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A Survey of Municipal Winter Road Maintenance in Maine

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A Report by the Margaret Chase Smith Policy Center
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Abstract

This report presents the results of a survey sent to municipalities in Maine to gather information on municipal winter road maintenance. It was part of a broader research project by the University of Maine in cooperation with the Maine Department of Transportation (MaineDOT) to examine winter roads with regard to maintenance practices, changing winter weather patterns, environmental impacts and costs, and winter road safety (Rubin et al. 2022).

Highlights

- Municipal governments are responsible for about 80% of all lane miles in the state.
- Maine used approximately 535,852 tons or 1,071,704,000 pounds of road salt in 2019–2020 (equivalent to 787 pounds per person or 23,510 pounds per lane mile). We estimate municipal salt use to be 59% of this total.
- Only 28% of Maine municipalities report using an anti-icing policy on their roads; the rest follow the traditional practice of applying sand with some salt mixed in.
- Larger municipalities are more likely to use the practice of pre-wetting salt, while most smaller ones report never pre-wetting their truckloads of salt.
- Most municipal crews receive training, while fewer than half of contracted crews do.
- Municipal governments spent $104 million (67% of all estimated statewide expenditures) on winter road maintenance in 2019-2020 season.
- Budgetary costs of winter road maintenance vary widely among municipalities, even when the costs per lane mile per capita are similar.

Acknowledgements and Disclaimers

We would like to specifically recognize Peter Coughlan and Brian Burne at MaineDOT who facilitated this municipal survey. The views and opinions expressed in this report are solely those of the Margaret Chase Smith Policy Center and the individual authors. They do not represent those of MaineDOT or any other individual or organization that has provided information or assistance.

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Introduction

This report presents the results of a survey sent to Maine municipalities to gather information on municipal winter road maintenance. The survey was part of a larger research project by the University of Maine in cooperation with the Maine Department of Transportation (MaineDOT) examining winter road maintenance in Maine with regard to practices and materials, changing winter weather patterns, environmental impacts and costs, and winter road safety (Rubin et al. 2022).

Responses to survey questions contribute to a statewide picture of municipal winter road maintenance and its associated impacts and costs. It is our hope that a better understanding of statewide winter road maintenance could identify areas to reduce the financial and environmental costs while maintaining area-specific, appropriate levels of service and mobility.

Some broad patterns are clear. By far the most widely used material on winter roads in Maine and nationwide is rock salt (sodium chloride, NaCl) due to its cost-effectiveness and ease of handling. Statewide, the total bulk salt purchased in Maine in 2019–2020, as reported from distributors, amounts to 535,852 tons.[1] This means that, statewide, Maine uses roughly 787 pounds of salt for every Maine resident, or 11 tons per lane mile per year. We estimate the municipal salt use to be 59% of this total, or 315,000 tons (Rubin et al. 2022).The most common winter maintenance practice at the municipal level remains the traditional approach of plowing and applying sand with salt mixed in. The cost of winter road maintenance is a significant part of a municipal budget yet varies widely among towns and cities. Impacts to the environment and to infrastructure are becoming more noticeable.

Recent studies of U.S. driver behavior indicate that as winter road maintenance practices improve, the traveling public expects to drive at the posted speed limit sooner after a storm and expects to have bare pavement within hours (Veneziano 2019). Achieving this greater mobility contributes to a cycle in which higher level-of-service (achieved by using best practices with modern equipment and better weather information) in turn generates a greater demand for service. The public is generally attentive to the direct costs incurred in winter maintenance, such as equipment, labor, and materials, but the indirect costs of environmental impacts and corrosion to infrastructure and vehicles are more difficult to quantify and communicate. In this survey, for example, 70% of responding towns had not explicitly communicated their level of service on winter roads to their residents (and we suspect most are unaware of the full costs of corrosion and environmental impact).

The fluctuating weather patterns seen in recent years together with an overall warming trend generally bring warmer winters with more cycles of thawing and freezing snow and rain, though

[1] We independently calculated salt totals by combining salt purchases from MDOT, MTA, and municipal governments. Using this method, we estimate approximately 493,000 tons, or about 42,000 tons or 9%, less than the bulk amount purchased. This 9% difference is likely explained by the non-road use of salt on commercial and industrial parking lots and other private uses.

with significant regional differences. These changing climate conditions will have an impact on winter maintenance practices in Maine and on the use of road salt and other de-icing chemicals.

Balancing cost, environmental impact, safety, and safe transit becomes a task for policy makers. For some jurisdictions, cost is the overriding consideration, while for others, it may be environmental impact, driver safety, or adhering to traditional practices. Even following recommended best management practices, local decision-making will impact road salt application rates, costs, and practices.

