Survey of Best Practices for Winter Maintenance in Maryland

Prepared by:

Center for Watershed Protection

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This project was conducted by Jordan Fox, Carol Wong, and Bill Stack (Center for Watershed Protection, Inc.) and Neely Law, PhD (Fairfax County, Virginia) in fulfillment of a grant from the Pooled Monitoring Initiative's Restoration Research Grant Program, which includes funding partners from Maryland Department of Transportation State Highway Administration (MD SHA), Maryland Department of Natural Resources (DNR), the National Fish and Wildlife Foundation (NFWF) through the U.S. Environmental Protection Agency's (EPA) Chesapeake Bay Program Office, and the Chesapeake Bay Trust (CBT).

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Acronym Definitions

AVL	Automatic Vehicle Location
$CaCl_2$	Calcium chloride
CWP	Center for Watershed Protection, Inc.
EPA	U.S. Environmental Protection Agency
LOS	Level(s) of Service
MD SHA	Maryland Department of Transportation's State Highway Administration
MDA	Maryland Department of Agriculture
$MgCl_2$	Magnesium chloride
MS4	Municipal Separate Storm Sewer System
NaCl	Sodium chloride
RWIS	Road Weather Information System
TMDL	Total Maximum Daily Load

Appendices to this Document

Appendix A	Survey Question Details	Overview of the questions in the survey and their respective best practices
Appendix B	Analysis of Survey Results	Analysis and narrative of all the survey responses
Appendix C	Primary Survey	Copy of primary survey
Appendix D	Secondary Survey	Copy of secondary survey

Attachments to this Document

Attachment A	Literature Review on Winter Maintenance Best Practices	Companion deliverable associated with this project
Attachment B	Survey Response Database	Excel spreadsheet organizing the responses received from this survey, including any edits made

Glossary

Abrasive: Sand or another solid material placed on a slippery surface to temporarily improve traction for walking and/or driving. Abrasives alone do not melt snow and ice.

Anti-icing: The application of a deicer chemical (liquid or solid) to a surface (e.g., road, sidewalk, parking lot, etc.) before a storm starts in order to prevent ice from forming and bonding to the surface or to enhance plowing efforts. This is often referred to as "pre-treating" a site, but pre-treating has a separate, more specific definition (see below).

Deicing: The application of a deicer chemical (typically either a solid or pre-wet solid) to an existing accumulation of ice or snow to melt it and weaken its bond to the surface.

Direct Liquid Application: A designated snow route that uses only a salt brine solution to prevent the snow and ice from bonding to the pavement for the duration of an event.

Level of Service (LOS): A description of the expected road surface condition from the snow and ice maintenance activities. An example, "Provide snow and ice maintenance service to achieve bare pavement conditions", or "Clearing the pavement bare of ice and snow over its entire width will be accomplished as soon as reasonably possible after the winter storm event"

Pre-treating: The application of a liquid deicer to a solid deicer (like rock salt) to enhance deicer performance. This is different from anti-icing.

Pre-wetting: Coating solid materials with liquid directly prior to application to increase effectiveness. It can be achieved in 3 main ways: 1) liquid application at the spinner as material leaves the spreader, 2) liquid application to each load prior to placing it in the spreader, and 3) liquid application to the entire load of salt in the spreader.

Snow Contractor: A person, business, or private organization that provides billed snow and ice management services for one or multiple clients.

Subcontractor/Independent Contractor: A person, business, or private organization that is contracted to perform specific services for another party; subcontractors/independent contractors do not have legal status as an employee as defined by federal, state, or provincial laws.

Project Background

Salt, specifically sodium chloride (NaCl), is a growing pollutant of concern in waterbodies throughout the United States. There are over 500 impaired waterbodies in the United States with a total maximum daily load (TMDL) for chloride[1]. As of 2018, the Maryland Department of the Environment (MDE) has listed 28 waterbodies with a chloride impairment, and chloride regulations are expected[2]. There is an overall trend in increasing concentrations of salts in waterbodies throughout the United States (Kaushal et al., 2018). Concern is also documented in Corsi et al. (2015) that the increase in the rate of chloride concentrations was greater than the increase in urban land cover from 1990 to 2011, implying that more salt is being applied per area of impervious cover than before.

Excessive salt in the environment is a hazard to both human and ecological health and well-being. Excessive chloride can affect water, soils, vegetation, and the health of aquatic/semi-aquatic organisms. Additionally, salt-contaminated water can damage infrastructure with its corrosive properties and impair drinking water sources, incurring additional water treatment requirements and costs to public health. While salt is a naturally occurring substance and is widely used in everyday life (e.g., as a component in fertilizer, concrete, and as a water softener), its use in urban areas for winter road maintenance is a major source to increasing concentrations of chloride and sodium in both surface and groundwater (e.g., Kelly et al., 2008; Moore et al., 2017; Bird et al., 2018; Overbo, 2019).

This project is funded through the Pooled Monitoring Initiative's Restoration Research Grant Program[3], addressing key restoration question B.6.b in the Restoration Research Request for Proposals: *Which techniques of salt application to roadways will result in less loading to streams?* This research project will test the following hypothesis: "Significant potential exists to reduce chloride inputs to surface and groundwater through adoption of salt reduction strategies in Maryland." Figure 1 provides a graphical representation of this hypothesis.

[1] https://ofmpub.epa.gov/waters10/attains_nation.tmdl_pollutant_detail?p_pollutant_group_id=966&p_pollutant_group_name=SALINITY/TOTAL%20DISSOLVED%20SOLIDS/CHLORIDES/SULFATES

[2] https://mde.maryland.gov/programs/Water/TMDL/Integrated303dReports/Pages/303d.aspx

[3] This grant program includes funding partners from the Maryland Department of Transportation State Highway Administration (MD SHA), Maryland Department of Natural Resources (DNR), the National Fish and Wildlife Foundation (NFWF) through the U.S. Environmental Protection Agency's (EPA) Chesapeake Bay Program Office, and the Chesapeake Bay Trust (CBT).

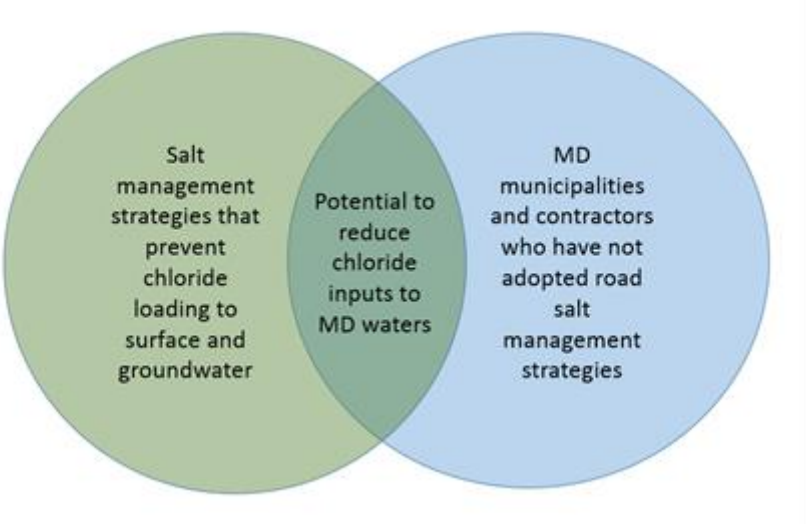


Figure 1. Potential exists to reduce chloride inputs to surface and groundwater through adoption of salt reduction strategies in Maryland.

The scope of the project includes a literature review and a survey to document the existing knowledge and understanding of snow and ice removal best practices by winter maintenance providers. This document contains the findings of the survey of Maryland municipalities; the results of the literature review have been published in a separate report (Attachment A). Both the literature review and the survey focus primarily on best practices for public agencies like the State Highway Administration, Departments of Public Works or Departments of Transportation; however, the best practices can be adopted by smaller private contractors as well.

Survey Development

Background

The purpose of this survey was to identify: 1) the extent to which best practices for winter road maintenance are currently being implemented by public agencies and the private industry, and 2) the potential to reduce chloride inputs to local waters through the adoption of best practices. The survey aimed to assess the current state of winter maintenance operations in Maryland municipalities to develop a baseline for improvement. The survey asked respondents about their use of the various best practices identified in the companion literature review to this report (Attachment A) that decrease chloride sources that make their way into waterbodies. The survey was originally intended to be distributed to both municipal organizations and private companies who perform winter maintenance services. However, following input from stakeholders, the primary survey scope was narrowed to focus on Municipal Separate Storm Sewer System (MS4) communities, with a secondary survey for private companies.

Another factor contributing to the shift to MS4 communities is from the findings in the literature review and the current development of salt reduction requirements by MDE for Phase I National Pollutant Discharge Elimination System (NPDES) Permits. From the literature review research and lessons learned from Minnesota's salt program, understanding the baseline of current practices is essential to understand and track how to reduce salt usage. Minnesota has a certified "Smart Salting" applicator program, which MDE is considering. The certification is one of the methods Minnesota is using to decrease salt usage in the private sector and has been shown to reduce salt usage by 30% – 70%[4]. Additionally, the MS4-focused survey included questions about best practices for winter road maintenance related to the use of contractors. These practices may decrease salt usage by MS4s' contractors.

It is important to note that the end of the survey period was the beginning of the COVID-19 pandemic. This may have affected the response rate, as a few municipalities expressed interest in completing the survey, but ultimately did not. This may have also affected the follow-up communications.

Target Audience

Primary Survey

The primary survey was distributed to every MS4 jurisdiction within the State of Maryland, which includes eleven (11) Phase I, including the Maryland Department of Transportation's State Highway Administration (MD SHA), and 35 Phase II communities.

Secondary Survey

The secondary survey was distributed to private contractors that manage private properties. In Maryland, the Lawn Fertilizer Law requires that lawn care professionals hired to apply fertilizer to lawns must be certified by the Maryland Department of

[4] https://www.pca.state.mn.us/water/salt-applicators

Agriculture (MDA). Since most winter road and parking lot maintenance is performed by landscape contractors, the survey was emailed to these certified fertilizer applicators through MDA.

Question Development

Primary & Secondary Survey

The questions included in the survey were developed from the results of the literature review (Attachment A). Table 1 provides an overview of the structure of the survey sent to the MS4 communities (Appendix C). The survey sent to private contractors was very similar, except it was shortened to include only the most relevant questions (see Appendix D).

Table 1. Overview of survey question categories.

Section Name	Number of Questions	Details
Survey Introduction/ Organization Information	Primary: 9 Secondary: 8	Identification of how survey was received and of key characteristics and responsibilities of the MS's winter maintenance team
Maintenance Plans & Guidance Documents	Primary: 9 Secondary: 9	Characterization of guidance/reference documents and operational plans, including Level(s) of Service
Products, Materials, & Equipment	Primary: 16 Secondary: 15	Inventory of equipment and retrofits, and identification of solid and liquid materials/products used
Strategies & Methods	Primary: 31 Secondary: 27	Characterization of organizational standard operating procedures
Salt Storage & Facilities	Primary: 5 Secondary: 0	Identification and characterization of respondent-operated storage facilities for solid and liquid materials/products
Budget & Contracts	Primary: 7 Secondary: 0	Characterization of contracting/subcontracting operations and budgetary considerations

The survey collected primarily qualitative data; however, quantitative metrics (e.g., average application rates, sizes of service areas, and output tracking metrics) were also collected. The survey question type (ex. Multiple choice, open-ended, checkboxes) varied based on the data collected. Most questions had an option to input a narrative response. This allowed users to provide non-conforming answers and clarification details. Appendices C and D include the survey questions in the primary and secondary surveys, respectively.

Survey Implementation

Primary Survey

The survey was hosted on an online survey website and the link to the website was distributed to MS4 points-of-contact via email. Respondents were also provided with a printable digital version (in PDF) of the survey to allow them to prepare information prior to entering it in the online version.

Pilot Survey & Revisions

Prior to distribution to the entire list of identified respondents, a pilot survey was conducted with three pilot respondents, two Phase II jurisdictions, and MD SHA. Upon receipt of the completed pilot surveys, responses to all questions were evaluated to ensure each question was worded in a clear way that elicited consistent responses. Pilot respondents were also asked to provide feedback on 1) the effectiveness of the wording of the questions, 2) the logic and flow of the survey, and 3) the length and overall amount of detail requested in the survey. With the feedback from pilot respondents, the project team met with representatives of MD SHA to review the survey and make final edits for clarity and to ensure the goals of the survey were being met.

Final Survey Distribution

A link to the final version of the online survey and a printable digital version (Appendix C) were distributed via email to the MS4 points-of-contact by CWP. Email and phone contact information for a CWP point-of-contact was provided to all respondents to answer questions about the survey, timeline constraints, and to provide clarification on specific questions on an as-needed basis.

The survey was originally intended to be open for two weeks. However, eliciting complete responses was more difficult and time-consuming than anticipated, and the survey was left open for an additional two weeks to allow for additional follow-up and responses. At least five follow-up attempts (a combination of emails and phone calls) were made for each contact who did not complete the survey after identifying themselves or being identified by the MS4 coordinator as the point-of-contact for their jurisdiction. Nearly a month after initial distribution, the online survey was closed, and responses were exported for review.

Final Survey Follow-up

All responses were thoroughly reviewed to identify missing information and ambiguous responses. The CWP reached out to seven respondents to request clarification on specific responses and to request references and documents in the survey. Follow-up clarifications were received from five respondents.

Secondary Survey

Due to the significant amount of time spent following up with respondents from the primary survey, it was decided that the focus would be on the primary survey to allow for a reasonable sample size. The secondary survey was still sent out, but less time was

spent securing responses. The secondary survey was also in an online format and was distributed to over 800 landscape contractors by MDA through their email distribution list for certified fertilizer applicators. Respondents were provided with a full PDF version of the survey to allow them to prepare information prior to entering it in the online version (Appendix D). From the experience of the primary survey, a low response rate was expected if there was no follow-up. Due to the lack of responses and limited time and resources, it was decided to end the survey after two weeks. Seventeen people opened the survey and eight responded, but none of respondents finished the survey in its entirety. There was limited useful information provided, so further analysis was not completed.

Survey Results & Analysis

Survey Analysis Method

The survey results were compiled into a spreadsheet and reviewed. Attempts were made to get clarification from the respondent when needed; if there was no response, the information was either changed or deleted, based on best professional judgement. Any changes or deletions were noted in the survey results spreadsheet (Attachment B). The following are general revisions made to the survey data for analysis:

- Typographic errors were corrected.
- There were some answers provided that indicated the respondent did not fully understand the question. A glossary of terms was provided in the beginning of the survey, but the respondent may not have thoroughly read the information. Conflicting or otherwise erroneous responses were removed.
- Ambiguous or contradictory data were either deleted or corrected.
- Numerical values that were given in ranges were averaged to allow for analysis. Some survey responses were estimates, and that was noted in the original survey data spreadsheet.
- One jurisdiction only hired contractors for their snow and ice removal, but still responded to the survey. This MS4 was removed from the analysis, since the data represents the contractor rather than the MS4.
- Information respondents did not want to include in the report (i.e., contact information or organization name) was redacted.
- Partially completed surveys were only included in the analysis if the question was answered; therefore, the number of survey responses varies through the analysis.

Due to the length of the survey, Appendix B contains the narrative explanation of each question. Select questions and responses are provided in the following section.

Overview of Results

This overview highlights some of the key findings in the survey and provides insight on related best practices, when applicable. The following section presents the most relevant results from the survey. To understand the terminology or best practices for winter maintenance, refer to the companion literature review to this report (Attachment A). The results of the survey are organized in the following categories:

- Maintenance Plans & Guidance Documents
- Products, Materials, & Equipment
- Strategies & Methods
- Salt Storage & Facilities
- Budget & Contracts

In total, 24 responses were submitted; 17 were fully completed, and seven were partially completed (Figure 2).

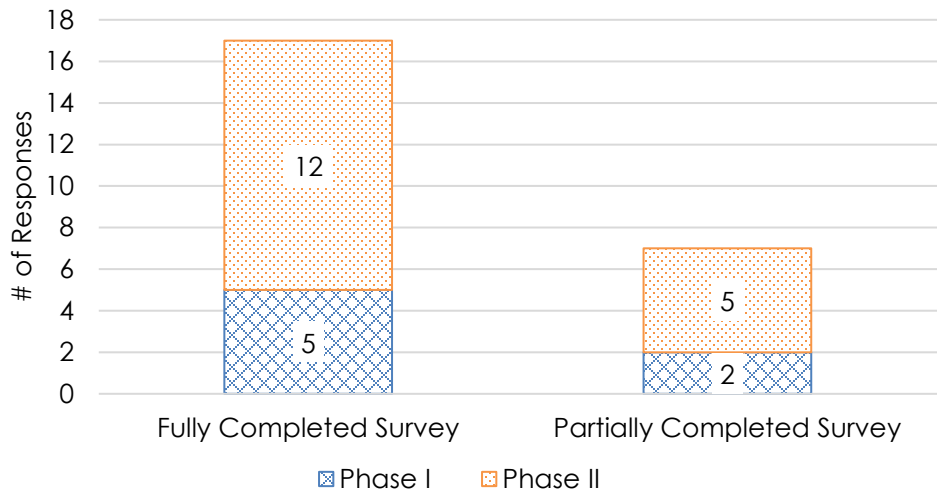


Figure 2: Survey Responses by MS4 Phase

Table 2 is the summary of the size of jurisdictions' service area, split into roads, sidewalks, and parking lots or other areas. The cells in green indicate that the MS4 communities treat for snow and ice in those areas but did not provide the size. It is unclear if respondents answered the road area in lane miles, or actual miles. For sidewalks, various units were reported, as noted. Due to the different units, unclear information, and missing information, this data could not be used to determine salt usage per unit area.

Table 2: Size MS4 Service Area for Winter Maintenance

	Jurisdiction	Roads (Lane Miles)	Sidewalk (Linear Foot)	Parking Lots/ other areas (acres)
Phase I	MD State Highway Administration	17,132	N/A	100
	19 (redacted)	6,722	N/A	N/A
	Prince George's County	5,500	N/A	N/A
	Montgomery County	5,200	316,800	N/A
	Anne Arundel County	4,300	N/A	N/A
	4 (redacted)	4,300*	N/A	
	Howard County	2,400	174 facilities	
Phase II	St. Mary's County	1,272		
	Wicomico County	700	N/A	N/A
	City of Frederick	451	95,000	92
	City of Gaithersburg	228	5680 sq. feet	
	15 (redacted)	120	3,000	6
	11 (redacted)	73	3,168	4
	City of Takoma Park	34	5,000	2 parking lots
	Town of Smithsburg	30	3 acres	
	Town of La Plata	29	8,500	2

	Jurisdiction	Roads (Lane Miles)	Sidewalk (Linear Foot)	Parking Lots/ other areas (acres)
	Town of Thurmont	25	600	1
	Town of Boonsboro	20	7,200	
	Town of Indian Head	14	9,240	
	Town of North East	7	1,000	

*The original number (22,000 lane miles) appeared to be incorrect. Since the respondent did not respond to the follow-up communication, the information was verified with a report from the jurisdiction and revised to 4,300 lane miles, as noted in the report.

Maintenance Plans & Guidance Documents

Proper documentation of best practice and application guidelines, including adherence to those documented guidelines are essential for effective winter maintenance. Respondents were asked to characterize the management plans, maintenance plans, and/or guidance documents utilized by their organization for winter maintenance operations.

The majority (76%) of communities have some type of plan that provides direction on their winter maintenance operations. Of those with guidance documents, 50% are updated annually, and 30% are update less frequently than once per year. One respondent indicated that their organization's guidance documents have not been updated in twenty (20) years.

Respondents provided a narrative response about factors that have limited or have the potential to limit their organization from achieving its Level of Service (LOS) requirements. Table 3 and Table 4 provide a summary list of responses, organized by MS4 permit phase. The most commonly reported limitations are extremely cold or difficult weather conditions (like freezing rain and ice), access to enough product/material for treatment, and availability of manpower.

Table 3: Phase I Responses to the question: "Please provide a brief summary of the major factors that may limit (or have limited) your organization from achieving its Level(s) of Service."

Phase I Responses	# of Responses
Major snowfall, blizzard conditions or white outs	5
Extended periods of extreme cold (below 19°F)	2
Salt Availability	2
Resource limitations	1
Hard-packed snow or ice	1
Timing of the day (rush hour)- traffic volume holding back operations	1

Table 4: Phase II Responses to the question: "Please provide a brief summary of the major factors that may limit (or have limited) your organization from achieving its Level(s) of Service."

Phase II Responses	# of Responses
Length of storm	4
Speed and extent of storm	3
Difficult weather (freezing rain or ice)	1
Unpredicted rain preceding that removes pre-treatments	1
Personnel/manpower	3
Equipment failure	2
Equipment availability and accessibility	1
Salt availability	2
Funding	1
Conflict with residents	1

Products, Materials, & Equipment

Respondents were asked a series of questions that aimed to identify the types of products/materials and types of equipment used by their organization for winter maintenance. Most respondents indicated that sodium chloride (NaCl) is the most commonly used material. Solid calcium chloride ($CaCl_2$) and magnesium chloride ($MgCl_2$) are never used by 65% and 53% of respondents, respectively (Figure 3).

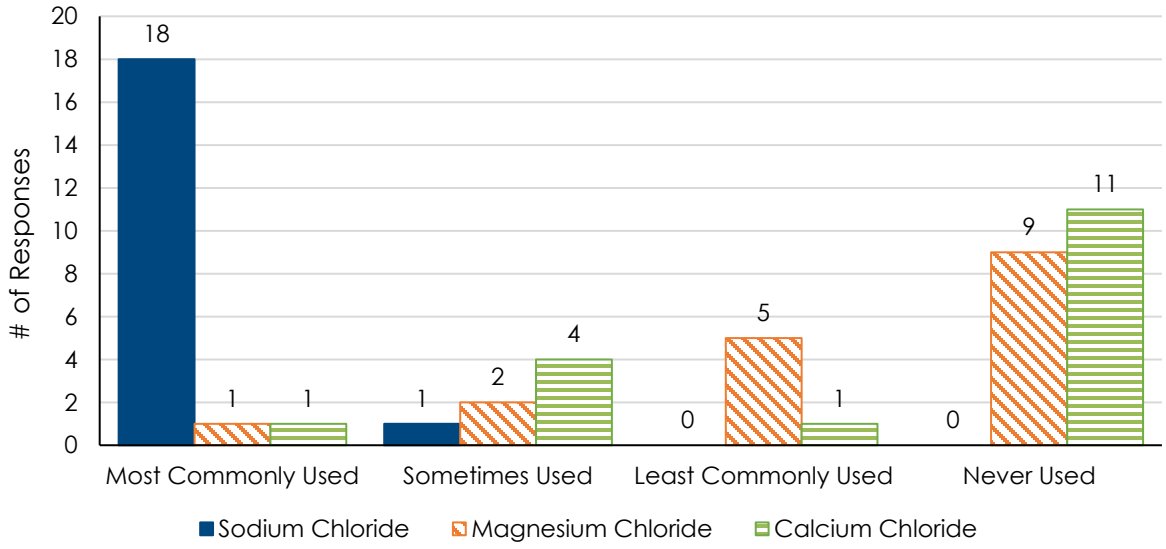


Figure 3: Usage of solid sodium chloride (NaCl), magnesium chloride ($MgCl_2$), and calcium chloride ($CaCl_2$).

Over half the respondents indicated they do not use liquid materials (Figure 4). For those that use liquid material, 88% most commonly use NaCl. One respondent indicated that liquid $MgCl_2$ and NaCl are mixed in storage and are not able to be separated. Using liquid materials for anti-icing is one of the most common and effective methods to reduce salt usage, as identified in the literature review.

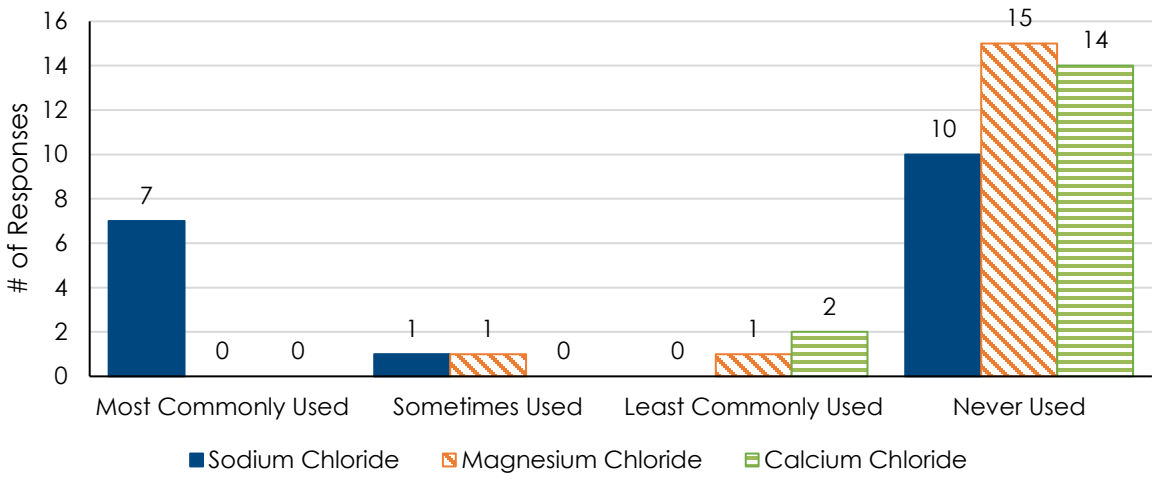


Figure 4. Usage of liquid sodium chloride (NaCl), magnesium chloride ($MgCl_2$), and calcium chloride ($CaCl_2$).

Approximately 40% of respondents have *equipment* necessary to make brine or other liquid mixtures on site, under the operations of their organization. Of those respondents, 80% have brine-manufacturing *facilities* on site. Having a brine facility on site can optimize the efficiency of facility operations.

Eight out of 18 jurisdictions use Direct Liquid Application (DLA) for anti-icing, and of those eight, two also use it during active storm events (Figure 5). Of the eight respondents that use DLA, five own their own equipment to make brine, and three use a third-party manufacturer[5]. A best practice for DLA is to minimize use during an active storm event, as liquid precipitation can wash the applied liquid from the road surface.

