# Training Video for the Implementation of Liquid-Only Plow Routes

Stonebrooke Engineering, Inc.

CLEAR ROADS

research for winter highway maintenance

**Project 1026088/CR16-06**
**May 2018**

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16. Abstract

Liquid-only plowing is a method of removing snow and ice on the road by applying liquid chemicals directly to the roadway surface. It also serves as an anti-icing tool. The goal of the Liquid-Only Plow Routes project was to create a set of training and promotional tools for the implementation of liquid-only roadway treatments. This information can serve as a resource for agencies seeking to gain buy-in within their organization for this type of winter maintenance, as well as for agencies already using these roadway treatments. It can also inform the general public while dispelling myths and misconceptions. The tools created as part of this project include:

1. Literature Search Report: We researched the documented practices of liquid-only plow routes from agency and media sources, evaluated the applicability of the sources, and created a literature search report.
2. Survey of Practice: We compiled a list of 679 survey recipients from agencies in 27 US states and sent them an online survey to determine if their agency uses liquid-only roadway treatments, and if they would be interested in participating in a phone interview. We identified 22 recipients that agreed to be interviewed regarding their usage of these treatments. We performed the interviews and compiled the results into a report.
3. Quick Reference Guides: We created two quick reference guides for easy access to liquid-only plowing resources and information. The first guide, "Liquid-Only Road Treatments Start-Up Reference Guide," includes information on benefits, tips for gaining buy-in, and equipment recommendations. The second guide, "Liquid-Only Road Treatments Technical Reference Guide," includes usage parameters and application rates.
4. Videos: We produced two videos – a shorter video that focuses on benefits and dispelling myths, and a longer video that includes that information along with recommendations on how to start a liquid-only program, equipment guidelines, and usage parameters and application rates. The final videos are available to view on YouTube through the following links:

- Short Version: https://www.youtube.com/watch?v=4cTmhl_nN8c
- Full Version: https://www.youtube.com/watch?v=Xd9xs0lKIGg

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## Executive Summary

Liquid-only plowing is a method of removing snow and ice on the road by applying liquid chemicals directly to the roadway surface. It also serves as an anti-icing tool. This technique offers many advantages over solid chemicals and salts, including reduced material use, reduced cost and workload, lower environmental impact, and enhanced effectiveness. The most effective times and locations to use liquid-only plowing are determined by pavement temperature, storm intensity, and moisture content. When used correctly, these roadway treatments are a safe and reliable solution for snow and ice prevention and removal.

The goal of the Liquid-Only Plow Routes project was to create a set of training and promotional tools for the implementation of liquid-only roadway treatments. These tools will promote liquid-only plowing by showing the benefits of this plowing method, demonstrating how and when to use it, and describing the steps needed to implement a program. This information can serve as a resource for agencies seeking to gain buy-in within their organization for this type of winter maintenance, as well as for agencies already using these roadway treatments. It can also inform the general public while dispelling myths and misconceptions.

The tools created as part of this project include:

1. **Literature Search Report:** We researched the documented practices of liquid-only plow routes from agency and media sources, evaluated the applicability of the sources, and compiled the results into a literature search report.
2. **Survey of Practice:** We compiled a list of 679 survey recipients from agencies in 27 US states. These users were sent an online survey to determine if their agency uses liquid-only roadway treatments, and if they would be interested in participating in a phone interview. We identified 22 recipients that agreed to be interviewed regarding their usage of these types of treatments. Their phone interviews revealed some similarities and differences among agencies, as well as some helpful guidance and learning opportunities. They also provided the additional benefits of identifying further research sources, providing advice for certain challenging situations, and verifying that the research released by Clear Roads is being used in the winter maintenance programs agencies nationwide.
3. **Quick Reference Guides:** We created two quick reference guides for easy access to liquid-only plowing resources and information. The first guide, “Liquid-Only Road Treatments Start-Up Reference Guide,” includes information on benefits, tips for gaining buy-in, and equipment recommendations. The second guide, “Liquid-Only Road Treatments Technical Reference Guide,” includes usage parameters, application rates, and general tips.
4. **Videos:** We produced two videos – a shorter video that focuses on benefits and dispelling myths, and a longer video that includes that information along with recommendations on how to start a liquid-only program, equipment guidelines, and usage parameters and application rates. The final videos are available to view on YouTube through the following links:
    - Short Version: https://www.youtube.com/watch?v=4cTmhl_nN8c
    - Full Version: https://www.youtube.com/watch?v=Xd9xs0lKIGg

Each of these tools was built using the knowledge gained during the creation of the previous tool. The information acquired from research documents and industry experts during the literature search assisted in the creation of questions for the survey of practice, which in turn shaped the quick reference guides and videos. These tools complement each other, and when used together, they will have a greater overall impact on awareness, support, and training.

## Introduction

Liquid-only plowing is a method of removing snow and ice on the road by applying liquid chemicals directly to the roadway surface. It also serves as an anti-icing tool. This technique offers many advantages over solid chemicals and salts, including reduced material use, reduced cost and workload, lower environmental impact, and enhanced effectiveness. The most effective times and locations to use liquid-only plowing are determined by pavement temperature, storm intensity, and moisture content. When used correctly, these roadway treatments are a safe and reliable solution for snow and ice prevention and removal.

The goal of the Liquid-Only Plow Routes project was to create a set of training and promotional tools for the implementation of liquid-only roadway treatments. These tools will promote liquid-only plowing by showing the benefits of this plowing method, demonstrating how and when to use it, and describing the steps needed to implement a program. This information can serve as a resource for agencies seeking to gain buy-in within their organization for this type of winter maintenance, as well as for agencies already using these roadway treatments. It can also inform the general public while dispelling myths and misconceptions.

The tools created as part of this project include:

- A literature search report on documented practices of liquid-only plow routes across all applicable agencies and media sources
- A survey of practice of applicable agencies to gather information about their liquid-only plow route experiences, successes, obstacles, usage, and other factors
- Two quick reference guides that include the benefits of liquid-only treatments, tips for gaining buy-in, equipment recommendations, and usage parameters
- Two videos – a shorter video that focuses on benefits and dispelling myths, and a longer video that includes that information along with information on how to start a liquid-only program, equipment guidelines, and usage parameters and application rates

Each of these tools was built using the knowledge gained during the creation of the previous tool. The information acquired from research documents and industry experts during the literature search assisted in the creation of questions for the survey of practice, which in turn shaped the quick reference guides and videos. These tools complement each other, and when used together, they will have a greater overall impact on awareness, support, and training.

## Literature Search

The first task in the Liquid-Only Plow Routes project was to perform a literature search on the current documented practices by transportation agencies on liquid-only roadway treatments. These agencies included city, county, state, federal, and international organizations.

We collected information from the following sources:

- Peer reviewed journal articles
- White papers
- Industry publications and websites
- City, county, and state transportation/public works websites
- Newspapers
- Online videos
- Sources suggested by Clear Roads staff

For each source that we found, we considered the following aspects in order to evaluate its applicability:

- Methods
- Measurements
- Statistical significance
- Experience / examples
- Limitations
- Recommendations
- Location
- Date range

After identifying applicable sources, we compiled the information into a report that included the following information:

- Source agency
- Title of literature or source
- Link to online source, or citation of printed source
- Author of source
- Date published or date range of examples
- Summary of findings / significance

The full literature search is included in Appendix A.

The knowledge gained through this task was used to craft the interview questions in the survey of practice and assisted with the information in the quick reference guides and video script. The authors and agencies identified in the Literature Search were included as survey recipients in the Survey of Practice.

## Survey of Practice

The goal of the survey of practice was to give a current and comprehensive "state of the practice" on liquid-only plow routes. The results of this survey were used in updating the quick reference guide, identifying interview candidates for the video, and providing guidance on the video script. The sub-tasks for the survey included:

1. Identifying Survey Recipients
2. Creating and Distributing an Online Survey
3. Conducting Phone Interviews with Select Respondents

Our approach to these sub-tasks and our results are detailed in the following sections.

### Identifying Survey Recipients

To compile the list of survey recipients, we first looked at which U.S. States receive the highest average annual snowfall, and we focused our efforts on the top 20 states. Thanks to the efforts of Technical Advisory Committee (TAC) members, we were able to include recipients from a total of 27 states. These recipients included DOT maintenance and district engineers, County and City public works directors and engineers, research specialists, Clear Roads members, and other similar contacts. In some states, such as Alaska and Delaware, the DOT maintains 95% of the roads, so in those cases, only DOT contacts were included. Some states such as Maryland and North Dakota have a policy that they will not share email addresses for any staff members, so recipients in those states were limited to Clear Roads members. The total number of survey recipients was 679 people.

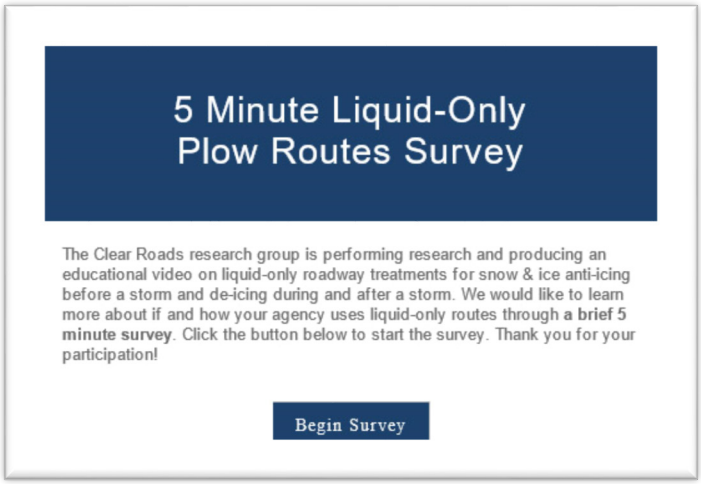
### Creating and Distributing an Online Survey

At the Project Kickoff Meeting, the TAC decided that survey recipients would be more likely to share their experiences through informal phone conversations as opposed to a lengthy online survey. According to Survey Monkey, online surveys that take longer than seven minutes to complete have a high rate of abandonment, and also have a tendency to cause users to speed through their answers without providing informative responses. Instead of using the online survey to gather information, we used it as a tool to narrow down our list of recipients based on two factors:

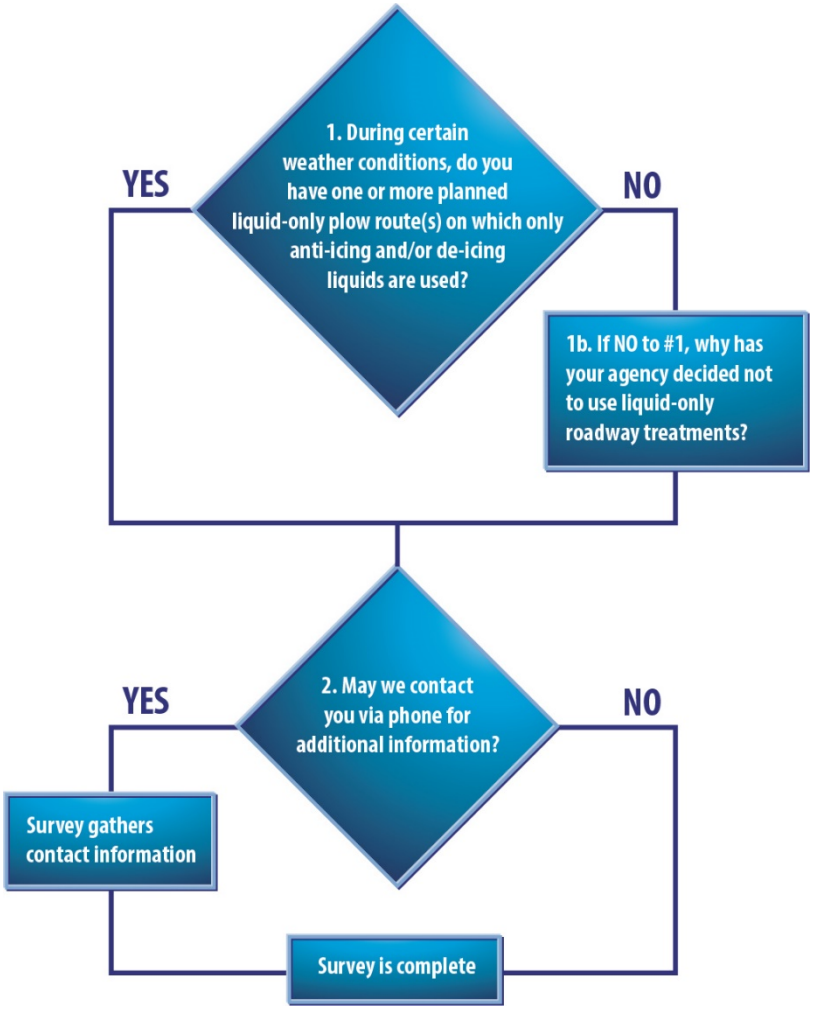
1. Users that work at an agency that has one or more liquid-only plow routes
2. Users that would be willing to participate in an informal phone interview

We used Survey Monkey, along with input from the TAC, to create the survey. The survey included a branching question, where the user would be given different questions based on their answer. The survey was sent to recipients via email, and two reminders were sent out to users who did not complete the survey. Our survey began with the following introductory paragraph:

*The Clear Roads research group is performing research and producing an educational video on liquid-only roadway treatments for snow & ice anti-icing before a storm and de-icing during and after a storm. We would like to learn more about if and how your agency uses liquid-only routes through a brief survey below. For the purposes of this survey, we are defining liquid-only plow routes as routes with roadway treatments where no crystalline material is applied, and does not include activities such as pre-wetting of salts. These routes would only contain liquid anti-icing and de-icing.*




*Email sent to recipients from Survey Monkey*



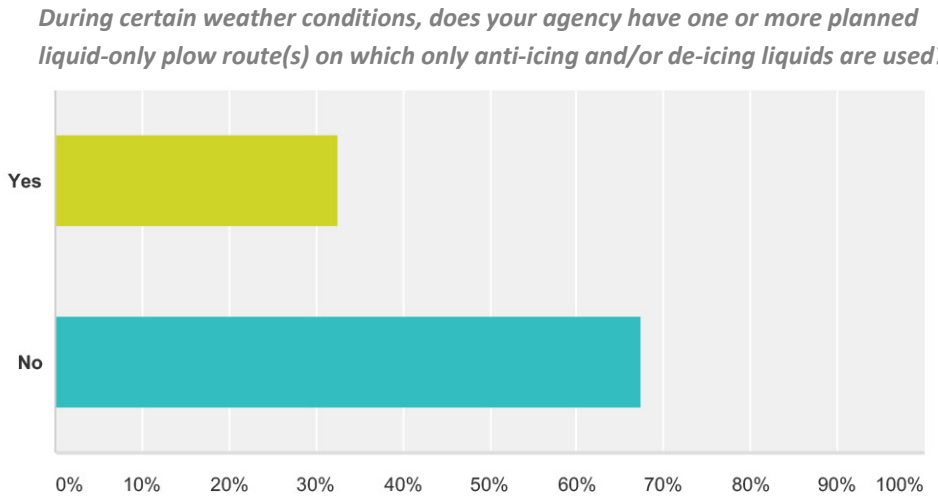

After this paragraph, the user was presented with the first question. The path that the user takes through this survey is shown in the flow chart (left). The first question is the following yes or no question: *During certain weather conditions, does your agency have one or more planned liquid-only plow route(s) on which only anti-icing and/or de-icing liquids are used?*

If the user answers no to this question, they are then given this question: *Why has your agency decided not to use liquid-only roadway treatments?*

Whether or not users answered yes or no to the initial question, they are presented with this question next: *May we contact you via phone for additional information?*

If the user answered yes to this question, the survey included standard fields that gather the recipient's name, agency, email, and phone. If the user answered no, the survey would be complete.

Out of the 679 recipients, we received 92 responses. This is a response rate of 14%, which is higher than Survey Monkey's average response rate of 10%. Out of the 92 respondents, 30 indicated that they have a liquid-only plowing route, which is 32% of the respondents. Out of those 30 there were 22 respondents who indicated that we could contact them for a phone interview. The raw survey data is included in Appendix B.




## Conducting Phone Interviews with Select Respondents

Along with input from the TAC, we prepared the following introduction and questions to ask during the phone interviews:

*The Clear Roads research group is performing research and producing an educational video on liquid-only roadway treatments for snow & ice anti-icing before a storm and de-icing during and after a storm. I am calling on behalf of this group to learn more about how your agency uses liquid-only plowing. For the purposes of our project, we are defining liquid-only plow routes as routes with roadway treatments where no crystalline material is applied, and does not include activities such as pre-wetting of salts. These routes would only contain liquid anti-icing and de-icing.*

1. *When and why did your agency start using liquid-only treatments?*
2. *Are the roads on your liquid-only route rural or urban? High volume or low volume?*
3. *How do you determine what type of road is appropriate for liquid only treatment?*
4. *What is your timing for beginning treatment based on storm events and temperature?*
5. *What application rates are you using and how does that change based on temperature and intensity of the event? Are there other factors that influence application rates?*
6. *What brine chemical composition and mix ratio are you using?*
7. *Do you make your own brine? If so, how many gallons/hour can you generate and what make and model of brine maker do you own? And what size of water line feeds your brine maker?*
8. *What type of equipment are you using on your trucks to apply the liquid-only treatments?*
9. *What is your off-site storage tank capacity?*

10. *What is your route length and cycle time, and does this vary with liquid only vs traditional plow routes?*
11. *What is your typical loading time from the storage tank to the truck, and what kind of transfer equipment do you use?*
12. *What is your yearly gallons use on your liquid only routes?*
13. *In your experience, is the liquid de-icing process more effective than using solids? And if so, in what ways?*
14. *Have you encountered situations where the liquid-only process was not effective, and how did you adjust to that situation?*
15. *What is the public perception of liquid-only plowing in your area?*
16. *How have you communicated the benefits of liquid-only plowing to the public and to policy makers? And if so, in what ways?*
17. *Have you addressed any misconceptions and if so, how?*
18. *How have you addressed environmental concerns?*
19. *Has your agency performed any formal research on liquid only vs traditional anti-icing and de-icing?*
20. *Is there anything else regarding the use of liquid only treatments that you encounter at your agency that I have not addressed?*

Out of the 22 recipients who indicated that they could be contacted for a phone interview, we were able to interview 14 candidates. The 8 candidates who could not be interviewed were either non-responsive to voicemails and emails, unavailable due to travel, or misunderstood the survey and did not use liquid-only treatments on roadways. The phone interview logs are located in Appendix C.

## Analyzing the Results

The 14 phone interviews revealed some similarities and differences among agencies, as well as some helpful guidance and learning opportunities. Our analysis of the responses is addressed on a question-by-question basis below.

### 1. When and why did your agency start using liquid-only treatments?

Among the users we interviewed, the earliest use of liquid-only treatments on specific routes dates back to the late 90's. The most recent started their liquid-only program only three years ago. In nearly every case, each agency started their program because of research that had been shared between agencies. Many respondents specifically mentioned the research that Clear Roads has performed and shared.

2. **Are the roads on your liquid-only route rural or urban? High volume or low volume?**

Most agencies that have liquid-only routes assign them to all types of roads regardless of location or volume. A few agencies use liquid-only treatments only on their high priority roads, which tend to be high volume.

3. **How do you determine what type of road is appropriate for liquid only treatment?**

Some agencies prefer to start their liquid only program with low volume roads that are close to their shops. From there they branch out either by priority or by proximity to the shop. Other agencies prefer to start with their highest priority roads, since those roads demand the highest level of service.

4. **What is your timing for beginning treatment based on storm events and temperature?**

Most agencies were in agreement that pretreating roads for anti-icing more than 24 hours before a storm is ineffective. Many agencies pretreat approximately 8-12 hours before a storm event. A few agencies wait to pretreat until 0-3 hours before a storm. Most agencies rely on the experience and training of their shop supervisors, as opposed to a standardized system that defines treatment based on temperature and storm type.

The lowest usage temperature reported was by the Utah DOT, who will use brine down to -6 degrees on hard packed snow for loosening packs for plowing.

5. **What application rates are you using and how does that change based on temperature and intensity of the event? Are there other factors that influence application rates?**

Applications rates ranged from 15 gallons per lane mile on the low end to 100 gallons per lane mile on the high end. The average was 50 gallons per lane mile. Most agencies did not change application rates based on temperature or storm intensity.

6. **What brine chemical composition and mix ratio are you using?**

In nearly every case, agencies were mixing brine at a ratio of 23.3%. Additives were rarely used, and when they were, it was typically for inhibiting corrosion.

The Delaware DOT mixes blue dye in with their brine so that it is easier to see which areas have been treated. It has been termed “Smurf Juice” in their state.

7. **Do you make your own brine? If so, how many gallons/hour can you generate and what make and model of brine maker do you own? And what size of water line feeds your brine maker?**

Nearly every agency made their own brine. The most common brine makers used were by Henderson – either the Brine Extreme Pro or the Brine Extreme Ultimate. With solar salts, these brine makers can produce 9,000 to 12,000 gallons per hour. Most agencies were producing around 5,000 gallons per hour, either because they were using standard salts, or using brine makers with lower outputs. The standard size water line being used was a 2” line, with a few agencies using 3” lines.

Utah and Delaware have central brine making facilities that can make larger quantities of brine and transport it to other facilities.

**8. What type of equipment are you using on your trucks to apply the liquid-only treatments?**

The truck equipment either included one larger tank, or two smaller side saddle tanks. The capacity of these trucks ranged from 800 gallons to 5,000 gallons. All agencies utilized spray bars with side sprayers. Some agencies also use large tanker trucks for spraying interstate highways and for transferring brine to other facilities. These larger tankers had an average storage capacity of 6,000 gallons.

**9. What is your off-site storage tank capacity?**

The off-site storage capacity varied by agency, but the average size was 6,000 gallons at each location. The majority of agencies used poly tanks as opposed to fiberglass or steel tanks.

**10. What is your route length and cycle time, and does this vary with liquid only vs traditional plow routes?**

For those users that knew their typical route times, it averaged around 1 hour and 45 minutes. Most users reported that the route times for liquid-only routes were faster due to decreased loading times or because the trucks were able to drive slightly faster while applying the treatments.

**11. What is your typical loading time from the storage tank to the truck, and what kind of transfer equipment do you use?**

All agencies used electric pumps with 2” lines to transfer from the tank to the truck. The average loading time was 15 minutes.

**12. What is your yearly gallons use on your liquid only routes?**

Yearly gallon use varied greatly by agency and location. Out of the agencies that we interviewed, the lowest was Delaware at around 350,000 gallons, and the highest was Montana at over 9 million gallons.

**13. In your experience, is the liquid de-icing process more effective than using solids? And if so, in what ways?**

Nearly every agency felt that liquids were more effective. The factors most often stated are:

- Liquids begin working immediately
- Liquids are more predictable
- It is easier to control the application of liquids
- Reload times are shorter for liquids
- Liquids stick to the road better
- There are no air quality issues like there are with sand
- There is less waste with liquids than solids, due to the bounce rate of solids
- Decreased overall salt usage

Only the Wisconsin DOT felt that liquids were less effective, although they were using liquids at a lower temperature than is recommended.