Background: Maine Roads and Winter Practices

The state of Maine has 45,586 lane miles of winter roads (MDOT 2017). Maine reported approximately 1,649,049 registered motor vehicles and 1,047,893 licensed drivers (Maine Bureau of Motor Vehicles 2020).[2] As a rural state with a population of 1.36 million, Maine has more miles of roadway per person than any other New England state, leading to a relatively high per resident cost for transportation maintenance and infrastructure.

Table 1: Maine Winter Miles by Jurisdictional Responsibility

Agent	Lane	Centerline	% of Total Lane Miles
MaineDOT	8,225	4,079	18
MTA	632	109	1.3
Municipal	36,729	18,283	80.6
State Total	45,586	22,471	

SOURCE: (MaineDOT, 2021)

There are 483 towns and cities, 3 reservations, and 10 counties with responsibility for winter road maintenance in Maine. These entities are responsible for 18,283 centerline miles of road (36,729 lane miles) or approximately 80% of the state total roadway. These include state aid highways and municipal and county mileage. Municipal governments either provide winter maintenance services directly through a public works department or town employees or use private contractors. Each municipal entity in Maine differs in the road mileage it maintains, the level-of-service provided on its roads, its use of contractors or staff, the materials used, and its training for winter crews. All these choices made for winter maintenance at the municipal level affect costs, level-of-service, safety, and environmental impacts.

Municipal maintenance varies from state-level winter road maintenance in some significant ways. Road surfaces and traffic patterns are different from state highways, while training, equipment, and technology are more varied. There is no uniform set of conditions for municipal roads; climate, slope, elevations, and volume all influence local conditions. Municipalities differ from each other in budget keeping, population density, and levels of service. Some of Maine's cities and

[2] Maine's population 1,362,359, 2020, US Census Bureau.

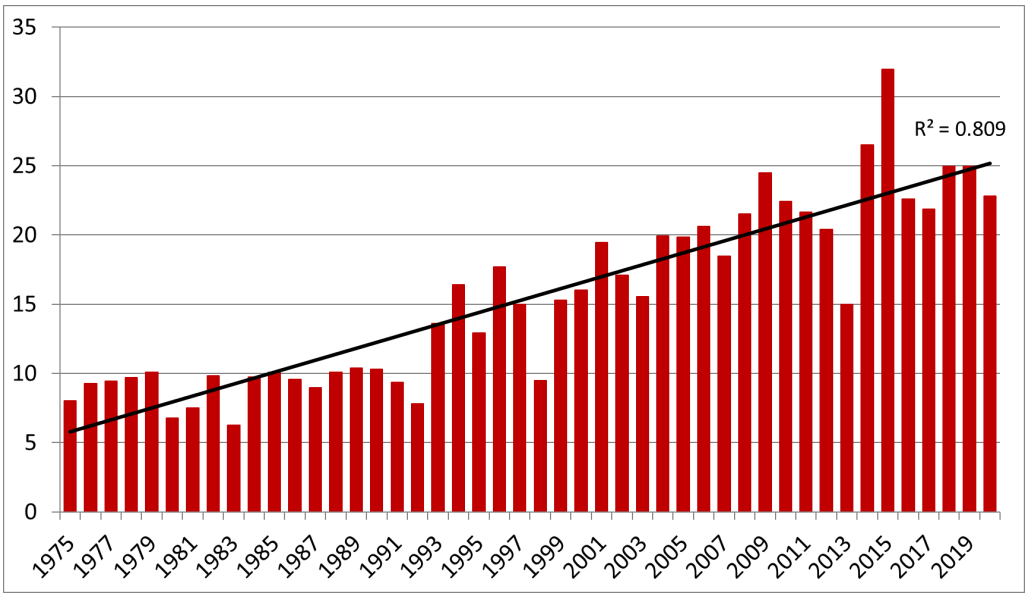
towns provide higher levels of service in downtown areas and clear sidewalks, parking lots, and school facilities.

Background: Materials and Costs

Sodium chloride (NaCl), or road salt, remains the most used and most cost-effective material for clearing roads. Melting occurs when the salt forms a brine. Sodium chloride loses effectiveness at temperatures below 15 degrees F, which leads to the use of additives that have similar effects but slightly different characteristics, including calcium chloride and magnesium chloride. Sand may be applied for traction, but salt used with physical snow removal (plowing) remains the dominant winter snow and ice road treatment method, while equipment and practices improve.

Nationwide, salt consumption has steadily increased since salt was first used on U.S. roads in the 1940s. In 2020, highway de-icing accounted for about 43% of total salt consumed in the US (USGS 2021).

Figure 1: NaCl Salt Used for De-icing in the United States (million metric tons)



(USGS 2021) With thanks to Victoria Kelly at the Cary Institute of Ecosystem Studies for sharing previous data.

Road salt is very effective in helping clear roads, providing safe travel and facilitating commerce. Stormwater runoff and meltwater, however, carries salt from roads to surface waters where it can travel more slowly through contaminated groundwater. Although Maine is a rural state, we already have watersheds with chloride impairment in areas of high road density or large percentages of impervious surface (See section on Impacts of Salt Use in Rubin et al. 2022).