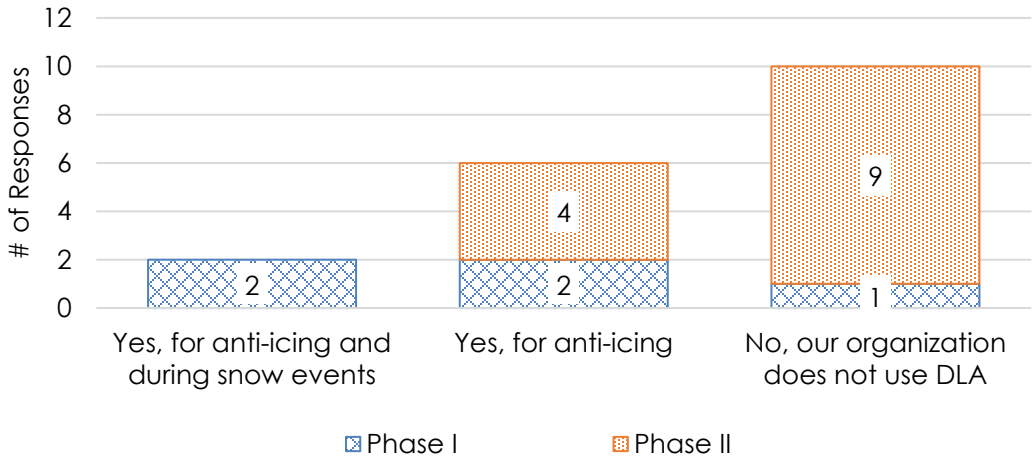
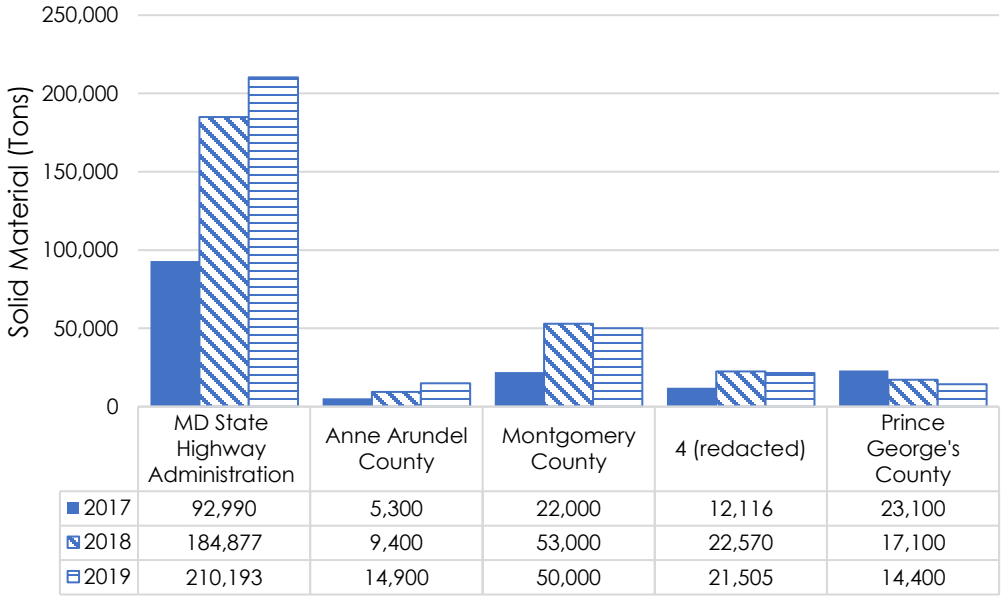


Figure 5. Usage of direct liquid application (DLA) in winter maintenance operations.

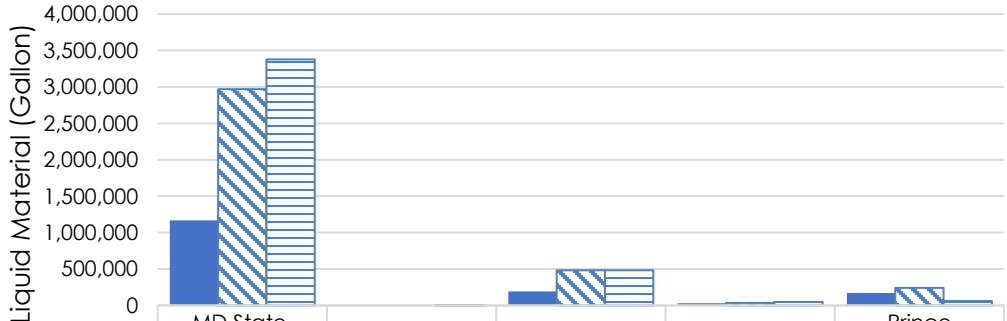
[5] The variation of answers to liquid related questions infers that some respondents may not have understood the questions or terminology used.

Respondents were asked how much solid and liquid material was used in 2017, 2018, and 2019. This includes the total of all types of solid and all types of liquid material. The results are shown below, separated by Phase I (Figure 6 and Figure 7) and Phase II (Figure 8 and Figure 9) jurisdictions. Note the scale difference between the Phase I and Phase II charts. It is important to mention that although there is an increase in some instances of material used, it does not represent poor winter maintenance practices. Various factors—such as availability, weather, snow type, precipitation amount, and temperature—all affect salt usage.



	MD State Highway Administration	Anne Arundel County	Montgomery County	4 (redacted)	Prince George's County
2017	92,990	5,300	22,000	12,116	23,100
2018	184,877	9,400	53,000	22,570	17,100
2019	210,193	14,900	50,000	21,505	14,400

Figure 6. Annual solid material used for winter maintenance operations by Phase I jurisdictions.



	MD State Highway Administration	Anne Arundel County	Montgomery County	4 (redacted)	Prince George's County
2017	1,169,839	-	194,000	28,900	172,500
2018	2,969,436	-	485,000	36,000	242,000
2019	3,378,560	550	485,000	50,000	63,200

Figure 7. Annual liquid material used for winter maintenance operations by Phase I jurisdictions.

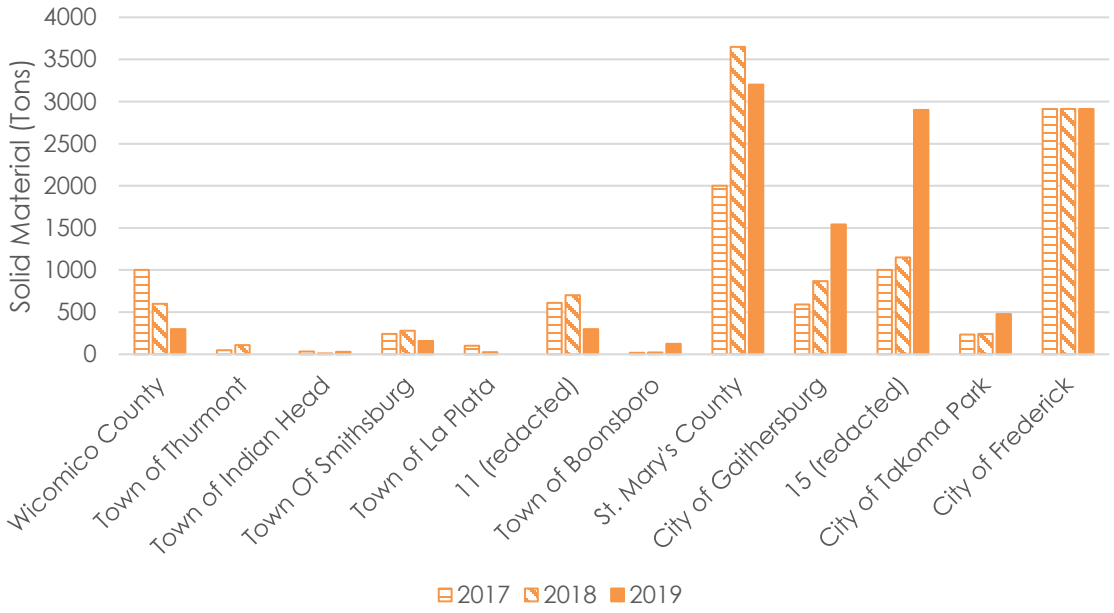


Figure 8. Annual solid material used for winter maintenance operations by Phase II jurisdictions.

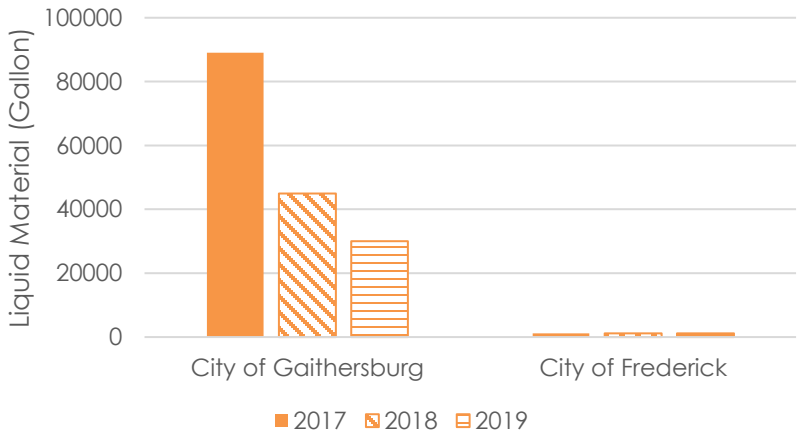


Figure 9. Annual liquid material used for winter maintenance operations by Phase II jurisdictions.

In addition to evaluating the respondents' organizations' product/material usage, this section also inventoried their vehicles, equipment, and retrofits to that equipment. When asked if their fleet's vehicles have the capability to apply liquid materials, most respondents (41.7%) indicated that their vehicles are not capable and therefore do not use liquid materials. Four out of five Phase I communities indicated that their vehicles are capable of applying liquids, and the remaining Phase I indicated that while their organization's vehicles are not capable, they have access to vehicles for liquid application through contractors (Figure 10). Two Phase II respondents indicated they have vehicles with liquid application capability, and one indicated that only one of their vehicles can apply liquid materials.

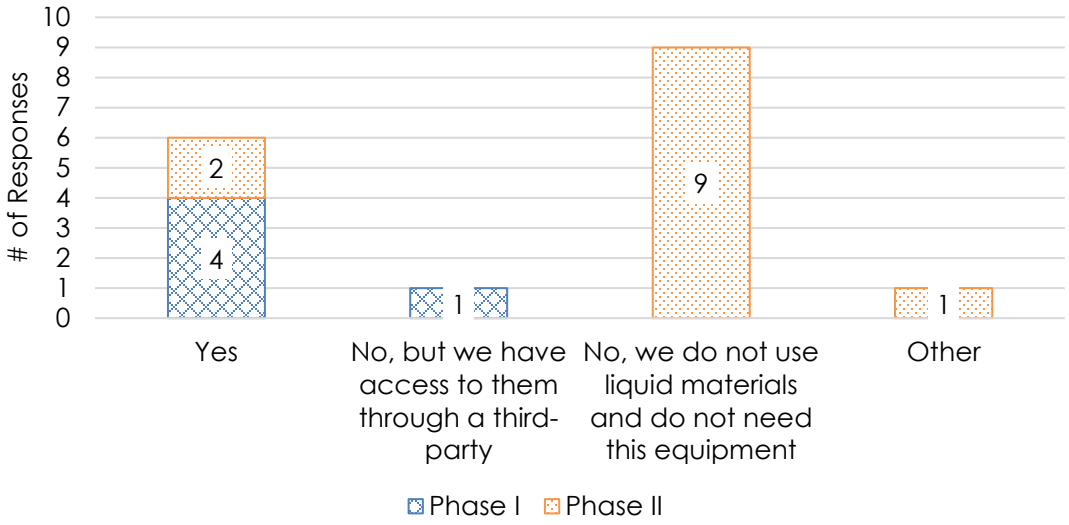


Figure 10: Vehicles with Liquid Application Capabilities

Figure 11 presents which equipment retrofits and technology advancements have been adopted by the jurisdictions. The most common retrofit that has been adopted are application regulators and Automated Vehicle Location (AVL) technology. All of these technologies can help use salt more efficiently.

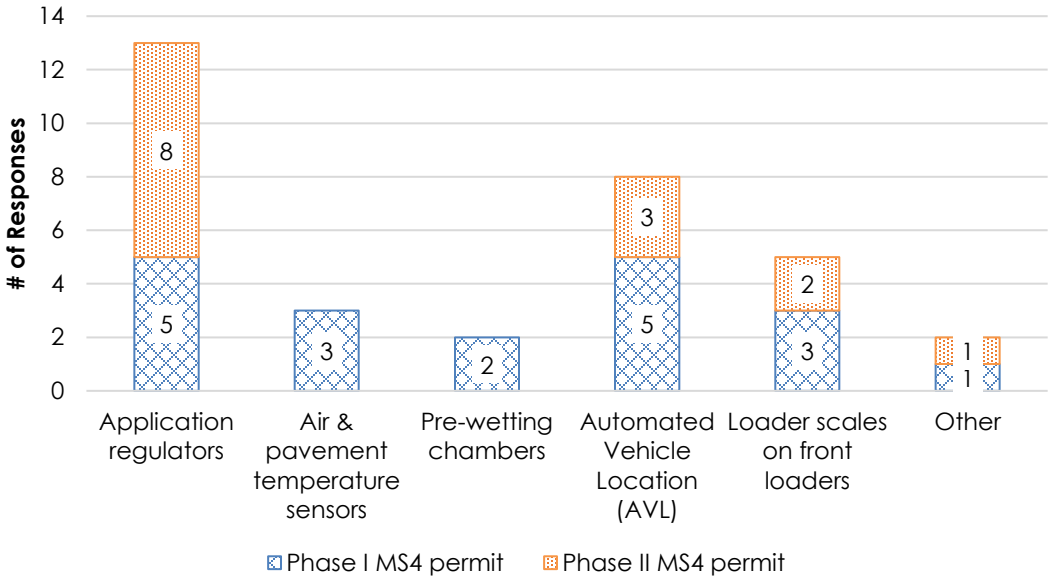


Figure 11. Number of jurisdictions with retrofits/advancements to the vehicles in their winter maintenance fleet.

The respondents were asked the *number* of retrofitted vehicles in their fleet. Table 5 and Table 6 provide the breakdown of retrofit types, with the total number of reported vehicles with retrofits, separated by Phase I and Phase II. All Phase I vehicles have Automated Vehicle Location (AVL) and application regulators/spreader controls. It is

important to note that not all vehicles can have all the capabilities (e.g., a front loader may not need a pre-wetting chamber if it is typically only used to load a truck). Phase II communities have a lower percentage of retrofitted vehicles and none have air and pavement temperature sensors nor pre-wetting chambers.

Table 5. Inventory of equipment retrofits and technology advancements adopted by respondent organizations for winter maintenance operations, Phase I.

Phase I	Electronic application regulators/spreader controls	Manual application regulators/spreader controls	Air & pavement temperature sensors	Pre-wetting chambers	Automated Vehicle Location (AVL)	Loader scales on front loaders	**Total Size of Fleet**
MD SHA	624	0	350	500	624	45	624
Anne Arundel County	35	35	35	35	72	6	72
Montgomery County	155	0	24	0	155	5	155
4 (redacted)	294	0	0	0	294	0	294
Prince George's County	75	60	0	0	135	0	135

Table 6. Inventory of equipment retrofits and technology advancements adopted by respondent organizations for winter maintenance operations, Phase II.

Phase II	Electronic application regulators/ spreader controls	Manual application regulators/ spreader controls	Air & pavement temperature sensors	Pre-wetting chambers	Automated Vehicle Location (AVL)	Loader scales on front loaders	Dump Truck Scale	**Total Size of Fleet**
Wicomico County	0	10	0	0	0	0	0	77
Town of Thurmont	0	4	0	0	0	0	0	33
Town of Indian Head	0	0	0	0	8	0	0	10
Town of Smithsburg	1	1	0	0	0	0	0	3
Town of La Plata	1	3	0	0	0	0	0	4
11 (redacted)	0	8	0	0	14	1	1	14

Phase II	Electronic application regulators/ spreader controls	Manual application regulators/ spreader controls	Air & pavement temperature sensors	Pre-wetting chambers	Automated Vehicle Location (AVL)	Loader scales on front loaders	Dump Truck Scale	**Total Size of Fleet**
Town of Boonsboro	3	0	0	0	0	0	0	9
St. Mary's County	0	16	0	0	0	0	0	18
City of Gaithersburg	21	13	0	0	0	0	0	36
15 (redacted)	11	1	0	0	0	0	0	12
City of Takoma Park	0	0	0	0	7	0	0	7
City of Frederick	0	0	0	0	0	1	0	61

Strategies & Methods

To understand the approaches to winter maintenance, respondents were asked to address core aspects of their specific strategies and methods, such as those related to calibration, tracking and accountability, training, application rate determination, and anti-icing.

Table 7 shows the responses for the question, "How often does your organization calibrate its spreaders?" Over 50% calibrated all of their equipment at least annually. Calibration is one of the most important, cost effective methods to ensure effective salt application.

Table 7: Response to question "How often does your organization calibrate its spreaders?"

Response	# of Responses
Calibration is checked before every event	1
All equipment calibrated yearly, if something looks wrong, or new equipment	2
All equipment calibrated yearly	6
Most equipment calibrated yearly	4
Only new equipment calibrated	1
Do not know	1

Equipment should also be recalibrated when material or product is changed in the equipment. Figure 12 shows that only three out of the 15 jurisdictions that change material recalibrate their equipment.

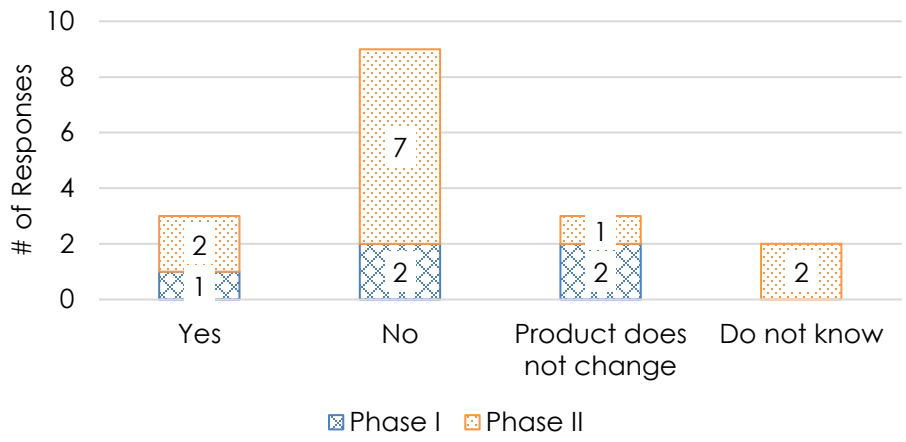


Figure 12: Equipment Recalibrated after Product Change

Over 50% of communities track their product/material usage on a per-storm-event basis and over 35% track it annually. Only one respondent indicated that their organization does not track product/material usage whatsoever.

This section also addressed more technical winter maintenance strategies and methods, such as the process for determining application rates, decision points for the timing of product/material application, and other technical decision points. Figure 13 provides an overview of which types of factors are considered prior to selecting an application rate (for both solid and liquid products/materials) for winter maintenance operations. Respondents were asked to select all that applied.

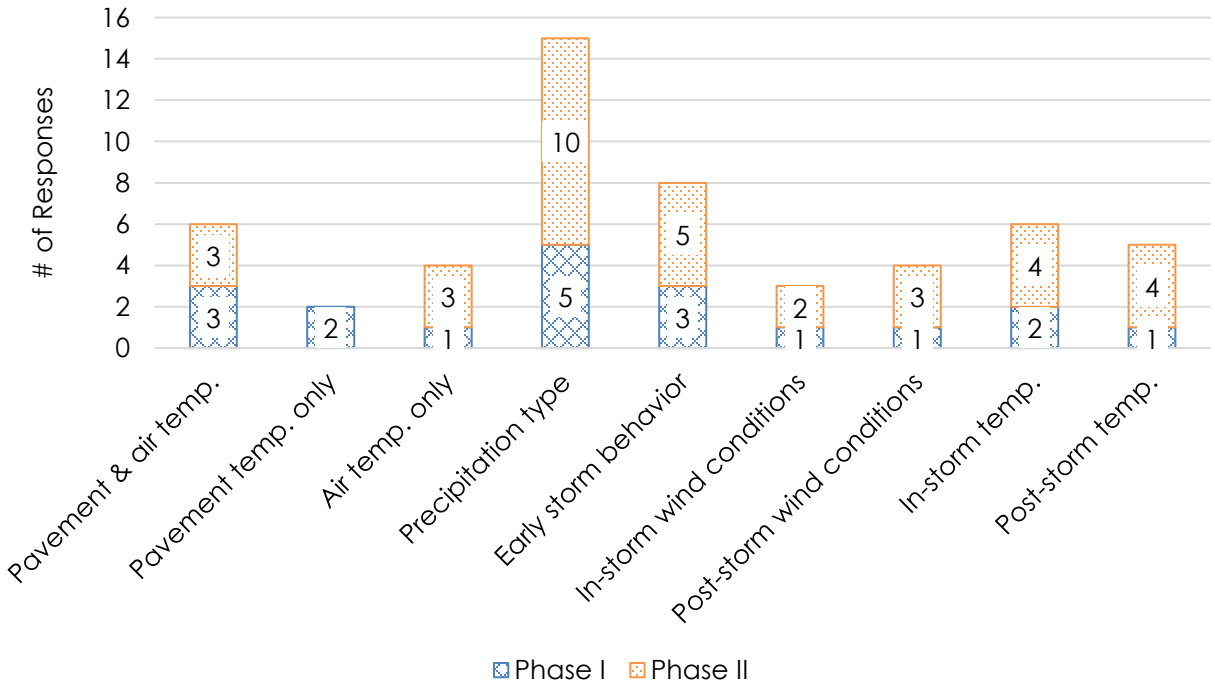


Figure 13: Factors Considered Prior to Selecting Application Rate

Figure 14 shows that 53% of jurisdictions only apply solid products or materials to targeted portion(s) of the roads they are treating, as opposed to the entire road surface. Examples of these targeted portions are the centerline or crown of the road. Two Phase II respondents indicated the portion of road treated was conditional on other variables, such as traffic volume and storm intensity. Treating only the necessary surface reduces the amount of salt applied.

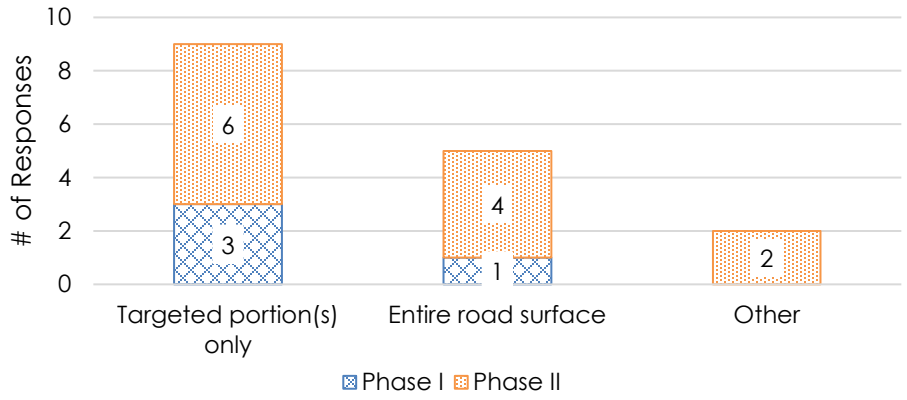


Figure 14. Placement of solid products/materials during the treatment of ROADS for winter maintenance.

Winter maintenance activities should also consider the limited effectiveness of many products/materials on cold and extremely cold pavements (classified as < 15°F and < 0°F, respectively). Sodium chloride significantly decreases in efficiency below 15°F. Table 8 illustrates the frequency of respondent organizations' application of dry granular salt when pavement temperatures are cold (< 15°F). Only one respondent (a Phase I jurisdiction) indicated that they frequently apply solid products/materials in cold pavement conditions. One jurisdiction indicated that they use a solid product/material and abrasive sand mixture in cold pavement conditions.

Table 8. Responses to the question: "When pavement temperatures are below 15°F, how often does your organization use dry granular salt?"

Response	# of Responses
Rarely or never	5
Sometimes	7
Frequently	1
Unknown	3
Other	1

Table 9 categorizes the application of solid products/materials in extremely cold (< 0°F) pavement condition winter maintenance operations. Only three respondents use products/materials that are more effective in extremely cold pavement conditions.

Table 9. Responses to the question: "When pavement temperatures are extremely cold (below 0°F), how does your organization proceed?"

Response	# of Responses
We do not apply any solid or liquid materials	3
We apply abrasives only	2
We use products that work better in cold temperatures than salt or brine	3
We use whatever products we have	8
Other: Apply mixed loads	1

Anti-icing can be a very effective practice for minimizing chloride-contaminated runoff following winter maintenance operations. Respondents were asked to characterize which types of areas they treat using anti-icing (Table 10).

Table 10. Responses to the question: "In which types of areas does your organization perform anti-icing?"

Response	# of Responses
Almost all areas that are salted	3
Most areas that are salted	1
Some areas that are salted	5
None of the areas that are salted	8
Other: Only on emergency roads	1

Salt Storage & Facilities

Proper storage of both solid and liquid products/materials for winter maintenance is essential for minimizing chloride-contaminated runoff from storage facilities. Respondents were asked to identify key components of their storage facilities and to characterize the maintenance and operation of those facilities.

Respondents were asked what their operators or crew does with leftover product or material at the end of a shift. All but one Phase II jurisdiction indicated that leftovers are brought back to the storage facility; the remaining Phase II jurisdiction indicated that they use up remaining product before returning to the storage facility.

All the Phase I communities have their own salt storage facilities, while nine out of 12 Phase II communities do (Figure 15). One respondent that answered "No" noted that they have a long-term lease of a SHA Salt Dome.

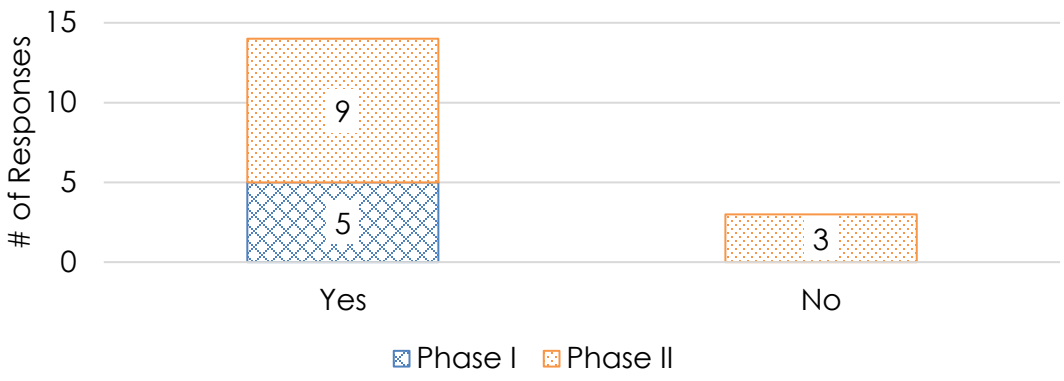


Figure 15. Number of jurisdictions who own and manage at least one salt storage facility.

