators Second Revision, 2012, [www.mnltap.umn.edu/publications/handbooks/documents/snowice.pdf](http://www.mnltap.umn.edu/publications/handbooks/documents/snowice.pdf)



## IMPORTANCE OF HAVING A SNOW AND ICE CONTROL POLICY

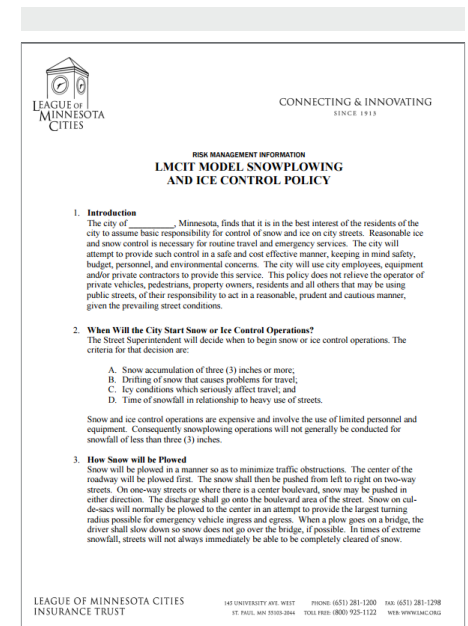
- Allows the agency to manage risks
- Encourages the agency to study, develop, follow policies
- Communicates the policy to citizens and staff
- Provides an opportunity for the agency to review and monitor the processes
- Allows the agency to learn and improve

Source: Is Salt Your Only Defense? Louis Smith, 15th Annual Road Salt Symposium, February 4, 2016

The League of Minnesota Cities provides a model Snowplowing and Ice Control Policy. [www.lmc.org/media/document/1/modelsnowplowingpolicy.pdf](http://www.lmc.org/media/document/1/modelsnowplowingpolicy.pdf)

Minnesota Pollution Control Agency Smart Salting (S2) Certification [stormwater.pca.state.mn.us/index.php/Smart\\_Salting\\_\(S2\)\\_training\\_information](http://stormwater.pca.state.mn.us/index.php/Smart_Salting_(S2)_training_information)

[www.pca.state.mn.us/water/training](http://www.pca.state.mn.us/water/training)

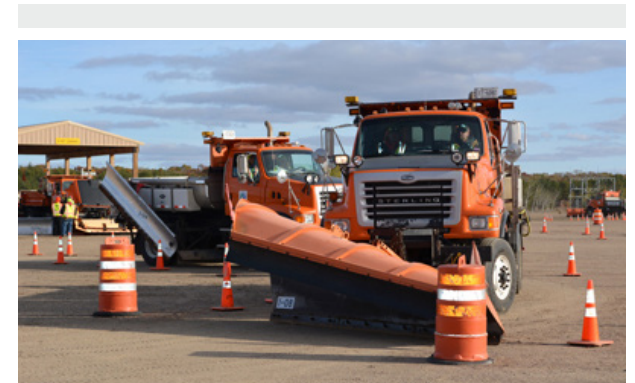


# TRAINING OPPORTUNITIES

- [MnDOT's Minnesota Snowplow and Safety Simulator Training for Local Agencies](#)
- [Snow Plow Operator Training \(SPOT\)](#)
- [Defensive Snow Plow Technical Training](#)
- [Dakota County Technical College](#)
- [St Cloud State Advanced Driving Skills Snow Plow Operators/Wing & Plow/Road Maintenance](#)
- [Minnesota Fall Maintenance Expo](#)
- [MnLTAP/CTAP Snow and Ice Material Application and Calibration classes](#)
- [MPCA Level 1 Certification Course: Snow & Ice Control Best Practices](#)
- [APWA North American Snow Conference](#)
- [APWA Winter Maintenance Supervisor Certificate Workshop](#)
- [Western Snow Conference](#)
- [University of Wisconsin – Managing Snow & Ice Control Operations Workshop](#)

# RESOURCES

- [Minnesota Snow and Ice Control – Field Handbook for Snowplow Operators](#), 2012
- LRRB YouTube Video – [Winter Chemicals for Local Agencies](#), 2015
- [Clear Roads](#) studies:
  - [Cost-Benefit of Various Winter Maintenance Strategies](#)
  - [Roadway Salt Best Management Practices](#)
- [Chloride Free Snow and Ice Control Material](#), MnDOT Transportation Research Synthesis, June 2014
- [Effect of Pre-wetting Brines on the Ice Melting Rate of Salt at Very Cold Temperatures](#), Cargill
- Salt Brine Blending to Optimize de-icing and Anti-Icing Performance and Cost-Effectiveness
  - [Phase I](#), 2012
    - [Anti-Icing Cost Model REV](#) (Excel) (Password: Mankato)
    - [De-icing Cost Model REV2](#) (Excel) (Password: Mankato)
  - [Phase II](#), 2014
  - Phase III in progress as of 2016
- [MPCA Winter Maintenance Assessment Tool](#)
- [Local Government Snowplow Salt and Sander Controller Calibration Guide](#)
- [SALT Symposium– Risk Management Presentation](#)





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[www.lrrb.org/](http://www.lrrb.org/)

Full Report

[www.lrrb.org/media/reports/2016RIC11.pdf](http://www.lrrb.org/media/reports/2016RIC11.pdf)