Figure 2: Statewide Salt Use Total (535,852 Tons), 2019–20

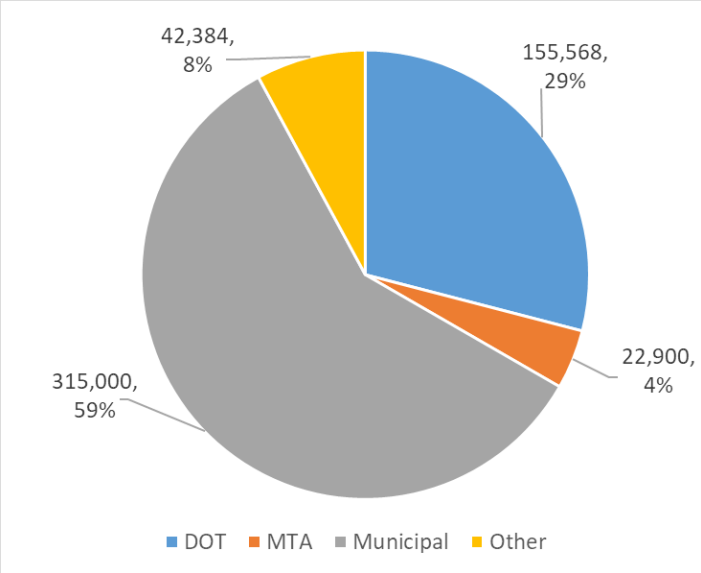


Figure 2 shows our estimate of the distribution of bulk salt use statewide in the winter of 2019–2020 (Rubin et al. 2022). The actual amount used in any one year is a combination of stockpiles left from prior years and the current year's use, while a remainder may again carry over. Estimating that municipalities tend to know their needs and that these average out over more than one year, we use the figure of what was purchased in a year as representative. Other use is made up of homeowners, private roads and parking lots, airports, colleges, shopping centers, and businesses.

We estimate the total costs to MDOT, MTA, and Maine municipalities for winter road maintenance of the 2019–2020 season to be $155 million (Rubin et al. 2022). The breakdown of these expenses is given in Table 2. This amount does not include non-budgeted costs of environmental impacts or corrosion of infrastructure and vehicles, nor does it include remediation costs of wells contaminated from road salts.

Table 2: Winter Maintenance Expenditures Total: MDOT, MTA, Municipal

Entity	Total	Cost/Lane Mile
MDOT	$46,167,855	$5,613
MTA	$4,219,892	$6,677
Municipal	$104,452,531	$2,844
State Total	$154,840,278	$3,397

Municipal governments are responsible for 67% of all statewide expenditures on winter road maintenance including materials, equipment, and labor. This reflects the fact that municipal governments are responsible for 80% of all lane miles. Both MDOT and MTA have higher overall costs per lane mile than municipal governments, also reflecting that state roads are maintained at an overall higher level-of-service than municipal roads.

The number of road miles and population size strongly affect the costs of municipal winter maintenance. Many municipalities have costs per person-mile below the state average of 0.25 cents, but many do not.[3] This difference indicates that there could be room for change in maintenance practices to reduce winter road maintenance costs to the municipality.

Economic impacts of the use of chlorides include the costs of deterioration of infrastructure and equipment, costs of salt storage, costs of materials applied, cost of accidents, and costs associate with commerce and remediation (Tiwari and Rachlin 2018; Shi et al. 2014; Fay and Shi 2012). Social and public safety impacts result from crashes, groundwater and drinking water contamination, and loss of mobility on roadways.

Environmental impacts include impact to surface waters, groundwater, soil, aquatic life and roadside vegetation. Salt for de-icing roadways is a major source of chloride to groundwater, streams and rivers, and lakes in northern North America and Europe. Trends of increasing chloride are found nationwide in streams and glacial aquifers (Dugan et al. 2017; Kaushal et al. 2005; Mullaney, Lorenz, and Arnston 2009). Chloride accumulations in groundwater can migrate through baseflow to surface waters and impact drinking water and aquatic life. Road salt affects roadside vegetation through direct contact as well as by altering the chemical composition of soils (Tiwari and Rachlin 2018; Corsi et al. 2015).

Most of the chloride applied to roads will end up in surface water or groundwater. There is no natural process which can break down or eliminate chlorides from water or soil; only dilution reduces their impact. In 2015 Maine convened a Snow and Ice Control Best Practices Working Group which concluded that, “We now know there is an upward trend for salt concentrations in many northern freshwaters. Because there are no effective measures for removing dissolved salt from freshwater, it is critical to minimize the amount of salt used” (Maine Snow and Ice Control Best Practices Working Group et al. 2015).

It is our intention with this report and its related statewide study to begin a closer examination of the use of chlorides in winter road maintenance in Maine and their associated impacts. We hope that through this examination Maine can identify measures to take to act upon the working Group’s recommendation.