**14. Have you encountered situations where the liquid-only process was not effective, and how did you adjust to that situation?**

Some agencies stated that when they pretreated their roads more than 12 hours before a storm, that traffic or rainfall would remove most of the treatment from the roads before the storm started. Those agencies adjusted their anti-icing time to be within 12 hours of a storm event. Some other agency-specific situations were:

- The Delaware DOT found that liquids don't work as well during heavy periods of heavy snowfall. During those times they adjusted by using only plows, and following up with liquids after the heavy snowfall stopped.
- The Oregon DOT had instances where the liquid treatments dry out during intense storms, and they found that repeat applications at a lower application rate are needed.
- The Utah DOT had an issue with roads treated with magnesium chloride getting slippery after certain storms. There is a winter inversion weather effect where the valleys will get very foggy, and above the fog canopy the air is humid and warmer. As the sun would rise, it would push the fog canopy further into the valley, the surface temperature of the roads would drop, the magnesium chloride would freeze, and the roads would get very slippery. The only fix was to wash it off with a weak brine solution. The accidents after the storm were worse than before the storm. In those particular areas, they had to use solids instead of liquids.
- Liquids were not effective for Waukesha County, Wisconsin, and they were not able to make adjustments that would make it work for their agency. The brine would refreeze ever time they used it, and it made the roads more dangerous. But the user admitted that they were not using any charts or guidelines for the treatment itself, only for the brine mix. They just experimented to see what would work. They abandoned the program after it was not successful for them that winter, but they are working to restart the program using new guidelines.

**15. What is the public perception of liquid-only plowing in your area?**

In nearly every case, the public was supportive of liquid-only plowing. Their only concerns were related to groundwater quality and corrosion on vehicles, and those issues were easily addressed by the agencies we interviewed.

**16. How have you communicated the benefits of liquid-only plowing to the public and to policy makers? And if so, in what ways?**

On the public side of things, many agencies communicated the benefits using press releases, social media, website updates, interviews on local news, and town hall meetings. Most users also interacted with members of the public on a one-on-one level whenever issues would arise.

With policy makers, some users spoke about the importance of educating local officials so that they are better equipped to talk to the public. Some users also worked with legislators on an individual level in states where winter tourism is important to the state economy.

Many states have training programs that educate shop personnel, area managers, and other appropriate users on the latest guidelines and research related to winter roadway operations, including liquid-only plowing.

**17. Have you addressed any misconceptions and if so, how?**

Nearly all users preferred to address misconceptions on an individual level, mostly because large scale misconceptions did not occur in their areas. The only stated misconceptions were related to groundwater quality and corrosion, and those misconceptions were cleared up be sharing research and manufacturer specifications.

**18. How have you addressed environmental concerns?**

Agencies stressed that they try to provide the highest level of service with the least environmental impacts. Many agencies are unable to use most additive due to their high content of phosphorus, heavy metals, nitrogen, or other materials that could affect their local environment. As with the misconceptions question above, nearly all users have only needed to address these concerns on an individual level with members of the public.

**19. Has your agency performed any formal research on liquid only vs traditional anti-icing and de-icing?**

Most agencies did not have a formal research process. Instead, they relied on agencies such as Clear Roads to perform and release research. These agencies frequently would perform informal trial and error testing at their facilities to fine tune their program for their local area.

The agencies with the most robust formal research programs were the Colorado DOT and the Utah DOT. Both agencies have formal research processes and publish their results online. They also provide funding to local universities and institutes, which perform a wide variety of research.

**20. Is there anything else regarding the use of liquid only treatments that you encounter at your agency that I have not addressed?**

Users had a variety of other comments related to liquid-only plowing. Some relevant comments were:

- Some agencies have experimented with calcium chloride, but stopped due to corrosion issues.
- A user from the Utah DOT commented that magnesium chloride is harder to store than brine. It can clog the pumps if it isn't diluted. Even when diluted, it would settle on the bottom of the tanks.
- Some users objected to the term "liquid-only routes", because once the temperature drops below a certain level, liquids are no longer a feasible option.

- Agencies looking to expand their programs frequently referenced Clear Roads as a source for information and research findings.

The goals of this part of the Liquid-Only Plow Routes project were to provide a "state of the industry" report, gather information for updating the Quick Reference Guide, identify interview candidates for the video, and provide guidance on the video script. The phone interviews were highly useful for all of these goals and provided the additional benefits of identifying further research sources, providing advice for certain challenging situations, and verifying that the research released by Clear Roads is being used in the winter maintenance programs agencies nationwide.

## Quick Reference Guides

The original quick reference guide, "During-Storm Liquid Applications (DLA) – A New Tool for the Winter Maintenance Toolbox" (2010) summarized a full research report into a useful 6-page document that included rules-of-thumb, application rates, general tips, equipment tips, and an expert contact list. Updating this guide was included as one of the tasks in this project. During the development of the literature search report and survey of practice, and through discussions with the TAC, it became clear that the overall goals of this project could best be summarized in the following objectives:

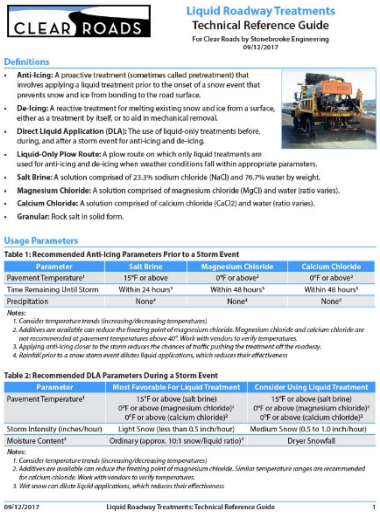
1. Inform agency decision makers and the general public about the benefits of liquid-only roadway treatments while dispelling common myths
2. Provide practical guidance for practitioners and for agencies looking to start a liquid-only program

With these objectives in mind, we created two separate reference guides that would each address one of these project goals. The first guide, "Liquid-Only Road Treatments Start-Up Reference Guide," includes the following sections:

- Benefits of Liquid-Only Treatments
- Definitions
- Tips for Gaining Buy-In
- Equipment Recommendations

The second guide, "Liquid-Only Road Treatments Technical Reference Guide," includes the following sections:

- Definitions
- Usage Parameters
    - Recommended Anti-Icing Parameters Prior to a Storm Event
    - Recommended DLA Parameters During a Storm Event
- Direct Liquid Application Rates & Cycle Times
    - Suggested Liquid Roadway Treatments Application Rates
- General Tips


CLEAR ROADS

Liquid Roadway Treatments
Technical Reference Guide
For Clear Roads by Stonebrooke Engineering
09/12/2017

Definitions

- **Anti-Icing:** A proactive treatment (sometimes called pretreatment) that involves applying a liquid treatment prior to the onset of a snow event that prevents snow and ice from bonding to the road surface.
- **De-Icing:** A reactive treatment for melting existing snow and ice from a surface, either as a treatment by itself, or to aid in mechanical removal.
- **Direct Liquid Application (DLA):** The use of liquid-only treatments before, during, and after a storm event for anti-icing and de-icing.
- **Liquid-Only Plow Route:** A plow route on which only liquid treatments are used for anti-icing and de-icing when weather conditions fall within appropriate parameters.
- **Salt Brine:** A solution comprised of 23.3% sodium chloride (NaCl) and 76.7% water by weight.
- **Magnesium Chloride:** A solution comprised of magnesium chloride (MgCl) and water (ratio varies).
- **Calcium Chloride:** A solution comprised of calcium chloride (CaCl2) and water (ratio varies).
- **Granular:** Rock salt in solid form.

Usage Parameters

Table 1: Recommended Anti-Icing Parameters Prior to a Storm Event

| Parameter | Salt Brine | Magnesium Chloride | Calcium Chloride |
|---|---|---|---|
| Pavement Temperature[1] | 15°F or above | 0°F or above[2] | 0°F or above[2] |
| Time Remaining Until Storm | Within 24 hours[3] | Within 48 hours[3] | Within 48 hours[3] |
| Precipitation | None[4] | None[4] | None[4] |

Notes:
1. Consider temperature trends (increasing/decreasing temperatures)
2. Additives are available can reduce the freezing point of magnesium chloride. Magnesium chloride and calcium chloride are not recommended at pavement temperatures above 40°. Work with vendors to verify temperatures.
3. Applying anti-icing closer to the storm reduces the chances of traffic pushing the treatment off the roadway.
4. Rainfall prior to a snow storm event dilutes liquid applications, which reduces their effectiveness

Table 2: Recommended DLA Parameters During a Storm Event

| Parameter | Most Favorable For Liquid Treatment | Consider Using Liquid Treatment |
|---|---|---|
| Pavement Temperature[1] | 15°F or above (salt brine)<br>0°F or above (magnesium chloride)[2]<br>0°F or above (calcium chloride)[2] | 15°F or above (salt brine)<br>0°F or above (magnesium chloride)[2]<br>0°F or above (calcium chloride)[2] |
| Storm Intensity (inches/hour) | Light Snow (less than 0.5 inch/hour) | Medium Snow (0.5 to 1.0 inch/hour) |
| Moisture Content[3] | Ordinary (approx. 10:1 snow/liquid ratio)[3] | Dryer Snowfall |

Notes:
1. Consider temperature trends (increasing/decreasing temperatures)
2. Additives are available can reduce the freezing point of magnesium chloride. Similar temperature ranges are recommended for calcium chloride. Work with vendors to verify temperatures.
3. Wet snow can dilute liquid applications, which reduces their effectiveness

09/12/2017 Liquid Roadway Treatments: Technical Reference Guide 1

*Technical Reference Guide*

Each guide is formatted as a one page front and back PDF document that is designed for quick reference and is suitable for laminating. They are designed for ease of use on mobile devices, and they are formatted for ADA compliance. These guides are included in Appendix D.

## Liquid-Only Roadway Treatments Video

The main focus of this project was a training and promotional video that discusses the benefits of liquid treatments, addresses common myths, offers tips for starting a liquid-only program, discusses equipment types, and shows recommended usage parameters and application rates. The production of this video occurred over several months, and included interviews and location footage shot in six different US states. The main tasks included in the creation of this video included:

- Interview candidate selection
- Interview filming
- Action footage filming
- Video production

### Interview Candidate Selection

In order to best represent the different aspects of liquid-only plowing, our interview candidates needed to include a variety of professions and perspectives. We identified the follow categories for interview candidates:

- Statewide-Level position
- Shop-level position
- Chemical expert
- Equipment expert
- Non-Technical Advocate

In a video interview, an ideal candidate is not only knowledgeable about their subject, but they are also able to talk about their subject in a natural way that is easy to understand. We were able to identify several candidates through the phone interviews that we performed during the Survey of Practice. We worked with the TAC to narrow down our list of candidates and include different viewpoints and locations. The following interview candidates were selected:

- Kyle Lester, Colorado Department of Transportation (Statewide-Level position)
- Anne Brown, Delaware Department of Transportation (Statewide-Level position)
- Roger Frantz, Utah Department of Transportation (Shop-level position)
- Ron Wright, Idaho Department of Transportation (Chemical Expert)
- Benjie Schoenrock, Vari-Tech Industries (Equipment Expert)
- Kurt Briggs, City of Prior Lake, Minnesota (Non-Technical Advocate)

Each of these candidates expressed interest in participating in this project, and we conducted and filmed interviews with them from June to September 2017.

## Interview Filming

Prior to filming the interviews, we worked with the TAC to create a list of interview questions for each category of candidate. We utilized the results of our survey of practice to draft interview questions that would provide useful and effective answers from our candidates. The survey results also showed us how some agencies have different definitions of liquid-only methods, such as anti-icing versus pre-treatment. With each set of interview questions, we included the following definitions:


*Interview with Non-Technical Advocate*

- **Anti-Icing:** A proactive treatment (sometimes called pretreatment) that involves the application of a liquid treatment prior to the onset of a snow event that prevents snow and ice from bonding to the road surface.
- **De-Icing:** A reactive treatment for melting existing snow and ice from a surface, either as a treatment by itself, or to aid in mechanical removal.
- **Direct Liquid Application (DLA):** The use of liquid-only treatments during and after a storm event for de-icing.
- **Liquid-Only Plow Routes:** A plow route on which only liquid treatments are used for anti-icing and de-icing when weather conditions fall within an appropriate range

We identified one set of baseline questions that would be asked to all candidates, regardless of their assigned category:

**Baseline Questions for All Interview Candidates:**

1. How would you define liquid-only roadway treatments?
2. How do liquid treatments work differently from solid treatments?
3. What are the benefits of using liquid-only treatments for anti-icing and de-icing?
4. In your experience, is the liquid de-icing process more effective than using solids? And if so, in what ways?
5. What are the cost differences between using liquids and solids?
6. What advice would you give to an agency that is considering starting a liquid-only program?
7. What misconceptions regarding liquid-only treatments are you aware of?
8. What environmental concerns or benefits regarding liquid-only treatments are you aware of?
9. Is there anything else regarding the use of liquid only treatments that I have not addressed?
10. What are the drawbacks in using solid deicers and abrasives?

We also had a second set of questions for each candidate that was specific to their area of expertise:

**Questions Specifically for Statewide-Level Position:**

1. What are the different types of liquid treatments and how do they differ?

2. What types of storage equipment is needed for liquid-only treatments?
3. What types of truck equipment and transfer equipment is needed?
4. For brine making, what are the differences between different brine makers?
5. What brine chemical composition and mix ratio is optimal?
6. What types of additives are available and what do they do?
7. When and why did your agency start using liquid-only treatments?
8. Are the roads on your liquid-only route rural or urban? High volume or low volume?
9. How do you determine what type of road is appropriate for liquid only treatment?
10. What is your timing for beginning treatment based on storm events and temperature?
11. What application rates are you using and how does that change based on temperature and intensity of the event? Are there other factors that influence application rates?
12. What is the bare lane recovery time difference between liquids and solids after the storm has stopped?
13. How does liquid-only treatments affect cycle time and route planning?
14. What is the public perception of liquid-only treatments in your area?
15. Do liquid-only treatments work in extreme weather conditions such as heavy snow, freezing rain, high winds, and extreme cold?
16. What obstacles have you encountered through your liquid-only program and how did you overcome them?
17. How do you stay informed on current research on roadway treatments?

**Questions Specifically for Shop-Level Position:**

1. What are the different types of liquid treatments and how do they differ?
2. What are the cost differences between using liquids and solids?
3. What types of storage equipment is needed for liquid-only treatments?
4. What types of truck equipment and transfer equipment is needed?
5. What kind of water connections and pumps are needed?
6. How can a new agency incorporate liquid-only equipment into their shop?
7. What kind of maintenance is required on this equipment?
8. How should a facility calibrate and test their equipment?
9. For brine making, what are the differences between different brine makers?
10. How do you ensure that your shop isn't leaking brine into the environment?
11. What brine chemical composition and mix ratio is optimal?
12. What types of additives are available and what do they do?
13. What is your timing for beginning treatment based on storm events and temperature?
14. What application rates are you using and how does that change based on temperature and intensity of the event? Are there other factors that influence application rates?
15. What is the bare lane recovery time difference between liquids and solids after the storm has stopped?
16. How do liquid-only treatments affect cycle time and route planning?
17. What is the public perception of liquid-only treatments in your area?

18. Do liquid-only treatments work in extreme weather conditions such as heavy snow, freezing rain, high winds, and extreme cold?
19. What obstacles have you encountered through your liquid-only program and how did you overcome them?
20. How do you stay informed on current research on roadway treatments?

**Questions for Chemical Expert:**

1. What are the different types of liquid treatments and how do they differ?
2. How do the different liquid-only treatments work at a chemical level?
3. What are the optimal temperature ranges for liquid-only treatments?
4. What brine chemical composition and mix ratio is optimal, and why?
5. What types of additives are available and what do they do?
6. Do liquid-only chemicals cause ice packs?
7. Do liquid-only chemicals reduce the amount of chlorides going into the environment?
8. What are the cost differences between using liquids and solids?
9. What types of storage equipment is needed for liquid-only chemicals?
10. How does your agency test liquid-only chemicals?
11. How should an agency determine which chemicals are right for them?

**Questions for Equipment Expert:**

1. What types of storage equipment is needed for liquid-only treatments?
2. What types of truck equipment and transfer equipment is needed?
3. What are the different options for spraying the liquids onto the roadway?
4. What are the different options for on-vehicle storage?
5. What are the different options for facility storage?
6. What kind of water connections and pumps are needed?
7. How can a new agency incorporate liquid-only equipment into their shop?
8. What kind of maintenance is required on this equipment?
9. How should a facility calibrate and test their equipment?
10. For brine making, what are the differences between different brine makers?
11. What brine chemical composition and mix ratio is optimal?
12. What types of additives are available and what do they do?
13. How should an agency determine which equipment is right for them?
14. How do you prepare your equipment for summer after winter operations are complete?

**Questions for Non-Technical Advocate Position:**

1. What is the public perception of liquid-only treatment in your area?
2. How have you communicated the benefits of liquid-only treatments to the public and to policy makers?
3. How does safety factor into liquid-only roadway treatments?
4. How do you weigh the pros and cons of liquid-only treatments?

5. How can someone advocate for liquid-only treatments at their agency?
6. How should an agency determine if a liquid-only program is right for them?

We conducted most of the interviews in the vicinity of the candidate's local maintenance garage or yard, as we typically filmed action footage at each location as well (described in next section). The interviews were set in a variety of backgrounds in order to add visual interest to the final video.

## Action Footage Filming

Action footage (also called b-roll footage) is used during voiceover segments of the video, and also during interviews to show certain equipment or processes based on the interview content. There is a wide variety of liquid-only plowing equipment available from different vendors. Our filming plan included multiple locations in order to capture these different types of equipment in our footage. We worked with the TAC and our interview candidates to select the following locations:

- Minnesota Department of Transportation: Chaska Shop
- Minnesota Department of Transportation: Mankato Shop
- City of Prior Lake, Minnesota, Shop
- Utah Department of Transportation: Parley's Canyon Shop
- Monroe Trucking: Monroe, Wisconsin
- Vari-Tech Industries: Alexandria, Minnesota

At these locations we filmed brine makers, hose connections, pumps, spray bars, nozzles, storage tanks, truck tanks, and other applicable equipment. In addition, we visited the Idaho Department of Transportation Central Lab during our interview with Ron Wright. At this location we filmed their testing procedures and equipment.

Additional footage was sent to us from the following agencies for use in the video:

- Delaware Department of Transportation
- Ohio Department of Transportation
- City of St. Louis Park, Minnesota

## Video Production

Prior to beginning production on this video, we discussed the potential video audiences with the TAC. Similar to the Quick Reference Guides, the video would have two main objectives:

1. Inform agency decision makers and the general public about the benefits of liquid-only roadway treatments while dispelling common myths
2. Provide practical guidance for practitioners and for agencies looking to start a liquid-only program

With these objectives in mind, instead of creating only one video, we created two videos for two different audiences:

- A shorter video for agency decision makers and the general public that discussed the benefits of liquid-only treatments while addressing common myths
- A full length video for practitioners that included the information from the short video, but also included tips for starting a liquid-only program, discussion of equipment types, and recommended usage parameters and application rates


The shorter video is more appropriate for social media distribution and sharing, while the longer video is more useful for agency staff training and cross agency communication.

The final videos were edited using Adobe Premiere Pro and included voiceover narration, background music, transitions, interviews, and equipment footage. The videos were formatted in high resolution 1080p and submitted in WMV format, which is one of YouTube's preferred file formats. We included transcription files for closed captioning which were W3C and ADA compliant. We also provided suggested YouTube titles, descriptions, and search tags, in order expand the potential reach of these videos.

The final videos are available to view on YouTube through the following links:

- **Short Version:** https://www.youtube.com/watch?v=4cTmhl_nN8c
- **Full Version:** https://www.youtube.com/watch?v=Xd9xs0lKIGg

## Conclusion

The main goal of this project was to help agencies garner support for the implementation of liquid-only roadway treatments through a set of promotional and informational tools. These tools can help agency staff put the right message in front of the right audience in a compelling and useful way. The literature search report serves as a resource for recent research on liquid-only roadway treatments. The survey of practice provides a current and comprehensive "state of the industry" summary on various agencies using these types of treatments. The quick reference guides offer useful summaries and parameters for gaining buy-in and for technical applications. And the two videos serve as modern communication tools for reaching a wider audience and showing them how public works agencies across the United States are using liquid-only treatments due to their ease of use, low costs, and fast response times.

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# Appendix A

- Literature Search Report

## Literature Search: Liquid-Only Plow Routes

| Agency | Title | Author | Date | Hyperlink to summary (click to jump) |
|---|---|---|---|---|
| **Clear Roads** | Liquid-only diet | Brian Hirt | September 2011 | Jump |
| **Clear Roads** | Quick Reference Guide During-Storm Direct Liquid Applications (DLA) | EVS, Inc. | September 2010 | Jump |
| **Salt Institute** | Snowfighter's Handbook A Practical Guide for Snow and Ice Control | Salt Institute | 2013 | Jump |
| **MnDOT** | Anti-Icing Guide | MnDOT | September 2010 | Jump |
| **Clear Roads/MnDOT** | Establishing Effective Salt and Anti-icing Application Rates | Blackburn and Associates | September 2014 | Jump |
| **Minnesota LTAP** | Field Handbook for Snowplow Operators Second Revision | Minnesota Local Road Research Board | October 2012 | Jump |
| **Snow & Ice forum / Kent County Road Commission** | Anti-Icing | Tom Byle | February 2000 | Jump |
| **Snow & Ice forum** | Salt Brine | Various | May 2007 | Jump |
| **Dept. of Civil Engineering, University of Iowa** | Developing a "Top Ten List" for Winter 1 Highway Maintenance | Wilfrid A. Nixon | 2015 | Jump |
| **MnDOT** | State Best Practice Report – Fall 2015 | Tom Peters | Fall 2015 | Jump |
| **Alaska DOT** | Winter Maintenance Best Practices in Alaska | Dennis Bishop | Fall 2015 | Jump |
| **FHWA** | Freezing-point of Chemical Solutions | FHWA | June 1996 | Jump |
| **AFM Engineering Services** | Basic Concepts of Snow and Ice Control | Duance Amsler | April 2005 | Jump |
| **FHWA** | Manual of Practice for An Effective Anti-Icing Program - A Guide for Highway Winter Maintenance Personnel | FHWA | June 1996 | Jump |
| **Alaska DOT** | Anti Icing 101 | Alaska DOT | March 2005 | Jump |
| **FHWA** | Anti Icing for Maintenance Personnel | FHWA | Fall 1996 | Jump |
| **Saint Louis Park, MN** | Anti Icing Roads | Saint Louis Park, MN | March 2016 | Jump |

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| Agency | Clear Roads |
|---|---|
| **Title** | Liquid-only diet |
| **Link** | http://clearroads.org/wp-content/uploads/dlm_uploads/09-02_WisDOT-0092-10-18-Liquid-only-diet-Article-Roads-and-Bridges.pdf |
| **Author** | Brian Hirt |
| **Date** | September 2011 |
| **Summary** | This article in short discusses timely application of liquids "During Storm Events"<br>- Pavement Temperature<br>- Storm Intensity<br>- Moisture Content<br>- Cycle Times |

**Timely application of liquids for During-Storm Direct Liquid Application (DLA)**

Pavement Temperature

- Above 25F – Most Favorable
- Below 20F – Less Appropriate

Storm Intensity

- Below 1 in/h – Good
- Below ½ in – Most Effective

Moisture Content

- 10:1 (Snow:Liquid) ordinary condition – Most Favorable
- Wetter snow dilute deicing liquids that can refreeze

Cycle Times

- Vary depending on locations
- 1.5 to 2 hours is the preferred cycle time

Note

If Brine is applied at 32F and temperature rapidly drops to 20F after the liquid dilutes, chances are high to form ice-rink

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| Agency | Clear Roads |
|---|---|
| **Title** | Quick Reference Guide During-Storm Direct Liquid Applications (DLA) |
| **Link** | http://clearroads.org/wp-content/uploads/dlm_uploads/09-02_WisDOT-0092-10-18-Quick-Reference-Guide.pdf |
| **Author** | EVS, Inc. |
| **Date** | September 2010 |
| **Summary** | This source discusses "During Storm Events"<br>- Application Rates<br>- Direct Liquid Application (DLA Guidance Chart)<br>- Equipment |