Respondents were asked to describe the flow and management of runoff from storage facilities. About 50% have some type of system that minimizes runoff from entering surface water or groundwater (Table 11).

Table 11. Responses to the question: "Where does the majority of the runoff from your storage facility go?"

Response	# of Responses
Runoff is collected and reused in a brine system	1
Runoff enters a treatment facility	1
Runoff flows into a pond with no connections to any other surface or groundwater systems	5
There is minimal runoff from the site	2
Runoff is permitted to flow into a pond with connections to another surface or groundwater system	3
Runoff is permitted to flow onto the surrounding landscape	3
There is no storage facility	1
Unknown	1

Budget & Contracts

Respondents were asked to characterize the frequency that third-party contractors are typically hired by their organization for winter maintenance operations. Nearly 30% of respondents hire contractors for every storm event, 41% sometimes hire contractors, and 29% never hire contractors (Figure 16).

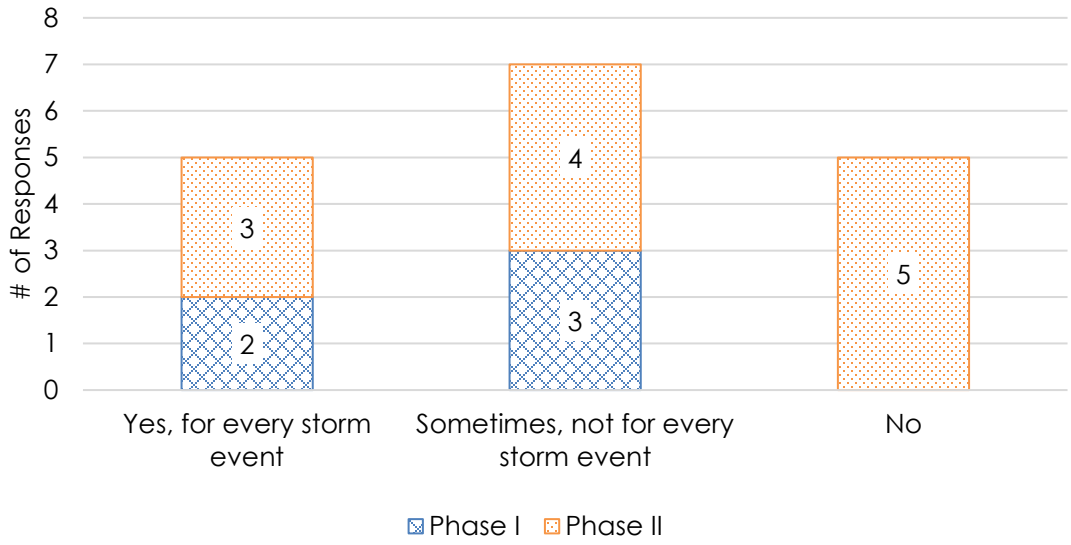


Figure 16. Frequency of third-party contractor hiring for winter maintenance operations.

Respondents were asked whether the contractors they hire use the same management/maintenance plan(s) and guidance document(s) as internal operators. All jurisdictions that hire contractors responded yes, except one who did not know.

Respondents were also asked to characterize their internal budget for winter maintenance operations. The majority of respondents (29.2%) have budgets under $100,000 USD, and 25% indicated they had budgets greater than $1,000,000 USD for Fiscal Year (FY) 2019.

Discussion of Results

The survey allowed for an initial understanding of the best practices for winter maintenance that Maryland MS4 communities currently implement. The process of implementing this survey also allowed for an understanding of the process the municipalities took to obtain the information. Although many MS4 contacts were willing to participate in the survey, obtaining the information proved difficult. Since winter maintenance is typically done in a different department, there was no incentive for the winter maintenance staff to provide the information. The information was also either not all documented in one consolidated location, or it was not documented at all, making it time-consuming or infeasible to complete. Regulations on salt usage may need to take this into consideration. Municipalities may want to start gathering information and building relationships with the winter maintenance team to allow for better data collection and access.

The best practices surveyed were compiled from the most common practices found in the literature review. This list is not exhaustive; it contains the most common, effective, and otherwise useful practices. Figure 17 and Figure 18 show a compiled list the best practices surveyed, with the respective percentage of Phase I and II jurisdictions that are:

- Fully implementing the practice
- Partially implementing the practice
- Not implementing the practice
- Unknown if they are implementing the practice
- Not applicable to the jurisdiction

It is important to note that if the practice is not applicable to the jurisdiction, they are labeled as "Not Applicable." For example, a jurisdiction that does use different products in equipment would not implement the practice to recalibrate equipment after products are changed. Unclear or no responses from jurisdictions are categorized as "Unknown."

In order to reduce the amount of salt used for winter maintenance, the goal would be to move the "Implementing" bar towards 100%, when applicable. There likely is some response bias in terms of jurisdictions who responded to the survey. Municipalities that are already advanced in salt management have easier access to the information collected, as tracking usage is a management practice in and of itself. The actual management practices implemented across all jurisdictions may be lower than what was found in the survey.

Figure 17. Percentage of Phase I Communities implementing best practices for winter maintenance operations.

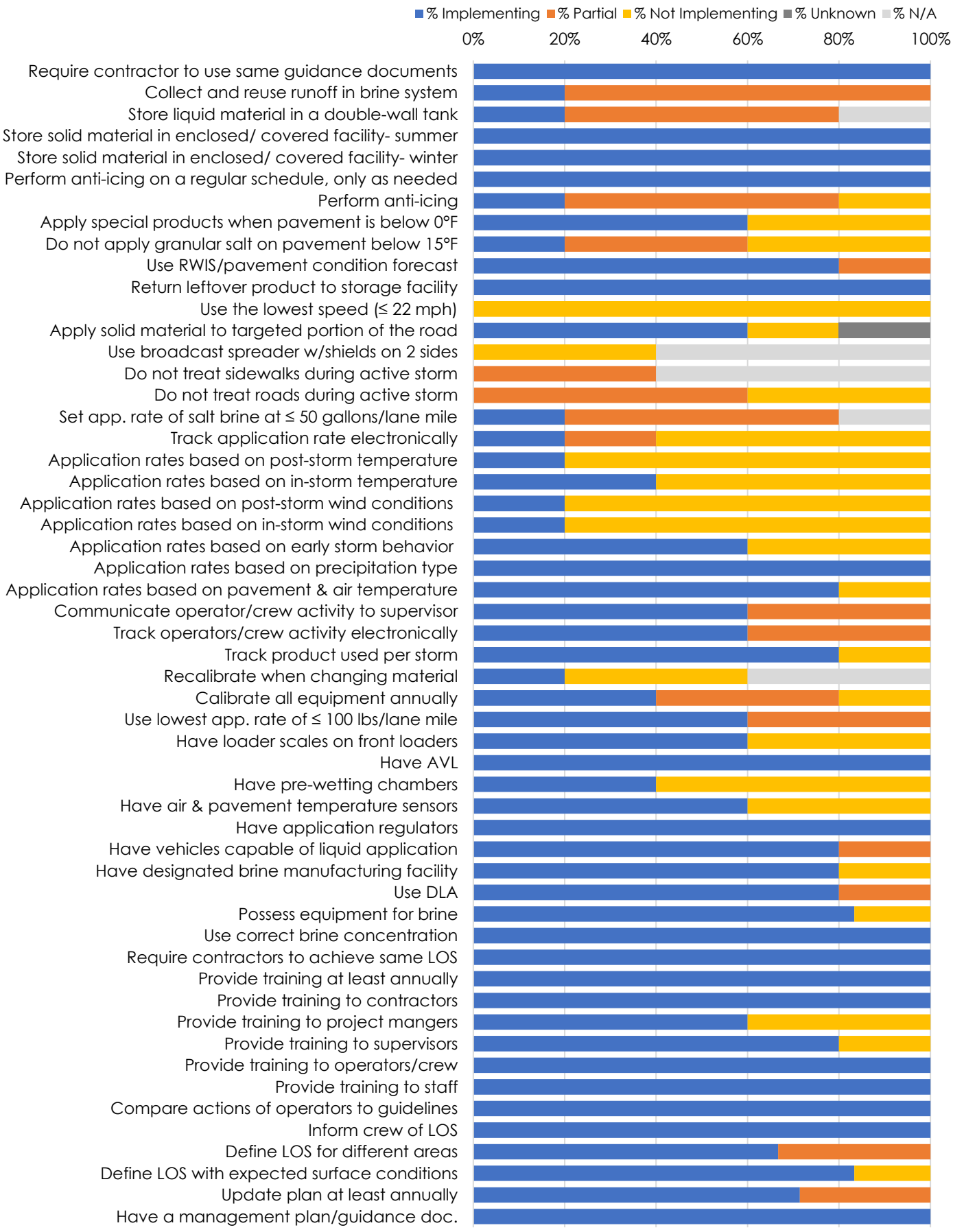


Figure 18. Percentage of Phase II Communities implementing best practices for winter maintenance operations.

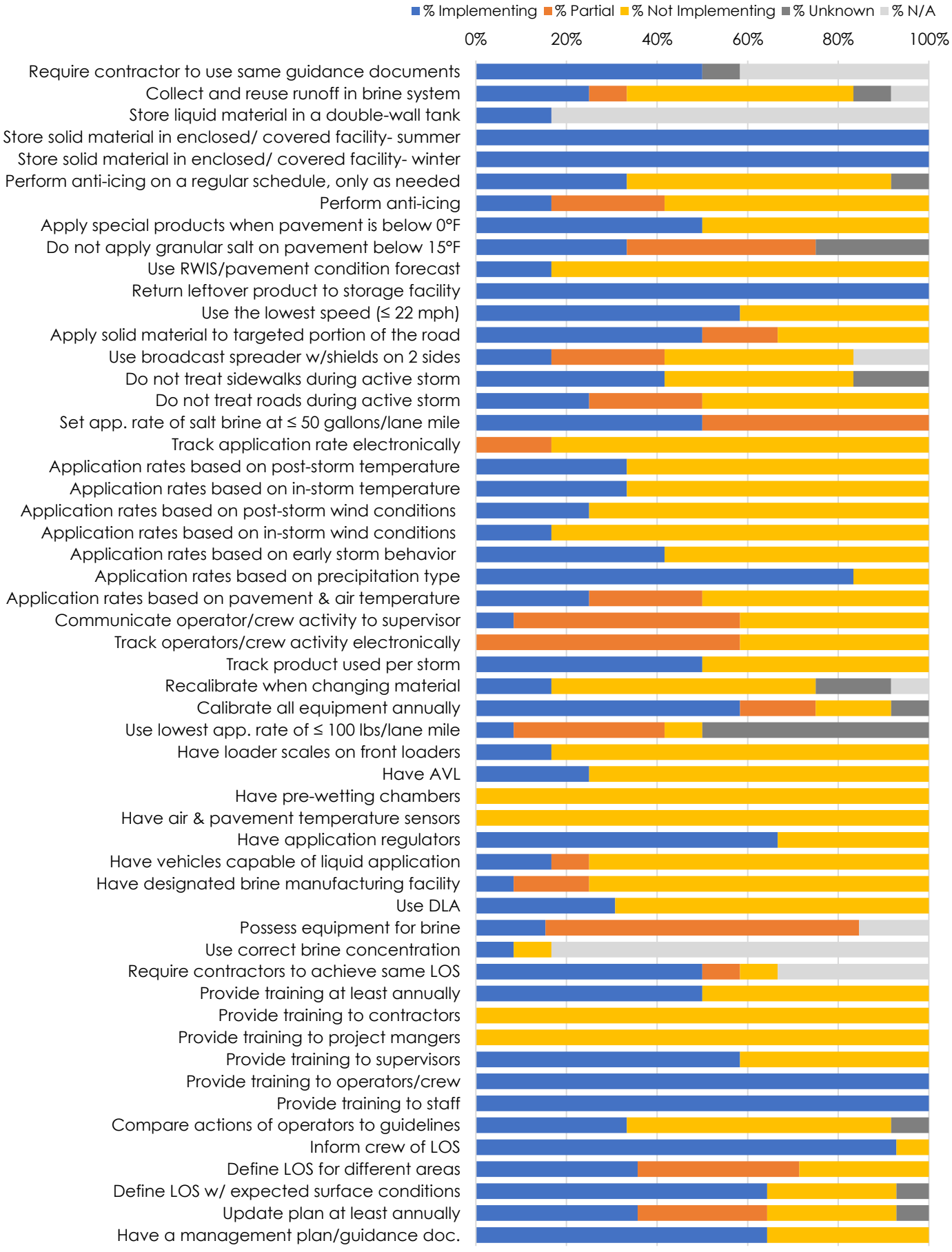


Figure 17 and Figure 18 above show a large variability of best practice implementation. Phase I communities have implemented more practices than Phase II, likely due to their larger budget and service area. From the literature review, it was shown that there is no silver bullet when it comes to salt management. Not all practices are applicable for every community, as various factors such as service area size, resources, and climate can all impact feasibility, implementation, and results. Some practices do not have a direct reduction rate (ex. Salt management plan), making it difficult to directly compare practices.

As stated in the literature review, the Salt Institute (Nixon, n.d.) organizes 11 recommended winter maintenance best practices into a framework called the fundamental five and supplemental six. The fundamental five—calibration, output measurement, accountability, designated levels of service, and training—are essential practices that do not require any substantial upfront capital investment. In general, these practices require an investment in time and the willingness to change. The supplemental six includes variable application rates, road-specific forecasts, cold-temperature-specific practices, liquid material usage, pre-wetting, and anti-icing. These practices require some level of capital or financial investment; however, they typically pay for themselves in one (1) to three (3) winter seasons. (Nixon, n.d.). The supplemental six practices are ancillary to the fundamental five and should be progressively adopted over time.

The survey responses also highlighted some factors hindering small jurisdictions from implementing some of these best management practices. The lack of resources—such as manpower, vehicles, and funding—indicate that the jurisdictions are already stretched thin. They will likely need additional resources to allow them to adopt additional best practices or make programmatic changes.

From the correspondence with MS4 jurisdictions and the survey responses, there were potential knowledge gaps that indicated training would be necessary. Below are some topics that respondents may not have fully understood:

- Difference between liquid terminology - direct liquid application (DLA), anti-icing, pre-wetting, and brine
- Steps for proper liquid implementation
- Definition of lane mile
- MS4 regulations – how the regulations work and why salt management will be needed to obtain MS4 permits
- Materials to use at different temperatures – for example, NaCl does not work well in extreme cold
- Best practices for tracking and accountability

Conclusion

Although there is limited research on fate and transport of chloride from road salts to streams, there is consensus that source reduction is the best way to decrease salinization of our local waterways. The literature review compiles the most effective types of chloride reducing winter maintenance practices, and the survey was able to gather insight on the scale of implementation of those practices in Maryland MS4 communities.

One of the key findings from the project was that recordkeeping and accountability of salt usage and practices are not implemented across all municipalities. Through follow-up conversations with MS4 contacts, many expressed that gathering the information would be difficult and time consuming. Without usage information, it is difficult to determine where improvements can be made. This should be a first step for some municipalities. The survey process also indicated a disconnect between the MS4 managers and the salt operators, as salt usage has not historically been considered in stormwater management. Some winter maintenance staff incorrectly identified their MS4 phase, further supporting needed communication and education. Although MS4 managers will be responsible for reducing salt usage if regulated under the MS4 permit, the winter maintenance staff, typically in the highway maintenance or public works department, will be the ones implementing the practices. Many survey respondents stated that education and buy-in from staff are major factors that would improve adoption of best practices. Lack of staff buy-in can become a barrier when municipalities are required to make changes. Public perception and political pressures are also barriers but are not addressed in this research.

A common concern with salt usage is related to contractors and private applicators. Although this survey was not able to assess contractors directly, there were some better practices that could be implemented by MS4 communities to improve their contractors' salt efficiency, such as requiring the contractor to use the same guidance documents. From the literature review, a method that other jurisdictions are using to reduce contractor salt usage is through a certification program. The certification would include requiring contractors to attend training and implement salt reduction strategies, but also include "liability protection against damages arising from snow and ice conditions"[6]. This creates an incentive for the contractors to reduce their salt usage, since liability is a major factor in the overuse of salt. Other popular practices that have shown reduced salt usage is anti-icing with liquids, calibrating equipment regularly and properly, and measurement, monitoring and accountability practices (such as electronic spreader controls). All will also require staff training and likely an update to guidance documents. Some may require capital costs for equipment, but many other jurisdictions have found that the cost can be recouped over a few years.

[6] https://www.des.nh.gov/organization/divisions/water/wmb/was/salt-reduction-initiative/salt-applicator-certification.htm

The survey was able to take a snapshot of current implementation, but it does not address prioritizing practices for implementation. There is a plethora of guidance available on salt management, but communities, especially Phase II's, may have a difficult time determining which is best suited for their organization. The Maryland State Highway Administration published the "Maryland Statewide Salt Management Plan" in 2019, which is a great resource for municipalities, although some practices may not be feasible due to size and budget constraints. Additional research is needed to determine which practices would be most efficient based on different characteristics of the jurisdictions, especially for smaller municipalities.

As the regulations for salt reduction evolves in Maryland, it is important to create a baseline to measure long term decreases in salt usage. It may be beneficial to gather implementation data on the MS4 communities that did not respond to the survey. It is also important to realize that salt reduction is not simply a total reduction in annual pounds used; weather and snow type are large factors in salt usage and are extremely variable year to year. One measurement that SHA uses to try to account for this is "pounds of salt used per lane mile per inch of snow". With the current science, there is no replacement road salts, but there are various methods to reduce salt usage and the impacts of chloride in the waterways, while still maintaining public safety.

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Appendix A. Survey Question Details

Column	Question Root	Question	Purpose	Details
A	--	N/A	Tracking	Respondent ID for confidentiality purposes
B	--	1. How did you obtain this survey?	Tracking	
C	2. Please provide the following information to identify the individual who will be responsible for completing the survey. The listed respondent may consult with others to answer questions, but only one (1) survey should be completed for each organization.	2A. Respondent Name (Last, First)	Background	Respondent details
D		2B. Respondent Title/Position		Respondent details
E		2C. Respondent Email		Respondent details
F		2D. Name of Affiliated Organization		Organization details
G		2E. Respondent Office Address (Street Address, City, State, Zip Code)		Organization details
H	--	3. Please select from the list below how you would prefer your organization be identified in the publication of the survey results.	Tracking	Respondent preferences for confidentiality
I	--	4. Please select which type of Municipal Separate Storm Sewer System (MS4) permit applies to your jurisdiction/organization.	Background	Phase I vs. Phase II differentiation
J	--	5. Does your organization implement snow & ice management/winter maintenance operations?	Background	Response validation
K	--	6. Which department or agency within your organization is responsible for snow & ice management?	Background	Organization details
L	7. On which type(s) of areas/properties does your organization implement snow & ice management?	7A. Public (e.g., roads, schools, sidewalks, etc.)	Winter Preparation	Service area characterization
M		7B. Private (e.g., residential streets, commercial areas, etc.)		

Column	Question Root	Question	Purpose	Details
N		7C. Both public & private		
O		7D. Other (please specify)		
P	8. Which type(s) of surfaces does your organization treat for snow & ice? Select all that apply.	8A. Roads (any type)	Winter Preparation	Service area characterization
Q		8B. Parking lots		
R		8C. Sidewalks		
S		8D. Other (please specify)		
T	9. For 2019, what was your service area for snow & ice management for the following? This question is referring to the areas your organization is responsible for, not necessarily what areas were actually treated. Please use the comment section to provide information that may help to interpret your responses if these road class types are not used by your organization.	9A. Total roadway (lane miles):	Winter Preparation	Service area characterization
U		9B. Total length/area of sidewalks (please specify units as linear feet or square feet):		
V		9C. Total area of other surfaces (specify units as acres, linear feet, or lane miles):		
W		9D. OPTIONAL - Arterial highways ONLY (lane miles):		
X		9E. OPTIONAL - Major arterial highways ONLY (lane miles):		
Y		9F. OPTIONAL - Minor arterial highways ONLY (lane miles):		
Z		9G. OPTIONAL - Collector roads ONLY (lane miles):		
AA		9H. Major collector roads ONLY (lane miles):		
AB		9I. OPTIONAL - Local collector roads only (lane miles):		
AC		9J. OPTIONAL - Total parking lots (not including Park & Ride lots) (acres):		
AD		9K. OPTIONAL - Total Park & Ride lots (acres):		
AE		9L. OPTIONAL - Other areas (type, lane miles):		
AF		9M. Additional Comments:		
AG	--	10. Does your organization have a snow & ice management	Winter Preparation	Assessment of guidance documents

Column	Question Root	Question	Purpose	Details
		maintenance plan, salt management plan, or other type of guidance document that provides direction on the application of road salt and other winter maintenance best management practices (BMPs)?		and other administrative documentation
AH	--	11. Please provide a link to your organization's maintenance plan, management plan, or other guidance document. If your organization does not have one, please describe what information/guidance is used to determine the type, amount, and timing of material/product application.	Winter Preparation	Assessment of guidance documents and other administrative documentation
AI	--	12. How frequently is your written plan or other guidance document reviewed and updated?	Winter Preparation	Assessment of guidance documents and other administrative documentation
AJ	--	13. Does your organization have a defined Level(s) of Service that states the expected condition of surfaces after winter maintenance activities are completed? Examples: "Provide snow and ice maintenance service to achieve bare pavement conditions," or "Clearing the pavement bare of ice and snow over its entire width will be accomplished as soon as reasonably possible after the winter storm event."	Winter Preparation	Assessment of guidance documents and other administrative documentation Characterization of Level(s) of Service

Column	Question Root	Question	Purpose	Details
AK	--	14. Does your organization define different Levels of Service for different types of areas?	Winter Preparation	Assessment of guidance documents and other administrative documentation Characterization of Level(s) of Service
AL	--	15. Please provide an example of a Level of Service for a major service area AND provide a link to a Level of Service document that can be reviewed, if available. Example: "For storm events with >4 inches of snow, residential streets will be plowed after emergency and collector roads are completed. Streets will be passable (may not be bare pavement, may be snow-packed) within 36 hours of the end of the storm."	Winter Preparation	Assessment of guidance documents and other administrative documentation Characterization of Level(s) of Service
AM	--	16. Are your organization's crew/operators informed of the Level(s) of Service that apply to their assigned maintenance area(s)?	Winter Preparation	Characterization of Level(s) of Service Staff training
AN	--	17. In general, are your organization's Level(s) of Service typically met during the winter season?	Winter Preparation	Analysis and improvement efforts
AO	--	18. Please provide a brief summary of the major factors that may limit (or have limited) your organization from achieving its Level(s) of Service.	Winter Preparation	Analysis and improvement efforts

Column	Question Root	Question	Purpose	Details
AP	19. Please rank the following SOLID product/materials on how commonly they are used by your organization for snow and ice management (1 = most commonly used, 2 = sometimes used, 3 = least commonly used, 4 = never used).	19A. Sodium chloride	During the Storm	Product/material usage
AQ		19B. Magnesium chloride		
AR		19C. Calcium chloride		
AS		19D. Other (please specify)		
AT	20. Please rank the following LIQUID products/materials on how commonly they are used by your organization for snow and ice management (1 = most commonly used, 2 = sometimes used, 3 = least commonly used, 4 = never used).	20A. Sodium chloride (brine)	During the Storm	Liquid usage
AU		20B. Magnesium chloride		
AV		20C. Calcium chloride		
AW		20D. Other (please specify)		
AX	21. Please provide the concentration for the liquid products/materials used by your organization. For example, standard sodium chloride solution (brine) is 23.3% sodium chloride.	21A. Name of liquid product/material (sodium, magnesium, or calcium chloride)	During the Storm	Liquid usage Practices for output measurement, monitoring, and increasing accountability
AY		21B. Concentration (as a percent) of liquid product/material		
AZ	--	22. Does your organization possess the equipment necessary to make brine or other liquid mixtures on-site and under the operation of your organization?	During the Storm	Liquid usage
BA	--	23. Does your organization use Direct Liquid Application (DLA) for snow & ice management?	During the Storm	Liquid usage

Column	Question Root	Question	Purpose	Details
BB	24. Please answer the following questions for the winter maintenance season of FY2019.	24A. In 2019, how much SOLID material (specify tons or pounds) was applied in total?	During the Storm	Practices for output measurement, monitoring, and increasing accountability
BC		24B. In 2019, what was the average application rate (lbs/lane mile) for SOLID material?		
BD		24C. In 2019, how much LIQUID material (gallons) was applied in total?		
BE		24D. In 2019, what was the average application rate (gal/lane mile) for LIQUID material?		
BF	25. Please answer the following questions for the winter maintenance season of FY2018.	25A. In 2018, how much SOLID material (specify tons or pounds) was applied in total?	During the Storm	Practices for output measurement, monitoring, and increasing accountability
BG		25B. In 2018, what was the average application rate (lbs/lane mile) for SOLID material?		
BH		25C. In 2018, how much LIQUID material (gallons) was applied in total?		
BI		25D. In 2018, what was the average application rate (gal/lane mile) for LIQUID material?		
BJ	26. Please answer the following questions for the winter maintenance season of FY2017.	26A. In 2017, how much SOLID material (specify tons or pounds) was applied in total?	During the Storm	Practices for output measurement, monitoring, and increasing accountability
BK		26B. In 2017, what was the average application rate (lbs/lane mile) for SOLID material?		
BL		26C. In 2017, how much LIQUID material (gallons) was applied in total?		