[3] Person-mile is the total cost divided by (population x lane miles).

Survey Results: Municipal Practices

With the assistance of MaineDOT's Local Road Center we surveyed nearly 500 units of local government including municipalities, counties, tribal governments, and plantations to better understand their winter practices for the winter of 2019–2020. This report's information on comes from that survey. Appendix 1 provides the survey instrument which was sent by email from MaineDOT's Maine Local Roads Center. We received 246 responses which range from Maine's largest cities to towns with population of fewer than 100 residents.

The survey responses on municipal operations are also examined by the five geographical regions (as used by MaineDOT) and by population size.

Table 3: Summary of Survey Responses on Municipal Winter Practices

Use "anti-icing" practices	28%	Highest rate in southern municipalities (53%) Highest in higher pop. municipalities
Use "sand with some salt in it" practices	72%	Highest rate in northern municipalities (94%) Highest in towns <5000
Use "pre-treating roads before a storm"	12%	Highest among towns > 5000 Highest in western municipalities (35%) Lowest in eastern municipalities (4%) More overall in municipal crews than contracted crews
Use "pre-wetting load of salt" always or sometimes	29%	71% never pre-wet 12% always pre-wet (highest in southern (22%)) Larger pop. is more likely to pre-wet (100% of pop>10,000, 58% of pop 5000-10,000)
"Sidewalks and parking lots included in municipal maintenance"	71%	Most municipalities maintain some mileage of parking lots and sidewalks
"Crews receive training"	69%	Municipal crews (89%); Contractors (45%)
"Follow guidance of Maine's BMP document"	36%	65% say they have seen the document 36% say they use the document

Anti-icing as a strategy—as opposed to de-icing—requires an earlier response, preventing ice from forming on the road. A majority 72% of responding towns reported relying on application of the traditional "sand with some salt in it" rather than an "anti-icing" strategy (28%). Sanding provides temporary traction while salt melts snow and ice so it can be cleared by plows. Communities in the Northern region are more likely to use traditional method of "sand-with-salt" (94% of responding use that approach). The Southern region has the highest rate of anti-icing (53% of southern municipalities surveyed). Communities with a population below 5,000 were more likely to rely on sanding, while higher-population communities were more likely to use anti-icing. More contracted crews than municipal crews rely on sand, likely reflecting that smaller towns contract out their maintenance more frequently than larger cities.

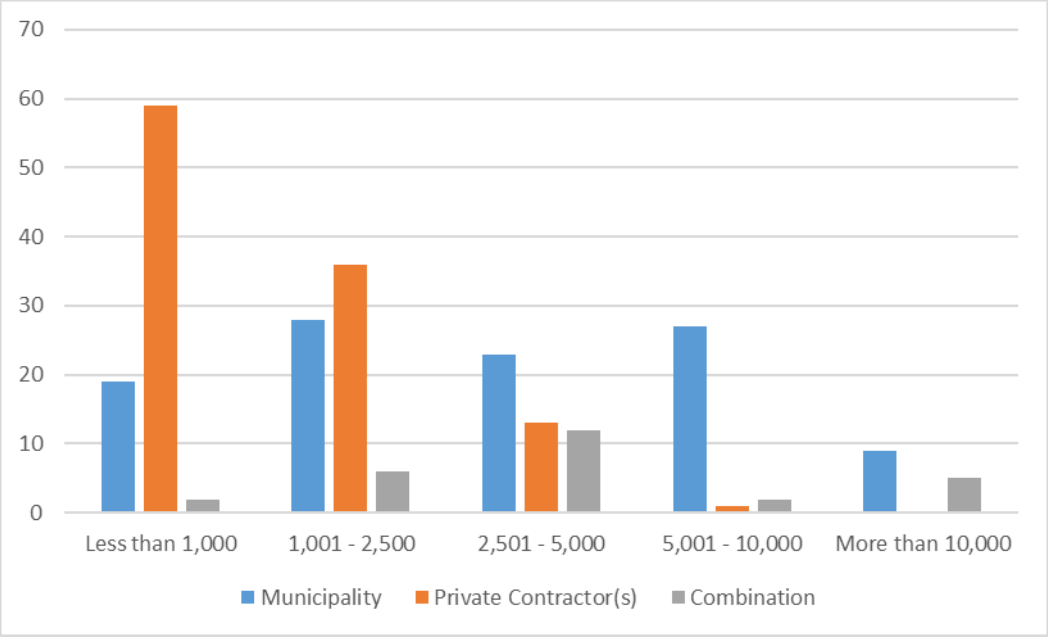
Pre-treating roads before a storm often involves the use of liquids, depends on more accurate weather information, and is often more costly. 12% of responding towns reported pre-treating their roads before a storm. (We did not ask whether pre-treating involved liquids or pre-wetted salt.) Not surprisingly, towns larger than 5,000 have the highest rate of pre-treating, while smaller towns have the lowest. Communities in the Western region are more likely to pre-treat (35% of western municipalities surveyed). The Eastern region is least likely to pre-treat (4% of eastern municipalities surveyed). More municipal crews than contracted crews report pre-treating.