**Application Rates during storm**

- Example of during storm DLA rates for NaCL Brine

Gallons Per Lane Mile (gplm)
*Pounds Per Lane Mile (pplm) shown in parentheses*

| | Pavement Temperature | | | |
|---|---|---|---|---|
| Event Type | 32-30°F | 29-27°F | 26-24°F | 23-21°F |
| **For 2-Hour (or less) Cycle Times** | | | | |
| Light Snow (less than 0.5"/hour) | 20 (45) | 35 (80) | 40 (91) | 55 (125) |
| Medium Snow[1] (0.5"/hour to 1.0"/hour) | 35 (80) | 45 (102) | 55 (125) | NR |
| **For 3-Hour Cycle Time[3]** | | | | |
| Light Snow (less than 0.5"/hour) | 35 (80) | 50 (114) | 65 (148) | 80 (182) |
| Medium Snow[1] (0.5"/hour to 1.0"/hour) | 50 (114) | 65 (148) | 80 (182) | NR |

- Low speed city roads are a good place to start or try during-storm DLA
- DLA can be especially effective at the end (last plow pass) of a lighter storm

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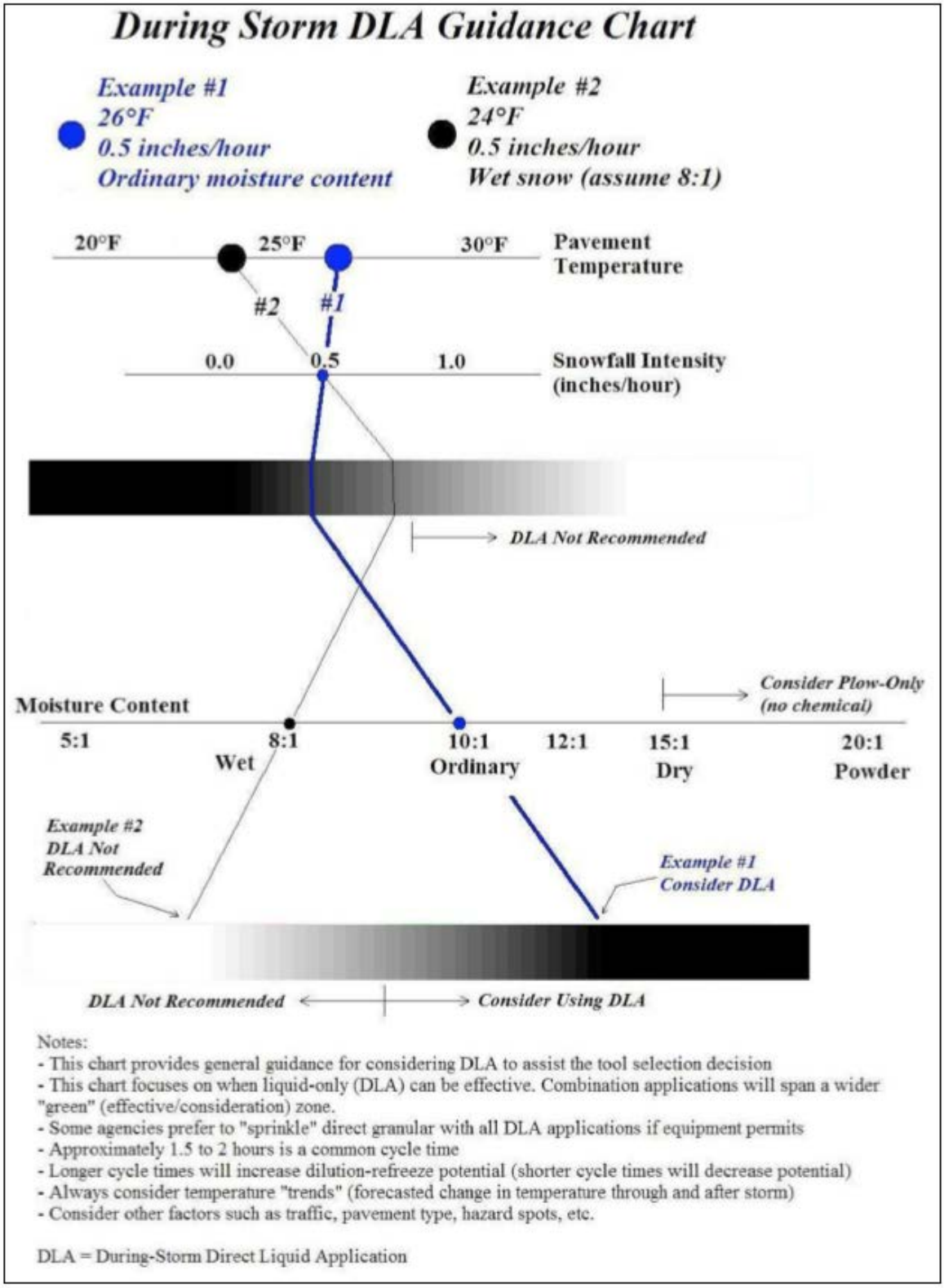
**During Storm DLA Guidance Chart**




Notes:
- This chart provides general guidance for considering DLA to assist the tool selection decision
- This chart focuses on when liquid-only (DLA) can be effective. Combination applications will span a wider "green" (effective/consideration) zone.
- Some agencies prefer to "sprinkle" direct granular with all DLA applications if equipment permits
- Approximately 1.5 to 2 hours is a common cycle time
- Longer cycle times will increase dilution-refreeze potential (shorter cycle times will decrease potential)
- Always consider temperature "trends" (forecasted change in temperature through and after storm)
- Consider other factors such as traffic, pavement type, hazard spots, etc.

DLA = During-Storm Direct Liquid Application

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**Equipment during Storm DLA Guidance Chart**

<table>
<tr><th>Equipment</th><th colspan="2">Tips</th></tr>
<tr><td rowspan="2">Applicator Loading Pump[1]</td><td colspan="2">• Chemical pump<br>• Ensure it is designed for a specific gravity of approximately 1.5 (not a water pump)<br>• Minimum 2” port (larger preferred)<br>• As short of discharge hose length as possible<br>• Consider applicator tank inflow line size<br>• Consider storage tank outflow lines and valve sizes to match pump capacity<br>• Design loading setup to be user-friendly</td></tr>
<tr><td><u>Minimum</u><br>• 2” port<br>• 140 gpm max<br>• 110 gpm @ 20 psi<br>• $1,500</td><td><u>Preferred</u><br>• Larger than 2” port<br>• 300 gpm max<br>• 275 gpm @ 20 psi<br>• $2,500</td></tr>
<tr><td>Applicator Discharge Pump and Plumbing</td><td colspan="2">During Storm DLA typically requires higher application rates than pre-storm anti-icing. Therefore, consider larger pumps (capacity). Actual size will depend on applicator spread width (number of lanes), etc. In one case, an agency suggested 370 gpm pumps over 210 gpm</td></tr>
<tr><td>Retrofitting/building liquid applicator trailers</td><td colspan="2">Do not use electric brakes (ie convert to air brakes).</td></tr>
</table>

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| Agency | Salt Institute |
|---|---|
| **Title** | Snowfighter's Handbook<br>A Practical Guide for Snow and Ice Control |
| **Link** | http://www.saltinstitute.org/wp-content/uploads/2013/07/Snowfighters_HB_2012.pdf |
| **Author** | Salt Institute |
| **Date** | 2013 |
| **Summary** | This source discusses the following:<br>- Advantages of Anti-icing with brine<br>- Commonly used Anti-Icing products<br>- How to measure and manufacture salt brine<br>- Equipment for salt brine<br>- Phase diagram for salt brine<br>- Decision making tool for choosing the right salt for anti-icing purpose<br>- Equipment for anti-icing and de-icing |

**Anti-Icing with Brine**

Advantages

- Returns road surfaces to normal faster
- Reduce airborne dust and salt particulates
- Applying brine jumpstarts melting process
- The salt residue may remain and help if a future storm occurs
- Less work for snowfighters as the storm progresses

Commonly used anti-icing products

- Sodium Chloride, Calcium Chloride, Magnesium Cloride, Potassium Acetite, Calcium Magnesium Acetate
- Sodium Chloride - most commonly used which is effective to -6F
- Other products are "more than six times" expensive than salt
- Calcium and Magnesium Chloride leave residue on road surfaces that can attract moisture at lower relative humidity than salt resulting in slippery conditions

Salt Brine Manufacture

- Mixture of rock salt or solar salt with water
- Proper brine mixture is 23.3% salt concentration by weight
- 23.3% - concentration at which salt brine has the lowest freezing point at -6F
- Eutectic Point – The point at which the solution achieves maximum salt concentration. (-6F for water)
- Adding more salt decreases the solubility of salt

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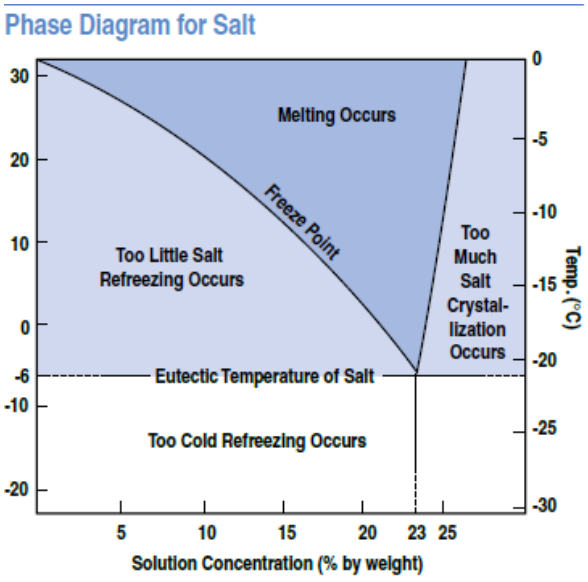
- The percentage of salt is measured with salometer.

| Hydrometer/Salometer Chart for Salt Brine | | |
|---|---|---|
| % Salt | Hydrometer Specific Gravity | Salometer Using 0-100% |
| 0 | 1.000 | 0 |
| 1 | 1.007 | 4 |
| 2 | 1.014 | 7 |
| 3 | 1.021 | 11 |
| 4 | 1.028 | 15 |
| 5 | 1.036 | 19 |
| 6 | 1.043 | 22 |
| 7 | 1.051 | 26 |
| 8 | 1.059 | 30 |
| 9 | 1.067 | 33 |
| 10 | 1.074 | 37 |
| 11 | 1.082 | 41 |
| 12 | 1.089 | 44 |
| 13 | 1.097 | 48 |
| 14 | 1.104 | 52 |
| 15 | 1.112 | 56 |
| 16 | 1.119 | 59 |
| 17 | 1.127 | 63 |
| 18 | 1.135 | 67 |
| 19 | 1.143 | 70 |
| 20 | 1.152 | 74 |
| 21 | 1.159 | 78 |
| 22 | 1.168 | 81 |
| 23 | 1.176 | 85 |
| 24 | 1.184 | 89 |
| 25 | 1.193 | 93 |
| 26 | 1.201 | 96 |
| 27 | - | 100 |

Equipment

- Applicators available for about $1,500
- Some agencies manufacture their own application equipment using water tanks and PVC pipe

Phase Diagram for Salt



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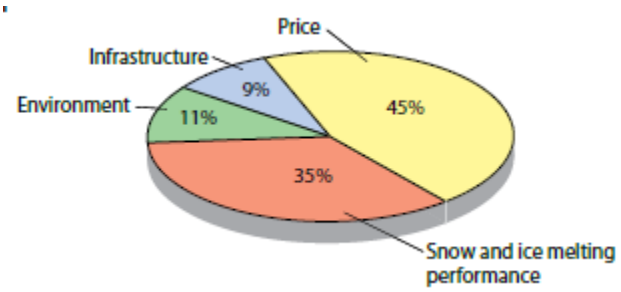
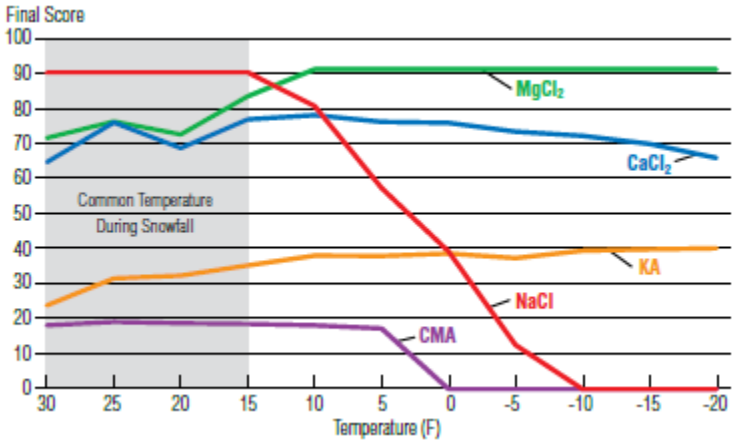
**Decision Making tools**

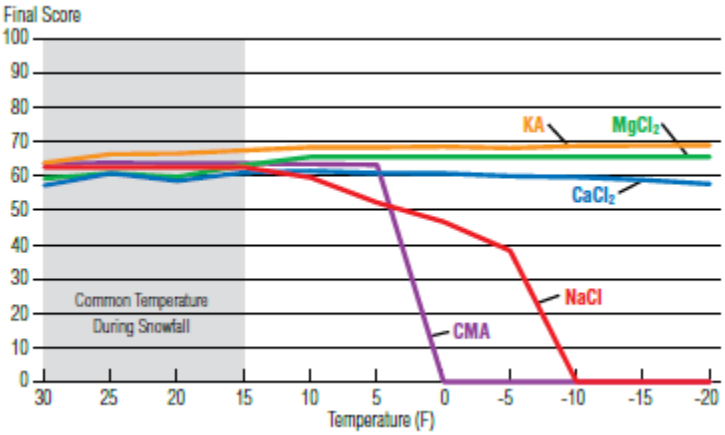
- A computer program that can be downloaded from TRB website to determine what material to use based on agency's priority

Cost Priority model




Environment/Infrastructure Model



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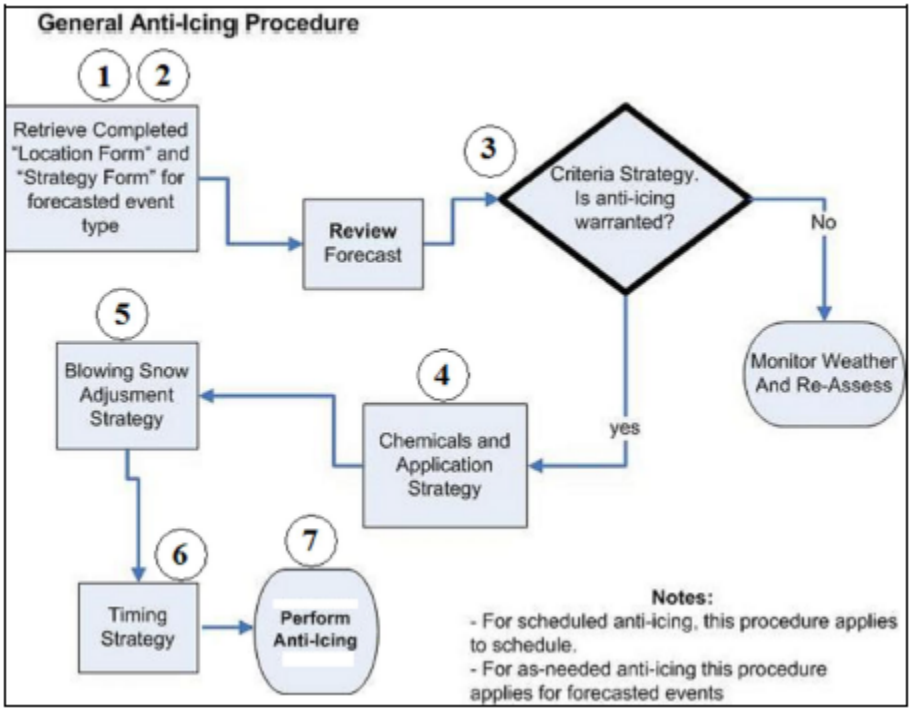
| Agency | MnDOT |
|---|---|
| **Title** | Anti-Icing Guide |
| **Link** | http://www.dot.state.mn.us/maintenance/pdf/research/AntiIcingGuide8Full.pdf |
| **Author** | MnDOT |
| **Date** | September 2010 |
| **Summary** | This source shares the following guidance:<br>- Procedure/chart for finding potential locations for anti-icing<br>- Chemical types, pros and cons, concentration, effective temperatures<br>- Calculation for determining suitable application rate and chart showing application rate for both single and multiple lane roads.<br>- Different types of equipment used (with pictures and description) in different districts of Minnesota. |

**Identifying Locations for Anti-Icing**



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| | Step | Procedure |
|---|---|---|
| 1 | Retrieve Forms | Utilize your completed "**Locations Form**" and "**Strategy Form**" for relevant event type. (See pages 16 and 17) |
| 2 | Schedule/Timing | If scheduled anti-icing, review schedule to know which days(s) to consider anti-icing. |
| 3 | Criteria (Is anti-icing warranted?) | Compare forecasted conditions with your criteria to determine if anti-icing is warranted. If so, continue. |
| 4 | Chemicals and Application | Using forecasted conditions, select chemicals and determine application rates and approach |
| 5 | Blowing Snow | Determine if blowing snow is expected at any "Open" anti-icing locations. If so, adjust application approach as needed. |
| 6 | Timing | Determine desired timing relative to start of event. |
| 7 | Perform Anti-Icing | Conduct anti-icing at target at selected timing. |

## Chemical Types

| Type | Examples | Adhere[5] | Suggested Min[1] (°F) | Practical Min[1] (°F) | Benefits | Cautions |
|---|---|---|---|---|---|---|
| Basic | NaCl Salt Brine | No[5] | 20° | 15° | - Handles a high percentage of storm events over a typical season<br>- Shorter road adherence, which can benefit areas prone to blowing snow | - Quality control (23.3% NaCl solution)<br>- If no precipitation will "dry up" and blow off roadway |
| Adhering (Sticky) | LCS[2,4] | Yes | 15° | 10° | Can adhere to roadway for multiple days if no precipitation | Ensure concentration is correct (10% corn syrup, 90% NaCl) |
| Depressed Freezing Point | Blends[3] | No | 10° | 0° | - More Effective at temperatures below 15°F | - Consider dilution[1], it is suggested to use 0°F as a general practical minimum |
| Adhering (Sticky) and Depressed Freezing Point | MgCl2, CaCl2, Blends[3,4] | Yes | 10° | 0° | - More Effective at temperatures below 15°F<br>- Can adhere to roadway for multiple days if no precipitation | - Do not apply if pavement temperature is above 32°F<br>- Consider dilution, it is suggested to use 0°F as a general practical minimum<br>- Blending $MgCl_2$ with salt brine has been reported to be problematic |

Notes

1) Minimum forecasted pavement temperature (during or after event). Always consider dilution and refreeze potential. The "suggested" value is the temperature (at or above) where all experts agree that the chemical is effective. The "practical" value is the temperature (at or above) where some experts have found the chemical effective when considering other factors.
2) Organic chemicals like LCS (liquid corn salt) do provide some freezing point depression as indicated on the chart
3) To achieve lowered freezing point down to 0°F, a blend should have at least 10% of $MgCl_2$ or $CaCl_2$. This is 10% of these products in solution; (respective solutions concentrations shown in tables below).
4) To achieve the "adhering" property, a blend should have at least 10% of organic (corn syrup, beet juice, molasses, etc). There are new blends that are strictly $CaCl_2$ solution with NaCl without the organic. It has not yet been determined at what concentration these provide the "adhering" property.
5) Even basic chemicals without the "adhere" property have proven to be effective for multiple days (i.e. over weekends) in some conditions. However, the conditions must be relatively calm (protected), with relatively low traffic volumes and speeds. Your experience will also help determine how long chemicals will remain effective on the roadway under different conditions.
6) Also see page 50 "Glossary"

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Anti-Icing Chemical Concentrations and Practical Effective Temperatures

| Chemical | Practical/Effective Minimum | Eutectic Freezing Point (Lab Only) | Concentration |
|---|---|---|---|
| NaCl | 15°F (20°F desired) | -6°F (-21°C) | 23.3% |
| LCS | 10°F (15°F desired) | | 10% Liquid Corn and 90% NaCl |
| $MgCl_2$ | 0°F (10°F desired) | -28°F (-33°C) | 21.6% |
| $CaCl_2$ | 0°F (10°F desired) | -60°F (-51°C) | 29.8% |
| CMA | 20°F | -17°F (-27°C) | 32.5% |
| KAc (Potassium Acetate) | 0°F | -76°F (-60°C) | 49% |
| (add more chemicals below) | | | |
| | | | |
| | | | |
| | | | |

**Notes:**
- Concentrations shown above are with water unless otherwise noted (ie 23.3% dry NaCl and 76.7% water)
- LCS is mixed with salt brine and not water
- Pavement temperatures should be considered before, during and after the event
- Consider multi-day forecast
- When NaCl is part of mix, the NaCl concentration should always be 23.3%
- Note that these temperatures may vary based on other field conditions
- Also see page 50 "Glossary" in Appendix for chemical abbreviations

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**Application Rate**

## Determining Actual Application Rate Quick Form

| Anti-Icing Unit Description | *Sample, 800 gallon capacity, slide in, gravity feed* | |
|---|---|---|
| Anti-Icing Unit Speed | **30 MPH** | |
| Place collection bucket(s) below discharge nozzles | | |
| Start timer and fill buckets (T) | **2 minutes** | |
| Determine volume[1] (V) | **15 gallons** | If weighing buckets, see "Conversion Tips" below |
| Calculate flow rate (V/T) | **7.5 gpm** | |
| Look up application rate[2] using flow rate (gpm) and vehicle speed (MPH) | **15 gplm** | Also see page 47 ("Application Rate Lookup Table") |
| | | |
| Notes:<br>1. CAUTION - Never lift more weight than the maximum weight allowed by your governing safety regulations.<br>2. gplm = gallons/lane-mile | | |

Conversion Tips

Pounds per gallon (water) = 8.34 pounds/gallon
Pounds per gallon (salt brine) = 10.26 pounds/gallon (15°C / 59°F)

So, for 125 pounds of water
Volume = 125 / 8.34 = 15 gallons

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Application Rate Lookup Table (gallons/mile)

| | | Liquid Flow Rate (Gallons Per Minute - gpm) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 5 | 7.5 | 10 | 12.5 | 15 | 17.5 | 20 | 22.5 |
| Truck Vehicle Speed (MPH) | 5 | 60.0 | 90.0 | 120.0 | 150.0 | 180.0 | 210.0 | 240.0 | 270.0 |
| | 10 | 30.0 | 45.0 | 60.0 | 75.0 | 90.0 | 105.0 | 120.0 | 135.0 |
| | 15 | 20.0 | 30.0 | 40.0 | 50.0 | 60.0 | 70.0 | 80.0 | 90.0 |
| | 20 | 15.0 | 22.5 | 30.0 | 37.5 | 45.0 | 52.5 | 60.0 | 67.5 |
| | 25 | 12.0 | 18.0 | 24.0 | 30.0 | 36.0 | 42.0 | 48.0 | 54.0 |
| | 30 | 10.0 | 15.0 | 20.0 | 25.0 | 30.0 | 35.0 | 40.0 | 45.0 |
| | 35 | 8.6 | 12.9 | 17.1 | 21.4 | 25.7 | 30.0 | 34.3 | 38.6 |
| | 40 | 7.5 | 11.3 | 15.0 | 18.8 | 22.5 | 26.3 | 30.0 | 33.7 |
| | 45 | 6.7 | 10.0 | 13.3 | 16.7 | 20.0 | 23.3 | 26.7 | 30.0 |
| | 50 | 6.0 | 9.0 | 12.0 | 15.0 | 18.0 | 21.0 | 24.0 | 27.0 |
| | 55 | 5.5 | 8.2 | 10.9 | 13.6 | 16.4 | 19.1 | 21.8 | 24.5 |

Note: If applying liquid on more than one lane your application rate will be reduced, divide by number of lanes. You may need to consider a second pass to maintain desired application rate.