Column	Question Root	Question	Purpose	Details
BM		26D. In 2017, what was the average application rate (gal/lane mile) for LIQUID material?		
BN	--	27. If your answers to the last three (3) questions changed between years, why was there an increase or decrease? If your answers were the same for FY2017, FY2018, and FY2019, please respond "N/A."	Winter Preparation	Analysis and improvement efforts
BO	--	28. Does your organization have one or more designated facilities for brine manufacturing?	During the Storm	Liquid usage
BP	--	29. In FY2019, how many vehicles were in your organization's fleet? ONLY include vehicles owned by your organization (not owned by your contractors).	Background	Inventory of vehicles, equipment, retrofits, etc.
BQ	--	30. In addition to the vehicles owned by your organization, typically, how many vehicles does your organization contract out annually for winter maintenance? If none, please respond "N/A."	Background	Inventory of vehicles, equipment, retrofits, etc.
BR	--	31. Does your organization's fleet include vehicles capable of applying liquid materials for snow & ice management?	Before the Storm	Inventory of vehicles, equipment, retrofits, etc. Liquid usage
BS	32. Advancements in technology have made new equipment available to improve the application of both solid and liquid materials/products for snow & ice management. Does your	32A. Application regulators (e.g., electronic spreader controls)	Before the Storm	Inventory of vehicles, equipment, retrofits, etc.
BT		32B. Air & pavement temperature sensors		
BU		32C. Pre-wetting chambers		
BV		32D. Automated Vehicle Location (AVL)		

Column	Question Root	Question	Purpose	Details
BW	organization's fleet include any of the following equipment? Only include vehicles owned by your organization (not owned by your contractors). Select all that apply.	32E. Loader scales on front loaders		
BX		32F. Other (please provide a list or describe any additional equipment/technology used to optimize or reduce the application of salt)		
BY	33. How many vehicles in your organization's winter maintenance fleet are retrofitted or include equipment from the previous question? Your response should NOT include vehicles owned by contractors or subcontractors.	33A. # of vehicles in fleet with electronic application regulators/spreader controls	Before the Storm	Inventory of vehicles, equipment, retrofits, etc.
BZ		33B. # of vehicles in fleet with manual application regulators/spreader controls		
CA		33C. # of vehicles in fleet with air & pavement temperature sensors		
CB		33D. # of vehicles in fleet with pre-wetting chambers		
CC		33E. # of vehicles in fleet with Automated Vehicle Location (AVL)		
CD		33F. # of vehicles in fleet with loader scales on front loaders		
CE		33G. # of vehicles in fleet with other retrofits (please describe)		
CF	--	34. What is the lowest application rate your organization's equipment can deliver with an even spread pattern?	During the Storm	Application rates
CG	35. How often does your organization calibrate its spreaders? If more than one option applies, you may select multiple options.	35A. All equipment is calibrated yearly	Before the Storm	Calibration
CH		35B. Equipment is calibrated if something looks wrong is if new equipment is acquired		
CI		35C. Most equipment is calibrated yearly		
CJ		35D. Most equipment is calibrated every other year		

Column	Question Root	Question	Purpose	Details
CK		35E. Only new equipment is calibrated		
CL		35F. I don't know		
CM		35G. Other (please specify)		
CN	--	36. Does your organization recalibrate its equipment each time the material/product used is changed?	Before the Storm	Calibration
CO	--	37. During the winter maintenance season, does your organization track how much product/material is used on an annual, monthly, or per storm event basis?	During the Storm	Practices for output measurement, monitoring, and increasing accountability
CP	--	38. How does your organization's operators/crew document their activities in the field (to include, for example, use of products/materials for winter maintenance)?	During the Storm	Practices for output measurement, monitoring, and increasing accountability
CQ	--	39. How is operator/crew activity information communicated by the operator/crew to a supervisor or manager (e.g., automated, downloaded from vehicle, etc.)?	During the Storm	Practices for output measurement, monitoring, and increasing accountability
CR	--	40. Do your organization's supervisors compare the actions of operators to application guidelines outlined in your organization's maintenance plan/management plan/other guidance document?	Winter Preparation	Analysis and improvement efforts Assessment of guidance documents and other administrative documentation
CS	--	41. Does your organization provide training (either in-house or by contract) to staff involved in snow & ice management?	Winter Preparation	Staff training

Column	Question Root	Question	Purpose	Details
CT	--	42. Please provide the name(s) & link(s) to training program(s)/resource(s) used by your organization.	Winter Preparation	Staff training
CU	43. Who at your organization is required to receive training? Select all who apply.	43A. Operators/crew (staff who drive/operate plows and/or spreaders)	Winter Preparation	Staff training
CV		43B. Supervisors		
CW		43C. Program managers		
CX		43D. Contractors		
CY		43E. Other (please specify)		
CZ	--	44. How often does your organization provide or receive training?	Winter Preparation	Staff training
DA	--	45. Prior to hiring outside contractors/subcontractors, does your organization require its contractors to achieve the same Level(s) of Service that is required internally within your organization?	Background and Winter Preparation	Contractor management Characterization of Level(s) of Service
DB	46. How are application rates for granular and liquid products/materials for snow & ice management determined? Select all that apply.	46A. Application rates are based on both pavement and air temperatures	During the Storm	Application rates
DC		46B. Application rates are based on pavement temperatures only		
DD		46C. Application rates are based on air temperatures only		
DE		46D. Application rates are based on precipitation type (e.g., heavy snow, medium snow, light snow, freezing rain)		
DF		46E. Application rates are based on early storm behavior (e.g., rain or snow)		

Column	Question Root	Question	Purpose	Details
DG		46F. Application rates are based on in-storm wind conditions (e.g., light <15 mph, strong >15 mph)		
DH		46G. Application rates are based on post-storm wind conditions (e.g., light <15 mph, strong >15 mph)		
DI		46H. Application rates are based on in-storm temperature (e.g., warm >32 F, moderately cold 25 F - 32 F, cold <25 F)		
DJ		46I. Application rates are based on post-storm temperature (e.g., warming or cooling)		
DK		46J. Other (please specify)		
DL	--	47. How does your organization ensure that operators/crew members follow application rate recommendations?	During the Storm	Practices for output measurement, monitoring, and increasing accountability
DM	--	48. What is your organization's most common anti-icing application rate for straight salt brine on roads? Anti-icing is the application of a deicer chemical (liquid or solid) to a surface before a storm starts in order to prevent ice from forming and bonding to the surface or to enhance plowing efforts. This is different than pre-treatment which is the application of a liquid deicer to a solid deicer (like rock salt) to enhance deicer performance.	During the Storm	Application rates Anti-icing
DN	--	49. Please provide your organization's average de-icing	During the Storm	Application rates Liquid usage

Column	Question Root	Question	Purpose	Details
		application rate for straight salt brine on roads.		
DO	--	50. What is your organization's most common anti-icing application rate for straight salt brine (23.3% sodium chloride solution) on parking lots/sidewalks?	During the Storm	Application rates Anti-icing
DP	--	51. Please provide your organization's average de-icing application rate for straight salt brine on parking lots/sidewalks.	During the Storm: Variable Application Rates	Application rates Liquid usage
DQ	--	52. Does your organization apply snow & ice management products/materials to ROADS during an active storm?	During the Storm	Treatment techniques
DR	--	53. Does your organization apply snow & ice management products/materials to PARKING LOTS/SIDEWALKS during an active storm?	During the Storm	Treatment techniques
DS	54. How does your organization apply granular salt to sidewalks?	54A. Drop spreader	During the Storm	Treatment techniques Inventory of vehicles, equipment, retrofits, etc.
DT		54B. Broadcast spreader with shields on two sides		
DU		54C. Broadcast spreader with shields on one side		
DV		54D. Broadcast spreader without shield		
DW		54E. We do not maintain sidewalks		
DX		54F. I don't know		
DY		54G. Other (please specify)		
DZ	--	55. When applying solid products/materials, do you apply to the entire road surface or targeted portion(s) of the road (e.g.,	During the Storm	Treatment techniques

Column	Question Root	Question	Purpose	Details
		centerline, crown, super-elevation, etc.; this may vary depending on the type of road)?		
EA	--	56. At what speed do your organization's vehicles spread granular salt on roads?	During the Storm	Treatment techniques
EB	--	57. What is done with leftover product(s)/ material(s) at the end of a shift?	After the Storm	Storage of materials
EC	58. Select the source(s) your organization uses for weather forecasts. Select all that apply.	58A. Local news forecasts	Before the Storm	Road-specific forecasts
ED		58B. National Weather Service (NWS)		
EE		58C. Contracted weather services		
EF		58D. Pavement condition forecasts		
EG		58E. Road Weather Information System (RWIS) through our organization or contracted		
EH		58F. I don't know		
EI		58G. Other (please specify)		
EJ	--	59. When pavement temperatures are below 15°F, how often does your organization use dry granular salt?	During the Storm	Treatment techniques Cold weather practices
EK	--	60. When pavement temperatures are extremely cold (below 0°F), how does your organization proceed?	During the Storm	Treatment techniques Cold weather practices
EL	--	61. What percentage of your organization's winter maintenance fleet is set up for liquid application (of the vehicles that apply products/materials)?	During the Storm	Inventory of vehicles, equipment, retrofits, etc. Liquid usage
EM	--	62. In which types of areas does your organization perform anti-icing? Anti-icing is the application of	Before the Storm	Anti-icing

Column	Question Root	Question	Purpose	Details
		a deicer chemical (liquid or solid) to a surface before a storm starts in order to prevent ice from forming and bonding to the surface or to enhance plowing efforts. This is different than pre-treatment which is the application of a liquid deicer to a solid deicer (like rock salt) to enhance deicer performance.		
EN	--	63. When does your organization perform anti-icing?	Before the Storm	Anti-icing
EO	--	64. Based on your previous responses, what challenges can you identify that may limit your organization's adoption of additional best practices?	Winter Preparation	Analysis and improvement efforts
EP	--	65. Based on your previous responses, what opportunities to implement best practices did your organization take advantage of?	Winter Preparation	Analysis and improvement efforts
EQ	--	66. Does your organization own and manage any salt storage facilities?	After the Storm	Storage of materials
ER	--	67. What is the most common way that your organization stores solid/granular products/materials during the WINTER?	After the Storm	Storage of materials
ES	--	68. What is the most common way that your organization stores solid/granular products/materials during the SUMMER?	After the Storm	Storage of materials
ET	--	69. How does your organization store liquid products/materials?	After the Storm	Storage of materials
EU	--	70. Where does the majority of the runoff from your storage facility go?	After the Storm	Storage of materials

Column	Question Root	Question	Purpose	Details
EV	--	71. Does your organization hire contractors/subcontractors for snow & ice management services?	Winter Preparation	Contractor management
EW	--	72. Do contractors/subcontractors hired by your organization use the same snow & ice management plan/guidance document(s) as those used internally in your organization?	Winter Preparation	Contractor management Assessment of guidance documents and other administrative documentation
EX	--	73. Is your organization's budget for snow & ice management adequate to meet your Level(s) of Service?	Winter Preparation	Analysis and improvement efforts
EY	--	74. If your organization's budget for snow & ice management is NOT adequate to meet your Level(s) of Service, why? If the budget is adequate, please respond "N/A."	Winter Preparation	Analysis and improvement efforts
EZ	--	75. Please select the budget for your organization's snow & ice management operations in FY2019.	Background	Budgeting
FA	76. What percentage of your organization's snow & ice management budget goes to each of the following?	76A. Staff	Background	Budgeting
FB		76B. Existing equipment maintenance		
FC		76C. New equipment purchases		
FD		76D. Retrofits to existing equipment		
FE		76E. Training		
FF		76F. Contractual snow & ice management services		
FG		76G. Other (please describe)		
FH	--	77. What factors have prevented or could prevent your organization from adopting additional snow & ice management best practices?	Winter Preparation	Analysis and improvement efforts

Appendix B. Analysis of Survey Results

Below are the results of the survey in a similar order to that of the survey questions themselves. Some results may be reordered to improve flow. In total, 24 responses were submitted, 17 of which were fully completed and seven of which were partially completed (Figure 1).

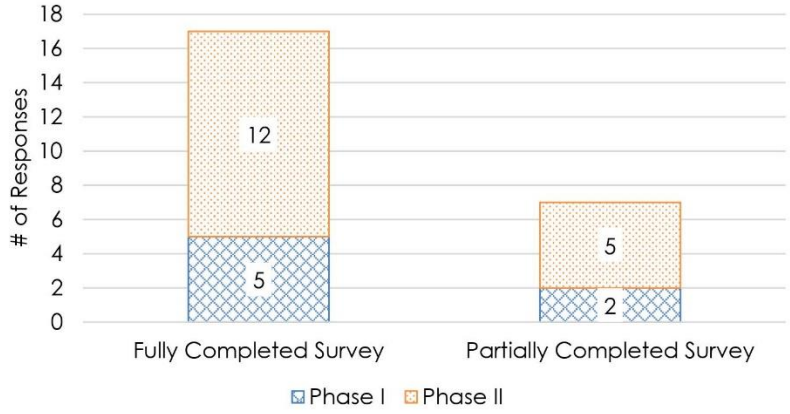


Figure 1: Overview of submitted survey responses, split by the type of MS4 permit held by the respondent's organization and by the degree of completeness.

Respondents were first asked to identify key characteristics and responsibilities of their organization in order to characterize the scope of their winter maintenance operations.

Figure 2 illustrates the types of areas treated by the respondents. The majority (87.5%) of respondents treat only public areas (e.g., publicly owned roads, schools, parking lots, and sidewalks). The only respondent to treat both public and private areas is a relatively small Phase II jurisdiction. The two respondents who provided their own responses ("Other") noted that they treat only public areas; however, they do not treat schools.

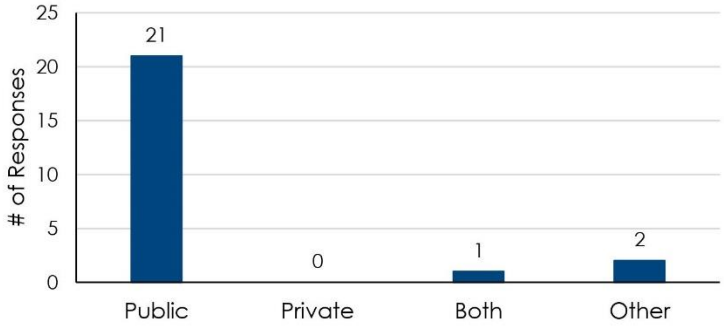


Figure 2: Overview of types of areas treated by respondent organizations (public: roads, schools, sidewalks, etc.; private: residential streets, commercial areas, etc.).

All the respondents treat roads, but only 71% treat parking lots and/or sidewalks (Figure 3). Of two respondents who provided their own responses ("Other"), one indicated that they also treat Public Works yards and municipal airports, and one indicated that they only treat parking lots and sidewalks at public properties.

Figure 3: Specific types of areas treated by respondent organizations.

Table 1 is the summary of the size of jurisdictions' service area, split into roads, sidewalks, and parking lots or other areas. The cells in green indicate that the respondents answered that they treat for snow and ice in those areas but did not provide the size. It is unclear if respondents answered the road area in lane miles, or actual miles. For sidewalks, various units were reported, and it is noted as such. Due to the different units, unclear information, and missing information, this data could not be used to determine salt usage per unit area.

Table 1: Size of Service Area of MS4 Jurisdictions

	Jurisdiction	Roads (Lane Miles)	Sidewalk (Linear Foot)	Parking Lots/ other areas (acres)
Phase I	MD State Highway Administration	17,132	N/A	100
	19 (redacted)	6,722	N/A	N/A
	Prince George's County	5,500	N/A	N/A
	Montgomery County	5,200	316,800	N/A
	Anne Arundel County	4,300	N/A	N/A
	4 (redacted)	4,300*	N/A	
	Howard County	2,400	174 facilities	
Phase II	St. Mary's County	1,272		
	Wicomico County	700	N/A	N/A
	City of Frederick	451	95,000	92
	City of Gaithersburg	228	5680 sq. feet	
	15 (redacted)	120	3,000	6
	11 (redacted)	73	3,168	4
	City of Takoma Park	34	5,000	2 parking lots
	Town of Smithsburg	30	3 acres	

Town of La Plata	29	8,500	2
Town of Thurmont	25	600	1
Town of Boonsboro	20	7,200	
Town of Indian Head	14	9,240	
Town of North East	7	1,000	

*The original number appeared to be incorrect. The information was verified with a report from the jurisdiction and corrected.

Maintenance Plans & Guidance Documents

Proper documentation of best practices and application guidelines, including adherence to those documented guidelines, is essential to effective winter maintenance. Respondents were asked to characterize the management plans, maintenance plans, and/or guidance documents utilized by their organization for winter maintenance operations.

The majority (76%) of respondents' organizations have a maintenance/management plan and/or other type of guidance/reference document that provides direction on their winter maintenance operations. Of those with guidance documents, 50% update their guidance annually, and 30% update them less frequently than once per year (Figure 4). The respondent who provided their own response ("Other") was a Phase II jurisdiction who indicated that their organization's guidance documents have not been updated in 20 years.

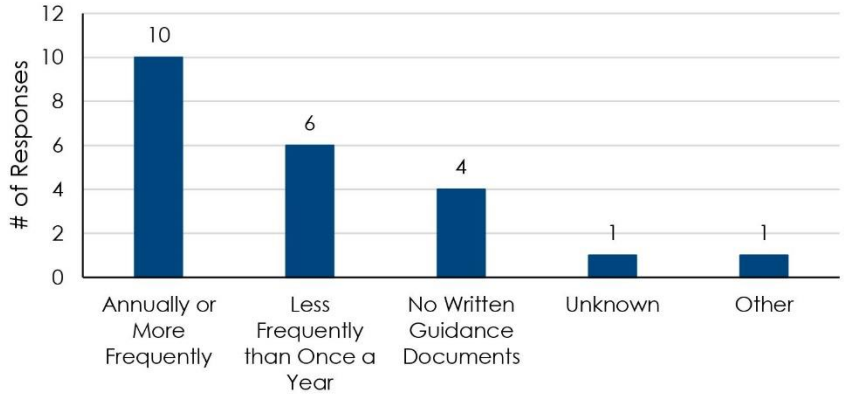


Figure 4: Frequency of updates to guidance/reference documents and maintenance/management plans.

Respondents were asked to provide access to their organization's guidance document(s) as a part of the survey as well. For those organizations without guidance documents, respondents were asked to describe the information that is used to determine the type, amount, and timing of product/material application.

This section of questions also evaluated the Level(s) of Service (LOS) for each respondent's organization. Majority reported that their organization have a defined LOS for the areas they treat (Table 2).

Table 2: Responses to the question: "Does your organization have a defined Level of Service that states the expected condition of surfaces after winter maintenance operations?"

Response	# of Responses
Yes	14
No	5
Unknown	1

Respondents were also asked whether their organization defines different LOS for different types of areas.

Table 3: Responses to the question: "Does your organization define different Levels of Service for different types of area?"

Response	# of Responses
Yes, different Levels of Service are documented for different areas	9
No, the same Level of Service is documented for all areas	7
No, Levels of Service are not documented	4

Respondents were asked to provide an example of a LOS for one of their organization's major service areas. Table 4 and

Table 5 list the responses, separated by MS4 permit type.

Table 4: Phase I Responses to the question: "Please provide an example of a Level of Service for a major service area AND provide a link to a Level of Service document that can be reviewed, if available."

Phase I Responses
For storms of 8 inches or less, our LOS requires that all interstate ad P1 arterial roadways (high volume roads or interstate connectors) are free from snow and ice from edge line to edge line (excluding shoulders) within 4 hours of the end of precipitation.
During a typical storm (under 4 inches), snow removal operations on County-maintained roadways should be completed within 24–36 hours after the end of the storm. Main and collector roads will be plowed to bare pavement. Our next priority will be ensuring residential roads are passable. Passable means that although the road may be snow-covered or snow-packed, at least one travel lane will be accessible with a front-wheel drive car.
All roads will be passable and treated for snow and ice.
Streets are to be made passable 24 hours after any event.
For storm events with less than 6 inches within 24 hours of the end of the storm, and 36 hours of the end of the storm if greater than 6 inches

Table 5: Phase II Responses to the question: "Please provide an example of a Level of Service for a major service area AND provide a link to a Level of Service document that can be reviewed, if available."

Phase II Responses
Roads on Salt List will be cleared, other roads plowed at least once.
Streets are cleared as soon as possible—no documentations, supervisors' responsibilities
Plow operations begin at two inches of accumulation. Salt is used up to two inches and to prevent freezing of wet roads after event.
Unwritten goal is all roads clear and passable within 8 hours. [link to policy document]

Phase II Responses
0 – 6 inches: it takes about 8 – 16 hours following the end of a 0- to 6-inch snowfall to plow and/or treat every road once. [link to policy document]
All streets are cleared at the same time.
Level I (minor storm) Operations: The DPW&T forces only under normal or up to 12-hour days. As soon as the snow begins to accumulate, equipment is dispatched to salt the Priority 1 Emergency/Salt Routes, which includes the heavier traveled arterial, major collector, urban commercial and minor collector roadways, steep hills, severe horizontal curves and dangerous intersections. Emergency Management Agencies and volunteer Fire and Rescue operational facilities are also assisted with salt/sand treatment applications at this time, as are the [redacted] Hospital and Governmental Center access roads. Level I Operations are fairly routine and often occur prior to the issuance of official Winter Weather Advisories. The convenience centers / landfill, and STS Transit Services should continue to operate without unusual disruptions or delays. [link to policy document]
Bare pavement on all City roads within 24 hours of the snow event.
For snow events with 6 inches or less, 2 travelable lanes in 12 hours. For events greater than 6 inches, 1 travelable lane in 12 hours.
Salt will be applied to Snow Emergency Routes first, collector streets will be treated second. Local streets will receive an application of salt after Snow Emergency Routes and Collector streets. When snow accumulates more than 2 inches, the 1st Plow Shift will be mobilized. [policy document was emailed to project team]
For storm events with greater than 4 inches of snow, residential streets will be plowed after emergency and collector roads are completed. Streets will be passable (may not be bare pavement, may be snow-packed).

All but one MS4 jurisdiction answered that they inform their operators/crew of the LOS required for their assigned maintenance area(s). Seventy-five percent of respondents indicated that their organization "almost always" achieves their LOS requirements, while 25% achieves their LOS "most of the time."

Respondents provided a narrative response as to factors that have limited or have the potential to limit their organization from achieving its LOS requirements. Table 6 and Table 7 provide a summary list of responses, separated by MS4 permit type. The most commonly reported limitations are extremely cold or difficult weather conditions (like freezing rain and ice), access to enough product/material for treatment, and availability of manpower.

Table 6: Phase I Responses to the question: "Please provide a brief summary of the major factors that may limit (or have limited) your organization from achieving its Level(s) of Service."

Phase I Responses	# of Responses
Major snowfall, blizzard conditions or white outs	5
Extended periods of extreme cold (below 19°F)	2
Salt Availability	2
Resource limitations	1
Hard-packed snow or ice	1

Timing of the day (rush hour)- traffic volume holding back operations	1

Table 7: Phase II Responses to the question: "Please provide a brief summary of the major factors that may limit (or have limited) your organization from achieving its Level(s) of Service."

Phase II Responses	# of Responses
Length of storm	4
Speed and extent of storm	3
Difficult weather (freezing rain or ice)	1
Unpredicted rain preceding that removes pre-treatments	1
Personnel/manpower	3
Equipment failure	2
Equipment availability and accessibility	1
Salt availability	2
Funding	1
Conflict with residents	1

Products, Materials, & Equipment

Respondents were asked a series of questions that aimed to identify the types of products/materials and types of equipment used by their organization for winter maintenance. The majority of respondents indicated that sodium chloride (NaCl) is the most commonly used material. Solid calcium chloride ($CaCl_2$) and magnesium chloride ($MgCl_2$) are never used by 65% and 53% of respondents, respectively.

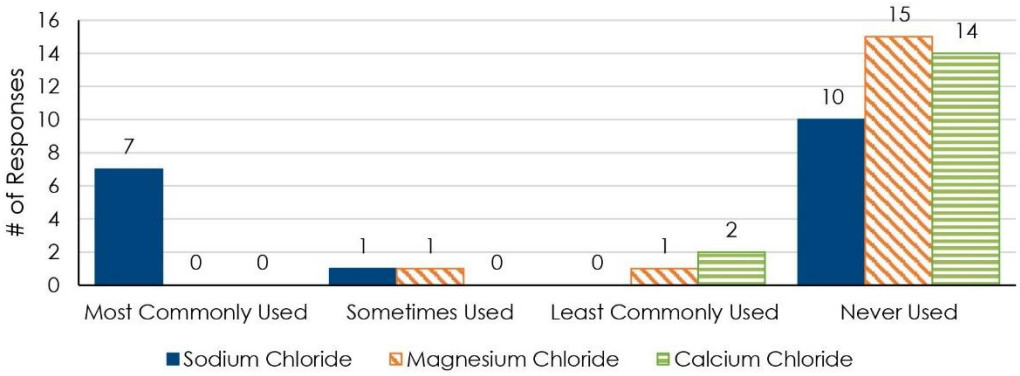


Figure 5: Usage of solid sodium chloride (NaCl), magnesium chloride ($MgCl_2$), and calcium chloride ($CaCl_2$).

Over half the respondents indicated they do not use liquid materials (Figure 6). For those that use liquid material, 88% most commonly use NaCl. One respondent indicated that liquid $MgCl_2$ and NaCl are mixed in storage and are not able to be separated.

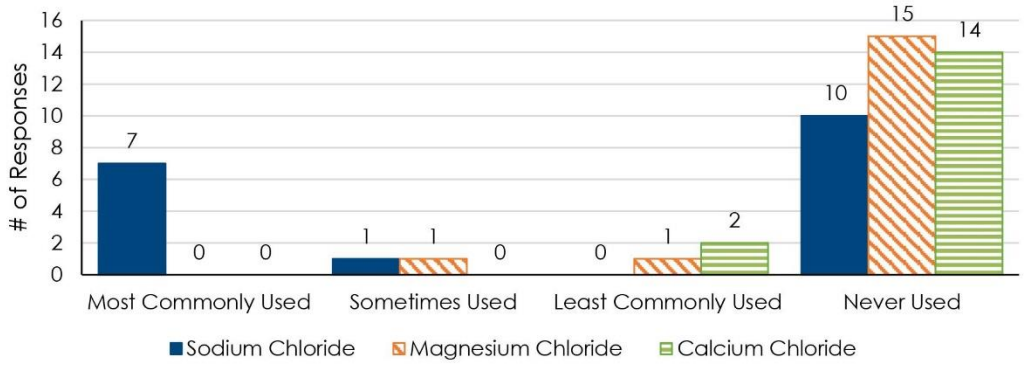


Figure 6: Usage frequency of LIQUID sodium chloride (NaCl), magnesium chloride ($MgCl_2$), and calcium chloride ($CaCl_2$).