Studies have found that when salt is applied dry (without pre-wetting the truckload) 30% ends up outside the roadway (i.e., in the ditch) while when applied pre-wet, only 4% ends up in the ditch (Nixon and DeVries 2015). Pre-wetting salt while spreading is recommended as a BMP and is employed by MaineDOT and MTA. 71% of towns surveyed report that they never pre-wet their salt before spreading, while 12% report that they always do. Some 29% of Maine municipalities report pre-wetting their salt always or sometimes, suggesting that there is room to improve effectiveness at the municipal level. Communities in the Southern region are more likely to "always" pre-wet (22% of respondents) than the other regions. Larger municipalities are more likely to pre-wet; 100% of respondents from towns larger than 10,000 report that they “always or sometimes” pre-wet their salt, while 58% of towns with population between 5000 and 10,000 do so.

Most of responding towns (71%) also include sidewalks and parking lots in their operations. Many did not specify mileage, but those who did reported maintaining a total of 1,165 sidewalk miles and 13 million square feet of parking lots.

Responding towns reported a relatively even split between those who use municipal crews (106) and those who use private contractors (108). A few (27) reported using a combination. Municipalities with smaller populations were more likely to use contractors for their winter maintenance.

Figure 3: Winter Maintenance Crew Type by Municipal Size



These findings on municipal operations are consistent with the rural composition of Maine; small towns with limited budgets, equipment, and staff make up most of the road mileage maintenance in the state. Larger communities have more flexibility in their budgets, ability to replace equipment, and staff to implement new practices.

Of municipalities that responded to our question on training (N = 189), 69% say that their drivers receive training. Municipal crews were more likely (89%) to receive training than contracted crews (45%). We also asked about whether towns follow the guidance of "Maine BMP for Winter Road Maintenance"(Maine Snow and Ice Control Best Practices Working Group et al. 2015). Though 65% report having seen the document, only 36% report using it in their operations.

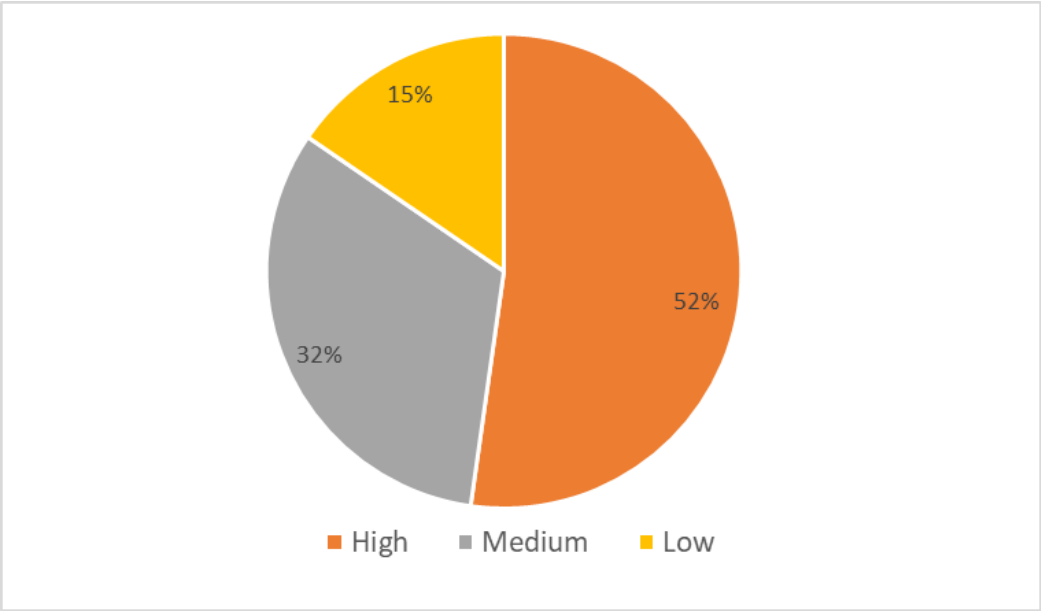
Among responding towns, 9% report some municipal areas that require special practices for winter maintenance, such as wetlands or public water supply, and 19% reported that they have had a well claim for salt contamination in their jurisdiction at some time in the past.

Calibration of equipment is a practice recommended to avoid over-salting. MaineDOT's Maine Local Roads Center training program teaches calibration techniques to municipalities. Recent experience from New York DOT and municipalities recommends monthly calibration of equipment (Lake George Association 2021). We do not have specific detail on the frequency of calibration in Maine municipalities. We did not ask this in our survey but suspect it to be less frequently.