Sample Calculation

10 gpm @ 30 MPH

(10 gallons/minute) * (60 minutes/hour) * (1 hour / 30 miles) = 20 gallons/mile

note: 'minute' and 'hour' cancel out; leaving us with gallons/mile

*This value (20 gallons/mile) can also be obtained in chart above:

Using 30 MPH (side) and 10 gpm (top) to obtain 20 gallons/mile

Determining rate when applying liquid onto multiple lanes

Sample using 20 gallons/mile from above

| Number of Lanes | Application rate (gallons/mile) | Application rate Adjusted to Lanes (gallons/lane-mile) |
|---|---|---|
| 1 | 20 | 20 |
| 2 | 20 | 20/2 = 10 |
| 3 | 20 | 20/3 = 6.7 |

## EQUIPMENT

It is suggested that the application unit should be:

- Solid stream nozzles
- Bar height of 12-14 inches
- Nozzle spacing of approximately 10 inches
- For higher operating speeds and/or with high winds (i.e. 15 MPH or more), consider extension tubes that reach closer to the road surface (although some have found that extension tubes can slightly reduce application pressure).

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- If wind speeds are too excessive (ie 15 MPH is commonly used) you may decide not to anti-ice as it may not be effective.

Liquid anti-icing operations are most effective with an application unit operating speed of 20 MPH to 30 MPH. Some experts have designed “shields” allowing higher operating speeds. Also see page 23 “Examples of Approximate Liquid Anti-Icing Coverage” for example anti-icing units.
If applying with a vehicle speed of greater than 30 MPH, it is suggested that special considerations should be given to the liquid nozzle configuration such as rubber tubing extensions, shields, etc.

| | |
|---|---|
|  | Combination Unit<br>District 1<br>Liquid Anti-Icing (1,000 gallon)<br>Snow plow with wing and underbody<br>Early warning device for road maintenance |
|  | Anti-Icing Unit on ¾ Ton Pickup<br>District 6<br>250-350 gallon |
|  | Designated Anti-Icing Unit<br>District 6<br>900-1,000 gallon |
|  | Tanker<br>Districts 6, 7, and Metro<br>4,500-5,500 gallon |

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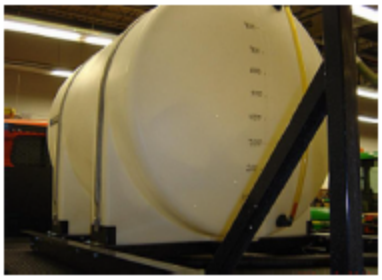
| | |
|---|---|
|  | Combination unit<br>District 4, District 8, Metro District<br>Custom-made anti-icing bar hooked up to pre-wet tanks (apply liquid and/or granular)<br>100-200 gallon |
|  | Slide-In Anti-Icing Tank<br>Metro District<br>800 gallon |
|  | Anti-Icing Unit<br>District 1<br>325 gallon |
|  | Anti-Icing Bar<br>Preferred height above ground = 12 inches<br>(adjust height if needed for truck configuration)<br>Optional Nozzle Hose Extensions |
|  | Anti-Icing<br>Nozzle Hose Extensions |

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| Agency | Clear Roads/MnDOT |
|---|---|
| **Title** | Establishing Effective Salt and Anti-icing Application Rates |
| **Link** | http://clearroads.org/wp-content/uploads/dlm_uploads/Summary-Report-of-Task-2-Findings.pdf |
| **Author** | Blackburn and Associates |
| **Date** | September 2014 |
| **Summary** | This source has information on<br>- Application rates for different brine solutions<br>- Survey results from 14 chemical manufacturing companies<br>- Survey results from winter maintenance experts from 19 state DOTs, 6 Canadian provinces and 6 local highway agencies. Questions include 1-General information, 2-Operational Consideration, 3-Application Rate Category, and 4-Evaluation Results |

**Application Rates for other various brine solution**

Table 1: Application rates for various brine solution expected to give the same freezing point depression as NaCl

| Pavement Temperature °F | Solid NaCl, lb/LM | 23% NaCl liquid, gal/LM | Solid 90-92% $CaCl_2$, lb/LM | 32% $CaCl_2$ liquid, gal/LM | Solid 100% $MgCl_2$, lbs/LM | 27% $MgCl_2$ liquid, gal/LM | Solid 100% Kac, lb/LM | 50% Kac liquid, gal/LM | Solid 96% CMA, lb/LM | 25% CMA liquid, gal/LM |
|---|---|---|---|---|---|---|---|---|---|---|
| 31-32 | 100 | 44 | 110 | 31 | 90 | 32 | 168 | 32 | 170 | 18 |
| 26-30 | 100 | 44 | 110 | 31 | 90 | 32 | 168 | 32 | 170 | 18 |
| 21-25 | 100 | 44 | 110 | 31 | 93 | 33 | 154 | 29 | 160 | 17 |
| 16-20 | 100 | 44 | 107 | 30 | 88 | 32 | 140 | 26 | 150 | 16 |
| 11-15 | 100 | 44 | 103 | 29 | 85 | 30 | 130 | 24 | 150 | 16 |
| 6-10 | 100 | 44 | 103 | 29 | 83 | 29 | 130 | 24 | 140 | 15 |
| Below 5 | | | | | | | | | | |

LM- Lane-mile

**Environmental Challenges**

- Potassium acetate (KAc) and calcium magnesium acetate (CMA) have already been mentioned as non-halide chemicals for winter maintenance operations.
- Both substances induce very little corrosion in metal as compared to NaCl, KCl, and CaCl2.

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| Agency | Minnesota LTAP |
|---|---|
| **Title** | Field Handbook for Snowplow Operators Second Revision |
| **Link** | http://www.mnltap.umn.edu/publications/handbooks/documents/snowice.pdf |
| **Author** | Minnesota Local Road Research Board (LRRB) |
| **Date** | Oct 2012 |
| **Summary** | This source discusses<br>• The best practices and limitations for snow and ice control<br>• When to use the tools and practices such as anti-icing, prewetting and pretreating<br>• Environmental tips<br>• Application rate guidelines<br>• Chemical melting temperatures |

## Anti-icing Application Rate Guidelines

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

| Condition | Gallons/Lane Mile | | | Other Products |
|---|---|---|---|---|
| | $CaCl_2$ | $MgCl_2$ | Salt Brine | |
| 1. Regularly scheduled applications | 15 – 25 | 15 – 25 | 20 – 40 | Follow manufacturers' recommendations. |
| 2. Prior to frost or black ice event | 15 – 25 | 15 – 25 | 20 – 40 | |
| 3. Prior to light or moderate snow | 15 – 25 | 15 – 25 | 20 – 50 | |

## Pounds of Ice Melted Per Pound of Salt

| Pavement Temp. °F | One Pound of Salt (NaCl) melts | Melt Times |
|---|---|---|
| 30 | 46.3 lbs of ice | 5 min. |
| 25 | 14.4 lbs of ice | 10 min. |
| 20 | 8.6 lbs of ice | 20 min. |
| 15 | 6.3 lbs of ice | 1 hour |
| 10 | 4.9 lbs of ice | Dry salt is ineffective and will blow away before it melts anything. |
| 5 | 4.1 lbs of ice | |
| 0 | 3.7 lbs of ice | |
| -6 | 3.2 lbs of ice | |

At temps below 15 degrees, it may be more cost-effective to use a chemical other than NaCl.

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| Agency | Snow & Ice forum, Kent County Road Commission |
|---|---|
| **Title** | Anti-Icing |
| **Link** | http://sicop.transportation.org/Documents/Anti-Icing%2c2-4-00.pdf |
| **Author** | Tom Byle, Engineer for Maintenance and local road construction |
| **Date** | Feb, 2000 |
| **Summary** | In this forum chain, a user discusses the chemicals and quantity he uses for anti-icing and the humidity issues he faces.<br>- The Kent County highway department used 32% liquid calcium chloride LiquidDOW Armor for anti icing liquid. They used it because it was for pre-wetting, readily available and good for temperature below 20F. Skid test was performed and Armor was found to have higher coefficient of friction than LiquidDOW. Anti-Icing was done on 200 lane miles of both urban arterial and freeway with ADTS up to 100,000. Application rate of 15 was used. The user didn't encounter issues with low humidity. Their concerns were about high humidity that resulted in ice-rink during middle of the night and early morning despite pavement and air temperatures were under 25F.<br>- A reply from Forensic Synamics Inc. shared similar opinion and based on their research suggested to be careful in low humidity range (below 32% for cal) and in the extreme upper range |

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| Agency | Snow & Ice forum |
|---|---|
| **Title** | Salt Brine |
| **Link** | http://sicop.transportation.org/Documents/SALTBRINEList-servethread4-2007.pdf |
| **Author** | Various users |
| **Date** | May, 2007 |
| **Summary** | In this forum chain, the users discuss their experience on hearing about vehicle brake jobs as a result of using salt brine on roads.<br>- A regional car dealership in Municipality of Peel in Southern Ontario shared that use of salt brine causes more brake jobs on vehicles.<br>- Many were not in favor of the claim but one affirmed discussing that a test in UK proved that salt brine in 20% more aggressive than dry salt and being supported by work that many leading European car producers are carrying out.<br>- Users also discusses about corrosion issues using different chemicals. |

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| Agency | Dept. of Civil Engineering, University of Iowa |
|---|---|
| **Title** | Developing a "Top Ten List" for Winter 1 Highway Maintenance |
| **Link** | http://sicop.transportation.org/Documents/2015%20NWM%20Peer%20Exchange/Developing%20a%20top%20ten%20list.pdf<br><br>http://sicop.transportation.org/Documents/2015%20NWM%20Peer%20Exchange/Presentations/top-10%20survey.pdf |
| **Author** | Wilfrid A. Nixon |
| **Date** | 2015 |
| **Summary** | This research paper summarizes the result of 85 respondents who took the survey on topics in the area of:<br>- Materials, Sustainability and the Environment<br>- Weather and Information<br>- Equipment<br>- Operation & Tactics<br>- Strategies, Public Relations and Training |

**TABLE 3 Most Frequently Selected Ideas from the WMTSP Steering Committee Members**

| Category | Topic | Votes |
|---|---|---|
| Chemicals | Liquid blends | 5 |
| Decision Support | RWIS data (the standard suite of instruments, plus, camera image and pavement grip) | 4 |
| Equipment | Plough & blade technology | 5 |
| Innovation | Technology transfer | 4 |
| Management | Adequate funding for operations and sustainability | 5 |
| Management | Performance measurement (measuring the ability to achieve prescribed levels of service) | 4 |
| Media Relations | Media relations (public and political relations) | 5 |
| Policy | -Defined levels of service (necessary for performance measurement) | 4 |
| Strategy | Maintenance facility design, operation and maintenance (safe and efficient traffic flow, proper storage facilities, indoor operations where possible, good housekeeping practices, drainage management, vehicle washing and wash water runoff management) | 6 |
| Tactics | Anti-icing and cold region | 4 |
| Tactics | Drift control and snow fence. | 5 |
| Tactics | Effective use of liquid de-icers (pre-wetting and anti-icing together) | 4 |
| Technology | AVL and automatic data collection from maintenance vehicles about ongoing activities | 6 |
| Technology | Measurements of residual road salt | 4 |
| Workforce | Staff training | 4 |
| Workforce | Trained and experienced decision makers | 4 |
| Workforce | Trained and experienced operatives/drivers | 4 |

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| Agency | MnDOT |
|---|---|
| **Title** | State Best Practice Report – Fall 2015 |
| **Link** | http://sicop.transportation.org/Documents/2015%20NWM%20Peer%20Exchange/Presentations/SBPR_MN_Peters.pdf |
| **Author** | Tom Peters |
| **Date** | Fall 2015 |
| **Summary** | This PowerPoint shares 2014-2015 winter maintenance report at a glance. |

- 2014-2015 Total Winter Maintenance Costs - $87.9 Million
- Frequency in Achieving Bare Lanes - 87%
- Statewide Average Snowfall – 39.4 inches
- Lane miles- 30,546
- Snowplow trucks- 839 plow trucks
- Full-time (Priority 1) Drivers- 1514
- Backup (Priority 2) Drivers – 297
- Number of Garages – 148
- 2014-2015 average price of salt per ton - $74.36
- Total salt used this past season- 174,000 tons
- Total sand used this past season- 40,000 tons
- Total Salt Brine used this past season – 2.2 million gallons
- Types of liquids used- Salt Brine, Magnesium Chloride, Calcium Chloride, Potassium Acetate , Liquid Corn Salt

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| Agency | Alaska DOT |
|---|---|
| **Title** | Winter Maintenance Best Practices in Alaska |
| **Link** | http://sicop.transportation.org/Documents/2015%20NWM%20Peer%20Exchange/Presentations/SBPR_AK_Coffey.pdf |
| **Author** | Dennis Bishop, Tok District Superintendent |
| **Date** | Fall 2015 |
| **Summary** | This PowerPoint discusses the smart technology vehicles Alaska DOT implements. It includes smart features and operations with pictures. |

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| Agency | FHWA |
|---|---|
| **Title** | Freezing-point of Chemical Solutions |
| **Link** | https://www.fhwa.dot.gov/publications/research/safety/95202/005.cfm |
| **Author** | FHWA |
| **Date** | June 1996 |
| **Summary** | This source provides a phase diagram of five chemical/brine solutions used in anti-icing |

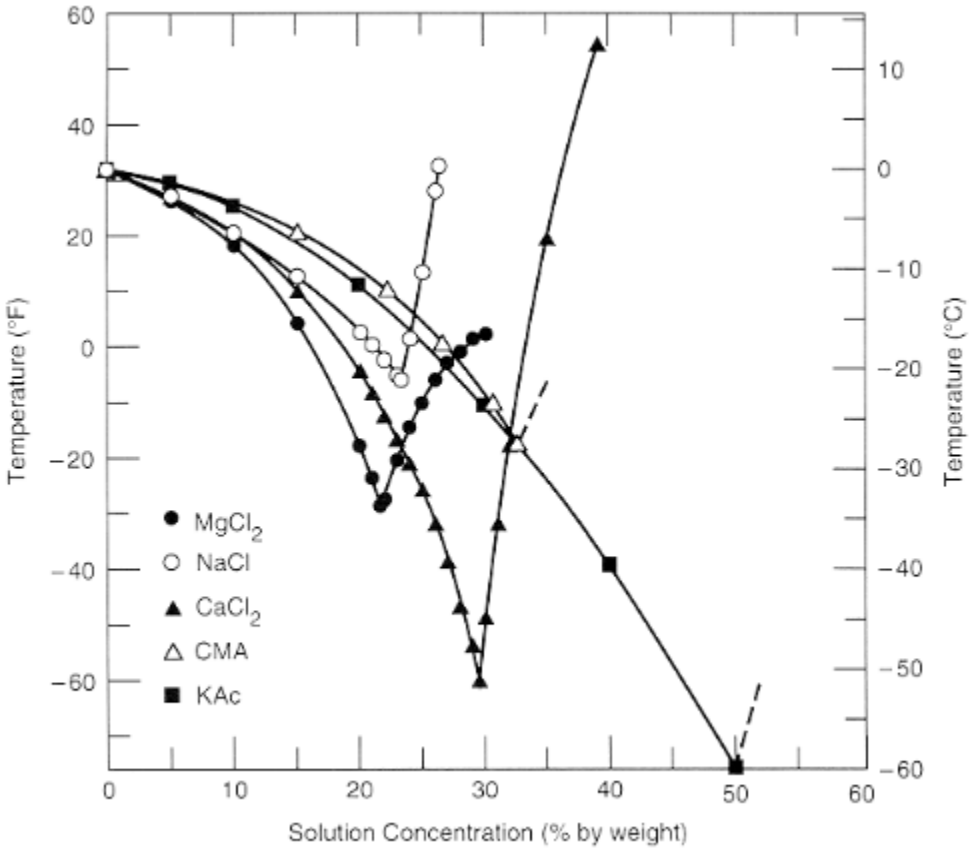


**Figure 17. Phase diagrams of five chemical solutions.**

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| Agency | AFM Engineering Services |
|---|---|
| **Title** | Basic Concepts of Snow and Ice Control |
| **Link** | http://www2.apwa.net/documents/Meetings/Snow/2005/Handouts/1584.pdf |
| **Author** | Duance E. Amsler |
| **Date** | April 2005 |
| **Summary** | This report briefly discusses and identifies key issues that agencies responsible for winter maintenance should address in their snow and ice control plans and operations.<br>- Discusses advantages and disadvantages of solid, liquid, combination and abrasives for combating winter storm maintenance.<br>- Snow and ice control strategies<br>- Guidelines for applying snow and ice control materials<br>- Application technologies for ice control chemicals for different lanes, multi lane highways, parking areas and walkways, bridges, curves, hills etc<br>- Snow plowing strategy |

**TABLE 2 DISCHARGE RATE AND APPLICATION RATE**

| Discharge Rate | Application Rate, kilograms per lane kilometer Number of Lanes Being Treated | | |
|---|---|---|---|
| (kilograms/kilometer) | 1 | 2 | 3 |
| 28 (100) | 28 (100) | 14 ( 50) | 9 ( 33) |
| 56 (200) | 56 (200) | 28 (100) | 19 ( 67) |
| 84 (300) | 84 (300) | 42 (150) | 28 (100) |
| 112 (400) | 112 (400) | 56 (200) | 37 (133) |
| 140 (500) | 140 (500) | 70 (250) | 47 (167) |
| 168 (600) | 168 (600) | 84 (300) | 56 (200) |
| 196 (700) | 196 (700) | 98 (350) | 65 (233) |
| 224 (800) | 224 (800) | 112 (400) | 75 (267) |
| (Pounds/Mile) | (Pounds per Lane Mile) | | |

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| Agency | FHWA |
|---|---|
| **Title** | Manual of Practice for An Effective Anti-Icing Program - A Guide for Highway Winter Maintenance Personnel |
| **Link** | https://www.fhwa.dot.gov/publications/research/safety/95202/index.cfm |
| **Author** | FHWA |
| **Date** | June 1996 |
| **Summary** | The manual is written to guide the maintenance manager in developing a systematic and efficient practice for maintaining roads in the best conditions possible during a winter storm |

**Table 2. Calcium chloride mixing proportions.**

| %$CaCl_2$ actual | Weight $CaCl_2$ 77% flake | | Crystallization | Weight per unit |
|---|---|---|---|---|
| | per volume solution kg/m³ (lb/gal) | per volume water kg/m³ (lb/gal) | temperature °C (°F) | volume of solution kg/m³ (lb/gal) |
| 10 | 139 (1.16) | 146 (1.22) | -5.4 (22.3) | 1085 (9.06) |
| 15 | 218 (1.82) | 238 (1.99) | -10.3 (13.5) | 1133 (9.46) |
| 20 | 303 (2.53) | 344 (2.87) | -18.0 (-0.4) | 1185 (9.89) |
| 25 | 397 (3.31) | 471 (3.93) | -29.4 (-21) | 1234 (10.3) |
| 29.8* | 491 (4.1) | 621 (5.18) | -55.0 (-67) | 1288 (10.75) |
| 30 | 498 (4.16) | 627 (5.23) | -46.0 (-50.8) | 1294 (10.8) |

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| Agency | Alaska DOT |
|---|---|
| **Title** | Anti Icing 101 |
| **Link** | https://www.youtube.com/watch?v=TL9dvD1hyEQ |
| **Author** | Alaska DOT |
| **Date** | March, 2005 |
| **Summary** | - Information about anti-icing<br>- Discusses anti-icing, de-icing and pre-wetting |

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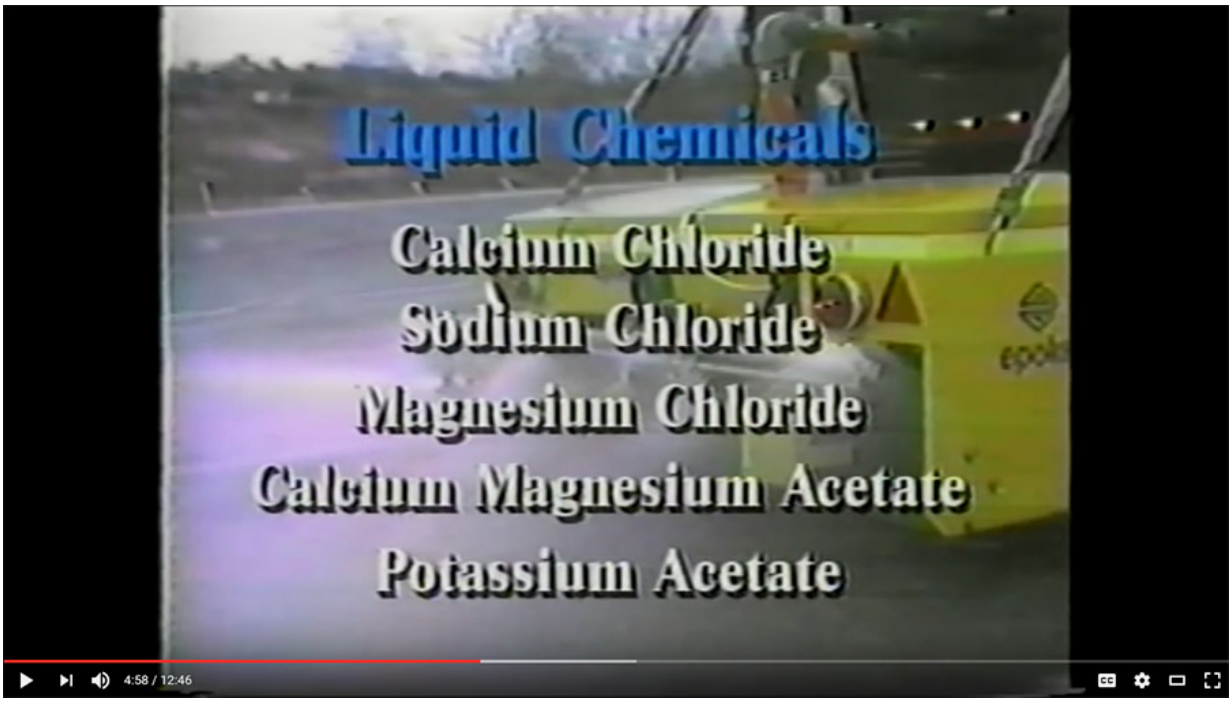
| Agency | FHWA |
|---|---|
| **Title** | Anti Icing for Maintenance Personnel |
| **Link** | https://www.youtube.com/watch?v=IjI0t19EUfY |
| **Author** | FHWA |
| **Date** | Fall 1996 |
| **Summary** | This video gives a quick introduction to these tools. It describes the action of sodium chloride in lowering freezing temperature, the importance of proper timing of chemical applications, selection of chemicals, calibration of spreaders, and application rate. Plowing, road weather information systems, and the importance of personnel training are also discussed |



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| Agency | Saint Louis Park, MN |
|---|---|
| **Title** | Anti Icing roads |
| **Link** | https://www.youtube.com/watch?v=Byfl7el33Ic |
| **Author** | Saint Louis Park |
| **Date** | March 2016 |
| **Summary** | This video informs road users what the stripes are on roads before storm, shows brine preparation, and application |