Respondents were asked to provide the name and concentration of the liquid product(s)/material(s) used by their organization. Nearly all respondents who answered this question indicated that they use 23.3% sodium chloride (NaCl) brine solution. However, two Phase II jurisdictions indicated that they use NaCl brine of an unknown concentration, and one Phase I jurisdiction indicated that they use both 23.3% NaCl brine and a "salt brine/liquid magnesium blend," which is 80% NaCl brine and 20% liquid $MgCl_2$.

Approximately 40% of respondents have *equipment* necessary to make brine or other liquid mixtures on site, under the operations of their organization. Of those respondents, 80% have brine-manufacturing *facilities* on site. Having a brine facility on site can optimize facility operation efficiency. Five respondents—four Phase I jurisdictions and one Phase II jurisdiction—indicated that their organization has one or more designated facilities for brine manufacturing. Three respondents—one Phase I jurisdiction and two Phase II jurisdictions—indicated that their organization uses brine that is provided by a third-party and is manufactured and managed off-site. The remainder of respondents indicated either that their organization does not use brine or did not provide a response.

For Direct Liquid Application (DLA), eight out of 18 of jurisdictions use it for anti-icing, and of that, two also use it during snow events (Figure 7). Of the eight respondents that use DLA, five own their own equipment to make brine, and three use a third-party manufacturer[1].

[1] The variation of answers to liquid related questions infers that some respondents may not have understood the questions or terminology used.

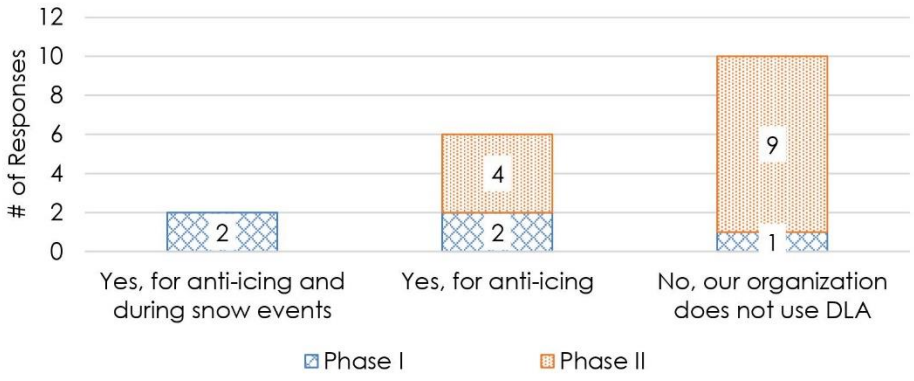
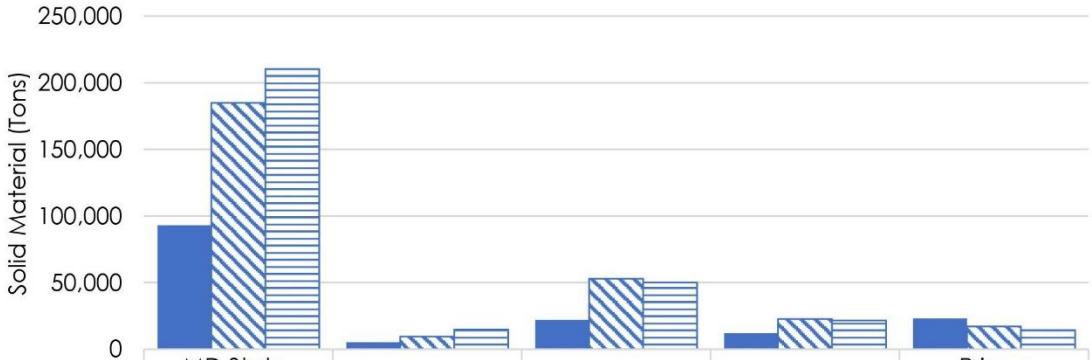


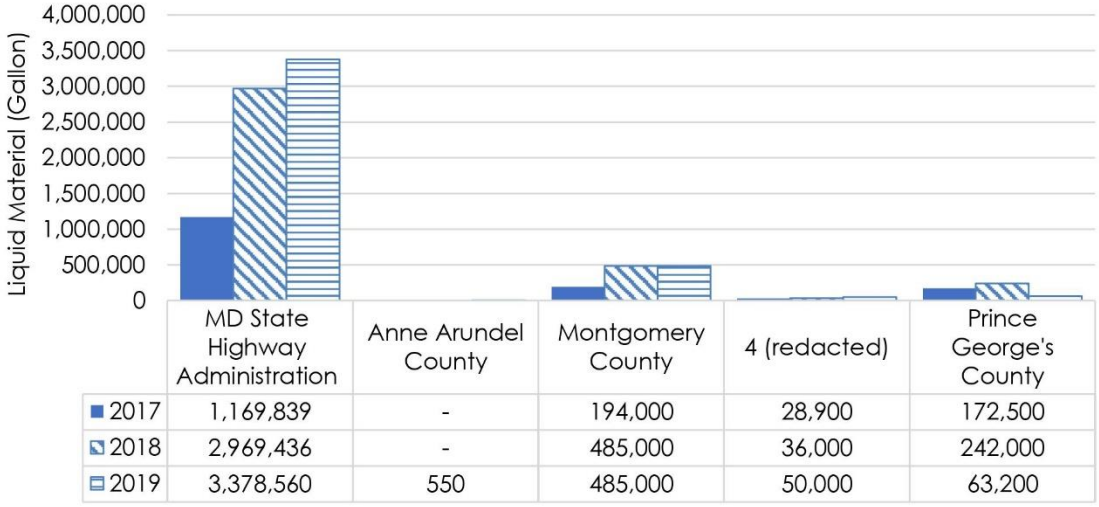
Figure 7. Usage of direct liquid application (DLA) in winter maintenance operations.

Respondents were asked how much solid and liquid material was used in 2017, 2018, and 2019. This includes the total of all types of solid and all types of liquid material. The results are shown below, separated by Phase I (Figure 8 and Figure 9) and Phase II (Figure 10 and Figure 11) communities. Note the scale difference between the Phase I and Phase II charts. It is important to mention that although there is an increase in some instants of material used, it does not represent poor salt practices. Various factors, such as availability, weather, snow type and amount, condition, and temperature all affect salt usage.



	MD State Highway Administration	Anne Arundel County	Montgomery County	4 (redacted)	Prince George's County
2017	92,990	5,300	22,000	12,116	23,100
2018	184,877	9,400	53,000	22,570	17,100
2019	210,193	14,900	50,000	21,505	14,400

Figure 8. Annual solid material used for winter maintenance operations by Phase I jurisdictions.



	MD State Highway Administration	Anne Arundel County	Montgomery County	4 (redacted)	Prince George's County
2017	1,169,839	-	194,000	28,900	172,500
2018	2,969,436	-	485,000	36,000	242,000
2019	3,378,560	550	485,000	50,000	63,200

Figure 9. Annual liquid material used for winter maintenance operations by Phase I jurisdictions.

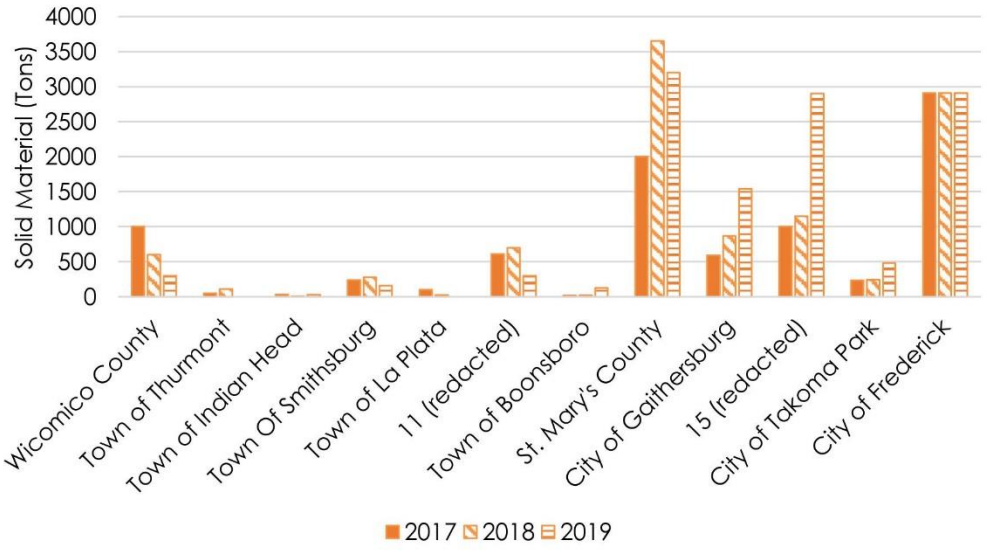


Figure 10. Annual solid material used for winter maintenance operations by Phase II jurisdictions.

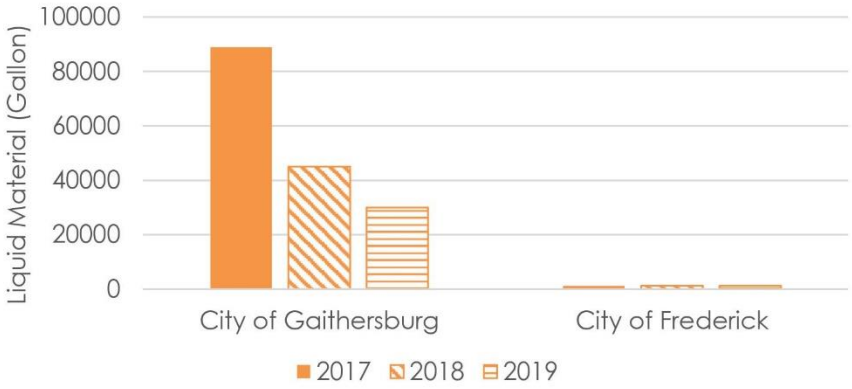


Figure 11. Annual liquid material used for winter maintenance operations by Phase II jurisdictions.

When asked why the material usage changed from year to year, majority indicated that the severity of the winter season and temperature difference was a major factor of material usage. One jurisdiction noted it was due to better training, tracking, and salt management.

In addition to evaluating the respondents' organizations' product/material usage, this section also inventoried their vehicles, equipment, and retrofits to that equipment.

Respondents were asked to provide a count of the number of vehicles in their winter maintenance fleet that are owned by their organization, excluding those owned by third-party contractors (Table 8).

Table 8: Responses to the question: "How many vehicles are in your organization's fleet for snow and ice maintenance? Only include vehicles owned by your organization (not owned by your contractors)."

Response	# of Responses
0	2
1 – 10	4
11 – 20	3
21 – 50	2
51 – 100	3
101 – 150	1
151 – 200	1
Greater than 200	2

Respondents were also asked to provide estimates of the number of vehicles that are contracted annually for winter maintenance (Table 9). Most respondents (29.2%) do not contract out any vehicles in a typical year.

Table 9: Responses to the question: "In addition to the vehicles owned by your organization, typically, how many vehicles does your organization contract out annually for winter maintenance operations?"

Response	# of Responses
0	7
1 – 10	5
11 – 20	0
21 – 50	0
51 – 100	0
101 – 150	3
151 – 200	0
Greater than 200	3
No Response	6

When asked if their fleet's vehicles have the capability to apply liquid materials, most respondents (41.7%) indicated that their vehicles are not capable and therefore do not use liquid materials. Four out of five Phase I communities indicated that their vehicles are capable of applying liquids, and one Phase I indicated that their organization's vehicles are not capable, but they have access to vehicles for liquid application through contractors (Figure 12). Two Phase II respondents indicated they have vehicles with liquid application capability, and one indicated that only one of their vehicles can apply liquid materials.

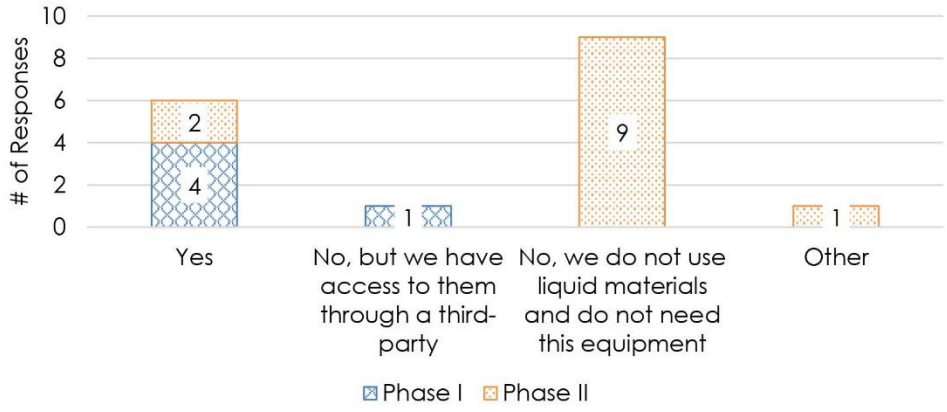


Figure 12: Vehicles with Liquid Application Capabilities

Respondents were also asked what percentage of the vehicles in their organization's winter maintenance fleet is capable of applying liquid products/materials. Most respondents have no capable vehicles (Figure 13).

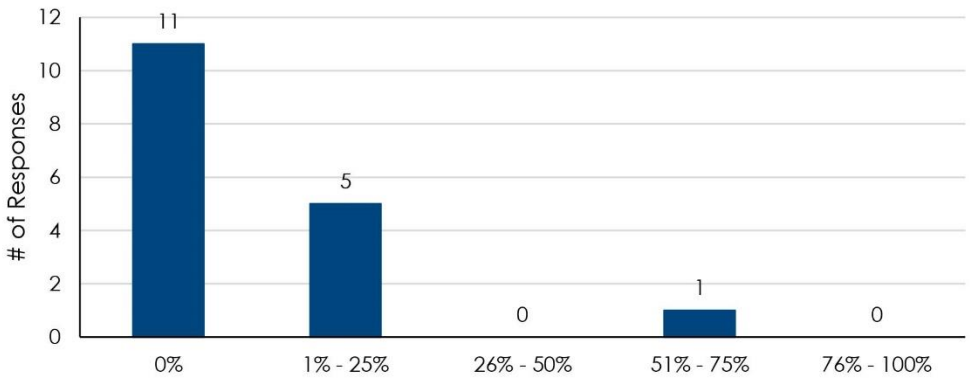


Figure 13: Percentage of vehicles in respondent organizations' winter maintenance fleet that are capable of applying liquid products/materials.

Figure 14 presents which equipment retrofits and technology advancements have been adopted by the jurisdictions. The most common retrofit that has been adopted are application regulators and Automated Vehicle Location (AVL) technology. All of these technologies can help use salt more efficiently.

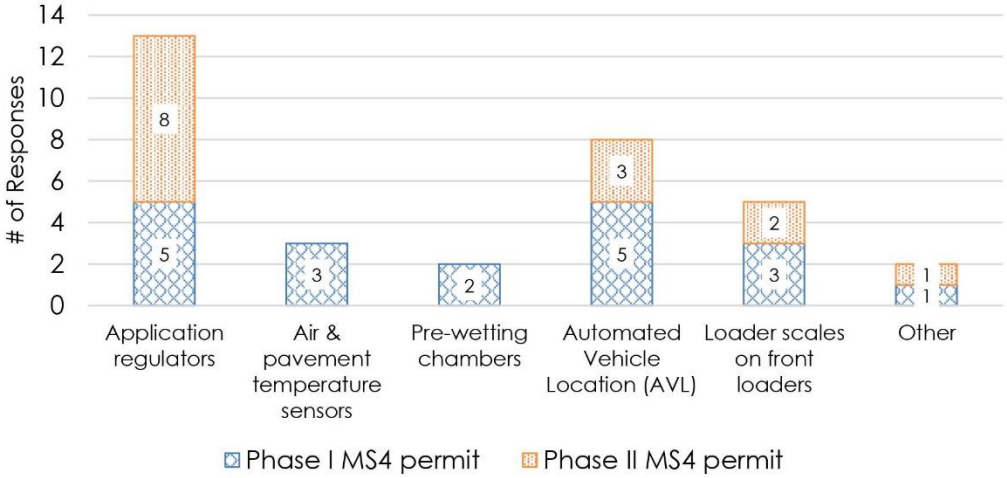


Figure 14. Number of jurisdictions with retrofits/advancements to the vehicles in their winter maintenance fleet.

The respondents were asked the *number* of retrofitted vehicles in their fleet. Table 10 and Table 11 provide the breakdown of retrofit types, with the total number of reported vehicles with retrofits, separated by Phase I and Phase II. All Phase I vehicles have Automated Vehicle Location (AVL) and application regulators/spreader controls. It is important to note that not all vehicles can have all the capabilities (ex. A front loader may not need a pre-wetting chamber if it is typically only used to load a truck). Phase II

communities have a lower percentage of retrofitted vehicles and none have air and pavement temperature sensors nor pre-wetting chambers.

Table 10. Inventory of equipment retrofits and technology advancements adopted by respondent organizations for winter maintenance operations, Phase I.

Phase I	Electronic application regulators/spreader controls	Manual application regulators/spreader controls	Air & pavement temperature sensors	Pre-wetting chambers	Automated Vehicle Location (AVL)	Loader scales on front loaders	**Total Size of Fleet**
MD SHA	624	0	350	500	624	45	624
Anne Arundel County	35	35	35	35	72	6	72
Montgomery County	155	0	24	0	155	5	155
4 (redacted)	294	0	0	0	294	0	294
Prince George's County	75	60	0	0	135	0	135

Table 11. Inventory of equipment retrofits and technology advancements adopted by respondent organizations for winter maintenance operations, Phase II.

Phase II	Electronic application regulators/ spreader controls	Manual application regulators/ spreader controls	Air & pavement temperature sensors	Pre-wetting chambers	Automated Vehicle Location (AVL)	Loader scales on front loaders	Dump Truck Scale	**Total Size of Fleet**
Wicomico County	0	10	0	0	0	0	0	77
Town of Thurmont	0	4	0	0	0	0	0	33
Town of Indian Head	0	0	0	0	8	0	0	10
Town of Smithsburg	1	1	0	0	0	0	0	3
Town of La Plata	1	3	0	0	0	0	0	4
10 (redacted)	0	8	0	0	14	1	1	14
Town of Boonsboro	3	0	0	0	0	0	0	9
St. Mary's County	0	16	0	0	0	0	0	18

Phase II	Electronic application regulators/ spreader controls	Manual application regulators/ spreader controls	Air & pavement temperature sensors	Pre-wetting chambers	Automated Vehicle Location (AVL)	Loader scales on front loaders	Dump Truck Scale	**Total Size of Fleet**
City of Gaithersburg	21	13	0	0	0	0	0	36
14 (redacted)	11	1	0	0	0	0	0	12
City of Takoma Park	0	0	0	0	7	0	0	7
City of Frederick	0	0	0	0	0	1	0	61

The majority of respondents were unable to provide the lowest application rate that their organization's equipment can deliver with an even spread pattern (Figure 15).

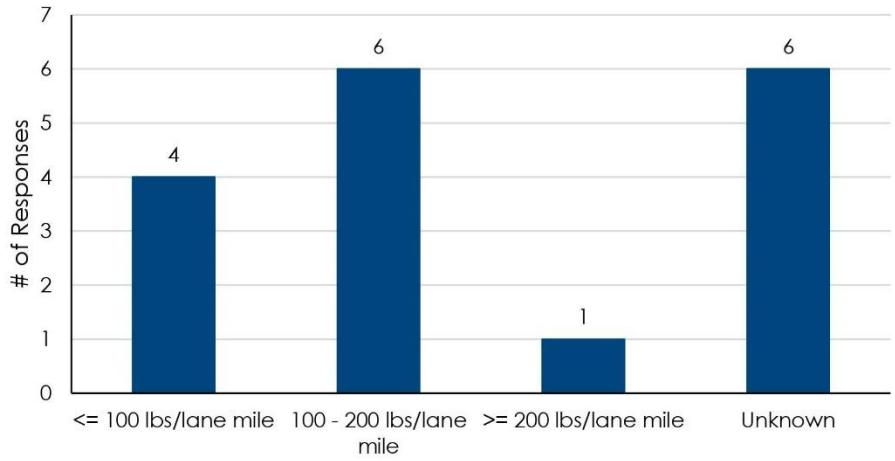


Figure 15: Lowest possible application rate deliverable with an even spread pattern by vehicles in respondent organization's winter maintenance fleets.

Strategies & Methods

To understand respondent organizations' approaches to winter maintenance, respondents were asked to address core aspects of their specific strategies and methods, such as those related to calibration, tracking and accountability, training, application rate determination, and anti-icing.

Table 12 shows the responses for the question, "How often does your organization calibrate its spreaders?" Over 50% calibrated all the equipment at least annually. Calibration is one of the most important methods to ensure proper salt application.

Table 12: Response to question "How often does your organization calibrate its spreaders?"

Response	# of Responses
Calibration is checked before every event	1
All equipment calibrated yearly, if something looks wrong, or new equipment	2
All equipment calibrated yearly	6
Most equipment calibrated yearly	4
Only new equipment calibrated	1
Do not know	1

Equipment should also be recalibrated when material or product is changed in the equipment. Figure 16 shows that only three of the 15 jurisdictions that change material recalibrate their equipment after switching materials.

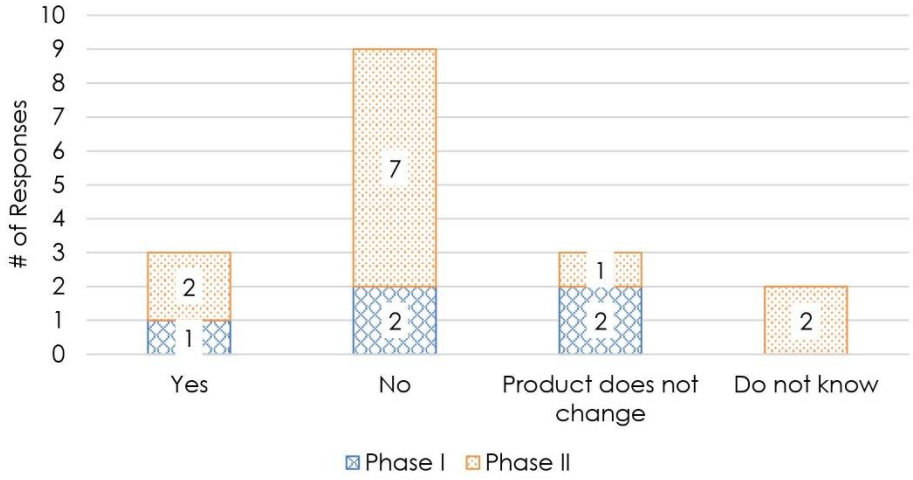


Figure 16: Equipment Recalibrated after Product Change

Most respondents track their product/material usage on a per-storm-event basis (Figure 17). Only one respondent indicated that their organization does not track product/material usage.

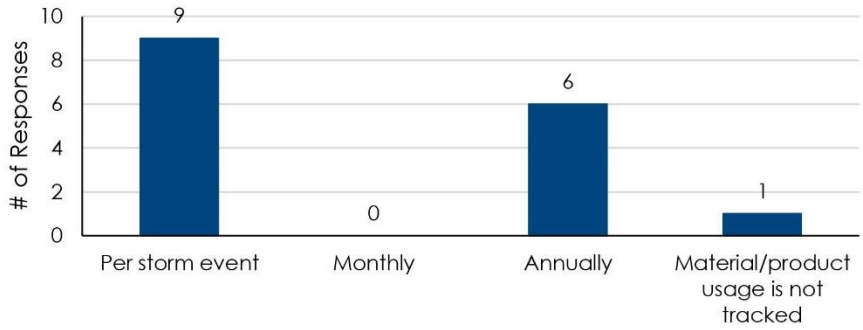


Figure 17: Time scale for tracking product/material usage.

Also related to tracking and accountability, respondents were asked how their organization's operators/crew document their field activities (Figure 18). Most respondents (41.7%) still use paper forms. Four respondents provided their own responses ("Other"). Two of those respondents were Phase I jurisdictions who indicated they use both paper forms and electronic capture, one Phase I jurisdiction indicated they are transition from paper forms to electronic tracking. The remaining "Other" response was from one Phase II jurisdiction who indicated that each operator has a defined route with a set amount of mileage; however, they did not specify how, or if, operator activity was tracked.

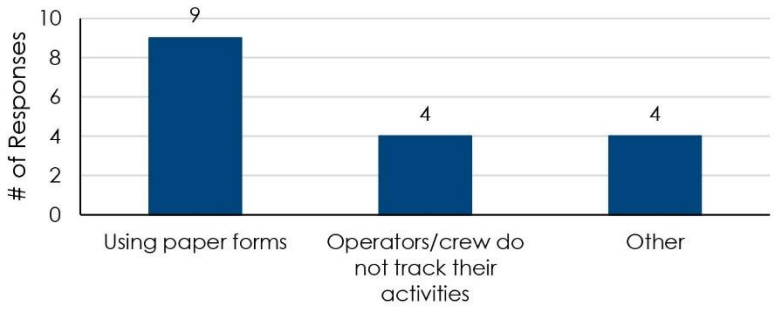


Figure 18: Type of tracking for operator/crew actions in the field during winter maintenance operations.

Respondents were asked how the operator/crew activity information is communicated by the operator/crew member to a supervisor or manager (Figure 19). The majority of respondents (eight) use paper forms. Six respondents provided their own responses ("Other"):

- Two Phase I jurisdictions indicated that they use both paper forms and electronic communication methods
- One Phase II jurisdiction respondent with "prescribed route," which is assumed to mean there is no communication to supervisors since routes are pre-determined
- One Phase II jurisdiction indicated that only verbal communication is used

- One Phase II jurisdiction indicated that completion of routes is reported verbally to a main dispatch system
- One Phase II jurisdiction indicated that "Operators contact supervisors directly as each type of route is cleared (emergency, collectors, then local streets). That information is then logged in an App by the supervisor to communicate to the public the status of snow removal in their area."