Survey respondents self-identified their level-of-service by priority ranking of a percentage of their mileage as high, medium, and low. Figure 4 shows the miles-weighted level-of-service reported. Collectively, just under 52% of municipalities' roads are considered high priority, while 32% and 15% are considered medium and low, respectively. A majority (70%) of the responding towns

reported that they have not formally defined and communicated to their residents a policy on level-of-service for their roads.

Figure 4: Municipal Respondent Winter Lane Miles by Priority



Survey Results: Winter Materials

As presented in the broader report, "Road Salt in Maine: An Assessment of Practices, Impacts and Safety" (Rubin et al. 2022), by far the most widely used material on winter roads in Maine is rock salt (sodium chloride or NaCl) due to its cost-effectiveness and ease of handling. The bulk salt purchased in Maine statewide in 2019–2020, as reported from distributors, totals 535,852 tons.[4] This means that, statewide, Maine uses roughly 787 pounds of salt for every Maine resident, or 11 tons per lane mile per year. Through this survey we estimate the municipal salt use to be 59% of this total, or 315,000 tons.

Prior to 2006, it was standard to treat roads with a salt and sand mix. Since then both MaineDOT and Maine Turnpike Authority have discontinued sand use on state roads for environmental and cost reasons. Sand has no melting properties, but it does provide temporary traction, particularly on lower speed roads. Sand also washes off the road to fill culverts and impact surface waters, however, and it can contribute to particulate emissions in urban areas as it is blown. The cost of cleaning up the excess sand in the spring can be high. Statewide - and nationwide - sand use has declined. Notwithstanding the decline in sand use by the MaineDOT and MTA, sand mixed with

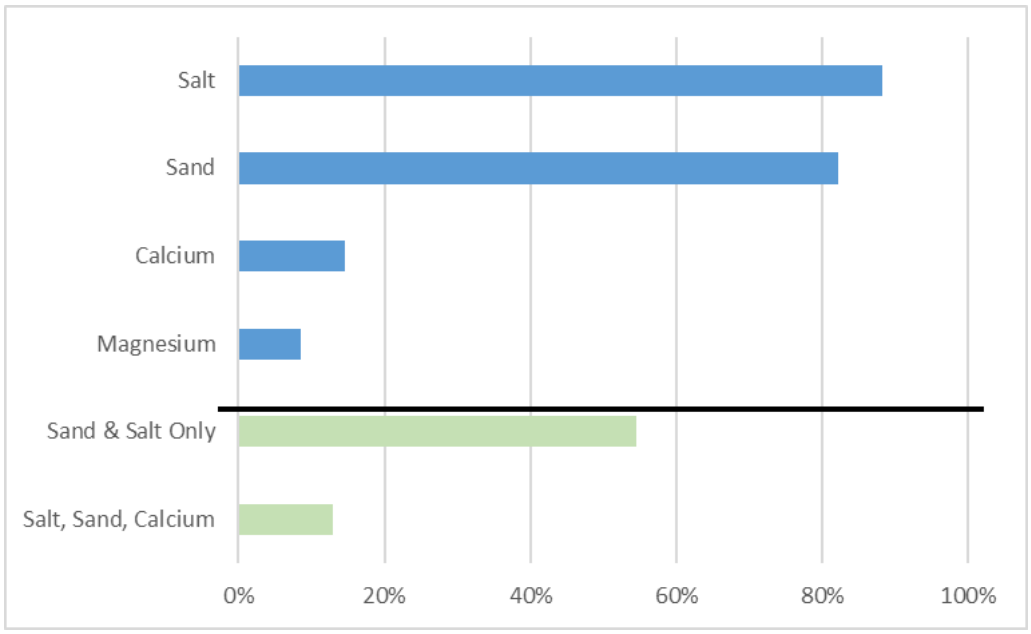
[4] We independently calculated salt totals by combining salt purchases from MDOT, MTA, and municipal governments. Using this method, we estimate approximately 493,000 tons, or about 42,000 tons or 9%, less than the bulk amount purchased. This 9% difference is likely explained by the non-road use of salt on commercial and industrial parking lots and other private uses.

salt continues to be used on many municipal roads in Maine. As sand use has declined overall, salt use continues to increase both in Maine and nationwide, likely reflecting a higher level-of-service, increased travel and higher driver expectations.

Municipal materials

By far the most common material used by Maine municipalities is road salt (NaCl) with almost 90% of responding municipalities reporting the amount purchased. Most municipalities also report purchasing sand (82%), and a lower number report the use of calcium chloride and magnesium chloride, see Figure 5.

Figure 5: Material Use Reported by Municipal Governments



The total amount of salt purchased by survey respondents (N=217) equals 187,000 tons in the 2019–2020 season. Extrapolating to the entire state, we estimate that all municipalities purchased 315,000 tons of salt during this season. Looking at distribution by geographic region, municipalities the Southern region purchased 138,000 tons of salt, the most of any region. This may be consistent with weather patterns of freeze/thaw and freezing rain being more prevalent in the south or higher levels-of-service.