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## Appendix B

- Online Survey Results

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| Email Address | During certain weather conditions, does your agency have one or more liquid-only plow route(s) on which only anti-icing and/or de-icing liquids are used? | Why has your agency decided not to use liquid-only roadway treatments? | May we contact you via phone for additional information? | Name | Agency | Email | Phone |
|---|---|---|---|---|---|---|---|
| marcus.zimmerman@alaska.gov | Yes | | Yes | Casey Walker | Alaska DOT | casey.walker@alaska.gov | 907-465-1787 |
| lrobjent@co.carver.mn.us | Yes | | Yes | Michael Legg | Carver County, MN | Mlegg@co.carver.mn.us | 952-466-5241 |
| rmelchert@auburnhills.org | Yes | | Yes | Dan Brisson | City of Auburn Hills, MI | dbrisson@auburnhills.org | 248-391-3777 |
| jhurt@grcity.us | Yes | | Yes | James Hurt | City of Grand Rapids, MI | jhurt@grcity.us | 616-456-3312 |
| jgibson@waukee.org | Yes | | Yes | Dan Werts | City of Waukee, WI | dwerts@waukee.org | 515-987-4363 ext.7399 |
| Mike.McVaugh@state.co.us | Yes | | Yes | Mike McVaugh | Colorado DOT | mike.mcvaugh@state.co.us | 970-385-1402 |
| kyle.lester@state.co.us | Yes | | Yes | Kyle Lester | Colorado DOT | kyle.lester@state.co.us | 303-512-5218 |
| alastair.probert@state.de.us | Yes | | Yes | Alastair Probert | Delaware DOT | alastair.probert@state.de.us | 302-853-1300 |
| frank.w.sharpe@Illinois.gov | Yes | | Yes | Frank Sharpe | Illinois DOT | Frank.W.Sharpe@Illinois.gov | (217) 782-8419 |
| billyjoe.wilson@ks.gov | Yes | | Yes | Bill Wilson | Kansas DOT | billyjoe.wilson@ks.gov | 785-366-1054 |
| randy.kunc@ks.gov | Yes | | Yes | Randy W Kunc | Kansas DOT | randy.kunc@ks.gov | 785-479-6568 |
| ssauter@sha.state.md.us | Yes | | Yes | Scott Simons | Maryland State Highway Administration | ssimons@sha.state.md.us | 410-582-5566 |
| bassam.salfity@dot.state.ma.us | Yes | | Yes | Sam Salfity | MassDOT | bassam.salfity@dot.state.ma.us | 857-368-9671 |
| Jeff.Perkins@state.mn.us | Yes (MnDOT later clarified that they do not have a liquid-only program, only some anti-icing treatments) | | Yes | Jeff Perkins | Minnesota DOT | jeff.perkins@state.mn.us | 218-846-3628 |
| dmcbroom@mt.gov | Yes | | Yes | Douglas McBroom | Montana DOT | dmcbroom@mt.gov | 406.444.6157 |
| dhenderson@englewoodco.gov | Yes | | Yes | Mike Miller | Montana DOT | mikmiller@mt.gov | 406-444-6991 |
| patti.caswell@odot.state.or.us | Yes | | Yes | Patti Caswell | Oregon DOT | patti.caswell@odot.state.or.us | 503.986.3008 |
| daniel.varilek@state.sd.us | Yes | | Yes | Dan Varilek | South Dakota DOT | daniel.varilek@state.sd.us | 605-773-3571 |
| alexa@superiorcolorado.gov | Yes | | Yes | Alex Ariniello | Town of Superior, CO | alexa@superiorcolorado.gov | 303-499-3675 |
| bklenk@utah.gov | Yes | | Yes | Brandon Klenk | Utah DOT | bklenk@utah.gov | 801-965-4094 |
| Kgriffin@utah.gov | Yes | | Yes | Kevin Griffin | Utah DOT | kgriffin@utah.gov | 801-965-4120 |
| Rfrantz@utah.gov | Yes | | Yes | Roger Frantz | Utah DOT | rfrantz@utah.gov | 801-910-2340 |
| michael.sproul@dot.wi.gov | Yes | | Yes | Pete Chladil | Waukesha County DPW/Highway Operations | pchladil@waukeshacounty.gov | 262.548.7843 |
| rhope@whiteplainsny.gov | Yes | | No | | | | |
| pwd@livingstonmontana.org | Yes | | No | | | | |
| Dpage@utah.gov | Yes | | No | | | | |
| clay.adams@ks.gov | Yes | | No | | | | |
| highway@wiltonmaine.org | Yes | | No | | | | |
| robert.dunning@alaska.gov | Yes | | No | | | | |
| j.williams@manchester-vt.gov | Yes | | No | | | | |
| daniel.schacher@alaska.gov | No | We do, but our plow routes are so large and our weather so extreme that we do not designate entire routes as "liquid only". | Yes | Daniel Schacher | Alaska DOT | daniel.schacher@alaska.gov | 907-451-5276 |
| mtrennepohl@azdot.gov | No | We have three routes in the state that are moving toward liquid only routes. The current winter maintenance season is our second season in which we've primarily used liquid on these routes, but not exclusively | Yes | Mark Trennepohl | AZ DOT | mtrennepohl@azdot.gov | 602-712-7011 |
| cbyrd@co.benton.mn.us | No | Don't have the equipment. | Yes | Chris Byrd | Benton County | cbyrd@co.benton.mn.us | 3209685051 |

| Email Address | During certain weather conditions, does your agency have one or more liquid-only plow route(s) on which only anti-icing and/or de-icing liquids are used? | Why has your agency decided not to use liquid-only roadway treatments? | May we contact you via phone for additional information? | Name | Agency | Email | Phone |
|---|---|---|---|---|---|---|---|
| Ryan.Thilges@blueearthcountymn.gov | No | We pre-treat very high traffic level roads and intersections prior to storm events, but also follow up with sanding and salting efforts as needed | Yes | Ryan Thilges | Blue Earth County, MN | ryan.thilges@blueearthcountymn.go | 507-304-4025 |
| skubista@co.chippewa.mn.us | No | We do not have the set up (equipment) to do it. | Yes | Steve Kubista | Chippewa County, MN | skubista@co.chippewa.mn.us | 320-269-2151 |
| Novakcj@cityofcf.com | No | We anti-ice with liquid only, but during storms, our trucks are set up with both liquid and dry material. Dry material is needed on trucks with limited liquid capacity. | Yes | Charles Novak | City of Cuyahoga Falls | novakcj@cityofcf.com | 330-971-8030 |
| ceudy@farmgov.com | No | Lack of equipment | Yes | Charles Eudy | City of Farmington | ceudy@farmgov.com | 248/473-7250 |
| jsheldon@greenwoodvillage.com | No | Political reason not to pre-treat roadways, so we do not keep a lot of liquid material. | Yes | Jeremy Hanak | City of Greenwood Village | jhanak@greenwoodvillage.com | 13037086100 |
| john.decastro@ct.gov | No | Right now we are looking into it and how it will be implemented. More research on our end is needed. Also we need to look into the equipment needs. | Yes | John DeCastro | CTDOT | john.decastro@ct.gov | 860-594-2614 |
| Thomas.greve@state.de.us | No | I personally don't have any experience with liquid only roadway treatments. | Yes | Tom Greve | DelDOT | Thomas.Greve@state.de.us | 302-760-2412 |
| anne.brown@state.de.us | No | We do not have a designated liquid only route. all routes are liquid and granular. | Yes | Anne Brown | DelDOT | anne.brown@state.de.us | 302-740-4183 |
| guy.kohlnhofer@co.dodge.mn.us | No | cost of additional equipment and material. | Yes | Guy Kohlnhofer | Dodge County, MN | guy.kohlnhofer@co.dodge.mn.us | (507) 635-6332 |
| tracey.vonbargen@co.grant.mn.us | No | We are just starting to use chloride and taking small steps into the implementation of different strategies for snow and ice control | Yes | Tracey Von Bargen | Grant County Highway Department | tracey.vonbargen@co.grant.mn.us | 218-685-8301 |
| james.grube@hennepin.us | No | Capacity of liquid plow trucks. Very cold weather can freeze up. | Yes | Andy Kraemer | Hennepin County, MN | andrew.kraemer@hennepin.us | 612 506-0280 |

| Email Address | During certain weather conditions, does your agency have one or more liquid-only plow route(s) on which only anti-icing and/or de-icing liquids are used? | Why has your agency decided not to use liquid-only roadway treatments? | May we contact you via phone for additional information? | Name | Agency | Email | Phone |
|---|---|---|---|---|---|---|---|
| brian.burne@maine.gov | No | The majority of the storms we get require solid applications during the storm. The few that could be treated in that manner would not justify the expense to gear up for that approach. | Yes | Brian Burne | MaineDOT | brian.burne@maine.gov | 207-624-3571 |
| paul.brown@state.ma.us | No | The technology and methods have not been available till the last few years. We have not identified the proper application yet. | Yes | Paul Brown | MassDOT | Paul.Brown@state.ma.us | 413-637-5719 |
| sue.lodahl@state.mn.us | No | Our approach has been to use liquid treatments either before a winter event or onto the surface of packed snow/ice. We have placed a high priority on improving our application practices though the utilization of new technologies and continual training along with increasing the accuracy of the actual recorded applications on both an event and seasonal basis. | Yes | Tom Peters | MnDOT | tpete1959@msn.com | 651-366-3578 |
| Chris.Kufner@state.mn.us | No | Rock Salt is still the best way to achieve our goals | Yes | Jay Emerson | MnDOT | jay.emerson@state.mn.us | 651/234-7907 |
| jed.falgren@state.mn.us | No | We don't have any routes that are "only" anything. Different weather situations and timing affect what tools we might use. In some situations, only liquids may be used on a given roadway. | Yes | Jed Falgren | MnDOT | jed.falgren@state.mn.us | 507-304-6104 |
| michael.lashmet@dot.ny.gov | No | We use salt as primary anti-icing chemical. Liquids mostly used for pre-storm anti-icing operations; and for pre-wetting salt. | Yes | Michael Lashmet | NYSDOT | michael.lashmet@dot.ny.gov | 518-457-5796 |
| Larry.Helscel@dot.ohio.gov | No | Most of the time we start out with rain then turns to snow and we don't have the storage capacity to support that large of an operation | Yes | Daniel Nartker | ODOT | daniel.nartker@dot.state.oh.us | 740-774-9017 |

| Email Address | During certain weather conditions, does your agency have one or more liquid-only plow route(s) on which only anti-icing and/or de-icing liquids are used? | Why has your agency decided not to use liquid-only roadway treatments? | May we contact you via phone for additional information? | Name | Agency | Email | Phone |
|---|---|---|---|---|---|---|---|
| bieniek.kaye@co.olmsted.mn.us | No | We have not went to liquid only because if the road refreeze it nice to have some sand or salt down for traction because the trucks cover 50 mile each route. It takes awhile to get around there routes. | Yes | Chad Schuman | Olmsted County, MN | schuman.chad@co.olmsted.mn.us | 507-328-7188 |
| mark.sehr@co.rock.mn.us | No | Funding and Staff Size | Yes | Mark R. Sehr, PE | Rock County, MN | mark.sehr@co.rock.mn.us | 507-283-5010 |
| Todd.Hanley@Alaska.Gov | No | We don't have enough equipment or brine to go liquid only. We are slowing building up our resources and using more liquid but not liquid only. | Yes | Todd Hanley | State of Alaska DOT&PF | todd.hanley@alaska.gov | 907-269-5613 |
| andrew.sander@co.swift.mn.us | No | Sand Salt only no tanks on the trucks. Lower traffic volumes allow us to work with the sand, salt blend rather than liquid. | Yes | Andy Sander | Swift County | andy.sander@co.swift.mn.us | (320) 842-5251 |
| trolland@somersct.gov | No | Do not use any liquids | Yes | Todd Rolland | Town of Somers DPW | trolland@somersct.gov | 860-763-8238 |
| drfortier@windhammaine.us | No | we user calcium chloride liquid with rock salt | Yes | Doug Fortier | Town of Windham | drfortier@windhammaine.us | 207-892-1909 |
| allen.williams@vdot.virginia.gov | No | Have not moved to that treatment option yet. We are looking at potential of a few routes. | Yes | Allen Williams | VDOT | allen.williams@vdot.virginia.gov | 540-387-5346 |
| todd.law@vermont.gov | No | We use a great deal of salt brine and "additive", but still use solid salt to ensure we maintain a salt residual, as our temperatures typically stay cold for long periods of time. | Yes | Todd Law | Vermont DOT | todd.law@vermont.gov | 802-839-0274 |
| Tammy.Ellis@vermont.gov | No | We mainly use liquids to pre-treat roads (in limited areas) but mostly use it to pre-wet salt as it is applied to the roadway. We are not equipped to apply liquid only. | Yes | Tammy J. Ellis | Vermont DOT | tammy.ellis@vermont.gov | 8022965568 |
| morinj@wsdot.wa.gov | No | We believe that there are multiple tools to use given certain weather conditions. We're not convinced that liquid is always appropriate. | Yes | James Morin | WA State DOT | morinj@wsdot.wa.gov | 360-705-7803 |

| Email Address | During certain weather conditions, does your agency have one or more liquid-only plow route(s) on which only anti-icing and/or de-icing liquids are used? | Why has your agency decided not to use liquid-only roadway treatments? | May we contact you via phone for additional information? | Name | Agency | Email | Phone |
|---|---|---|---|---|---|---|---|
| jeff.m.pifer@wv.gov | No | No buy in from upper management, yet... | Yes | Jeff Pifer | WVDOH | jeff.m.pifer@wv.gov | 304-677-9839 |
| cliff.spoonemore@wyo.gov | No | Wyoming is an aggregate state with high elevations and strong winds. | Yes | Clifford Spoonemore | WYDOT | cliff.spoonemore@wyo.gov | 3077776377 |
| Nathan.White@raymondmaine.org | No | Cost | No | | | | |
| tdrath@co.winona.mn.us | No | Don't feel that our terrain & wind conditions will allow for liquid only routes. | No | | | | |
| doug.fischer@co.anoka.mn.us | No | We find that the best practice is to use a combination of liquid chemical, mechanical removal and solid chemicals works best for our situation. | No | | | | |
| Phil.Zoppi@ct.gov | No | Not Sure | No | | | | |
| steveb@co.morrison.mn.us | No | do not have the equipment | No | | | | |
| joevitalijr@madison-heights.org | No | Not enough experience using this practice. Concerns about liability too. | No | | | | |
| Doug.Hoevet@Nebraska.gov | No | Variances in roadway geometry (hills), route distances, refilling station locations, etc. may require different treatment combinations. | No | | | | |
| jeffrey.doerning@alaska.gov | No | Have not had this opportunity. | No | | | | |
| publicworks@town.exeter.ri.us | No | money | No | | | | |
| publicworks@broomfield.org | No | Refreeze | No | | | | |
| tknepper@cityofjackson.org | No | We have not found that to be the correct response for the operation. | No | | | | |
| dstahurski@fedheights.org | No | Do not have room for the facilities needed. | No | | | | |
| dan.sauve@co.clearwater.mn.us | No | Cost and complexity. Plus we find in northern Minnesota salt/sand mix works just find at a reduced price on low volume county roads. We are not MnDOT. Law restricts salt use. | No | | | | |
| kzawacki@waterfordct.org | No | Expense, unfamiliar | No | | | | |
| twebb@ellington-ct.gov | No | start up costs | No | | | | |
| Tim.stahl@co.jackson.mn.us | No | need sand for traction on hills and curves | No | | | | |

| Email Address | During certain weather conditions, does your agency have one or more liquid-only plow route(s) on which only anti-icing and/or de-icing liquids are used? | Why has your agency decided not to use liquid-only roadway treatments? | May we contact you via phone for additional information? | Name | Agency | Email | Phone |
|---|---|---|---|---|---|---|---|
| bill.pirkl@state.mn.us | No | Extreme cold temps in our district. Concern of creating slippery conditions. | No | | | | |
| jonfleming@pa.gov | No | Trucks are specs , are for dry Salt with pre-wetting system | No | | | | |
| Mitch.Blackford@dot.ohio.gov | No | dont have capacity ( fleet count) with liquid only trucks. Our trucks plow multiple routes. | No | | | | |
| timb@co.sibley.mn.us | No | Do not have the equipment or storage. | No | | | | |
| jbivins@cityofinkster.com | No | Cost and equipment storage etc | No | | | | |
| JKtripl@co.chisago.mn.us | No | funding at this point. | No | | | | |
| lesley.jones@augustamaine.gov | No | Do not have equipment set up for liquids only. | No | | | | |
| pwdept@vermontel.net | No | | No | | | | |
| rburch@cityofchubbuck.us | No | | No | | | | |
| loren.fellbaum@co.todd.mn.us | No | | No | | | | |
| jim.willis@cityoffortmorgan.com | No | | No | | | | |
| dpwrequest@nashuanh.gov | No | | No | | | | |
| steven.lund@state.mn.us | No | | No | | | | |

## Appendix C

- Phone Interview Logs

# Liquid-Only Plow Routes Phone Interview Log

**Recipient:**

Casey Walker Alaska DOT casey.walker@alaska.gov 907-465-1787

1. **When and why did your agency start using liquid-only treatments?**

Casey is the supervisor of the Juneau Station in the Southcoast District of the Alaska DOT. Their shop began experimenting with brine roadway treatments in 2012 after reading about the positive experiences of other DOTs. They started a liquid only route in 2014 after their initial tests were successful.

2. **Are the roads on your liquid-only route rural or urban? High volume or low volume?**

The liquid-only route is a high volume highway that is a mix of urban and rural settings.

3. **How do you determine what type of road is appropriate for liquid only treatment?**

They selected their liquid-only route because it had to be cleared quickly in the event of the storm due to it being a major collector. It is also a bus route with many stops.

4. **What is your timing for beginning treatment based on storm events and temperature?**

Their shop receives hourly NOAA weather forecasts. They also have probes that measure pavement temperature in 8 locations through the Road Weather Information System (RWIS). Casey uses this information to determine when to pretreat before a storm. In his location, they pretreat 1-3 hours before a storm. They can't typically pretreat earlier than that due to high humidity. Occasionally when the humidity is low, they will pretreat the night before a storm

5. **What application rates are you using and how does that change based on temperature and intensity of the event? Are there other factors that influence application rates?**

They run their truck at 60 gallons per lane mile no matter the temperature or storm event.

6. **What brine chemical composition and mix ratio are you using?**

Casey has two different mix ratios that he uses depending on pavement temperature. The mixture for temperatures above 25 degrees is 95% brine and 5% mag chloride. The mixture for temperatures below 25 degrees is 90% brine and 10% mag chloride.

7. **Do you make your own brine? If so, how many gallons/hour can you generate and what make and model of brine maker do you own? And what size of water line feeds your brine maker?**

Casey's ship uses a Brine Extreme by Henderson. They used to use an ice slicer, but they had to clean it every few hours. They use solar salts, and now they only have to clean the new brine maker once per season. It will make 3,000 gallons per hour. They use a 2.5" water line.

8. **What type of equipment are you using on your trucks to apply the liquid-only treatments?**

They have a 4,000 gallon tanker with a spray bar with 4 nozzles and a side sprayer. This truck is an older model, and they are considering upgrading to a newer truck next winter.

9. **What is your off-site storage tank capacity?**

They have four 10,000 gallon poly tanks. Brine is in 3 of the tanks and magnesium chloride is in the one. The mag chloride has an anti-corrosive additive.

10. **What is your route length and cycle time, and does this vary with liquid only vs traditional plow routes?**

The route length is 80 lane miles. The cycle time is 3.5 hours total, which includes 3 fill-ups. This cycle time is the same for them as traditional plow routes, but Casey attributes that to loading times (see question below).

11. **What is your typical loading time from the storage tank to the truck, and what kind of transfer equipment do you use?**

They use an electric pump with a 2.5" line to fill the tank. It takes 32 minutes. The mag chloride distributer recommended that they load half the brine first, then the mag chloride, and then the other half of the brine. The mag chloride is thicker and loads slower.

12. **What is your yearly gallons use on your liquid only routes?**

Their shop used 148,000 gallons in 2015, and 302,000 gallons last year. They increased the liquid-only route length last year.

13. **In your experience, is the liquid de-icing process more effective than using solids? And if so, in what ways?**

They are trying to cut down their use of sand substantially due to air quality concerns and clean-up costs. Casey estimates that the true cost of using sand is 8-10 times higher than the purchase price because of the extensive clean-up tasks. He likes using liquids because the results are almost instant and he can cover more ground when treating the roads than with solids. He says it is "the fastest, most efficient thing we do."

14. **Have you encountered situations where the liquid-only process was not effective, and how did you adjust to that situation?**

In his area it will frequently rain before a snow storm, which washes some of the pretreatment off. So the liquid-only process was not effective when they treated the roads too early. They adjusted it until they found that 1-3 hours before a storm is ideal.

**15. What is the public perception of liquid-only plowing in your area?**

The public perception is positive. Accident levels have dropped on the liquid-only route over the past 3 years. Two years ago the liquid-only truck broke down before a storm, and they had to use solids. The quality of service was noticeably lower, and they received many complaints. People wanted the liquid truck back.

**16. How have you communicated the benefits of liquid-only plowing to the public and to policy makers? And if so, in what ways?**

Casey doesn't hear anything at the policy-maker level. At the public level, Casey leaves the marketing to the DOT central office. He takes care of resident concerns at an individual level.

**17. Have you addressed any misconceptions and if so, how?**

There have been a few concerns raised over corrosion on vehicles, and Casey has addressed these concerns at a one-on-one level. He shows the residents the research from his distributor regarding the anti-corrosive additives that they use.

**18. How have you addressed environmental concerns?**

Casey has not had any environmental concerns addressed.

**19. Has your agency performed any formal research on liquid only vs traditional anti-icing and de-icing?**

They have not performed any formal research. Casey does ongoing testing in small doses. Last year he experimented with cutting through a dense 2" snow pack with liquids. He had the truck drive slowly and used rear sprayer. It burned through the pack, hit the asphalt, and made plowing much easier. It took a lot of liquid, but it worked well. He is going to experiment with that again using different mix ratios next winter.

**20. Is there anything else regarding the use of liquid only treatments that you encounter at your agency that I have not addressed?**

Casey is attending the US DOT Road Weather Management conference in Minneapolis from June 20-22$^{nd}$. He is hoping to learn new things about liquid-only plowing that he can apply at his shop.

## Liquid-Only Plow Routes Phone Interview Log

**Recipient:**

| | | | |
|---|---|---|---|
| Michael Legg | Carver County, MN | Mlegg@co.carver.mn.us | 952-466-5241 |

This candidate was non-responsive to voicemails and emails.

## Liquid-Only Plow Routes Phone Interview Log

**Recipient:**

| | | | |
|---|---|---|---|
| Mike McVaugh | CDOT | mike.mcvaugh@state.co.us | 970-385-1402 |

This candidate deferred to Kyle Lester at the Colorado DOT as a better source of information. Kyle's interview log is included in this document.

## Liquid-Only Plow Routes Phone Interview Log

**Recipient:**

| | | | |
|---|---|---|---|
| Dan Brisson | City of Auburn Hills | dbrisson@auburnhills.org | 248-391-3777 |

This candidate was doing extensive traveling during the weeks that these phone interviews took place, and was unable to find a time to complete a phone interview.

## Liquid-Only Plow Routes Phone Interview Log

**Recipient:**

| | | | |
|---|---|---|---|
| James Hurt | City of Grand Rapids, MI | jhurt@grcity.us | 616-456-3312 |

This candidate was non-responsive to voicemails and emails.

## Liquid-Only Plow Routes Phone Interview Log

**Recipient:**

| | | | |
|---|---|---|---|
| Dan Werts | City of Waukee, WI | dwerts@waukee.org | 515-987-4363 ext.7399 |

This candidate was non-responsive to voicemails and emails.

# Liquid-Only Plow Routes Phone Interview Log

**Recipient:**

Alastair Probert Delaware DOT alastair.probert@state.de.us 302-853-1300

1. **When and why did your agency start using liquid-only treatments?**

The Delaware DOT started their first liquid-only route 4 years ago. They were inspired by information and results that were shared at a Clear Roads Conference.

2. **Are the roads on your liquid-only route rural or urban? High volume or low volume?**

They started with rural, low volume roads to test the treatments and build their program. Since then they have moved up to high volume roads that include both urban and rural settings.

3. **How do you determine what type of road is appropriate for liquid only treatment?**

Once their program was sustainable, they never ever ruled out any particular roads.

4. **What is your timing for beginning treatment based on storm events and temperature?**

It varies based on the expected forecast and pavement temperature. They receive regular forecast updates, and the manager of each facility decides on the appropriate treatment timing.