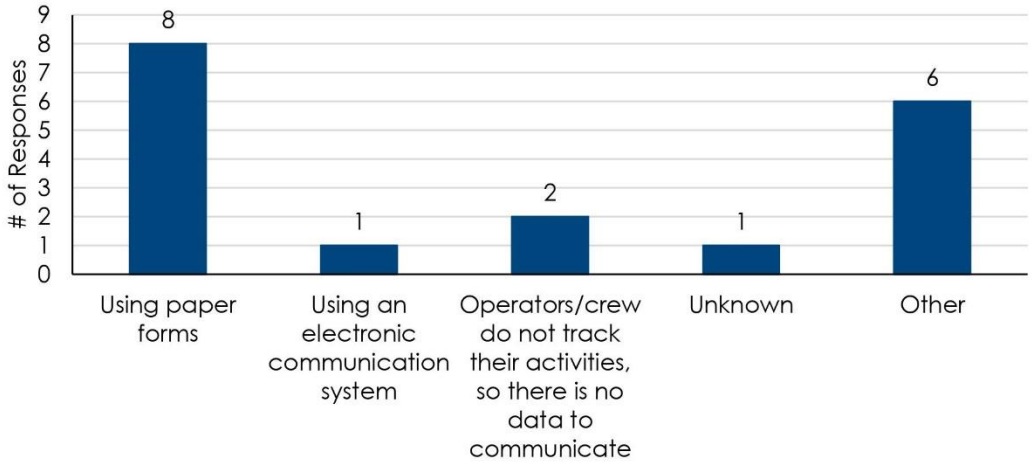


Figure 19: Methods for communicating operator/crew actions tracked in the field during winter maintenance operations to supervisors/managers.

Not all the jurisdictions who track their operators'/crew's field activities have their supervisors/managers compare those actions to the practices documented in their respective guidance documents. Of the 14 respondents who indicated they do track field activities, 64% also have supervisors compare to reference documents; however, of those same 14 respondents, 36% do not (Table 13).

Table 13: Responses to the question: "Do supervisors compare the actions of operators/crew to application guidelines outline in your organization's maintenance plan/management plan/other guidance document?"

Response	# of Responses
Yes	9
No	5
N/A, our organization does not have a guidance or planning document	2
Unknown	1

This section also asked about each organization's training requirements for winter maintenance personnel.

Respondents were asked if their organization provides training (either in-house or by contract) to staff involved in winter maintenance operations. All of those who responded to this question said yes except for one Phase II jurisdiction.

Respondents were also asked to provide the name(s) and link(s) to training program(s)/resource(s) used by their organization. Table 14 provides an inventory of those responses, organized by MS4 permit type.

Table 14: Responses to the question: "Please provide the name(s) and link(s) to training program(s)/resource(s) used by your organization."

Phase I Responses
https://www.roads.maryland.gov/OOM/ Statewide_Salt_Management_Plan.pdf
Operator Training & Salt Management Training
Safety and Training that is within jurisdiction
Annual Snow and Ice Training for all DPW&T Employees
Phase II Responses
Not a formal training program. In-house, hands-on, common sense
In-house
Trained by supervisor
In-house training of equipment safety
Internal verbal, no training program or resource
In-house presentation and with hands-on time with equipment
www.clearroads.com
We have a yearly Snow Roadeo
In-house training on use of the equipment
In-house training, manufacturers' guidance
Training is provided on the job

All jurisdictions require their operators/field crew to receive training, and 65% require their organization's supervisors (Figure 20). Only 17% and 30% of respondents require their program managers and external contractors, respectively, to receive training.

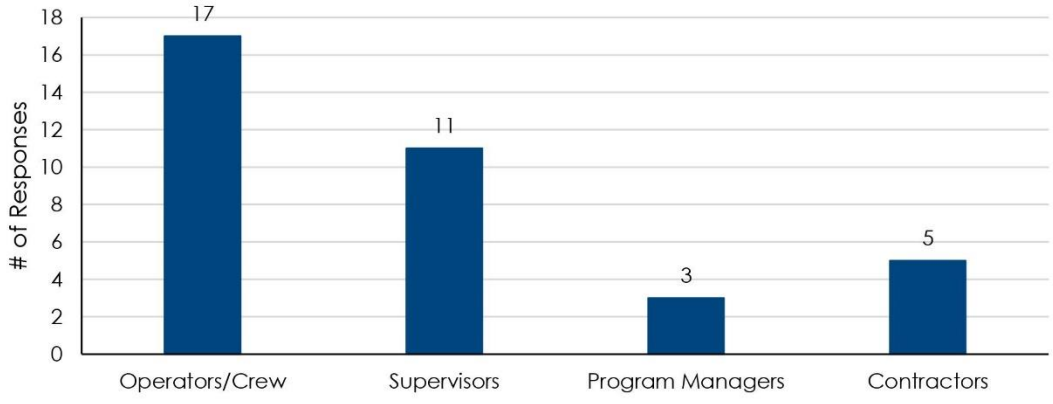


Figure 20: Types of winter maintenance personnel who are required to receive training.

Most respondents (65%) require their aforementioned winter maintenance staff to receive training annually. However, 18% of respondents only train new employees, and 18% only train on an as-needed basis (Figure 21).

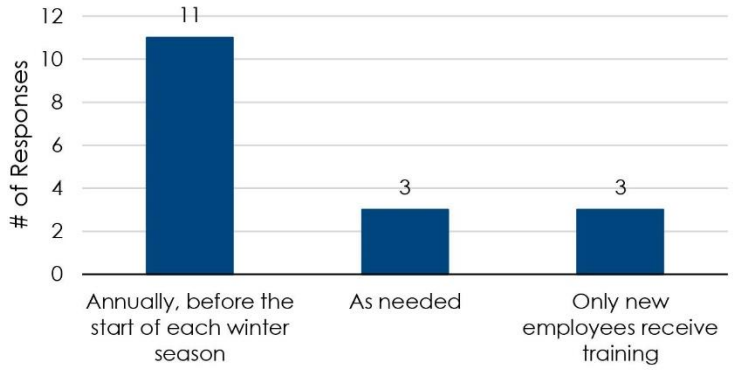


Figure 21: Frequency of training requirements for winter maintenance personnel.

Respondents were also asked specifically about their oversight requirements for third-party contractors. Prior to hiring contractors, most respondents require their contractors to achieve the same LOS required of the jurisdictional organizations' operations (Table 15).

Table 15: Response to "Prior to hiring outside contractors/subcontractors, does your organization require its contractors to achieve the same Level(s) of Service that is required internally within your organization?"

Response	# of Responses
Yes	11
No	1
Unknown	1
Do not use contractors	5

This section also addressed more technical winter maintenance strategies and methods, such as the process for determining application rates, decision points for the timing of product/material application, and other technical decision points.

Figure 22 provides an overview of which types of factors are considered prior to selecting an application rate (for both solid and liquid products/materials) for winter maintenance operations.

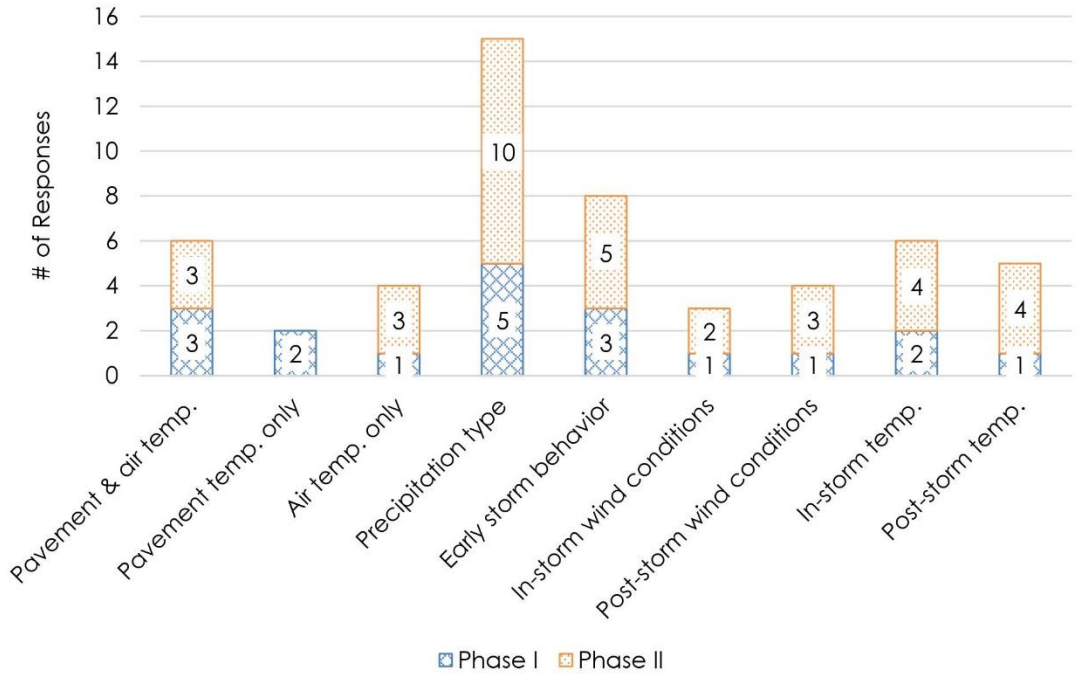


Figure 22: Factors Considered Prior to Selecting Application Rate

Respondents were asked to explain how their organization ensures that operators/crew members follow application rate recommendations. Table 16 inventories those responses, organized by MS4 permit type.

Table 16: Responses to the question: "How does your organization ensure that operators/crew members follow application rate recommendations?"

Phase I Responses	Phase II Responses
Spot checks are done during and after events for any inconsistent usage rates. Using AVL and loader sheets.	Coverage of roads on schedule/number of loads used
Spreader controls	Supervisors' requirement to discuss with operators
Each route has an estimated salt amount to be applied and the actual amount is checked by the supervisors or inspectors.	Spreader controls
This is physically checked by managers.	Visual follow-up
Reviewing event salt totals vs. per-inch of snow vs. pounds-per-lane-mile	Pre-set all salt spreaders
	Follow-up drive through in areas and spot truck settings
	Supervisor inspections
	Track mileage vs. pounds of load applied
	By the number of loads/tons of salt

Phase I Responses	Phase II Responses
	Supervisors manage the storm manually checking streets for completion
	Supervisors inform crew prior to start of shift
	This is determined by the contracted service providers directly

Respondents were asked to identify their most common application rate for anti-icing when using liquid NaCl brine on roads (Table 17). Of the respondents who indicated that they use liquid NaCl brine for anti-icing, the majority (66.7%) use application rates greater than 50 gallons/lane mile.

Table 17: Responses to the question: "What is your organization's most common anti-icing rate for straight sodium chloride brine on roads?"

Response	# of Responses
≤ 50 gallons/lane mile	2
≥ 50 gallons/lane mile	4
We do not use liquid products/materials	11

Following the evaluation of their anti-icing application rates, respondents were asked for their most common de-icing rate for liquid NaCl brine on roads. Most respondents did not provide a response to this question, likely because they do not use liquid products/materials for de-icing. The quantitative responses to this question were variable:

- One Phase I jurisdiction indicated that they use 45 gallons/lane mile for anti-icing and 80 gallons/lane mile for DLA (during event operations)
- Two Phase I jurisdictions indicated that they use 60 gallons/lane mile
- One Phase II jurisdiction indicated that they use 10 gallons/lane mile

The timing of performing winter maintenance operations relative to the progress of a storm is also important. Figure 23 and Figure 24 illustrate how the respondents time and manage their treatment of roads and parking lots/sidewalks, respectively, during an active storm event.

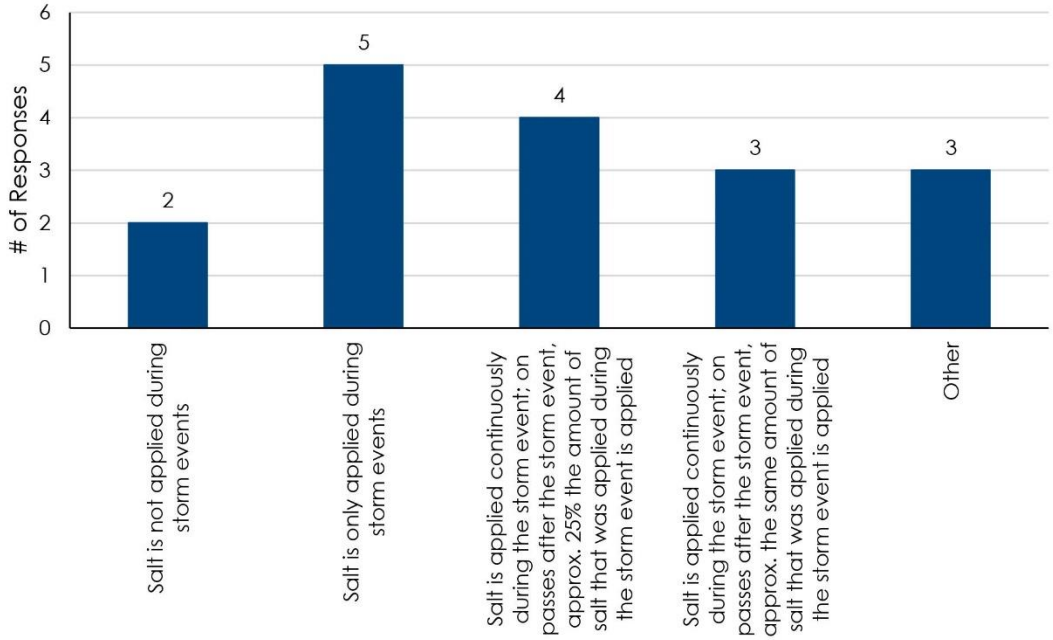


Figure 23: Timing of application of winter maintenance products/materials to ROADS during an active storm event.

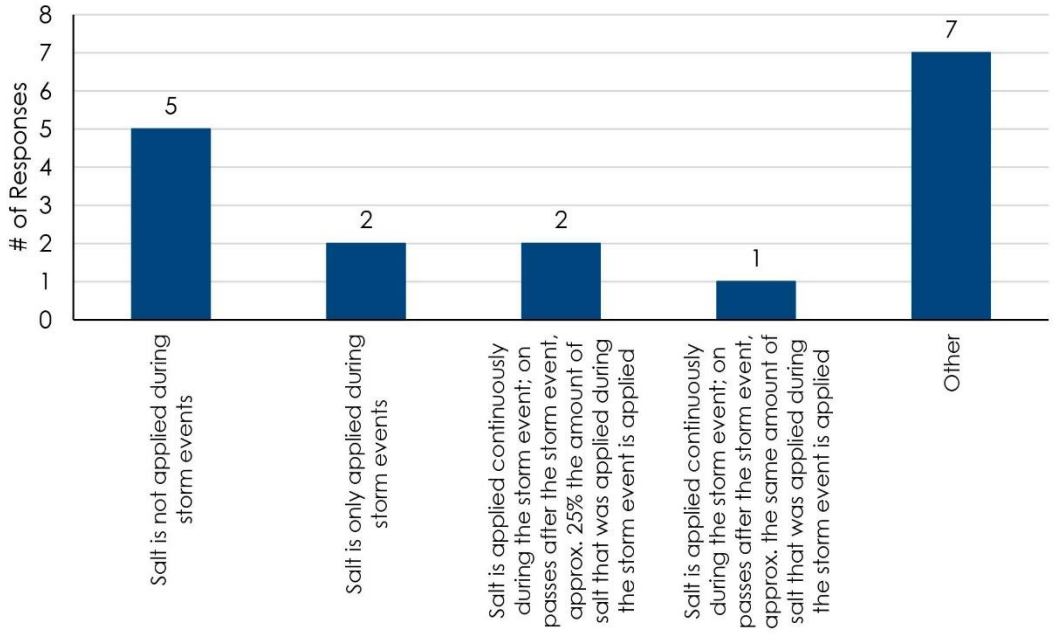


Figure 24: Timing of application of winter maintenance products/materials to PARKING LOTS/SIDEWALKS during an active storm event.

Respondents were also asked about their techniques for applying solid products/materials to sidewalks (Figure 25). Four (4) respondents provided their own responses ("Other"):

- One Phase I jurisdiction indicated that they use both drop spreaders and small vehicles with salt hoppers for this purpose
- One Phase II jurisdiction indicated that they use broadcast spreaders with shields on all four sides of the spreader
- One Phase II jurisdiction indicated that they do not use granular products on sidewalks (only "calcium-based applications," which is assumed to mean liquid $CaCl_2$)
- One Phase II jurisdiction indicated that they do not maintain sidewalks, only walkways and parking lots on public facilities.

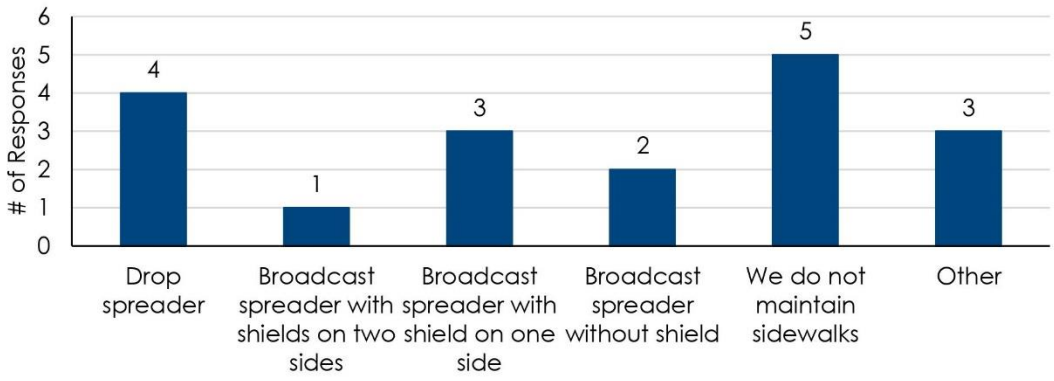


Figure 25: Application technique for applying solid products/materials to SIDEWALKS during winter maintenance operations.

Figure 26 shows that 53% respondents only apply solid products or materials to targeted portion(s) of the roads they are treating, as opposed to the entire road surface. Examples of these targeted portions are the centerline and/or crown of the road. Two respondents provided their own responses ("Other")—both of these responses were from Phase II jurisdictions who indicated that whether they treat the entire road surface or targeted portion(s) only was conditional on other variables, such as traffic volume and intensity of storm. Treating only the necessary surface reduces the amount of salt applied.

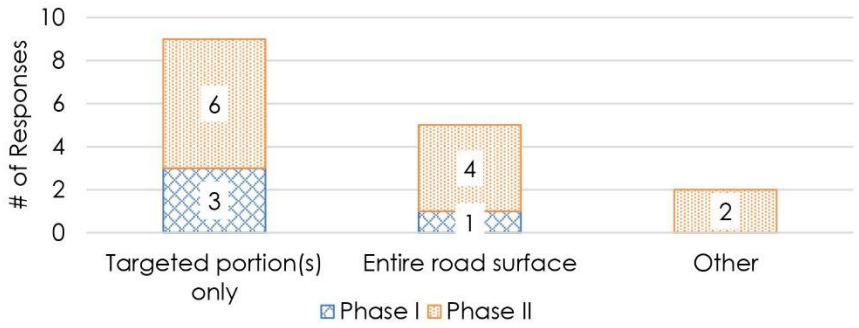


Figure 26. Placement of solid products/materials during the treatment of ROADS for winter maintenance.

When applying solid products/materials to roads, the speed of the vehicle can affect the degree of bounce and scatter. Most respondents (59%) indicated that the vehicles in their organization's winter maintenance fleet spread solid products/materials at 23 – 29 miles per hour (mph). An additional 41% of respondents indicated that they spread at less than or equal to 22 mph (Figure 27).

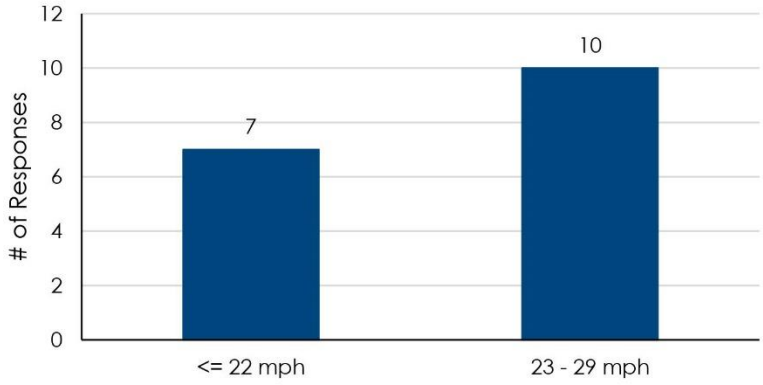


Figure 27: Vehicle speed during the application of solid products/materials to roads during winter maintenance.

The source and type of weather forecasts affects the relevance of that information to winter maintenance operations. Road-specific forecasts from Road Weather Information Systems (RWIS) are the most effective source of accurate, relevant weather data for winter maintenance; only 29% of respondents indicated that their organizations use RWIS (Figure 28). Most respondents use forecasts from the National Weather Service or local news stations.

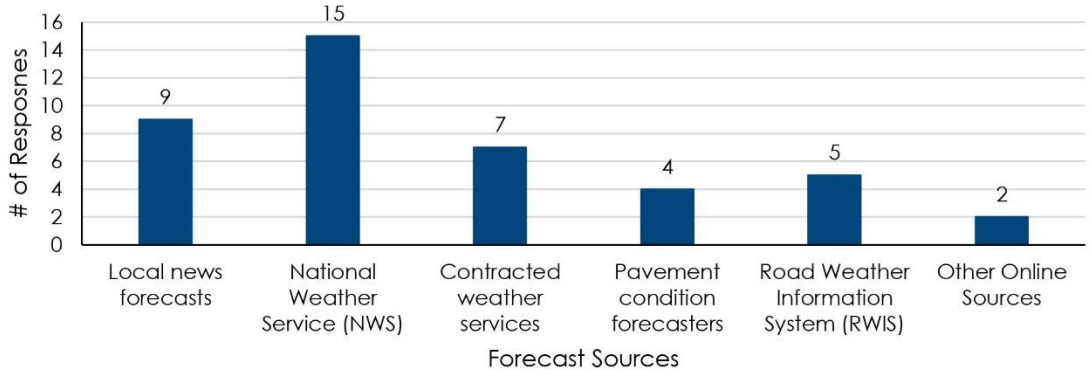


Figure 28: Sources of weather forecasts used by respondent organizations to inform winter maintenance operations.

Winter maintenance activities should also be informed by the limited effectiveness of many products/materials on cold and extremely cold pavements (classified as < 15°F and < 0°F, respectively). Table 18 illustrates the frequency of respondent organizations' application of dry granular salt when pavement temperatures are cold (< 15°F). Only one respondent (a Phase I jurisdiction) indicated that they frequently apply solid products/materials in cold pavement conditions. One jurisdiction indicated that they use a solid product/material and abrasive sand mixture in cold pavement conditions.

Table 18. Responses to the question: "When pavement temperatures are below 15°F, how often does your organization use dry granular salt?"

Response	# of Responses
Rarely or never	5
Sometimes	7
Frequently	1
Unknown	3
Other	1

Table 19 categorizes the application of solid products/materials in extremely cold (< 0°F) pavement condition winter maintenance operations. Only three respondents use products/materials that are more effective in extremely cold pavement conditions.

Table 19. Responses to the question: "When pavement temperatures are extremely cold (below 0°F), how does your organization proceed?"

Response	# of Responses
We do not apply any solid or liquid materials	3
We apply abrasives only	2
We use products that work better in cold temperatures than salt or brine	3
We use whatever products we have	8
Other: Apply mixed loads	1

Anti-icing can be a very effective practice for minimizing chloride-contaminated runoff following winter maintenance operations. Respondents were asked to characterize which types of areas they treat using anti-icing (Table 20).

Table 20. Responses to the question: "In which types of areas does your organization perform anti-icing?"

Response	# of Responses
Almost all areas that are salted	3
Most areas that are salted	1
Some areas that are salted	5
None of the areas that are salted	8
Other: Only on emergency roads	1

Salt Storage & Facilities

Proper storage of both solid and liquid products/materials for winter maintenance is essential for minimizing chloride-contaminated runoff from storage facilities. Respondents were asked to identify key components of their storage facilities and to characterize the maintenance and operation of those facilities.

Respondents were asked what their operators or crew does with leftover product or material at the end of a shift. All but one Phase II jurisdiction indicated that leftovers are brought back to the storage facility; the aforementioned Phase II jurisdiction indicated that they use up remaining product before returning to the storage facility.

All the Phase I communities have their own salt storage facilities, while nine out of 12 Phase II communities do (Figure 29). One respondent that answered "No" noted that they have a long-term lease of a SHA Salt Dome.

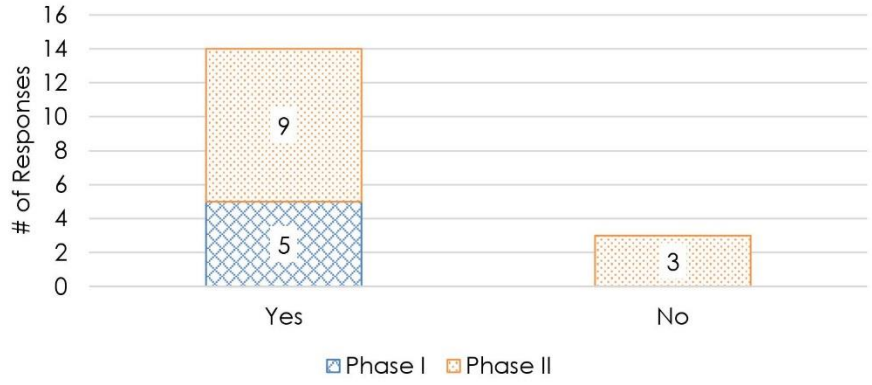


Figure 29. Number of jurisdictions who own and manage at least one salt storage facility.

Respondents were asked to characterize their storage of solid products/materials in both the winter and summer; the responses for both seasons were the same. Fifteen jurisdictions indicated that their storage piles for solid products/materials are located in an enclosed/covered facility and two indicated they do not have salt piles.

Respondents were also asked about their storage of liquid products/materials. Table 21 provides an overview of those responses. Three respondents provided their own responses ("Other"):

- One Phase I jurisdiction indicated that their organization has a combination of double-wall tanks with no containment area and single-wall tanks with containment areas
- One Phase I jurisdiction indicated that they have double-wall tanks with secondary containment areas currently under construction
- One Phase I jurisdiction indicated that they have twelve (12) separate tanks within a building; they did not indicate whether the tanks were single- or double-wall or whether there is a containment area

Table 21: Responses to the question: "How does your organization store liquid products/materials?"