Table 4: Salt Purchased by Municipalities in 2019-2020 across Regions

Region (weighted)	Total Tons
Southern	138,332
Midcoast	58,862
Western	35,982
Eastern	64,906
Northern	16,948
Statewide municipal Total	315,030

Many small municipalities rely on the use of sand. Responding municipalities purchased 502,000 cubic yards of sand. Extrapolating to the entire state, 894,000 cubic yards of sand were purchased during the 2019–2020 winter season. We estimate that the Northern region purchased the least amount of sand and the Eastern region purchased the most.

Table 5: Sand Purchased by Municipalities in 2019–2020 Across Regions

Region (weighted)	Total Cubic Yards
Southern	167,016
Midcoast	200,531
Western	179,056
Eastern	248,342
Northern	98,771

De-icers such as calcium chloride ($CaCl_2$) and magnesium chloride ($MgCl_2$) have a lower effective temperature than sodium chloride and can be mixed with salt to facilitate melting at lower temperatures. Fewer than half the survey respondents reported using additional de-icers. Some towns use more than one type of additional de-icer. The most common type was calcium chloride.

Table 6: Use of Other De-icers by Municipalities 2019-20

De-icer (Responses not weighted, N=155)	**Use**	**Percentage**
Calcium chloride ($CaCl_2$)	36	23%
Magnesium chloride ($MgCl_2$)	21	14%
Other	17	11%
None	81	52%

Respondents reported their total purchases of $CaCl_2$ (66,000 gallons and 3,000 tons) and $MgCl_2$ (103,000 gallons and 10,000 tons). Given the small number of towns (52) reporting use of these additional de-icers, we do not weight these figures statewide.

Table 7: Amount of Other De-icers Purchased by Municipalities

CaCl2 (Gallons)	**CaCl2 (Tons)**	**MgCl2 (Gallons)**	**MgCl2 (Tons)**
Responses unweighted, N = 52			
65,970	3,149	104,377	10,405

What is notable about the mix of materials at the municipal level is how it differs from state agencies. A much greater proportion of sand use by municipalities contrasts with the change made by MaineDOT and MTA to anti-icing policies. Most towns, especially smaller ones, continue to rely on sand. This practice is common in smaller municipalities across the Northeast.

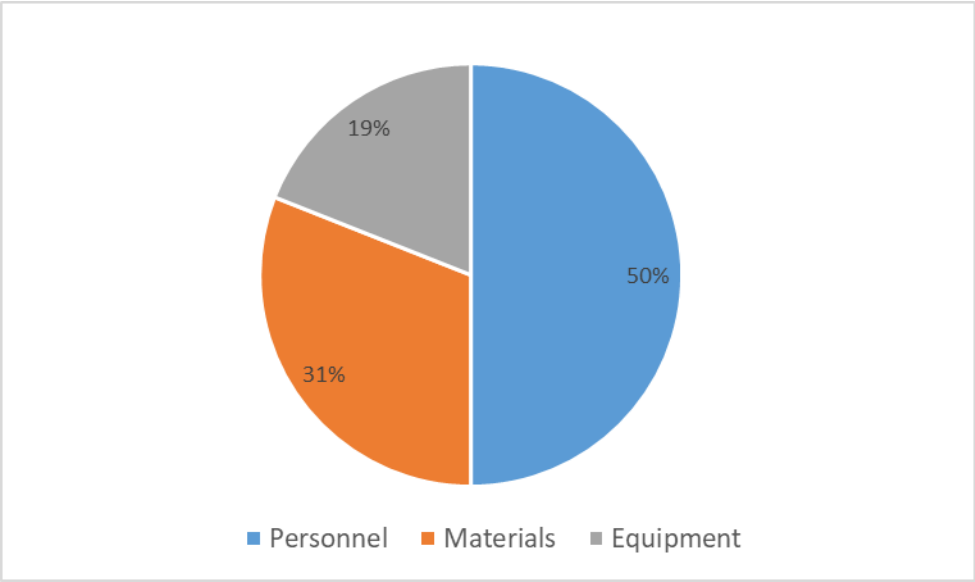
Survey Results: Winter Maintenance Costs

As noted previously in Table 2, municipal governments carry 67% of Maine's almost $155 million winter maintenance expenditures. We examine these costs by component category, by region, by lane-mile, by lane-mile per capita, and by population size.

Municipal costs

At the municipal level, winter road maintenance is a significant portion of a local budget. Responding municipalities report having a total winter maintenance budget of $54 million during the 2019–2020 winter season. This figure includes personnel (50%), materials (31%), and equipment (19%). Communities spent *on average* $256,000, with some spending as little as $3,830 and others spending as much as $2,300,000. When *extrapolating* to the state as a whole (based on DOT region, population, winter lane miles maintained), we estimate that all municipalities spent an estimated $104 million on winter road maintenance during the 2019–2020 season.