5. **What application rates are you using and how does that change based on temperature and intensity of the event? Are there other factors that influence application rates?**

Originally they were applying the treatments at a rate of 50 gallons/lane mile. Over the past three years they have increased their usage to 80-100 gallons/lane mile depending on the type of storm. They have noticed that the higher application rates are more effective for both anti-icing, DLA, and de-icing.

6. **What brine chemical composition and mix ratio are you using?**

They are using brine at a 23.3% solution. They also mix in blue dye so that it is easier to see which areas have been treated. It has been termed “Smurf Juice” in their state.

7. **Do you make your own brine? If so, how many gallons/hour can you generate and what make and model of brine maker do you own? And what size of water line feeds your brine maker?**

They are using a Henderson Brine Extreme Ultimate at some of their facilities. They use a 3” water line and that brine maker can produce 12,000 gallons per hour. A few of their facilities have a Henderson Brine Extreme Pro which can produce 9,000 gallons per hour. They had to use solar salt in order to get that high of a production rate.

8. **What type of equipment are you using on your trucks to apply the liquid-only treatments?**

Most of their trucks have 1800 gallon sliding tanks with spray bars and side sprayers. They also have a few 6000 gallon tankers that can be used for spraying or transporting.

9. **What is your off-site storage tank capacity?**

The typical size at each facility is 6,000 gallons, but they have one 10,000 and one 20,000 gallon tank.

10. **What is your route length and cycle time, and does this vary with liquid only vs traditional plow routes?**

Their route lengths vary, but they try to keep their cycle times around 1.5 hours. Since switching to liquid-only treatments, their cycle times have been around 15 minutes shorter due to faster reloading.

11. **What is your typical loading time from the storage tank to the truck, and what kind of transfer equipment do you use?**

They use high speed electric pumps with a 3" line that can transfer 500 gallons/minute to the truck.

12. **What is your yearly gallons use on your liquid only routes?**

They use between 300,000 and 400,000 gallons per year.

13. **In your experience, is the liquid de-icing process more effective than using solids? And if so, in what ways?**

Alastair said that the liquids product faster results, the reload times are faster, and the application rate can be better controlled. These factors also made it easier to gain operator buy-in.

14. **Have you encountered situations where the liquid-only process was not effective, and how did you adjust to that situation?**

They found that liquids don't work as well during heavy periods of heavy snowfall. During those times they adjusted by using only plows, and following up with liquids after the heavy snowfall stopped.

15. **What is the public perception of liquid-only plowing in your area?**

The public only asked about the blue dye that was added to the brine. During one storm they ran out of blue dye, and just applied the brine without it. They received many comments from the public to bring back the "Smurf Juice" because it worked better. This shows that it is a perception issue, and that the public likes it.

16. **How have you communicated the benefits of liquid-only plowing to the public and to policy makers? And if so, in what ways?**

Their only communication with the public on a wide scale has been to explain the blue coloring, and through that communication, explain the benefits of brine. That was done through press releases and a few video interviews.

Alastair has not had to communicate the benefits to policy makers yet. He does send regular reports to the DOT central office on his liquid usage and results.

17. **Have you addressed any misconceptions and if so, how?**

Alastair has not had to address any misconceptions.

18. **How have you addressed environmental concerns?**

Alastair has not had to address any environmental concerns, but they are aware of the sensitivity of their watersheds, which has prevented them from using additives thus far.

19. **Has your agency performed any formal research on liquid only vs traditional anti-icing and de-icing?**

They have not performed any formal research.

20. **Is there anything else regarding the use of liquid only treatments that you encounter at your agency that I have not addressed?**

All of their watersheds flow into the Chesapeake Bay, so anything with phosphorus and nitrogen is a concern for them. They have been approached by suppliers with Magnesium Chloride products, but the products didn't meet their specifications for phosphorus and nitrogen, or far exceeded the cost of brine.

# Liquid-Only Plow Routes Phone Interview Log

**Recipient:**

Frank Sharpe Illinois DOT Frank.W.Sharpe@Illinois.gov (217) 782-8419

1. **When and why did your agency start using liquid-only treatments?**

Illinois started using liquid-only treatments on bridges 14 years ago. They started using these treatments on interstate highways 9 years ago.

2. **Are the roads on your liquid-only route rural or urban? High volume or low volume?**

The roads are rural and urban interstates, which are typically high volume.

3. **How do you determine what type of road is appropriate for liquid only treatment?**

They are not currently adding more roads into their liquid-only program – they are only treating interstate highways. So they do not have a system of determination outside of that classification.

4. **What is your timing for beginning treatment based on storm events and temperature?**

They pretreat the roads 24 hours before a storm event. Shops are provided with a state manual that lists application rates and timing, but the treatment specifics are determined by the shop supervisor. They typically do not use liquid-only treatments when the temperature drops below 20 degrees.

5. **What application rates are you using and how does that change based on temperature and intensity of the event? Are there other factors that influence application rates?**

They use a rate of 20-50 gallons per lane mile if the temperature is 29-32 degrees. If it is 20-28 degrees, they increase their rates to 30-60 gallons per lane mile.

6. **What brine chemical composition and mix ratio are you using?**

They used to use magnesium chloride, but they found that it was detrimental to the concrete used in their bridges. It caused expansion and premature cracking. So they switched to salt brine mixed at the standard ratio.

7. **Do you make your own brine? If so, how many gallons/hour can you generate and what make and model of brine maker do you own? And what size of water line feeds your brine maker?**

A few Illinois shops use 5000 gallon per hour brine makers by Henserson. Frank was not sure of the water line size. A few shops use brine makers that they make themselves, but Frank has not seen these in person.

8. **What type of equipment are you using on your trucks to apply the liquid-only treatments?**

Their equipment varies substantially from shop to shop. Some trucks which are dedicated to liquid-only treatments have a 5000 gallon tank with spray bars and side sprayers. Others use large weed spraying trucks that they converted to liquid-only trucks for the winter. They also have a few tanker trucks for longer routes.

9. **What is your off-site storage tank capacity?**

The average storage capacity is 7,500 – 10,000 gallons at each site, and almost all of these are poly tanks.

10. **What is your route length and cycle time, and does this vary with liquid only vs traditional plow routes?**

The average route length is 30-40 miles, with cycle times of 45 minutes to one hour. The trucks typically drive at 30 mph. Frank says this is the same speed for both liquids and solids.

11. **What is your typical loading time from the storage tank to the truck, and what kind of transfer equipment do you use?**

Frank wasn't sure about the specifics, and said it most likely was different at each shop.

12. **What is your yearly gallons use on your liquid only routes?**

They use just over 7 million gallons per year.

13. **In your experience, is the liquid de-icing process more effective than using solids? And if so, in what ways?**

Frank likes liquid-only treatments because they break the ice bonds quickly. Also it has cut their total salt usage by 30%.

14. **Have you encountered situations where the liquid-only process was not effective, and how did you adjust to that situation?**

Originally they were pretreating the roads 3 days prior to a storm event, and that was not effective for them. The treatment was worn off the roads by the time the storm started.

15. **What is the public perception of liquid-only plowing in your area?**

The public appreciates the drop in accident rates since they started using liquid-only treatments. Shops and the DOT social media pages get questions from residents on why they are spraying the roads when it's sunny outside. These questions are easily answered, and the public appreciates the proactive approach.

16. **How have you communicated the benefits of liquid-only plowing to the public and to policy makers? And if so, in what ways?**

Frank sends out a “winter is coming” campaign in October with information on winter driving and plowing, including liquid-only treatments. This campaign is sent through press releases, clips on news and radio shows, social media announcements, and is posted on the state website.

17. **Have you addressed any misconceptions and if so, how?**

There have been some concerns regarding corrosion on vehicles, but these have been addressed on a one-on-one basis.

18. **How have you addressed environmental concerns?**

people are concerned about the level of chlorides in the water supply, but the DOT has explained how less salts enter the water supply with liquid salt brine than with solid salts.

19. **Has your agency performed any formal research on liquid only vs traditional anti-icing and de-icing?**

They have not performed any formal testing. The watershed groups in the state do testing and sampling to see where chlorides are coming from and how to address them.

20. **Is there anything else regarding the use of liquid only treatments that you encounter at your agency that I have not addressed?**

They will be experimenting with adding beet juice to their salt brine next year in order to drop the freezing point.

# Liquid-Only Plow Routes Phone Interview Log

**Recipient:**

Bill Wilson KDOT Shop Supervisor billyjoe.wilson@ks.gov 785-366-1054

1. **When and why did your agency start using liquid-only treatments?**

Bill's district was the first one in Kentucky to use liquid-only treatments. He started 17 years ago in the winter of 1999 after research on the effectiveness of brine treatments came through KDOT.

2. **Are the roads on your liquid-only route rural or urban? High volume or low volume?**

One of his roads is a very high volume road, while the others are low volume. They are all rural.

3. **How do you determine what type of road is appropriate for liquid only treatment?**

He says that wind is a major factor. Some roads have no trees to block the wind, and it makes those roads more difficult to treat. Otherwise he believes that all roads are a good candidate for liquid-only treatments.

4. **What is your timing for beginning treatment based on storm events and temperature?**

They apply the liquid treatments during the day before the storm. He says the temperature drops too much at night, so they almost always have to treat the roads in the daytime. He doesn't use a chart or a database – he just goes by his own experience. The lowest temperature he uses liquid-only treatments at is 10 degrees.

5. **What application rates are you using and how does that change based on temperature and intensity of the event? Are there other factors that influence application rates?**

Bill uses an application rate of 50 gallons per lane mile. His trucks drive 35mph when applying the liquid-only treatments.

6. **What brine chemical composition and mix ratio are you using?**

He always uses a mix ratio of 23%. He does not use any additives.

7. **Do you make your own brine? If so, how many gallons/hour can you generate and what make and model of brine maker do you own? And what size of water line feeds your brine maker?**

His shop has a Ditmire Pro Brine Maker. He says it makes just over 5,000 gallons an hour with clean salt. After 10,000 gallons you have to open it up and clean the screen off. But he says this is a very quick process, and takes less than 5 minutes. He runs a 2" line into his brine maker.

8. **What type of equipment are you using on your trucks to apply the liquid-only treatments?**

All of his trucks use Henderson equipment. Each truck has 1600 gallon tanks. He is considering upgrading them to 2000 tanks once the budget allows for it. The trucks all use 2" lines as well.

9. **What is your off-site storage tank capacity?**

He has two 10,000 tanks at his shop. Next winter he is removing one of the tanks and transferring it to a different facility, and is getting a 20,000 gallon tank to replace it. So he will have a total storage capacity of 30,000 gallons.

10. **What is your route length and cycle time, and does this vary with liquid only vs traditional plow routes?**

His longest route is 37 miles, and his shortest is 17 miles. He couldn't remember the cycle times, but he said it is a lot faster than with solids, because he can run the trucks 10-15mph faster with the liquid-only treatments.

11. **What is your typical loading time from the storage tank to the truck, and what kind of transfer equipment do you use?**

It takes 15 minutes to load the 1600 gallon tank. He uses electric motors with 2" lines, but he can also suction directly from the trucks in case of a power failure, which has been an issue in the past during bad storms.

12. **What is your yearly gallons use on your liquid only routes?**

His shop averages 80,000 gallons per year. He has been using more brine as more storage space has become available. Kentucky uses approximately 1.8 million gallons per year.

13. **In your experience, is the liquid de-icing process more effective than using solids? And if so, in what ways?**

In his experience, using liquid-only treatments is much more effective than solids, and as long as the temperature and wind speed are within range, he will always use liquids. He likes how it sticks to the roads, and how it works a lot faster than solids.

14. **Have you encountered situations where the liquid-only process was not effective, and how did you adjust to that situation?**

He said that as long as they are using liquids at the right times for the right storms they have never had an issue.

15. **What is the public perception of liquid-only plowing in your area?**

The local residents have not raised any concerns. They appreciate that their roads are cleared faster than in other areas.

16. **How have you communicated the benefits of liquid-only plowing to the public and to policy makers? And if so, in what ways?**

Bill has not had to directly communicate anything about his liquid-only program to the public or to policy makers. He has worked with other areas in Kentucky to help them build up their own liquid-only programs. He said that some areas were using it when temperatures were too low, and then complained that it was ineffective. But he said that hasn't been as much of an issue the past 5 or 6 years, as the DOT has been very supportive on a statewide level.

17. **Have you addressed any misconceptions and if so, how?**

The only misconceptions were addressed in the previous question, regarding other areas claiming the liquid-only treatments were ineffective, but only because they were using them at temperature ranges which were too low.

18. **How have you addressed environmental concerns?**

Bill has not had to address any concerns, but he heard of other facility that had a leaky pump that leeched brine into a farmer's field, and it caused an issue. The state had to dig up the area and bring in new soil. He makes sure that nothing like that happens in his area.

19. **Has your agency performed any formal research on liquid only vs traditional anti-icing and de-icing?**

He has not done any research. They make adjustments as needed, but they don't do anything formally.

20. **Is there anything else regarding the use of liquid only treatments that you encounter at your agency that I have not addressed?**

He says that liquid-only treatments are great when the conditions are right, but it's just another tool in the tool box. The most important thing is knowing when to use it. For him it comes from experience, but for agencies that are just starting out, the guidelines from Clear Roads are a great starting point.

# Liquid-Only Plow Routes Phone Interview Log

**Recipient:**

Randy W Kunc KDOT Shop Surpervisor randy.kunc@ks.gov 785-479-6568

1. **When and why did your agency start using liquid-only treatments?**

Randy's district has been using liquid-only treatments for 7 years. Prior to that, the area supervisor didn't believe in the benefits of liquid treatments, and wasn't interested in trying them. But a new area supervisor was hired, began experimenting with brine solutions, and liked the benefits. The main reason for starting was the cost savings in salt versus brine.

2. **Are the roads on your liquid-only route rural or urban? High volume or low volume?**

Randy has 5 liquid-only routes, and they are all rural. One is a high volume road and the others are low volume. The only times solids are used is when the temperature drops below 8 degrees – when that happens, Randy uses a liquid treatment first, and then follows it with a solid treatment.

3. **How do you determine what type of road is appropriate for liquid only treatment?**

Randy believes that it is appropriate for all types of roads. He said that some agencies don't like to use it on high volume roads. But in his experience, it is easier to apply in the traffic of a high volume road than solids because the trucks can drive faster.

4. **What is your timing for beginning treatment based on storm events and temperature?**

The pretreatment time depends on the type of storm and the pavement temperature. If the wind speed is too high, they don't pretreat the road. Randy has a series of charts regarding temperature, road type, wind speed, and precipitation that help him determine when to begin treatment. The trucks have temperature gauges inside, just in case they need to adjust the treatments while they are on a route.

5. **What application rates are you using and how does that change based on temperature and intensity of the event? Are there other factors that influence application rates?**

Randy keeps the application rate at 50 gallons per lane mile no matter what the temperature and storm is. His trucks can spray up to 60 gallons per lane mile, but then they need to drive slower. They did not notice any benefits of changing their application rates, so they stay at 50.

6. **What brine chemical composition and mix ratio are you using?**

They are using a 23.3% brine solution.

7. **Do you make your own brine? If so, how many gallons/hour can you generate and what make and model of brine maker do you own? And what size of water line feeds your brine maker?**

Yes, Randy's shop has a Ditmire Pro Brine Maker. He can make 5200 gallons of brine per hour. They purchased this brine maker 4 years ago and have been very happy with it. He says it is important to have a brine maker that discharges from the bottom. He couldn't remember what their previous model was, but it was double stacked, and required extensive cleaning every 20,000 gallons, which began to slow their operations down. They have a 6 inch water line coming into their facility, then a 4 inch line coming into their yard, and then a 2 line inch going into brine maker. He says the pressure from the 2 inch line is perfect for their brine making.

8. **What type of equipment are you using on your trucks to apply the liquid-only treatments?**

The liquid sprayers and tanks on the trucks are made by Monroe. The truck capacity varies from 1800 gallons to 2000 gallons. The trucks have 2" lines at the pump.

9. **What is your off-site storage tank capacity?**

Their facility has 20,000 gallons of total storage, comprised of two 10,000 gallon tanks. Normally this is more than sufficient, but it does start to run low after a 2-3 day long storm.

10. **What is your route length and cycle time, and does this vary with liquid only vs traditional plow routes?**

The average route length is 48 miles. They make this trip in one hour and ten minutes, and then with reload time and the flow of vehicles through the facility, the total cycle time is one hour and twenty five minutes. This is 25% faster than routes that use only solids in Kentucky.

11. **What is your typical loading time from the storage tank to the truck, and what kind of transfer equipment do you use?**

When using one pump it takes 20 minutes to load the truck. But Randy added an extra fill line and pump to each tank. Now it only takes 10 minutes to load the truck. They use 220V electric motors to run the pumps, and they use 2" lines on everything.

12. **What is your yearly gallons use on your liquid only routes?**

In the winter of 2013/2014 they used 480,000 gallons. In the winter of 2014/2015 they used 400,000 gallons. In the winter of 2015/2016 they used 260,000 gallons. He has not calculated last year's usage yet. Kentucky uses approximately 1.8 million gallons per year.

13. **In your experience, is the liquid de-icing process more effective than using solids? And if so, in what ways?**

Randy hasn't had a road freeze up during the 7 years they have been using brine. He attributes it to how well the brine sticks to the road. He says it is more predictable than solids, and much more effective at removing ice.

14. **Have you encountered situations where the liquid-only process was not effective, and how did you adjust to that situation?**

Randy has never had a situation where the liquid-only process was not effective when used during the proper temperature ranges.

15. **What is the public perception of liquid-only plowing in your area?**

The local residents like it, and have had no issues or concerns.

16. **How have you communicated the benefits of liquid-only plowing to the public and to policy makers? And if so, in what ways?**

Randy has had calls from other KDOT districts because their residents asked why the roads are so much better in his district than other districts. He says the difference is very noticeable at the points where the trucks turn around and the next district begins. Each year he advocates for liquid-only treatments at KDOT annual meetings, and more and more agency staff are willing to try it after seeing his results. He says that he has not had to communicate the benefits to the public, because they see the results and are very happy with it.

17. **Have you addressed any misconceptions and if so, how?**

Other districts addressed the cost of purchasing the storage and brine making equipment. Randy showed them how the savings on purchasing salt more than pays for the extra equipment. He says they are using 30% of the amount of salt they used before starting the liquid-only program.

18. **How have you addressed environmental concerns?**

No, he has not had to address any environmental concerns. He says that they keep the storage areas very clean to prevent any runoff issues.

19. **Has your agency performed any formal research on liquid only vs traditional anti-icing and de-icing?**

No – they only perform trial and error tests.

20. **Is there anything else regarding the use of liquid only treatments that you encounter at your agency that I have not addressed?**

Randy says that some people at KDOT think he is crazy for using brine at the low temperatures he does, but it really does work, and is very effective. Also, next winter he is going to start experimenting with adding beet juice to the brine mix. He read that it lowers the freezing point

another few degrees. He joked that it might turn the roads purple, but it will be worth it if they can use only liquids in colder weather.

# Liquid-Only Plow Routes Phone Interview Log

**Recipient:**

| | | | |
|---|---|---|---|
| Kyle Lester | Colorado DOT Director of Highway Maintenance | kyle.lester@state.co.us | 3035125218 |

1. **When and why did your agency start using liquid-only treatments?**

The Colorado DOT (CDOT) has been using liquid-only treatments for 18 years. They had received research from other agencies, and they started experimenting with liquid treatments. Part of their interest stemmed from air quality issues with their sand usage.

2. **Are the roads on your liquid-only route rural or urban? High volume or low volume?**

CDOT mostly uses liquid-only treatments on urban and high volume roads.

3. **How do you determine what type of road is appropriate for liquid only treatment?**

They factor in the cost of treatment with the priority level of the road. Their focus is on keeping traffic moving, which isn't as critical on low volume roads.

4. **What is your timing for beginning treatment based on storm events and temperature?**

They start anti-icing approximately 8 hours before the storm. Their goal is to hit as many roads as possible before the storm starts, but they found that anti-icing earlier than 8 hours before a storm is less effective. They begin de-icing after the snow starts to stick to the road.

5. **What application rates are you using and how does that change based on temperature and intensity of the event? Are there other factors that influence application rates?**

CDOT has a winter operations plan with a decision matrix that is provided to all facilities. The two factors that drive their decisions are what the environmental conditions are and what products are available. Even though the decision matrix is built into all patrol plans, operators are still using historical knowledge instead of the matrix at times. Application rates can vary based on the storm and product used, but it averages at 60 gallons per lane mile. Their range of usage is between 50 and 80 gallons per lane mile.

6. **What brine chemical composition and mix ratio are you using?**

The mix ratio of their magnesium chloride is 28% and their salt brine is 23.3%. They have experimented with additives in salt brine, but the problem with most performance enhancers is that they don't meet the state's environmental specs. Most of them are too high in heavy metals, phosphates, ammonia, or nitrogen. Those items can hurt the local agriculture. They do use a

corrosion inhibitor in their salt brine and their magnesium chloride. Their mag chloride also includes a cold weather additive called Apex. They are currently testing an Envirotech performance enhancer product called Amp and a GMCO product called Torch.

7. **Do you make your own brine? If so, how many gallons/hour can you generate and what make and model of brine maker do you own? And what size of water line feeds your brine maker?**

Because of water quality issues, most of the state uses magnesium chloride that is purchased from a contractor. There is some brine use in the southwest part of the state. Those facilities have a variety of different types of brine makers and line sizes. Some of them use an Accubrine with a 2" line.

8. **What type of equipment are you using on your trucks to apply the liquid-only treatments?**

The typical setup on each truck is 2 side saddle tanks with 900 gallons each. They also have large tankers with 6000 gallon tanks that they use for spraying interstate highways.

9. **What is your off-site storage tank capacity?**

CDOT has 12,000 gallon poly tanks at most of their shops. They are slowly replacing their older 5,000 gallon fiberglass and steel tanks.

10. **What is your route length and cycle time, and does this vary with liquid only vs traditional plow routes?**

This varies greatly depending on each facility. The route length and cycle time for liquids are very similar to the times for solids.

11. **What is your typical loading time from the storage tank to the truck, and what kind of transfer equipment do you use?**

All facility have electric pumps, but the types and transfer times vary by facility.

12. **What is your yearly gallons use on your liquid only routes?**

Colorado uses approximately 14 million gallons per year.

13. **In your experience, is the liquid de-icing process more effective than using solids? And if so, in what ways?**

Kyle likes using liquids because they are active immediately, and there is less waste than with solids. Solids have a bounce factor and are carried by wind.

14. **Have you encountered situations where the liquid-only process was not effective, and how did you adjust to that situation?**

Their only issues occurred when they tried anti-icing more than 8 hours before a storm. The treatment was scattered by traffic and was ineffective. Since then, they perform anti-icing within 8 hours.

15. **What is the public perception of liquid-only plowing in your area?**

The public thinks very highly of it, and once they were informed, they appreciate the environmental benefits.

16. **How have you communicated the benefits of liquid-only plowing to the public and to policy makers? And if so, in what ways?**

The CDOT media department has released videos, interviews, and press releases to inform residents. They have also held town hall sessions.

There are legislative committees regarding winter operations. It is an important topic in Colorado because of tourism and the ski industry. There are high expectations for levels of service. Kyle has worked with legislators on a one-on-one basis to educate them on winter maintenance operations, including the use of liquids.

17. **Have you addressed any misconceptions and if so, how?**

Kyle has not had to address any specific misconceptions – only questions regarding when the treatments are effective, and how often the roads are re-treated.

18. **How have you addressed environmental concerns?**

Kyle has addressed some water quality issues with residents and legislatures individually, and has shown them information from the manufacturers of the magnesium chloride. There has also been some concerns about corrosion on vehicles. Kyle explains that salt is corrosive, but all of their liquid products are anti-corrosive. A small amount of corrosion could still occur, but their goal is to provide the best level of service at their cost with the least overall impact to the environment.