Response	# of Responses
In a double-wall tank with a secondary containment area	1
In a double-wall tank	1
In a single-wall tank with a secondary containment area that has a volume greater than or equal to tank capacity	1
My organization does not store liquid products/materials	12
Other	3

Respondents were asked to describe the flow and management of runoff from storage facilities. About 50% have some type of system that minimizes runoff from entering surface or ground water (Table 22).

Table 22. Responses to the question: "Where does the majority of the runoff from your storage facility go?"

Response	# of Responses
Runoff is collected and reused in a brine system	1
Runoff enters a treatment facility	1
Runoff flows into a pond with no connections to any other surface or groundwater systems	5
There is minimal runoff from the site	2
Runoff is permitted to flow into a pond with connections to another surface or groundwater system	3
Runoff is permitted to flow onto the surrounding landscape	3
There is no storage facility	1
Unknown	1

Budget & Contracts

Respondents were asked to characterize the hire frequency and standards for hiring third-party contractors for winter maintenance operations. Respondents also characterized their organization's budget for winter maintenance and provided insight on how those budgetary considerations affect their adoption of best practices.

Respondents were asked to characterize the frequency that third-party contractors are typically hired by their organization for winter maintenance operations. Nearly 30% of respondents hire contractors for every storm event, 41% sometimes hire contractors, and 29% never hire contractors (Figure 30).

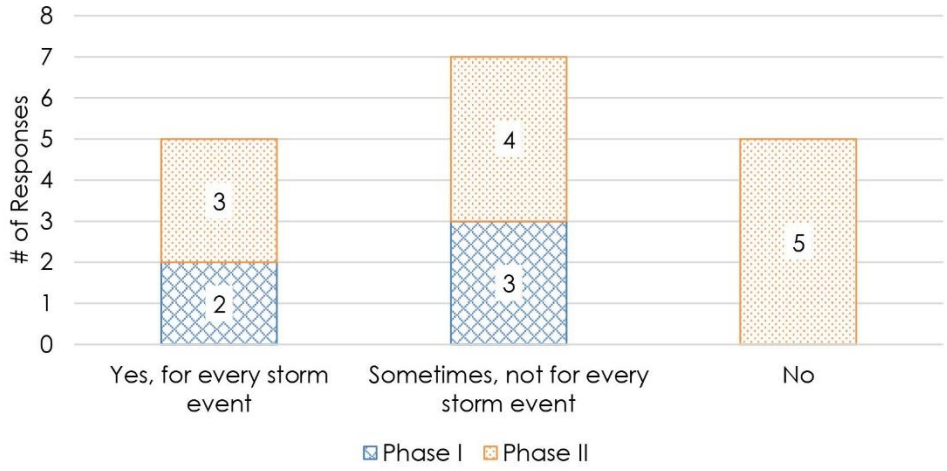


Figure 30. Frequency of third-party contractor hiring for winter maintenance operations.

Respondents were also asked whether the contractors they hire use the same management/maintenance plan(s) and guidance document(s) as internal operators. All jurisdictions that hire contractors responded yes, except one who did not know.

In addition to questions characterizing the contractor usage of respondent organizations, respondents were also asked to characterize their internal budget for winter maintenance operations. Most respondents (29.2%) have budgets under $100,000 USD, and 25% indicated they had budgets greater than $1,000,000 USD for Fiscal Year (FY) 2019.

When asked if their organizations budget for snow and ice management is adequate to meet their LOS, 75% responded "Yes," and 25% responded "Sometimes." Those that answered "Sometimes" stated that the variability of weather makes it difficult to plan.

The following list includes the best practices jurisdictions have implemented:

- Public outreach
- Brine in anti-icing

- Expand use of AVL and loader scales
- Tracking, reporting, and managing material usage
- The anti- icing with usage of salt brine.
- Additional anti-icing
- Historical knowledge of road conditions
- Electronic spreader
- Minimizing the application areas and times for an event
- Use of lowest available application rates
- Post event street sweeping

The following list includes challenges jurisdictions have identified as challenges to adopting additional best practices:

- Political pressures
- Funding
- Staff
- Time
- Education
- Equipment and storage
- insufficient information
- Sophistication of equipment
- Communication
- Minimal existing guidance
- Ingrained framework

Appendix C. Primary Survey

<table>
<tr><th>Survey Question Type</th><th>SECTION 1: Survey Introduction</th></tr>
<tr><td>Text</td><td>
Salt in freshwater streams is a rising concern in the United States as it affects water quality, infrastructure like bridges, and, in some cases, drinking water, which can affect public health and treatment costs. Salt concentrations in streams have been steadily rising for the past four decades, largely as a result of persistent road salt (i.e., granular sodium chloride) application to roads, parking lots, and sidewalks for winter maintenance. The purpose of this survey is to identify: 1) the extent to which winter road maintenance practices are currently being implemented by public agencies and the private industry, and 2) the potential to reduce chloride inputs to local waters through the adoption of best practices. The results of the survey will be used to understand the current state of practice.

This survey was developed by the Center for Watershed Protection, Inc. (the Center) with funding provided by the Chesapeake Bay Trust Pooled Monitoring Initiative's Restoration Research Grant Program, which includes funding partners from the Maryland Department of Transportation State Highway Administration (MD SHA), Maryland Department of Natural Resources (DNR), the National Fish and Wildlife Foundation (NFWF) through the U.S. Environmental Protection Agency's (EPA) Chesapeake Bay Program Office, and the Chesapeake Bay Trust (CBT).

SURVEY DESCRIPTION AND INSTRUCTIONS

The survey includes seven (7) sections and a total of 77 questions to describe your organization's or company's winter maintenance practices. Many of the questions will ask you to select a response from a list. There are nine (9) questions that ask you to quantify a response about the size and type of your winter maintenance fleet, service area, amount of material applied and type of surface (roads, parking lots). A copy of the survey is provided for your reference to familiarize yourself with the information requested. Please complete the survey online.
<table>
<tr><td>Section 1:</td><td>Survey Introduction</td><td>1 question</td></tr>
<tr><td>Section 2:</td><td>Organization/Company Information</td><td>8 questions</td></tr>
<tr><td>Section 3:</td><td>Snow & Ice Management Maintenance Plan/Documents</td><td>9 questions</td></tr>
<tr><td>Section 4:</td><td>Products, Materials, & Equipment</td><td>16 questions</td></tr>
<tr><td>Section 5:</td><td>Strategies & Methods</td><td>31 questions</td></tr>
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<tr><th>Survey Question Type</th><th>SECTION 1: Survey Introduction</th></tr>
<tr><td></td><td>
<table>
<tr><td></td><td>e.g., Type of equipment, calibration, tracking & reporting, training, application rates</td><td></td></tr>
<tr><td>Section 6:</td><td>Salt Storage & Facilities</td><td>5 questions</td></tr>
<tr><td>Section 7:</td><td>Budget & Contracts</td><td>7 questions</td></tr>
</table>
The survey results will identify the name of the public organization or company. You will have the opportunity in the survey to opt to keep the name of your organization and/or respondent's name anonymous, or share that information as part of the publication of the survey results.
We respectfully request your response to this survey by Wednesday, March 4th, 2020.
</td></tr>
<tr><td>Text</td><td>
Please review the following list of definitions prior to beginning the survey:

Abrasive: Sand or another solid material placed on a slippery surface to temporarily improve traction for walking and/or driving. Abrasives alone do not melt snow and ice.
Anti-icing: The application of a deicer chemical (liquid or solid) to a surface (e.g., road, sidewalk, parking lot, etc.) before a storm starts in order to prevent ice from forming and bonding to the surface or to enhance plowing efforts. This is often referred to as "pre-treating" a site, but pre-treating has a separate, more specific definition (see below).
Deicing: The application of a deicer chemical (typically either a solid or pre-wet solid) to an existing accumulation of ice or snow to melt it and weaken its bond to the surface.
Direct Liquid Application (DLA): A designated snow route that uses only a salt brine solution to prevent the snow and ice from bonding to the pavement for the duration of an event.
Level of Service (LOS): A description of the expected road surface condition from the snow and ice maintenance activities. E.g., "Provide snow/ice maintenance to achieve bare pavement conditions" or "Clear pavement entirely of snow/ice over its entire width as soon as reasonably possible after a storm event."
Pre-treating: The application of a liquid deicer to a solid deicer (like rock salt) to enhance deicer performance. This is different from anti-icing.
Pre-wetting: Coating solid materials with liquid directly prior to application to increase effectiveness. It can be achieved in 3 main ways: 1) liquid application at the spinner as material

</td></tr>
</table>

Survey Question Type	SECTION 1: Survey Introduction
	leaves the spreader, 2) liquid application to each load prior to placing it in the spreader, and 3) liquid application to the entire load of salt in the spreader. • Snow Contractor: A person, business, or private organization that provides billed snow and ice management services for one or multiple clients. • Subcontractor/Independent Contractor: A person, business, or private organization that is contracted to perform specific services for another party; subcontractors/independent contractors do not have legal status as an employee as defined by federal, state, or provincial laws. [1] Definitions provided by the Snow & Ice Management Association's Snow & Ice Management Standard Glossary of Terms (SIMA, 2017).
Multiple Choice	1. How did you obtain the survey? • Directly from the Center for Watershed Protection, Inc. • In an email from the Maryland Department of Agriculture (MDA) • Other (please specify):

SECTION 2: Organization/Company Information	
Text	**The purpose of this section is to identify key characteristics and responsibilities of your affiliated organization.**
Multiple Textboxes	2. Please provide the following information to identify the individual who will be responsible for completing the survey. The listed respondent may consult with others to answer questions, but only one (1) survey should be completed for each organization.
	Respondent Name (Last, First):
	Respondent Title/Position:
	Respondent Email:
	Name of Agency/Organization:
	Your Office: • Street Address: • City: • State: • Zip Code:
Multiple Choice	3. Please select from the list below how you would prefer your organization be identified in the publication of the survey results. • Include the name & title of the respondent and the name of the organization • Include the name of the organization only • Do not include the name & title of the respondent or the name of the organization
Multiple Choice	4. Please select which type of Municipal Separate Storm Sewer System (MS4) permit applies to your jurisdiction/organization. • Phase I MS4 permit • Phase II MS4 permit • Organization does not have/need an MS4 permit • I don't know • Other
Multiple Choice	5. Does your organization implement snow & ice management? • Yes • No * If response is no, Thank you for your response. This will end the survey.
Single Textbox	6. Which department or agency within your organization is responsible for snow & ice management?
Multiple Choice	7. On which type(s) of areas/properties does your organization implement snow & ice management? • Public (e.g., roads, schools, sidewalks, etc.) • Private (e.g., residential streets, commercial areas, etc.)

SECTION 2: Organization/Company Information	
	• Both public & private
Checkboxes	8. Which type(s) of surfaces does your organization treat for snow & ice? Select all that apply. ☐ Roads (any type) ☐ Parking lots ☐ Sidewalks ☐ Others (please specify):
Multiple Textboxes	9. For 2019, what was your service area for snow & ice management for the following? This question is referring to the areas your organization is responsible for treating, not necessarily what areas were actually treated. Please use the comment section to provide information that may help to interpret your responses if these road class types are not used by your jurisdiction or company.
	Total roadway (lane miles):
	Total length/area of sidewalks (please specify units as linear feet or square feet):
	Total area of other surfaces (specify units as acres, linear feet, or lane miles):
	OPTIONAL – Arterial highways ONLY (lane miles):
	OPTIONAL – Major arterial highways ONLY (lane miles):
	OPTIONAL – Minor arterial highways ONLY (lane miles):
	OPTIONAL – Collector roads ONLY (lane miles):
	OPTIONAL – Major collector roads ONLY (lane miles):
	OPTIONAL – Local collector roads ONLY (lane miles):
	OPTIONAL – Total parking lots (not including Park & Ride lots) (acres):
	OPTIONAL – Total Park & Ride lots (acres):
	OPTIONAL – Other areas (type, lane miles):
	Additional Comments:

SECTION 3: Snow & Ice Management Maintenance Plan/Guidance Document(s)	
Text	**The purpose of this section is to characterize your organization's snow & ice management maintenance plan (or other guidance/reference documents).**
Multiple Choice	10. Does your organization have a snow & ice management maintenance plan, salt management plan, or other type of guidance document that provides guidance and direction on the application of road salt (sodium chloride) and other winter maintenance best management practices (BMPs)? • Yes • No • I don't know
Single Textbox	11. Please provide a link to your organization's maintenance plan, management plan, or other guidance document. If your organization does not have one, please describe what information/guidance is used to determine the type, amount, and timing of material/product application.
Multiple Choice	12. How frequently is your written plan or other guidance document reviewed and updated? • Annually or more frequently • Less frequently than once a year • We do not have any written policy/guidance • I don't know • Other (please specify)
Text	**The following section will ask about your organization's Level(s) of Service.**
Essay Box	13. Does your organization have a defined Level of Service that states the expected condition of surfaces after snow & ice maintenance? Examples: "Provide snow and ice maintenance service to achieve bare pavement conditions," or "Clearing the pavement bare of ice and snow over its entire width will be accomplished as soon as reasonably possible after the winter storm event." • Yes • No • I don't know
Multiple Choice	14. Does your organization define different Levels of Service for different types of areas? • Yes, different Levels of Service are documented for different areas • No, the same Level of Service is documented for all areas • No, Levels of Service are not documented • I don't know
Essay Box	15. Please provide an example of a Level of Service for a major service area AND provide a link to a Level of Service document that can be reviewed, if available.

SECTION 3: Snow & Ice Management Maintenance Plan/Guidance Document(s)	
	Example: "For storm events with ≥ 4 inches of snow, residential streets will be plowed after emergency and collector roads are completed. Streets will be passable (may not be bare pavement, may be snow-packed) within 36 hours of the end of the storm."
Multiple Choice	16. Are your organization's operators/crew informed of the Level(s) of Service required for their assigned maintenance area(s)? • Yes • Sometimes • No • I don't know
Multiple Choice	17. In general, are your organization's Level(s) of Service typically met during the winter season? • Almost always • Most of the time • Sometimes • Occasionally • Rarely • I don't know
Essay Box	18. Please provide a brief summary of the major factors that may limit (or have limited) your organization from achieving its Level(s) of Service.

SECTION 4: Products, Materials, & Equipment Used for Snow & Ice Management	
Text	**The purpose of this section is to determine which types of snow & ice management products/materials and equipment are being used by your organization.**
Matrix	19. Please rank the following SOLID product/materials on how commonly they are used by your organization for snow and ice management (1 = most commonly used, 2 = sometimes used, 3 = least commonly used, 4 = never used). ☐ Sodium chloride ☐ Magnesium chloride ☐ Calcium chloride ☐ Other (please specify):
Matrix	20. Please rank the following LIQUID product/materials on how commonly they are used by your organization for snow and ice management (1 = most commonly used, 2 = sometimes used, 3 = least commonly used, 4 = never used). ☐ Sodium chloride brine ☐ Magnesium chloride ☐ Calcium chloride ☐ Other (please specify):
Multiple Textboxes	21. Please provide the concentration for the liquid products/materials used by your organization. For example, a mixture of sodium chloride brine is 23.3% sodium chloride.
	Name of liquid product/material (e.g., sodium chloride, magnesium chloride, etc.):
	Concentration (as a percent) of liquid product/material:
Multiple Choice	22. Does your organization possess the equipment necessary to make brine or other liquid mixtures on-site and under the operation of your organization? • Yes • No • Not applicable, our organization does not use liquid products • I don't know
Multiple Choice	23. Does your organization use Direct Liquid Application (DLA) for snow & ice management? • Yes, for anti-icing • Yes, for anti-icing & during snow events • No, our organization does not use DLA • I don't know • Other (please specify):
Text	**The following section will ask about the rates of application and amounts of solid and liquid materials applied to your organization's service area(s).**
Multiple Textboxes	24. Please answer the following questions for winter maintenance season of FY2019.
	In 2019, how much SOLID material (pounds) was applied in total?

SECTION 4: Products, Materials, & Equipment Used for Snow & Ice Management	
	In 2019, what was the average application rate (lbs/lane mile) for solid material?
	In 2019, how much LIQUID material (gallons) was applied in total?
	In 2019, what was the average application rate (gal/ lane mile) for liquid material?
Multiple Textboxes	25. Please answer the following questions for winter maintenance season of FY2018.
	In 2018, how much SOLID material (pounds) was applied in total?
	In 2018, what was the average application rate (lbs/lane mile) for solid material?
	In 2018, how much LIQUID material (gallons) was applied in total?
	In 2018, what was the average application rate (gal/ lane mile) for liquid material?
Multiple Textboxes	26. Please answer the following questions for winter maintenance season of FY2017.
	In 2017, how much SOLID material (pounds) was applied in total?
	In 2017, what was the average application rate (lbs/lane mile) for solid material?
	In 2017, how much LIQUID material (gallons) was applied in total?
	In 2017, what was the average application rate (gal/ lane mile) for liquid material?
Single Textbox	27. If your answers to the last question changed between years, why was there an increase or decrease? If your answers were the same for FY2017, 2018, and 2019, please respond "N/A."
Text	**The following section will ask about the types of equipment your organization uses to manage, track, and report the use of salt for snow & ice management (NOT the removal of snow via plowing). When completing this section, include ONLY equipment that is owned by your organization (not contractors) unless otherwise noted.**
Multiple Choice	28. Does your organization have one or more designated facilities to manufacture brine? • Yes • No; we use brine, but it is provided by a third-party or is manufactured and managed off-site • No; we do not use brine • Other (please specify):
Single Textbox	29. How many vehicles are in your organization's fleet for snow and ice maintenance? Only include vehicles owned by your organization (not owned by your contractors).
Single Textbox	30. In addition to the vehicles owned by your organization, typically, how many vehicles do you contract out annually for winter maintenance? If none, please respond "N/A."
Multiple Choice	31. Does your organization's fleet include vehicles capable of applying liquid materials for snow & ice management? • Yes • No, but we have access to them through a third-party (i.e., contractor or subcontractor) • No, we do not use liquid materials and do not need this equipment • Other (please specify):

SECTION 4: Products, Materials, & Equipment Used for Snow & Ice Management	
Checkboxes	32. Advancements in technology have made new equipment available to improve the application rate of both solid and liquid road salt. Does your organization's fleet include any of the following equipment? Select all that apply. ☐ Application regulators (e.g., spreader controls) ☐ Air & pavement temperature sensors ☐ Pre-wetting chambers ☐ Automated Vehicle Location (AVL) ☐ Loader scales on front-loaders ☐ Other (please provide a list or describe any additional equipment or technology used to optimize or reduce the application of sodium chloride):
Multiple Textboxes	33. How many vehicles in your organization's fleet used for snow and ice maintenance are retrofitted or include equipment from the list in Question 32? Your response should NOT include vehicles owned by contractors or subcontractors and not your organization.
	# of vehicles in fleet with electronic application regulators/spreader controls:
	# of vehicles in fleet with manual application regulators/spreader controls:
	# of vehicles in fleet with air & pavement temperature sensors:
	# of vehicles in fleet with pre-wetting chambers:
	# of vehicles in fleet with Automated Vehicle Location (AVL):
	# of vehicles in fleet with loader scales on front-loaders:
	# of vehicles in fleet with other retrofits (please describe):
Multiple Choice	34. What is the lowest application rate your organization's equipment can deliver with an even spread pattern? • ≤ 100 lbs/lane mile (≤ 300 lbs/acre) • 100–200 lbs/lane mile (300–500 lbs/acre) • ≥ 200 lbs/lane mile (≥ 500 lbs/acre) • I don't know

SECTION 5: Strategies & Methods	
Text	**The purpose of this section is to understand how your organization approaches snow & ice management by addressing core aspects of your organization's specific strategies and methods.**
Checkboxes	35. How often does your organization calibrate its spreaders? If more than one applies, you may select multiple options. ☐ All equipment is calibrated yearly ☐ Equipment is calibrated if something looks wrong or if new equipment is acquired ☐ Most equipment is calibrated yearly ☐ Most equipment is calibrated every other year ☐ Only new equipment is calibrated ☐ I don't know
Multiple Choice	36. Does your organization recalibrate its equipment each time the material/product being used is changed? • Yes • No • I don't know
Multiple Choice	37. During the winter maintenance season, does your organization track how much product/material is used on an annual, monthly, or per storm event basis? • Annual • Monthly • Per storm event • Product/material use is not tracked • I don't know • Other (please specify):
Multiple Choice	38. How does your organization's operators/crew document their activities in the field (to include, for example, use of product(s)/material(s) for snow & ice management)? • Using paper forms • Using an automated, electronic tracking system • Operators/crew do not track their activities • I don't know • Other (please specify):
Essay Box	39. How is operator/crew activity information communicated by the operator/crew to a supervisor or manager (e.g., automated, downloaded from vehicle, paper, etc.)? • Using paper forms Using an electronic communication system

SECTION 5: Strategies & Methods	
	Operators/crew do not track their activities, so there is no data to communicate • I don't know • Other (please specify):
Multiple Choice	40. Do supervisors compare the actions of operators to application guidelines outlined in your organization's maintenance plan/management plan/other guidance document? • Yes • No • Not applicable, our organization does not have a guidance or planning document • I don't know
Multiple Choice	41. Does your organization provide training (in-house or contractual) to staff involved in snow & ice management? • Yes • No • I don't know • Other (please specify)
Single Textbox	42. Please provide the name(s) & link(s) to training program(s) or resource(s) used.
Checkboxes	43. Who is required to receive training? Select all who apply. ☐ Operators/Crew (staff driving plows/spreaders) ☐ Supervisors ☐ Program managers ☐ Contractors ☐ Other (please specify):
Multiple Choice	44. How often does your organization provide or receive training? • Annually, before the start of each winter season • Every other year • Every five (5) years • As needed • Only new employees are trained • Other (please specify):
Multiple Choice	45. Prior to hiring outside contractors/subcontractors, does your organization require its contractors to achieve the same Level(s) of Service that is required internally within your organization? • Yes • No • I don't know • Other (please specify)

SECTION 5: Strategies & Methods	
Checkboxes	46. How are application rates for granular and liquid products/materials for snow & ice management determined? Please select all that apply. ☐ Application rates are based on both pavement and air temperatures ☐ Application rates are based on pavement temperatures only ☐ Application rates are based on air temperatures only ☐ Application rates are based on precipitation type (e.g., heavy snow, medium snow, light snow, freezing rain) ☐ Application rates are based on early storm behavior (e.g., rain or snow) ☐ Application rates are based on in-storm wind conditions (e.g., light <15 mph, strong >15 mph) ☐ Application rates are based on post-storm wind conditions (e.g., light <15 mph, strong >15 mph) ☐ Application rates are based on in-storm temperature (e.g., warm > 32°F, moderately cold 25°F – 32°F, cold < 25°F) ☐ Application rates are based on post-storm temperature (e.g., warming, cooling) ☐ Other (please specify):
Single Textbox	47. How does your organization ensure that operators follow application rate recommendations?
Multiple Choice	48. What is your organization's most common anti-icing rate for straight salt brine on roads ? Anti-icing is the application of a deicer chemical (liquid or solid) to a surface before a storm starts in order to prevent ice from forming and bonding to the surface or to enhance plowing efforts. This is different than pre-treatment which is the application of a liquid deicer to a solid deicer (like rock salt) to enhance deicer performance. • ≤ 50 gallons/lane mile • ≥ 50 gallons/lane mile • We use a liquid other than straight salt brine for anti-icing • We do not use liquid products • I don't know
Single Textbox	49. Please provide your organization's average application rate for straight salt brine on roads.
Multiple Choice	50. What is your organization's most common anti-icing rate for straight salt brine on parking lots/sidewalks? • ≤ 0.8 gallons/1,000 square feet • ≥ 0.8 gallons/1,000 square feet • We use a liquid other than straight salt brine for anti-icing • We do not use liquid products • I don't know

SECTION 5: Strategies & Methods	
Single Textbox	51. Please provide your organization's average application rate for straight salt brine on parking lots/sidewalks.
Multiple Choice	52. Does your organization apply snow & ice management products/materials to ROADS during an active storm? • Salt is not applied during storm events • Salt is only applied during the storm events • Salt is applied continuously during the storm event; on passes after the storm event, approximately ¼ the amount of salt that was applied during the storm event is applied • Salt is applied continuously during the storm event; on passes after the storm event, approximately ½ the amount of salt that was applied during the storm event is applied • Salt is applied continuously during the storm event; on passes after the storm event, approximately the same amount of salt that was applied during the storm event is applied • I don't know • Other (please specify):
Multiple Choice	53. Does your organization apply snow & ice management products/materials to PARKING LOTS/SIDEWALKS while it is snowing? • Salt is not applied during storm events • Salt is applied continuously during the storm event; on passes after the storm event, approximately ¼ the amount of salt that was applied during the storm event is applied • Salt is applied continuously during the storm event; on passes after the storm event, approximately ½ the amount of salt that was applied during the storm event is applied • Salt is applied continuously during the storm event; on passes after the storm event, approximately the same amount of salt that was applied during the storm event is applied • I don't know • Other (please specify):
Checkboxes	54. How does your organization apply granular salt to sidewalks? ☐ Drop spreader ☐ Broadcast spreader with shields on two sides ☐ Broadcast spreader with shield on one side ☐ Broadcast spreader without shield ☐ We do not maintain sidewalks ☐ I don't know ☐ Other (please specify):
Multiple Choice	55. When applying solid products/materials, do you apply to the entire road surface or targeted portion(s) of the road (e.g., centerline, crown, etc.; this may vary depending on the type of road)?