19. **Has your agency performed any formal research on liquid only vs traditional anti-icing and de-icing?**

CDOT has a formal research process and publishes their results online. They also provide funding to the Western Transportation Institute, which performs a wide variety of research. They just finished an anti-icing study in the northeast part of the state that will be published soon. Two years ago they finished a study on automated anti-icing Fixed Automated Spray Technology (FAST) Systems. They also perform internal route optimization studies that are generally not published. Their research website is located here: https://www.codot.gov/programs/research

20. **Is there anything else regarding the use of liquid only treatments that you encounter at your agency that I have not addressed?**

In Colorado their routes can’t truly be liquid-only due to low temperatures. They are liquid-only down to a certain temperature range, which is also dependent on wind speed and other factors, and then they need to switch to using solids.

# Liquid-Only Plow Routes Phone Interview Log

**Recipient:**


| | | | |
|---|---|---|---|
| Scott Simons | Maryland DOT Office of Maintenance | ssimons@sha.state.md.us | 410-582-5566 |


1. **When and why did your agency start using liquid-only treatments?**

Maryland started with liquid treatments for anti-icing around 15 years ago. They started using Direct Liquid Application (DLA) 6 years ago at one facility. After thorough testing there, it spread to other districts, and then went statewide last year. There are a total of 18 liquid-only plow routes.

2. **Are the roads on your liquid-only route rural or urban? High volume or low volume?**

Their liquid-only routes are a mix of all road types and traffic volumes.

3. **How do you determine what type of road is appropriate for liquid only treatment?**

At first, lower traffic routes were selected while they refined their program. Also the routes were close to each facility for fast reaction times if things weren't working out. Over the past few years they have branched out to higher volume roads and more urban locations. They expect to be adding more routes next year.

4. **What is your timing for beginning treatment based on storm events and temperature?**

They typically pretreat 2 hours before the storm event, and always within 12 hours of it. They discovered that putting it down 24 hours before an event is ineffective – the traffic pushes it around. They begin pretreatment on lower volume roads and move to higher volume roads as it gets closer to the storm. During the storm, they use Direct Liquid Application (DLA) to treat the roads as precipitation falls. They follow up with de-icing as needed.

5. **What application rates are you using and how does that change based on temperature and intensity of the event? Are there other factors that influence application rates?**

They typically stay at 60 gallons per lane mile. They will go up to 80 during an intense storm or ice event.

6. **What brine chemical composition and mix ratio are you using?**

Salt brine at the 23.3% mixture of salt to water.

7. **Do you make your own brine? If so, how many gallons/hour can you generate and what make and model of brine maker do you own? And what size of water line feeds your brine maker?**

They have 15 brine makers around the state serving 20 facilities. Most are Veritech brine makers. They are older models, and require frequent cleaning and testing with a hydrometer. Their current brine makers can produce 2,000 gallons per hour. They are currently testing a Henderson Brine Maker Extreme Ultimate. Scott is training on the machine in a few weeks. This new model has automated controls and testing. It should be able to product around 6,000 gallons per hour.

8. **What type of equipment are you using on your trucks to apply the liquid-only treatments?**

The state uses contractors for plowing, anti-icing, and transporting brine. The contractors have various set-ups on their individual trucks.

9. **What is your off-site storage tank capacity?**

Maryland has a 1.5 million gallon capacity statewide. This includes the purchase of 190,000 gallons of extra capacity over the last 2 seasons. The facilities have some 10,000 gallon and some 6,000 gallons tanks. Their largest location has 42,000 gallons total capacity between main site and satellite facilities.

10. **What is your route length and cycle time, and does this vary with liquid only vs traditional plow routes?**

Scott says that since they have to use less material on the roads with liquids than solids, with the size of their routes the truck can do a route twice before going back to the shop for reloading. One shop has 5 routes, and on certain storms they will use 30,000 gallons on 120 lane miles in 2 cycles.

11. **What is your typical loading time from the storage tank to the truck, and what kind of transfer equipment do you use?**

This varies by contractor truck, but he believes the loading time is typically 15 minutes. They use electric pumps with 2” lines.

12. **What is your yearly gallons use on your liquid only routes?**

He did not have this information available.

13. **In your experience, is the liquid de-icing process more effective than using solids? And if so, in what ways?**

Maryland cut its salt usage statewide by 60% so far by growing their liquid-only program. Scott says this is better for the environment, and better for the public, because they are getting a higher level of service with the liquids.

14. **Have you encountered situations where the liquid-only process was not effective, and how did you adjust to that situation?**

The only situations that Scott encountered was when they pretreated high volume roads more than 12 hours before a storm event. The traffic pushed it off the roads and it was not effective. Now they always pretreat within 12 hours, and they pretreat the highest volume roads closest to the storm.

15. **What is the public perception of liquid-only plowing in your area?**

The public believes that the benefits outweigh the drawbacks, and they are supportive.

16. **How have you communicated the benefits of liquid-only plowing to the public and to policy makers? And if so, in what ways?**

Scott has been traveling to each facility each season for training sessions. These sessions include the costs and benefits of using liquid-only routes, so that each facility is better prepared to talk to the public in their areas. They believe in educating each branch so that they can educate the public and local officials. At a state level, they also send out press releases, social media notices, and they hold public information sessions.

17. **Have you addressed any misconceptions and if so, how?**

The only misconceptions were the environmental concerns raised in the question below.

18. **How have you addressed environmental concerns?**

Scott has encountered concerns that the liquid treatments will leech salt into the environment faster than solids. Scott has informed these residents and elected officials that the solid salt eventually turns to liquid anyways, and that much less salt is used overall with the liquid treatments. The alternative would be to not have clear roads.

19. **Has your agency performed any formal research on liquid only vs traditional anti-icing and de-icing?**

No, they only do informal testing. They are currently testing mixing magnesium chloride into their brine.

20. **Is there anything else regarding the use of liquid only treatments that you encounter at your agency that I have not addressed?**

Resource availability is an issue. During intense storms some facilities will run out of brine, and the contractor will need to transport some from another facility. They are performing internal planning to determine where more storage is needed.

# Liquid-Only Plow Routes Phone Interview Log

**Recipient:**

Sam Salfity MassDOT bassam.salfity@dot.state.ma.us 857-368-9671

1. **When and why did your agency start using liquid-only treatments?**

MassDOT has been using brine for 12-15 years. They started with pre-wetting their solids, and then after reading research from Clear Roads, they experimented with liquid-only treatments.

2. **Are the roads on your liquid-only route rural or urban? High volume or low volume?**

They use liquid-only treatments on high volume, urban roads.

3. **How do you determine what type of road is appropriate for liquid only treatment?**

Currently they are treating their highest priority roads, and as their program expands, they move to lower priority roads.

4. **What is your timing for beginning treatment based on storm events and temperature?**

They begin treatment two days before storm when using brine, or within 12 hours of a storm when using magnesium chloride. They trust supervisors to use their own experience and training when it comes to the specific treatment. They have a weather provider that gives detailed forecasts for each area.

5. **What application rates are you using and how does that change based on temperature and intensity of the event? Are there other factors that influence application rates?**

They apply at 20-30 gallons per lane mile depending on temperature and storm. It is up to each shop supervisor to determine the application rate.

6. **What brine chemical composition and mix ratio are you using?**

They create the brine at 23.3%, and then dilute it to a ratio of 85% brine and 15% water. They have found that this is just as effective as using 100% brine.

7. **Do you make your own brine? If so, how many gallons/hour can you generate and what make and model of brine maker do you own? And what size of water line feeds your brine maker?**

They have one plant that makes brine with a Brine Extreme by Henderson. Sam was not sure of the hourly production capabilities or water line specifications. They ship the brine to the 4 districts in the state out of 6 that use brine. Shipping brine has been an issue during large storm events, and they are considering opening a second plant for brine production.

8. **What type of equipment are you using on your trucks to apply the liquid-only treatments?**

MassDOT uses contractors for the trucks themselves, so he isn't sure of the specifications. But they all have spray bars and side sprayers.

9. **What is your off-site storage tank capacity?**

The typical setup at each shop is either one 6,000 gallon tank or two 5,000 gallon tanks. The total state storage capacity is 500,000 gallons.

10. **What is your route length and cycle time, and does this vary with liquid only vs traditional plow routes?**

Sam wasn't sure of the specifics related to route length and cycle time.

11. **What is your typical loading time from the storage tank to the truck, and what kind of transfer equipment do you use?**

The contractors take care of the transfer, so Sam wasn't sure of the specifics on this. He knows they use electric motors, but he didn't know the type or voltage.

12. **What is your yearly gallons use on your liquid only routes?**

MassDOT uses approximately 500,000 gallons per year.

13. **In your experience, is the liquid de-icing process more effective than using solids? And if so, in what ways?**

Sam prefers liquid treatments because they are more accurate and easier to control.

14. **Have you encountered situations where the liquid-only process was not effective, and how did you adjust to that situation?**

No – the liquids have worked well in every situation that they have tested them in.

15. **What is the public perception of liquid-only plowing in your area?**

The public just wants the roads to be clear, and they support any type of plowing as long as it achieves that goal and maintains groundwater integrity.

16. **How have you communicated the benefits of liquid-only plowing to the public and to policy makers? And if so, in what ways?**

Liquid-only plowing has not been a concern for policy makers or legislators. They have not needed to communicate directly with the public on these treatments on a wide scale. There is information on their DOT website that the public can access.

17. **Have you addressed any misconceptions and if so, how?**

Sam has not had to address any misconceptions.

18. **How have you addressed environmental concerns?**

There have been some concerns raised at an individual level regarding groundwater quality, and Sam has addressed these comments directly.

19. **Has your agency performed any formal research on liquid only vs traditional anti-icing and de-icing?**

They have performed informal trials at different shops, but they have not performed any formal research.

20. **Is there anything else regarding the use of liquid only treatments that you encounter at your agency that I have not addressed?**

They want to expand their use of brine, but shipping it to each shop is difficult, and they don't have the budget for brine makers at each shop. Their first step will be adding a second brine making facility.

They originally used calcium chloride, but stopped due to corrosion issues.

They are using 30% less salt than they were 5 years ago because of increased liquid use.

## Liquid-Only Plow Routes Phone Interview Log

**Recipient:**

| | | | |
|---|---|---|---|
| Jeff Perkins | MnDOT | jeff.perkins@state.mn.us | 218-846-3628 |

Jeff misunderstood the survey – his MnDOT district does not have liquid-only routes. They only do liquid-only anti-icing on certain bridges. They do not use liquid-only treatments on roadways.

## Liquid-Only Plow Routes Phone Interview Log

**Recipient:**

| | | | |
|---|---|---|---|
| Douglas McBroom | MDOT | dmcbroom@mt.gov | 406.444.6157 |

Doug deferred to Mike Miller at MDOT. Mike's interview log is included in this appendix.

# Liquid-Only Plow Routes Phone Interview Log

**Recipient:**

Patti Caswell Oregon DOT patti.caswell@odot.state.or.us 503.986.3008

1. **When and why did your agency start using liquid-only treatments?**

ODOT decided to start using magnesium chloride based on research performed in the late 90's. They started using it statewide in the year 2000.

2. **Are the roads on your liquid-only route rural or urban? High volume or low volume?**

The routes are in all types of settings with all types of volumes.

3. **How do you determine what type of road is appropriate for liquid only treatment?**

Their goal is to meet or exceed driver expectations. This means that interstates and highways come first. After those major roads are covered, they expand their reach to lower priority roads.

4. **What is your timing for beginning treatment based on storm events and temperature?**

Shop supervisors rely on their own experience. They are developing standardized application rate guidelines right now. Annual training is provided each year for shop supervisors, area managers, and any other personnel who would benefit from it. Treatment times vary by region. On the west side of Oregon, rain typically comes before snow, which washes any pretreatment off the road. Sometimes the trucks have to wait for the rain to turn into snow before starting treatment. The east side of state pretreats one day in advance. Occasionally they will pretreat two days in advance. Their magnesium chloride sticks to road for up to two days.

5. **What application rates are you using and how does that change based on temperature and intensity of the event? Are there other factors that influence application rates?**

For standard usage they treat at 30 gallons per lane mile. When they are touching up sections that they have already treated sometimes they will go down to 15 gallons per lane mile.

6. **What brine chemical composition and mix ratio are you using?**

ODOT uses a corrosion inhibited magnesium chloride from a supplier.

7. **Do you make your own brine? If so, how many gallons/hour can you generate and what make and model of brine maker do you own? And what size of water line feeds your brine maker?**

ODOT does not use brine.

8. **What type of equipment are you using on your trucks to apply the liquid-only treatments?**

Their typical setup is for trucks is one 2,000 gallon tank with spray bars and side sprayers on both sides. They have a few large tanker trucks with 6,000 gallon tanks. They treat interstates with the large tankers, but they also help with moving liquid to other shops if a contractor's delivery isn't going to arrive in time. They had a shortage of magnesium chloride last winter, and the contractor's delivery didn't come in time. So they had to do some extensive transportation of liquid between shops using these large tankers.

9. **What is your off-site storage tank capacity?**

The typical size of the storage tanks at their shops is 10,000 gallons.

10. **What is your route length and cycle time, and does this vary with liquid only vs traditional plow routes?**

This varies so much that show could not give me a range of lengths or times.

11. **What is your typical loading time from the storage tank to the truck, and what kind of transfer equipment do you use?**

She was not familiar with this aspect of their equipment.

12. **What is your yearly gallons use on your liquid only routes?**

The typically use between 4 million and 5 million gallons per year.

13. **In your experience, is the liquid de-icing process more effective than using solids? And if so, in what ways?**

It is far more effective for anti-icing and de-icing than solids. It also works faster, and is more predictable.

14. **Have you encountered situations where the liquid-only process was not effective, and how did you adjust to that situation?**

They have had instances where the liquid treatments dry out during intense storms, and they found that repeat applications at a lower application rate are needed.

15. **What is the public perception of liquid-only plowing in your area?**

The public is supportive.

16. **How have you communicated the benefits of liquid-only plowing to the public and to policy makers? And if so, in what ways?**

Initially they had public inquiries regarding the treatments sticking to their vehicles, since the magnesium chloride liquid is stickier than brine. They addressed these concerns on an individual level. Otherwise they have distributed general winter maintenance information via their website.

17. **Have you addressed any misconceptions and if so, how?**

Some field personnel felt that magnesium chloride was less effective than solids. After analyzing their concerns, Patti discovered that they were using it at the wrong temperatures, and that they were pretreating the roads so close to the storm that part of their pretreatment overlapped with the storm. Further training fixed these misconceptions.

18. **How have you addressed environmental concerns?**

No

19. **Has your agency performed any formal research on liquid only vs traditional anti-icing and de-icing?**

No they do not perform any research on liquid treatments.

20. **Is there anything else regarding the use of liquid only treatments that you encounter at your agency that I have not addressed?**

She could not think of anything else that we hadn't already discussed.

## Liquid-Only Plow Routes Phone Interview Log

**Recipient:**

| | | | |
|---|---|---|---|
| Dan Varilek | South Dakota DOT | daniel.varilek@state.sd.us | 605-773-3571 |

Dan misunderstood the survey – the South Dakota DOT does not have liquid-only routes. They only do liquid-only anti-icing on certain bridges. They do not use liquid-only treatments on roadways.

## Liquid-Only Plow Routes Phone Interview Log

**Recipient:**

| | | | |
|---|---|---|---|
| Alex Ariniello | Operations Manager, Town of Superior, CO | alexa@superiorcolorado.gov | 303-499-3675 |

1. **When and why did your agency start using liquid-only treatments?**

Their city has been using liquid-only treatments for over 10 years.

2. **Are the roads on your liquid-only route rural or urban? High volume or low volume?**

They only use liquid-only treatments on their urban, high volume roads.

3. **How do you determine what type of road is appropriate for liquid only treatment?**

Smaller streets are a lower priority, so they do not perform anti-icing on them. Their reasoning is that low volume local traffic can get to high volume roads at low speeds during storms.

4. **What is your timing for beginning treatment based on storm events and temperature?**

Their trucks and plowing are through a contractor, and the contractor determines when to begin treatment based on the level of service described by the city.

5. **What application rates are you using and how does that change based on temperature and intensity of the event? Are there other factors that influence application rates?**

Alex isn't sure what rates the contractor is using.

6. **What brine chemical composition and mix ratio are you using?**

The City uses brine from the CDOT tanks, which is mixed at a 23.3% ratio.

7. **Do you make your own brine? If so, how many gallons/hour can you generate and what make and model of brine maker do you own? And what size of water line feeds your brine maker?**

The brine is made by CDOT, but Alex doesn't know the specifics of their system.

8. **What type of equipment are you using on your trucks to apply the liquid-only treatments**?

The contractor's trucks have side saddle tanks, and Alex thinks they are 900 gallons per side.

9. **What is your off-site storage tank capacity?**

Their brine comes from the CDOT tanks. Alex stays in contact with them regarding availability of materials.

10. **What is your route length and cycle time, and does this vary with liquid only vs traditional plow routes?**

The route length is 90 lane miles. Alex did not know the cycle time.

11. **What is your typical loading time from the storage tank to the truck, and what kind of transfer equipment do you use?**

Alex did not have this information.

12. **What is your yearly gallons use on your liquid only routes?**

They used 34,000 gallons this past winter. Their average usage is between 20,000 and 40,000 gallons.

13. **In your experience, is the liquid de-icing process more effective than using solids? And if so, in what ways?**

Liquids work better for anti-icing because it works faster. In the past, they had air quality issues with sand, and the liquids solved that. Also their town is very hilly, and liquid treatments stick to the roads on the hills better.

14. **Have you encountered situations where the liquid-only process was not effective, and how did you adjust to that situation?**

No, it has been effective for them since they started.

15. **What is the public perception of liquid-only plowing in your area?**

The city offers a high level of service and the residents are pleased.

16. **How have you communicated the benefits of liquid-only plowing to the public and to policy makers? And if so, in what ways?**

Alex has communicated with residents and businesses on a one on one basis when questions have come up.

17. **Have you addressed any misconceptions and if so, how?**

No, Alex has not had to address any misconceptions.

18. **How have you addressed environmental concerns?**

Alex receives occasional questions from residents regarding how the liquids interact with the local environment. He provides them with research information from CDOT.

19. **Has your agency performed any formal research on liquid only vs traditional anti-icing and de-icing?**

No

**20. Is there anything else regarding the use of liquid only treatments that you encounter at your agency that I have not addressed?**

Alex could not think of anything else that we had not already discussed.

# Liquid-Only Plow Routes Phone Interview Log

**Recipient:**

| | | | |
|---|---|---|---|
| Kevin Griffin | UDOT Director of Maintenance | kgriffin@utah.gov | 801-965-4120 |

1. **When and why did your agency start using liquid-only treatments?**

UDOT started around the year 2000. It began with optimizing roadway pretreatments, and it was based on research from other agencies.

2. **Are the roads on your liquid-only route rural or urban? High volume or low volume?**

UDOT uses liquid-only treatments on all types of roads.

3. **How do you determine what type of road is appropriate for liquid only treatment?**

They don't have a system of determination – it works well for them on all roads.

4. **What is your timing for beginning treatment based on storm events and temperature?**

They typically treat 24 hours before a storm for anti-icing. Then they treat during the storm for loosening snow packs and for de-icing. They use liquid-only treatments down to 15 degrees. Dual meteorology groups give two forecasts per day to each maintenance station with details on weather and air/road temperature. It is up to the station supervisors to determine the treatment times.

5. **What application rates are you using and how does that change based on temperature and intensity of the event? Are there other factors that influence application rates?**

Application rates are typically 30-40 gallons per lane mile, but station supervisors have the freedom to adjust these for more intense events

6. **What brine chemical composition and mix ratio are you using?**

UDOT uses the standard 23.3% brine solution. Utah has the advantage of having plentiful salt deposits around Great Salt Lake.

7. **Do you make your own brine? If so, how many gallons/hour can you generate and what make and model of brine maker do you own? And what size of water line feeds your brine maker?**

Each shop has their own brine makers, but state also has 3 locations with tank farms and automatic brine makers. They transport brine from these tank farms to stations as needed with a tanker. The tanks are 5,000 gallon tanks, with up to 35,000 gallons being made at a time at each tank farm. The

brine makers are under contract. They are vendor specific and are a proprietary design. Kevin wasn't sure of the water line size.

8. **What type of equipment are you using on your trucks to apply the liquid-only treatments?**

The trucks have between 1300 and 1800 gallon tanks, and are all equipped with spray bars and side sprayers. They also have a large tanker for spraying interstates and transporting brine. Kevin wasn't sure of the capacity of the tanker.

9. **What is your off-site storage tank capacity?**

The typical set-up at each station is two or three 5,000 gallon tanks. The largest station has 40,000 gallons of storage.

10. **What is your route length and cycle time, and does this vary with liquid only vs traditional plow routes?**

When the capacity of the tanks is factored in, the pretreatment process can take longer with anti-icing, because the trucks may have to reload more often, depending on their tank size. Liquid treatment speeds are also limited during de-icing because they are plowing at the same time.

11. **What is your typical loading time from the storage tank to the truck, and what kind of transfer equipment do you use?**

They use 2" lines and electric pumps. The loading times are usually 15-20 minutes.

12. **What is your yearly gallons use on your liquid only routes?**

2,500,000 gallons statewide.

13. **In your experience, is the liquid de-icing process more effective than using solids? And if so, in what ways?**

Liquids stick to the road better. They are able to treat roads earlier and more effectively.

14. **Have you encountered situations where the liquid-only process was not effective, and how did you adjust to that situation?**

The liquid dilutes faster than solids. It begins mixing with water on the roads immediately. During storms with high wind and wind chill, the liquids were not effective, and they had to supplement their treatments with pre-wetted salts.

15. **What is the public perception of liquid-only plowing in your area?**

The public likes it. They understand that it is a safety measure..

16. **How have you communicated the benefits of liquid-only plowing to the public and to policy makers? And if so, in what ways?**

Kevin works with the state media group regarding the anti-icing program. This group releases videos, press releases, radio sound bites, interviews, and social media posts.

They have a comprehensive statewide training program that includes “Snow Schools”. This re-education occurs annually, and policy makers are welcome to attend.

17. **Have you addressed any misconceptions and if so, how?**

No

18. **How have you addressed environmental concerns?**

He has not dealt with any environmental concerns.

19. **Has your agency performed any formal research on liquid only vs traditional anti-icing and de-icing?**

UDOT has an internal research group that has done a formal research project on brine. It is posted online on the state website under maintenance studies. They also have another program called UTRACK – it provides funding to local universities for research, and includes winter maintenance research. They currently have a route optimization study ongoing that will be implemented for next winter. It will be published publicly once it is finished.

20. **Is there anything else regarding the use of liquid only treatments that you encounter at your agency that I have not addressed?**

They experimented with calcium chloride, but found it to be too corrosive for their program. They are going to test a brine and magnesium chloride mix next winter.

# Liquid-Only Plow Routes Phone Interview Log

**Recipient:**

| | | | |
|---|---|---|---|
| Roger Frantz | UDOT Roadway Operations Manager | rfrantz@utah.gov | 8019102340 |

1. **When and why did your agency start using liquid-only treatments?**

UDOT started using liquid treatments in the late 90's as a pretreatment option.

2. **Are the roads on your liquid-only route rural or urban? High volume or low volume?**

The routes encompass all roadway types and volumes.

3. **How do you determine what type of road is appropriate for liquid only treatment?**

They use liquid-only treatments on all types of roads.

4. **What is your timing for beginning treatment based on storm events and temperature?**

Depends on amount of precipitation prior to storm. Using brine down to -6 degrees on hard packed snow on bridges for loosening packs for plowing.

5. **What application rates are you using and how does that change based on temperature and intensity of the event? Are there other factors that influence application rates?**

The typical application rates are 30-40 gallons per lane mile, but these can be increased depending on the storm event.

6. **What brine chemical composition and mix ratio are you using?**

They use a brine solution at 23.3%

7. **Do you make your own brine? If so, how many gallons/hour can you generate and what make and model of brine maker do you own? And what size of water line feeds your brine maker?**

UDOT makes their own brine at each facility and at three large brine farms. These brine farms reuse waste water from parking lots to make the brine. They transport brine from these tank farms to stations as needed with a tanker. The tanks are 5,000 gallon tanks, with up to 35,000 gallons being made at a time at each tank farm. The brine makers are under contract. They are vendor specific and are a proprietary design.

8. **What type of equipment are you using on your trucks to apply the liquid-only treatments?**

Their facilities have some older units and some newer ones. The new units are called 1st responder units. They have 1500 gallon stainless steel tanks with spray bars and side sprayers. They also have the capability to do solids if needed. Roger wasn't sure which brand they were. The older units have 1300 gallon plastic tanks. They also have liquid-only trucks with 1800 gallon tanks and a large tanker which is used for spraying interstates and also for transporting brine.

9. **What is your off-site storage tank capacity?**

The typical set-up at each station is two or three 5,000 gallon tanks. The largest station has 40,000 gallons of storage.

10. **What is your route length and cycle time, and does this vary with liquid only vs traditional plow routes?**

The route lengths and cycle times vary all over the state. They are similar to the cycle times for traditional plowing.

11. **What is your typical loading time from the storage tank to the truck, and what kind of transfer equipment do you use?**

The loading time is typically 15 minutes, but it depends on the truck and the facility. They are using 2" lines and electric pumps.

12. **What is your yearly gallons use on your liquid only routes?**

2,500,000 gallons statewide.

13. **In your experience, is the liquid de-icing process more effective than using solids? And if so, in what ways?**

The goal of their liquid program is to be back on the road after 30 minutes to check the conditions and treat it again if needed. That isn't possible with solids, because they don't even start to become effective for 45 minutes, and in that time, an ice pack could build up. Liquids allow them to monitor their treatments to each storm more effectively. When they are able to retreat roads within 30 minutes, it keeps them clear for traffic to flow.

One example that he gave is a 3 lane highway mountain pass with a 3000 foot climb along 11 miles up to an elevation of 7000 feet. Turnaround time is very important in settings like this. Roger breaks up this section based on lane miles and how many gallons a truck can hold. Each truck has a treatment range of approximately 40 miles. Even on a challenging road like this, he is able to have his trucks retreat it within 30 minutes.

Statewide snow plan is to look at it as precipitation per hour. All shops need to handle up to 1 inch per hour. Some routes are long and might have 1-2 hour turnaround time. Salt doesn't start to work

for 45 minutes. If they had to turn around and hit that stretch again in 30 minutes, nothing would have changed yet, and an ice pack or snow pack could have formed in that time.

For longer routes the state is mostly using salt. They haven't replaced enough equipment yet to do all of those routes with liquid. For some storms they might do one lane with liquid and the rest with solids.

**14. Have you encountered situations where the liquid-only process was not effective, and how did you adjust to that situation?**

No – the salt brine has been effective in their program. Magnesium chloride has not been as effective (see Question 19 below)

**15. What is the public perception of liquid-only plowing in your area?**

They like it.

**16. How have you communicated the benefits of liquid-only plowing to the public and to policy makers? And if so, in what ways?**

Roger works with the state media group regarding the anti-icing program. This group releases videos, press releases, radio sound bites, interviews, and social media posts.

They have a comprehensive statewide training program that includes "Snow Schools". This re-education occurs annually, and policy makers are welcome to attend.

**17. Have you addressed any misconceptions and if so, how?**

He has not had to address any particular misconceptions.

**18. How have you addressed environmental concerns?**

There were some concerns when the program started regarding how much salt was being used, but when they were educated on how much less salt is used with liquid treatments, they were satisfied.

**19. Has your agency performed any formal research on liquid only vs traditional anti-icing and de-icing?**

They have done testing on magnesium chloride, potassium acetate, and calcium chloride. They use magnesium chloride rarely, and they don't use the others. There are issues with the road surface getting slippery after storms with magnesium chloride. Certain areas of Utah have large elevation changes. There is a winter inversion effect where the valleys will get very foggy. Above the fog canopy the air is humid and warmer. When they were using magnesium chloride, when this inversion condition would happen, there would be accidents after the storm because of the additives making the roads slippery. As the sun would rise, it would push the fog canopy further into the valley. Those colder roads would get very slippery. The only fix was to wash it off with a weak

brine solution. The accidents after the storm were worse than before the storm. Roger says this is a bigger deal than most agencies realize. It could be a problem for them without them knowing it.

**20. Is there anything else regarding the use of liquid only treatments that you encounter at your agency that I have not addressed?**

Magnesium chloride is hard to store. It can clog the pumps if it isn't diluted. Even when diluted, it would settle on the bottom of the tanks.

The state has embedded sensors 18 inches in the soil beneath the road that monitor the asphalt temperature. These sensors don't cover all routes, but they do cover many of them. They are very helpful for each station as they plan their treatments. Roger is pushing for more of these to be installed. There are also non-evasive sensors, but Roger feels that these are not as accurate.

One thing they learned from their liquid program to cut back on salt application on their solid routes. They learned from their studies of application rates of liquids that a lower application rate is better for solids on those routes.

# Liquid-Only Plow Routes Phone Interview Log

**Recipient:**


| | | | |
|---|---|---|---|
| | Waukesha County | | |
| Peter Chladil | DPW/Highway Operations | pchladil@waukeshacounty.gov | 262.548.7843 |


1. **When and why did your agency start using liquid-only treatments?**

They started in 2015 as a pilot program for WisDOT. They used liquid-only treatments for one winter (2015/2016), and it was not successful for them, so they are re-evaluating their program, and doing more research.

2. **Are the roads on your liquid-only route rural or urban? High volume or low volume?**

The route is rural and low volume, but high speed.

3. **How do you determine what type of road is appropriate for liquid only treatment?**

They selected their test route because it was close to the shop and was low volume.

4. **What is your timing for beginning treatment based on storm events and temperature?**

They tried different timing on three different storms – once they did one day before the storm, once 12 hours before, and once 2 hours before.

5. **What application rates are you using and how does that change based on temperature and intensity of the event? Are there other factors that influence application rates?**

They used 40 gallons per lane mile, and did not adjust it.

6. **What brine chemical composition and mix ratio are you using?**

They used a 23.3% solution of brine.

7. **Do you make your own brine? If so, how many gallons/hour can you generate and what make and model of brine maker do you own? And what size of water line feeds your brine maker?**

They have an Accubrine that can make 5,000 gallons per hour. But the truck that brought the salt frequently had limestone in with the sold, which would clog the screen in the brine maker. So they had to clean it out every 20,000 gallons, and it was a time consuming cleanup. It is fed by a 2" water line.

8. **What type of equipment are you using on your trucks to apply the liquid-only treatments?**

Their one truck has a 1800 gallon sliding tank with a spray bar.

9. **What is your off-site storage tank capacity?**

They have three 6,000 gallon poly tanks.

10. **What is your route length and cycle time, and does this vary with liquid only vs traditional plow routes?**

When they were using solids the cycle time was 2 hours. With liquids it was 1 hour 45 minutes.

11. **What is your typical loading time from the storage tank to the truck, and what kind of transfer equipment do you use?**

They used an electric pump, and it took about 15 minutes to transfer.

12. **What is your yearly gallons use on your liquid only routes?**

They used 500,000 gallons during the winter that they tried a liquid-only route.

13. **In your experience, is the liquid de-icing process more effective than using solids? And if so, in what ways?**

No – each time they tried liquid-only treatments for de-icing it would refreeze quickly. The temperatures that they were using liquids at ranged from 10 degrees to 20 degrees. Eventually they had to follow the liquid truck with another truck dropping solid salt.

14. **Have you encountered situations where the liquid-only process was not effective, and how did you adjust to that situation?**

Liquids were not effective for them, and they were not able to adjust to make it work. It would refreeze ever time, and made the roads more dangerous. Peter admits that they were not using any charts or guidelines for the treatment itself, only for the brine mix. They just experimented to see what would work. They abandoned the program after it was not successful for them that winter. Peter would like to try it again with new information on a low speed road.

15. **What is the public perception of liquid-only plowing in your area?**

They were upset that the roads were more dangerously slippery.

16. **How have you communicated the benefits of liquid-only plowing to the public and to policy makers? And if so, in what ways?**

The public was not informed before the program began – only afterwards when the treatment was not successful, and then it was only on a one-on-one basis with residents who were upset.

17. **Have you addressed any misconceptions and if so, how?**

No

18. **How have you addressed environmental concerns?**

The residents did not have any environmental concerns.

19. **Has your agency performed any formal research on liquid only vs traditional anti-icing and de-icing?**

No – they only performed trial and error within their shop.

20. **Is there anything else regarding the use of liquid only treatments that you encounter at your agency that I have not addressed?**

After reading additional research from Clear Roads and other agencies, Peter would like to try a liquid-only route again.

# Liquid-Only Plow Routes Phone Interview Log

**Recipient:**

Mike Miller Montanta DOT mikmiller@mt.gov 406-444-6991

1. **When and why did your agency start using liquid-only treatments?**

50/50 brine / mag chloride. Easter half of state has colder temperatures on average. Mag Chloride is Freeze Guard CI+ by Compass Minerals. Supplied by Dust Busters. Mag Chloride has longer window of forgiveness on temperatures. Mag Chloride since the 90's, but limited. Really started in 2000. Sakt brine in 2006. Started from research.

The Montana DOT (MDOT) stated using magnesium chloride in the 90's to prewet salts. In 2000 they started their first liquid-only route using brine. In 2006 they added liquid-only magnesium chloride routes. They started their liquid-only program because of research performed by other agencies.

2. **Are the roads on your liquid-only route rural or urban? High volume or low volume?**

They typically don't select Interstates and high speed roadways for their liquid-only routes. They have found that traffic pushes it around too much, which means they have to make too many return trips. They are still testing the timing and application for using liquids on their interstates.

3. **How do you determine what type of road is appropriate for liquid only treatment?**

Other than high speed roads and interstates, they don't have a process for determining which other roads are applicable.

4. **What is your timing for beginning treatment based on storm events and temperature?**

Supervisors at each shop go by their own experience. The state provides extensive training for maintenance staff in the off season. They have new trucks which can be programmed to automatically adjust the treatment based on road temperature, but they found that it doesn't work as well as relying on the supervisor's training.

Their policy is that they won't apply liquids until the storm is actually happening. Storms can change, and they don't want to treat the roads early and then have the storm miss the area. They feel that this wastes time and material. They call this "Just In Time" winter maintenance.

5. **What application rates are you using and how does that change based on temperature and intensity of the event? Are there other factors that influence application rates?**

They use 40-60 gallons per lane mile. The rate depends on the storm and temperature.

6. **What brine chemical composition and mix ratio are you using?**

Their salt brine mix ratio is 23.3%. They have a corrosion inhibitor added to their brine and their magnesium chloride, which is Shield GLT+ from Paradigm Chemicals.

7. **Do you make your own brine? If so, how many gallons/hour can you generate and what make and model of brine maker do you own? And what size of water line feeds your brine maker?**

They use Brine Extremes by Henderson, and they typically use 3" lines. They use large tankers to bring the liquids to their shops.

8. **What type of equipment are you using on your trucks to apply the liquid-only treatments?**

Their trucks either have one 1800 gallon tank on the back, or saddle tanks with two 500 gallon tanks. The brands and types vary. Instead of spray bars they use wheel track sprayers which spray 2 feet behind each tire as opposed to the entire road. They have flow meters and a pump system on each truck which helps to track material use.

9. **What is your off-site storage tank capacity?**

Their largest plant has ten 10,000 gallon tanks. They have two other shops with five tanks this size. Their smaller shops typically have one 10,000 gallon tank.

10. **What is your route length and cycle time, and does this vary with liquid only vs traditional plow routes?**

Their route lengths are 50 lane miles on average. They have found that their liquid-only trucks can go a little faster because of how solid material bounces around. However, if they drive too fast, the liquid is carried more by the air.

11. **What is your typical loading time from the storage tank to the truck, and what kind of transfer equipment do you use?**

He wasn't sure of the average timing or set-up for this.

12. **What is your yearly gallons use on your liquid only routes?**

They use approximately 9 million gallons per year.

13. **In your experience, is the liquid de-icing process more effective than using solids? And if so, in what ways?**

When used properly it is more effective and it works faster. Their strategy is that they are not trying to melt everything – they are trying to plow it off. Liquids work the best for them under this strategy.

14. **Have you encountered situations where the liquid-only process was not effective, and how did you adjust to that situation?**

As described earlier, it doesn't work as well for them on high speed roads. They are still testing and adjusting to this situation.

15. **What is the public perception of liquid-only plowing in your area?**

The overall public perception is positive. When they first got magnesium chloride in the 90's they used too much material, and he said it "gave MDOT a black eye" due to environmental concerns and corrosion. They have had to overcome that over the past 20 years or so.

16. **How have you communicated the benefits of liquid-only plowing to the public and to policy makers? And if so, in what ways?**

Legislators want to limit use of chemicals on Montana roads. Mike works with legislators to inform them and present research and manufacturer test results. He brought in people from the Salt Institute to hold training sessions for policy makers and the general public, which worked very well for them.

Communication is performed through limited PSA announcements, legislature sessions, and social media.

17. **Have you addressed any misconceptions and if so, how?**

Mike has to address the occasional corrosion misconception, and he does this on a one-on-one basis utilizing research material and test results.

18. **How have you addressed environmental concerns?**

The trout stream and fishery industry is concerned about water quality issues. Mike has shown them test results that show their chemicals are safe. For now, the issue has calmed down.

19. **Has your agency performed any formal research on liquid only vs traditional anti-icing and de-icing?**

No – they support agencies like Clear Roads for formal testing. They do have a lab to measure ratios for quality assurance.

20. **Is there anything else regarding the use of liquid only treatments that you encounter at your agency that I have not addressed?**

In Montana there are a lot of conditions where liquid isn't the best choice because of cold temperatures. Once a road becomes snow packed, adding liquid on top of that can be a problem for them because it can refreeze. But they have been very happy with their liquid program, and it grows larger every year.

## Appendix D

- Liquid-Only Road Treatments Start-Up Reference Guide
- Liquid-Only Road Treatments Technical Reference Guide

# Liquid Roadway Treatments
## Start-Up Reference Guide

**For Clear Roads by Stonebrooke Engineering**
**08/28/2017**

## Benefits of Liquid Roadway Treatments

**Liquid roadway treatments are:**

- **Responsive:** Liquid treatments begin working immediately
- **Reliable:** Liquids work predictably and accurately
- **Straightforward:** Liquids are easy to control and apply
- **Effective:** Liquid treatments stick to the road better than solids
- **Efficient:** Reload times can be shorter for liquids than solids, depending on pump capacity
- **Controlled:** There is less waste with liquids due to the bounce rate of solids
- **Economical:** Most agencies decrease their salt usage by 25-50%

## Definitions

- **Anti-Icing:** A proactive treatment (sometimes called pretreatment) that involves the application of a liquid treatment prior to the onset of a snow event that prevents snow and ice from bonding to the road surface.
- **De-Icing:** A reactive treatment for melting existing snow and ice from a surface, either as a treatment by itself, or to aid in mechanical removal.
- **Direct Liquid Application (DLA):** The use of liquid-only treatments before, during, and after a storm event for anti-icing and de-icing.
- **Liquid-Only Plow Route:** A plow route on which only liquid treatments are used for anti-icing and de-icing when weather conditions fall within appropriate usage parameters.
- **Salt Brine:** A solution comprised of 23.3% sodium chloride (NaCl) and 76.7% water by weight.
- **Magnesium Chloride:** A solution comprised of magnesium chloride (MgCl) and water (ratio varies).
- **Calcium Chloride:** A solution comprised of calcium chloride ($CaCl_2$) and water (ratio varies).
- **Granular:** Rock salt in solid form.

## Tips for Gaining Buy-In

- **Start Slowly:** Consider supplementing existing granular applications with liquids. As success is observed and confidence increases, expand the liquid program and reduce granular rates.
- **Visit Other Shops:** Visiting facilities that already have a successful liquid program can accelerate team buy-in.
- **Partner:** If you do not have a brine maker, consider purchasing brine from a nearby agency while you start your program.
- **Contact Experts:** Utilize online resources to get contact information for liquid treatment experts, including the Clear Roads website at www.clearroads.org
- **Utilize Existing Equipment:** Consider converting or upgrading existing equipment to save on up-front costs.
- **Communicate Effectively:** Keep your team informed of all lessons learned, challenges, and success stories as you test the products. Keeping your team involved in the program can help turn critics into advocates
- **Know the Limitations:** Remember that liquid roadway treatments are just one tool in the toolbox, and they are only effective during certain weather conditions.

## Equipment Recommendations

- **Applicator Loading Pump:** This pump will be pumping chemicals, so make sure it is designed for a specific gravity of approximately 1.5 (not a water pump). The minimum port size is 2", but many agencies prefer a 3" size for faster flow rates. The minimum flow rate should be 110 gallons per minute (gpm) at 20 psi. A preferred flow rate is 275 gpm at 20 psi. The discharge hose length should be as short as possible. When choosing the port size, consider the applicator tank inflow line size, outflow line size, and valve sizes. These should match the pump capacity. Most liquid deicers are corrosive, so you will need to select a pump that can resist corrosion. Rock salt also contains stone partials that can cause excessive wear on pump parts, which should be considered when selecting your equipment.
- **Applicator Discharge Pump and Plumbing:** Heavier snowfall with lower temperatures typically requires high application rates. Larger pumps will increase your speed and efficiency. The actual size will depend on your applicator spread width. In one case, an agency suggested 370 gpm pumps for agencies with heavy usage.
- **Applicator Spray Bars:** Spray bars either mount to the tank, the pump, a slide-in bar, or are attached to the truck like a hitch receiver. Many varieties are available, including single, two-lane, and three-lane assemblies.
- **Storage Tanks:** Storage tank size and material will vary, but most agencies have a minimum tank size of 5,000 gallons. The most common types are polyethylene or fiberglass vertical storage tanks. Before choosing a tank, check with your local environmental control agency to determine what your state requires for containment.
- **Loading Area:** Design your loading set-up to be as user-friendly as possible. This will help gain buy-in among the entire team, and will result in a more efficient operation. The number of pumps required for loading will vary depending on your number of trucks using liquids.

# Liquid Roadway Treatments
## Technical Reference Guide

For Clear Roads by Stonebrooke Engineering
09/12/2017

## Definitions


- **Anti-Icing:** A proactive treatment (sometimes called pretreatment) that involves applying a liquid treatment prior to the onset of a snow event that prevents snow and ice from bonding to the road surface.
- **De-Icing:** A reactive treatment for melting existing snow and ice from a surface, either as a treatment by itself, or to aid in mechanical removal.
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- **Granular:** Rock salt in solid form.

## Usage Parameters

**Table 1: Recommended Anti-Icing Parameters Prior to a Storm Event**

| Parameter | Salt Brine | Magnesium Chloride | Calcium Chloride |
|---|---|---|---|
| Pavement Temperature[1] | 15°F or above | 0°F or above[2] | 0°F or above[2] |
| Time Remaining Until Storm | Within 24 hours[3] | Within 48 hours[3] | Within 48 hours[3] |
| Precipitation | None[4] | None[4] | None[4] |

***Notes:***

1. *Consider temperature trends (increasing/decreasing temperatures)*
2. *Additives are available can reduce the freezing point of magnesium chloride. Magnesium chloride and calcium chloride are not recommended at pavement temperatures above 40°. Work with vendors to verify temperatures.*
3. *Applying anti-icing closer to the storm reduces the chances of traffic pushing the treatment off the roadway.*
4. *Rainfall prior to a snow storm event dilutes liquid applications, which reduces their effectiveness*

**Table 2: Recommended DLA Parameters During a Storm Event**

| Parameter | Most Favorable For Liquid Treatment | Consider Using Liquid Treatment |
|---|---|---|
| Pavement Temperature[1] | 15°F or above (salt brine)<br>0°F or above (magnesium chloride)[2]<br>0°F or above (calcium chloride)[2] | 15°F or above (salt brine)<br>0°F or above (magnesium chloride)[2]<br>0°F or above (calcium chloride)[2] |
| Storm Intensity (inches/hour) | Light Snow (less than 0.5 inch/hour) | Medium Snow (0.5 to 1.0 inch/hour) |
| Moisture Content[3] | Ordinary (approx. 10:1 snow/liquid ratio)[3] | Dryer Snowfall |

***Notes:***

1. *Consider temperature trends (increasing/decreasing temperatures)*
2. *Additives are available can reduce the freezing point of magnesium chloride. Similar temperature ranges are recommended for calcium chloride. Work with vendors to verify temperatures.*
3. *Wet snow can dilute liquid applications, which reduces their effectiveness*

## Direct Liquid Application Rates & Cycle Times

Agencies have had success with direct liquid application rates generally from 20 gallons per lane mile (gplm) to 80 gplm, depending on conditions, timing, if granular is also being applied, level of service, and other local factors. Your local experience will allow you to fine-tune your application rates.

Cycle times will vary depending on location. Shorter cycle times help reduce refreeze potential, and longer cycle times increase dilution-refreeze potential. Generally about 1.5 or 2 hours is considered a preferred cycle time. Cycle time incudes the time needed to refill the truck tanks and the "dead head" time to the treatment route. As cycle times increase, supplementing liquids with direct granular should be considered.

**Table 3: Suggested Liquid Roadway Treatments Application Rates (adjust based on local experience)**

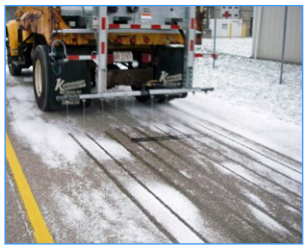
*Application rates are in gallons of salt brine per lane mile (gplm)*

| Event Type | Pavement Temperature | | | |
|---|---|---|---|---|
| | 32-30°F | 29-27°F | 26-24°F | 23-15°F |
| **For 2-Hour (or less) Cycle Times** | | | | |
| Light Snow (less than 0.5 inch/hour) | 20 gplm | 35 gplm | 40 gplm | 55 gplm |
| Medium Snow (0.5 to 1.0 inch/hour)[1] | 35 gplm | 45 gplm | 55 gplm | Not Recommended |
| **For 3-Hour Cycle Times[3]** | | | | |
| Light Snow (less than 0.5 inch/hour) | 35 gplm | 50 gplm | 65 gplm | 80 gplm |
| Medium Snow (0.5 to 1.0 inch/hour)[1] | 50 gplm | 65 gplm | 80 gplm | Not Recommended |

***Notes:***

1. *For medium snow events, only consider using liquid treatments based on your experience, and when other factors are highly favorable, such as pavement temperature and moisture content.*
2. *It is suggested to generally supplement the liquid application with a light direct pre-wet granular application (70 pplm) when possible (especially as dilution-refreeze potential increases).*
3. *For cycle times greater than 2 hours, supplementing liquids with direct granular is strongly suggested.*
4. *For magnesium chloride, calcium chloride, additives, and blends, work with vendors to verify application rates.*

## General Tips



- Supplementing liquid treatments with granular can achieve a "best of both worlds" solution by producing the full road liquid coating (to prevent bonding), some traction (granular), and also allowing the granular to slow down the dilution of the liquid treatment.
- If the storm is severe, consider using only mechanical snow removal until the severity lessens, and then resume liquid treatments.
- Liquid treatments can be used on hard packed snow to loosen it for plowing.
- Magnesium chloride and calcium chloride are typically 2-5 times the cost of brine, depending on location and vendor. The application rates of magnesium chloride and calcium chloride are typically 30% lower than salt brine.


research for winter highway maintenance

Lead state:

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