SECTION 5: Strategies & Methods	
	• Entire road surface • Targeted portion(s) only • I don't know • Other (please specify):
Multiple Choice	56. At what speed do your organization's vehicles spread granular salt on roads? • ≤ 22 mph • 23–29 mph • 30–39 mph • 40–50 mph • I don't know • Other (please specify):
Multiple Choice	57. What is done with leftover products at the end of a shift? • Brought back to the storage facility • Kept in the truck • Used up before returning • I don't know • Other (please specify):
Checkboxes	58. Please identify the source(s) your organization uses for weather forecasts. Select all that apply. ☐ Local news forecasts ☐ National Weather Service (NWS) ☐ Contracted weather services ☐ Pavement condition forecasters ☐ Road Weather Information System (RWIS) through our organization, or other ☐ I don't know ☐ Other (please specify):
Multiple Choice	59. When pavement temperatures are below 15°F, how often does your organization use dry granular salt? • Rarely or never • Sometimes • Frequently • I don't know
Multiple Choice	60. When pavement temperatures are extremely cold (below 0°F), how does your organization proceed? • We do not apply any solid or liquid products • We apply sand only

SECTION 5: Strategies & Methods	
	• We use products that work better in cold temperatures than salt or brine (like potassium acetate, super slurry, etc.) • We use whatever products we have • I don't know
Multiple Choice	61. What percentage of your organization's winter maintenance fleet is set up for liquid application (of the vehicles that apply products/materials)? • 76%–100% • 51%–75% • 26%–50% • 1%–25% • 0% • I don't know
Multiple Choice	62. In which types of areas does your organization perform anti-icing? Anti-icing is the application of a deicer chemical (liquid or solid) to a surface before a storm starts in order to prevent ice from forming and bonding to the surface or to enhance plowing efforts. This is different than pre-treatment which is the application of a liquid deicer to a solid deicer (like rock salt) to enhance deicer performance. • Almost all areas that are salted • Most areas that are salted • Some areas that are salted • Few areas that are salted • None of the areas that are salted • I don't know • Other (please specify)
Multiple Choice	63. When does your organization perform anti-icing? • On a regular schedule (e.g., every 6 hours), if there is not adequate salt on the surface • On a regular schedule (e.g., every 6 hours), no matter how much residual salt is on the surface • Never • I don't know
Single Textbox	64. Based on your previous responses, what challenges can you identify that may limit your organization's adoption of additional best practices?
Single Textbox	65. Based on your previous responses, what opportunities to implement best practices did your organization take advantage of?

SECTION 6: Salt Storage Facilities	
Text	**The purpose of this section is to understand how your organization stores both granular & liquid products/materials.**
Multiple Choice	66. Does your organization own and manage any salt storage facilities? • Yes • No • I don't know • Other (please specify)
Multiple Choice	67. What is the most common way that your organization stores solid products/materials during the WINTER? • Product/material piles are located in an enclosed or covered facility • We do not have a product/material pile in the winter • Product/material piles are tarped but are not strictly maintained • Product/material piles are uncovered or stored on un-tarped ground • I don't know
Multiple Choice	68. What is the most common way that your organization stores solid products/materials during the SUMMER? • Solid products/materials are located in an enclosed or covered facility • We do not have a pile of solid products/materials in the summer • Product/material piles are tarped but are not strictly maintained • Product/material piles are uncovered or stored on un-tarped ground • I don't know
Multiple Choice	69. How does your organization store liquid products/materials? • In a double-wall tank with a secondary containment area • In a double-wall tank • In a single-wall tank with a secondary containment area that has a volume greater than or equal to tank capacity • In a single-wall tank with a secondary containment area that has a volume less than tank capacity • In a single-wall tank • My organization does not use liquid products/materials • I don't know
Multiple Choice	70. Where does the majority of the runoff from your storage facility go? • Runoff is collected and reused in a brine system • Runoff flows into a pond with no connections to any other surface or groundwater systems • Runoff is collected and brought to a sanitary sewer • Runoff is directed into a sanitary sewer

SECTION 6: Salt Storage Facilities	
	• Runoff is permitted to flow into a storm sewer • Runoff is permitted to flow onto the surrounding landscape • Runoff is permitted to flow into a pond with connections to another surface or groundwater system • I don't know

SECTION 7: Contracts & Budgets	
Text	**The purpose of this section is to understand how your organization handles: 1) contracting and/or subcontracting snow & ice management work, and 2) budgetary considerations.**
Multiple Choice	71. Does your organization hire contractors/subcontractors for snow & ice management services? • Yes, every storm event • Sometimes, not every storm event • No • I don't know • Other (please specify)
Multiple Choice	72. Do your organization's contractors/subcontractors use the same snow & ice management plan/guidance document as public operators? • Yes • No • I don't know
Multiple Choice	73. Is your organization's budget for snow & ice management adequate to meet your Level(s) of Service? • Yes • Sometimes • No • I don't know • Other (please specify):
Single Textbox	74. If your organization's budget for snow & ice management is NOT adequate to meet your Level(s) of Service, why? If the budget is adequate, please respond "N/A."
Multiple Choice	75. Please select the budget for your organization for snow & ice management in FY2019. • Less than $100,000 • Between $100,000 – $249,999 • Between $250,000 – $499,999 • Between $500,000 – $999,999

SECTION 7: Contracts & Budgets	
	• Greater than $1,000,000
Multiple Textboxes	76. What percentage of your organization's snow & ice management budget goes to each of the following? • Staff: • Existing equipment maintenance: • New equipment purchases: • Retrofits to existing equipment: • Training: • Contractual snow & ice management services: • Other (please specify):
Essay Box	77. What factors have prevented or could prevent your organization from adopting additional snow & ice management best practices?

Appendix D. Secondary Survey

<table>
<tr><th>Survey Question Type</th><th>SECTION 1: Survey Introduction</th></tr>
<tr><td>Text</td><td>
Salt in freshwater streams is a rising concern in the United States, as it affects water quality, infrastructure like bridges, and, in some cases, drinking water, which can affect public health and treatment costs. Salt concentrations in streams have been steadily rising for the past four decades, largely as a result of persistent road salt (i.e., granular sodium chloride) application to roads, parking lots, and sidewalks for winter maintenance. The purpose of this survey is to identify: 1) the extent to which winter road maintenance practices are currently being implemented by public agencies and the private industry, and 2) the potential to reduce chloride inputs to local waters through the adoption of best practices. The results of the survey will be used to understand the current state of practice.

This survey was developed by the Center for Watershed Protection, Inc. (the Center) with funding provided by the Chesapeake Bay Trust Pooled Monitoring Initiative's Restoration Research Grant Program, which includes funding partners from the Maryland Department of Transportation State Highway Administration (MD SHA), Maryland Department of Natural Resources (DNR), the National Fish and Wildlife Foundation (NFWF) through the U.S. Environmental Protection Agency's (EPA) Chesapeake Bay Program Office, and the Chesapeake Bay Trust (CBT).

SURVEY DESCRIPTION AND INSTRUCTIONS

This survey will take between 30 minutes to 1 hour, depending on the size of your organization or company.

The survey includes five (5) sections and a total of 59 questions to describe your organization's or company's winter maintenance practices. Many of the questions will ask you to select a response from a list. There are nine (9) questions that ask you to quantify a response about the size and type of your winter maintenance fleet, service area, amount of material applied and type of surface (roads, parking lots). A copy of the survey is provided for your reference to familiarize yourself with the information requested. Please complete the survey online.
<table>
<tr><td>Section 1:</td><td>Survey Introduction</td><td>1 question</td></tr>
<tr><td>Section 2:</td><td>Organization/Company Information</td><td>7 questions</td></tr>
<tr><td>Section 3:</td><td>Snow & Ice Management Maintenance Plan/Documents</td><td>9 questions</td></tr>
<tr><td>Section 4:</td><td>Products, Materials, & Equipment</td><td>15 questions</td></tr>
</table>
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</table>

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<table>
<tr><th>Survey Question Type</th><th>SECTION 1: Survey Introduction</th></tr>
<tr><td></td><td>
<table>
<tr><td>Section 5:</td><td>Strategies & Methods
e.g., Type of equipment, calibration, tracking & reporting, training, application rates</td><td>27 questions</td></tr>
</table>

The survey results will identify the name of the public organization or private company. You will have the opportunity in the survey to opt to keep the name of your organization and/or respondent's name anonymous, or you may share that information as part of the publication of the survey results.

We respectfully request your response to this survey by COB Wednesday, March 16th, 2020 or mail a hard copy by COB March 25th to:

Center for Watershed Protection, Inc.
Attn: Jordan Fox
3290 North Ridge Road
Suite 290
Ellicott City, MD 21043</td></tr>
<tr><td>Text</td><td>Please review the following list of definitions prior to beginning the survey:
• Abrasive: Sand or another solid material placed on a slippery surface to temporarily improve traction for walking and/or driving. Abrasives alone do not melt snow and ice.
• Anti-icing: The application of a deicer chemical (liquid or solid) to a surface (e.g., road, sidewalk, parking lot, etc.) before a storm starts in order to prevent ice from forming and bonding to the surface or to enhance plowing efforts. This is often referred to as "pre-treating" a site, but pre-treating has a separate, more specific definition (see below).
• Deicing: The application of a deicer chemical (typically either a solid or pre-wet solid) to an existing accumulation of ice or snow to melt it and weaken its bond to the surface.
• Direct Liquid Application (DLA): A designated snow route that uses only a salt brine solution to prevent the snow and ice from bonding to the pavement for the duration of an event.
• Level of Service (LOS): A description of the expected road surface condition from the snow and ice maintenance activities. E.g., "Provide snow/ice maintenance to achieve bare pavement conditions" or "Clear pavement entirely of snow/ice over its entire width as soon as reasonably possible after a storm event."</td></tr>
</table>

Survey Question Type	SECTION 1: Survey Introduction
	• Pre-treating: The application of a liquid deicer to a solid deicer (like rock salt) to enhance deicer performance. This is different from anti-icing. • Pre-wetting: Coating solid materials with liquid directly prior to application to increase effectiveness. It can be achieved in 3 main ways: 1) liquid application at the spinner as material leaves the spreader, 2) liquid application to each load prior to placing it in the spreader, and 3) liquid application to the entire load of salt in the spreader. • Snow Contractor: A person, business, or private organization that provides billed snow and ice management services for one or multiple clients. • Subcontractor/Independent Contractor: A person, business, or private organization that is contracted to perform specific services for another party; subcontractors/independent contractors do not have legal status as an employee as defined by federal, state, or provincial laws. [1] Definitions provided by the Snow & Ice Management Association's Snow & Ice Management Standard Glossary of Terms (SIMA, 2017).
Multiple Choice	1. How did you obtain the survey? • Directly from the Center for Watershed Protection, Inc. • In an email from the Maryland Department of Agriculture (MDA) • Other (please specify):

SECTION 2: Organization/Company Information	
Text	**The purpose of this section is to identify key characteristics and responsibilities of your affiliated organization.**
Multiple Textboxes	2. Please provide the following information to identify the individual who will be responsible for completing the survey. The listed respondent may consult with others to answer questions, but only one (1) survey should be completed for each organization.
	Respondent Name (Last, First):
	Respondent Title/Position:
	Respondent Email:
	Name of Organization/Company:
	Your Office: • Street Address: • City: • State: • Zip Code:
Multiple Choice	3. Please select from the list below how you would prefer your organization or company be identified in the publication of the survey results. • Include the name & title of the respondent and the name of the organization • Include the name of the organization only • Do not include the name & title of the respondent or the name of the organization
Multiple Choice	4. Does your organization implement snow & ice management? • Yes • No * If response is no: Thank you for your response. This will end the survey.
Single Textbox	5. Does your organization or company have any certifications for snow and ice removal? If yes, please list them.
Multiple Choice	6. On which type(s) of areas/properties does your organization or company implement snow & ice management? • Public (e.g., roads, schools, sidewalks, etc.) • Private (e.g., residential streets, commercial areas, etc.) • Both public & private
Checkboxes	7. Which type(s) of surfaces does your organization treat for snow & ice? Select all that apply. ☐ Roads (any type) ☐ Parking lots ☐ Sidewalks

SECTION 2: Organization/Company Information	
	☐ Others (please specify):
Multiple Textboxes	8. For 2019, what was your service area for snow & ice management for the following? This question is referring to the areas your organization is responsible for treating, not necessarily what areas were actually treated. Please use the comment section to provide information that may help to interpret your responses.
	Total roadway (lane miles):
	Total length/area of sidewalks (please specify units as linear feet or square feet):
	Total area of parking lots (specify units as acres or square feet):
	Total area of other surfaces (specify units as acres, linear feet, or lane miles):

SECTION 3: Snow & Ice Management Maintenance Plan/Guidance Document(s)	
Text	**The purpose of this section is to characterize your organization's snow & ice management maintenance plan (or other guidance/reference documents).**
Multiple Choice	9. Does your organization or company have a snow & ice management maintenance plan, salt management plan, or other type of guidance document that provides guidance and direction on the application of road salt (sodium chloride) and other winter maintenance best management practices (BMPs)? • Yes • No • I don't know
Single Textbox	10. Please provide a link to your organization's maintenance plan, management plan, or other guidance document. If your organization does not have one, please describe what information/guidance is used to determine the type, amount, and timing of material/product application.
Multiple Choice	11. How frequently is your written plan or other guidance document reviewed and updated? • Annually or more frequently • Less frequently than once a year • We do not have any written policy/guidance • I don't know • Other (please specify)
Text	**The following section will ask about the type of contracts and Level(s) of Service your company provides to its clients.**
Checkboxes	12. Please select the type of snow and ice removal contracts your company uses. ☐ Per event or per inch contract ☐ Seasonal ☐ Multi-year (if this option applies, please specify an average service period for the contract–e.g., 2 years, 3 years–in using the textbox with the "Other" option) ☐ Other
Essay Box	13. What type of contract is typical for your company? • Time and Materials • Fixed Fee • Other
Essay Box	14. Please describe the Levels of Service for a major client and the type of service area. Example: "For storm events with ≥ 4 inches of snow, residential streets will be plowed after emergency and collector roads are completed. Streets will be passable (may not be bare

SECTION 3: Snow & Ice Management Maintenance Plan/Guidance Document(s)	
	pavement, may be snow-packed) within 36 hours of the end of the storm" OR "Plow the parking lot to be free of ice and snow when the snow stops."
Multiple Choice	15. Are your organization's or company's operators/crew informed of the Level(s) of Service required for their assigned maintenance area(s)? • Yes • Sometimes • No • I don't know
Multiple Choice	16. In general, are your organization's or company's Level(s) of Service typically met during the winter season? • Almost always • Most of the time • Sometimes • Occasionally • Rarely • I don't know
Essay Box	17. Please provide a brief summary of the major factors that may limit (or have limited) your organization from achieving its Level(s) of Service.

SECTION 4: Products, Materials, & Equipment Used for Snow & Ice Management	
Text	**The purpose of this section is to determine which types of snow & ice management products/materials and equipment are being used by your organization.**
Matrix	18. Please rank the following SOLID product/materials on how commonly they are used by your organization for snow and ice management (1 = most commonly used, 2 = sometimes used, 3 = least commonly used, 4 = never used). ☐ Sodium chloride (rock salt) ☐ Magnesium chloride ☐ Calcium chloride ☐ Other (please specify):
Matrix	19. Please rank the following LIQUID product/materials on how commonly they are used by your organization for snow and ice management (1 = most commonly used, 2 = sometimes used, 3 = least commonly used, 4 = never used). ☐ Sodium chloride brine ☐ Magnesium chloride ☐ Calcium chloride ☐ Other (please specify):
Multiple Textboxes	20. Please provide the concentration for the liquid products/materials used by your organization. For example, a mixture of sodium chloride brine is 23.3% sodium chloride.
	Name of liquid product/material (e.g., sodium chloride, magnesium chloride, etc.):
	Concentration (as a percent) of liquid product/material:
Multiple Choice	21. Does your organization possess the equipment necessary to make brine or other liquid mixtures on-site and under the operation of your organization? • Yes • No • Not applicable, our organization does not use liquid products • I don't know
Multiple Choice	22. Does your organization use Direct Liquid Application (DLA) for snow & ice management? • Yes, for anti-icing • Yes, for anti-icing & during snow events • No, our organization does not use DLA • I don't know • Other (please specify):
Text	**The following section will ask about the rates of application and amounts of solid and liquid materials applied to your organization's service area(s).**
Multiple Textboxes	23. Please answer the following questions for winter maintenance season of FY2019.
	In 2019, how much SOLID material (specify lbs or acres) was applied in total?

SECTION 4: Products, Materials, & Equipment Used for Snow & Ice Management	
	In 2019, what was the average application rate (specify lbs/lane mile or lbs/acre) for solid material?
	In 2019, how much LIQUID material (gallons) was applied in total?
	In 2019, what was the average application rate (gal/ lane mile) for liquid material?
Multiple Textboxes	24. Please answer the following questions for winter maintenance season of FY2018.
	In 2018, how much SOLID material (specify lbs or acres) was applied in total?
	In 2018, what was the average application rate (specify lbs/lane mile or lbs/acre) for solid material?
	In 2018, how much LIQUID material (gallons) was applied in total?
	In 2018, what was the average application rate (gal/ lane mile) for liquid material?
Multiple Textboxes	25. Please answer the following questions for winter maintenance season of FY2017.
	In 2017, how much SOLID material (specify lbs or acres) was applied in total?
	In 2017, what was the average application rate (specify lbs/lane mile or lbs/acre) for solid material?
	In 2017, how much LIQUID material (gallons) was applied in total?
	In 2017, what was the average application rate (gal/ lane mile) for liquid material?
Single Textbox	26. If your answers to the last question changed between years, why was there an increase or decrease? If your answers were the same for FY2017, 2018, and 2019, please respond "N/A."
Text	**The following section will ask about the types of equipment your organization uses to manage, track, and report the use of salt for snow & ice management (NOT the removal of snow via plowing).**
Multiple Choice	27. Does your organization or company have one or more designated facilities to manufacture brine? • Yes • No; we use brine, but it is provided by a third-party or is manufactured and managed off-site • No; we do not use brine • Other (please specify):
Single Textbox	28. How many vehicles are in your organization's or company's fleet for snow and ice maintenance?
Multiple Choice	29. Does your organization's fleet include vehicles capable of applying liquid materials for snow & ice management? • Yes • No, but we have access to them through a third-party (i.e., contractor or subcontractor) • No, we do not use liquid materials and do not need this equipment • Other (please specify):
Checkboxes	30. Advancements in technology have made new equipment available to improve the application rate of both solid and liquid road salt. Does your organization's or company's fleet include any of the following equipment? Select all that apply. ☐ Application regulators (e.g., spreader controls)

SECTION 4: Products, Materials, & Equipment Used for Snow & Ice Management	
	☐ Air & pavement temperature sensors ☐ Pre-wetting chambers ☐ Automated Vehicle Location (AVL) ☐ Loader scales on front-loaders ☐ Other (please provide a list or describe any additional equipment or technology used to optimize or reduce the application of sodium chloride):
Multiple Textboxes	31. How many vehicles in your organization's fleet used for snow and ice maintenance are retrofitted or include equipment from the list in Question 32? Your response should NOT include vehicles owned by contractors or subcontractors and not your organization.
	# of vehicles in fleet with electronic application regulators/spreader controls:
	# of vehicles in fleet with manual application regulators/spreader controls:
	# of vehicles in fleet with air & pavement temperature sensors:
	# of vehicles in fleet with pre-wetting chambers:
	# of vehicles in fleet with Automated Vehicle Location (AVL):
	# of vehicles in fleet with loader scales on front-loaders:
	# of vehicles in fleet with other retrofits (please describe):
Multiple Choice	32. What is the lowest application rate your organization's equipment can deliver with an even spread pattern? • ≤ 100 lbs/lane mile (≤ 300 lbs/acre) • 100–200 lbs/lane mile (300–500 lbs/acre) • ≥ 200 lbs/lane mile (≥ 500 lbs/acre) • I don't know • N/A

SECTION 5: Strategies & Methods	
Text	**The purpose of this section is to understand how your organization approaches snow & ice management by addressing core aspects of your organization's specific strategies and methods.**
Checkboxes	33. How often does your organization calibrate its spreaders? If more than one applies, you may select multiple options. ☐ All equipment is calibrated yearly ☐ Equipment is calibrated if something looks wrong or if new equipment is acquired ☐ Most equipment is calibrated yearly ☐ Most equipment is calibrated every other year ☐ Only new equipment is calibrated ☐ I don't know
Multiple Choice	34. Does your organization recalibrate its equipment each time the material/product being used is changed? • Yes • No • I don't know
Multiple Choice	35. During the winter maintenance season, does your organization track how much product/material is used on an annual, monthly, or per storm event basis? • Annual • Monthly • Per storm event • Product/material use is not tracked • I don't know • Other (please specify):
Multiple Choice	36. How does your organization's operators/crew document their activities in the field (to include, for example, use of product(s)/material(s) for snow & ice management)? • Using paper forms • Using an automated, electronic tracking system • Operators/crew do not track their activities • I don't know • Other (please specify):
Essay Box	37. How is operator/crew activity information communicated by the operator/crew to a supervisor or manager (e.g., automated, downloaded from vehicle, paper, etc.)? • Using paper forms Using an electronic communication system

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	Operators/crew do not track their activities, so there is no data to communicate • I don't know • Other (please specify):
Multiple Choice	38. Do supervisors compare the actions of operators to application guidelines outlined in your organization's maintenance plan/management plan/other guidance document? • Yes • No • Not applicable, our organization does not have a guidance or planning document • I don't know
Multiple Choice	39. Does your organization or company provide training (in-house or contractual) to staff involved in snow & ice management? • Yes • No • I don't know • Other (please specify)
Checkboxes	40. How are application rates for granular and liquid products/materials for snow & ice management determined? Please select all that apply. ☐ Application rates are based on both pavement and air temperatures ☐ Application rates are based on pavement temperatures only ☐ Application rates are based on air temperatures only ☐ Application rates are based on precipitation type (e.g., heavy snow, medium snow, light snow, freezing rain) ☐ Application rates are based on early storm behavior (e.g., rain or snow) ☐ Application rates are based on in-storm wind conditions (e.g., light <15 mph, strong >15 mph) ☐ Application rates are based on post-storm wind conditions (e.g., light <15 mph, strong >15 mph) ☐ Application rates are based on in-storm temperature (e.g., warm > 32°F, moderately cold 25°F – 32°F, cold < 25°F) ☐ Application rates are based on post-storm temperature (e.g., warming, cooling) ☐ Other (please specify):
Single Textbox	41. How does your organization ensure that operators follow application rate recommendations?
Multiple Choice	42. What is your organization's most common anti-icing rate for straight salt brine on roads ? Anti-icing is the application of a deicer chemical (liquid or solid) to a surface before a storm starts in order to prevent ice from forming and bonding to the surface or to enhance plowing

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	efforts. This is different than pre-treatment which is the application of a liquid deicer to a solid deicer (like rock salt) to enhance deicer performance. • ≤ 50 gallons/lane mile • ≥ 50 gallons/lane mile • We use a liquid other than straight salt brine for anti-icing • We do not use liquid products • I don't know
Single Textbox	43. Please provide your organization's average application rate for straight salt brine on roads.
Multiple Choice	44. What is your organization's most common anti-icing rate for straight salt brine on parking lots/sidewalks? • ≤ 0.8 gallons/1,000 square feet • ≥ 0.8 gallons/1,000 square feet • We use a liquid other than straight salt brine for anti-icing • We do not use liquid products • I don't know
Single Textbox	45. Please provide your organization's average application rate for straight salt brine on parking lots/sidewalks.
Multiple Choice	46. Does your organization apply snow & ice management products/materials to ROADS during an active storm? • Salt is not applied during storm events • Salt is only applied during the storm events • Salt is applied continuously during the storm event; on passes after the storm event, approximately ¼ the amount of salt that was applied during the storm event is applied • Salt is applied continuously during the storm event; on passes after the storm event, approximately ½ the amount of salt that was applied during the storm event is applied • Salt is applied continuously during the storm event; on passes after the storm event, approximately the same amount of salt that was applied during the storm event is applied • I don't know • Other (please specify):
Multiple Choice	47. Does your organization apply snow & ice management products/materials to PARKING LOTS/SIDEWALKS while it is snowing? • Salt is not applied during storm events • Salt is applied continuously during the storm event; on passes after the storm event, approximately ¼ the amount of salt that was applied during the storm event is applied • Salt is applied continuously during the storm event; on passes after the storm event, approximately ½ the amount of salt that was applied during the storm event is applied

SECTION 5: Strategies & Methods	
	• Salt is applied continuously during the storm event; on passes after the storm event, approximately the same amount of salt that was applied during the storm event is applied • I don't know • Other (please specify):
Checkboxes	48. How does your organization apply granular salt to sidewalks? ☐ Drop spreader ☐ Broadcast spreader with shields on two sides ☐ Broadcast spreader with shield on one side ☐ Broadcast spreader without shield ☐ We do not maintain sidewalks ☐ I don't know ☐ Other (please specify):
Multiple Choice	49. When applying solid products/materials, do you apply to the entire road surface or targeted portion(s) of the road (e.g., centerline, crown, etc.; this may vary depending on the type of road)? • Entire road surface • Targeted portion(s) only • I don't know • N/A • Other (please specify):
Multiple Choice	50. At what speed do your organization's vehicles spread granular salt on roads? • ≤ 22 mph • 23–29 mph • 30–39 mph • 40–50 mph • I don't know • Other (please specify):
Multiple Choice	51. What is done with leftover products at the end of a shift? • Brought back to the storage facility • Kept in the truck • Used up before returning • I don't know • Other (please specify):
Checkboxes	52. Please identify the source(s) your organization uses for weather forecasts. Select all that apply. ☐ Local news forecasts

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	☐ National Weather Service (NWS) ☐ Contracted weather services ☐ Pavement condition forecasters ☐ Road Weather Information System (RWIS) through our organization, or other ☐ I don't know ☐ Other (please specify):
Multiple Choice	53. When pavement temperatures are below 15°F, how often does your organization use dry granular salt? • Rarely or never • Sometimes • Frequently • I don't know
Multiple Choice	54. When pavement temperatures are extremely cold (below 0°F), how does your organization proceed? • We do not apply any solid or liquid products • We apply sand only • We use products that work better in cold temperatures than salt or brine (like potassium acetate, super slurry, etc.) • We use whatever products we have • I don't know
Multiple Choice	55. What percentage of your organization's winter maintenance fleet is set up for liquid application (of the vehicles that apply products/materials)? • 76%–100% • 51%–75% • 26%–50% • 1%–25% • 0% • I don't know • N/A
Multiple Choice	56. In which types of areas does your organization perform anti-icing? Anti-icing is the application of a deicer chemical (liquid or solid) to a surface before a storm starts in order to prevent ice from forming and bonding to the surface or to enhance plowing efforts. This is different than pre-treatment which is the application of a liquid deicer to a solid deicer (like rock salt) to enhance deicer performance. • Almost all areas that are salted • Most areas that are salted

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	• Some areas that are salted • Few areas that are salted • None of the areas that are salted • I don't know • Other (please specify)
Multiple Choice	57. When does your organization perform anti-icing? • On a regular schedule (e.g., every 6 hours), if there is not adequate salt on the surface • On a regular schedule (e.g., every 6 hours), no matter how much residual salt is on the surface • Never • I don't know
Single Textbox	58. Based on your previous responses, what challenges can you identify that may limit your organization's adoption of additional best practices?
Single Textbox	59. Based on your previous responses, what opportunities to implement best practices did your organization take advantage of?