Figure 6: Respondent Municipal Winter Budget Breakdown



Municipalities were asked to categorize their expenses by estimating what percentage of their total cost was spent on personnel, materials, and equipment, and in some cases, contractors. We see in Figure 6 that for municipalities which do some or all their own winter maintenance about 50% of their expenditures is for labor, 30% is for materials (primarily salt), and 20% for equipment.

Figure 7: Municipal Respondent Winter Road Maintenance Cost by Region

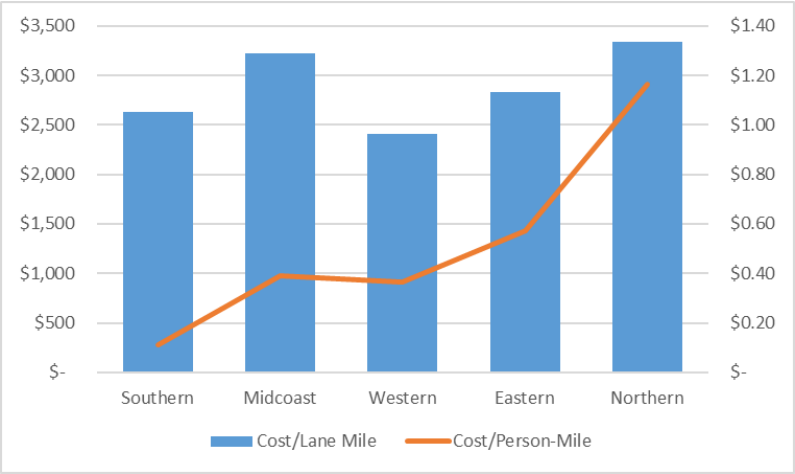


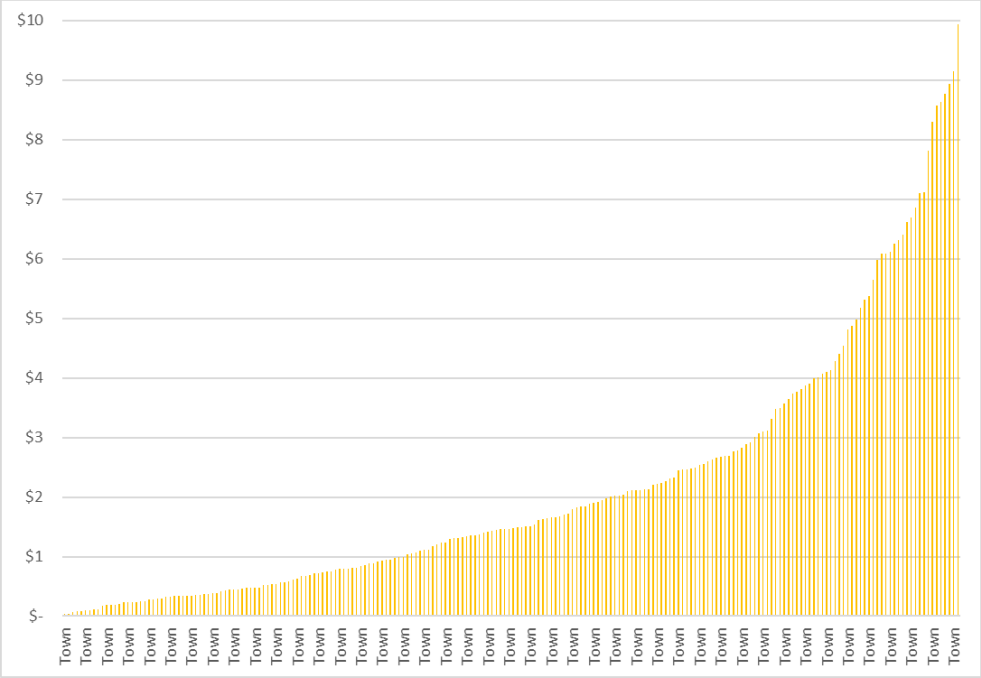
Figure 7 groups towns by region and shows costs per lane mile and as well as cost per person-mile. Costs per lane mile vary widely across municipalities, reflecting different geographies and weather as well as municipality size and number of miles of roads and sidewalks maintained. These costs also reflect different choices in the level of service and whether a town employs municipal workers or contractors.

Based on our survey, total cost per lane mile at the town level ranges from $555 to $6620, excluding outliers. (The simple costs per lane mile shown in the blue bars are unweighted.) On average, municipalities in the Northern and Midcoast regions report significantly higher costs per *lane-mile* which is likely due to the higher winter severity routinely experienced in this part of the state and the lower population density.

When comparing per-capita costs (orange line in Figure 7) the grouped towns are weighted by person-miles because towns of different size populations and costs need to account for the fact that unequal number of people have different costs per mile (i.e., we use a harmonic mean as opposed to an arithmetic mean).

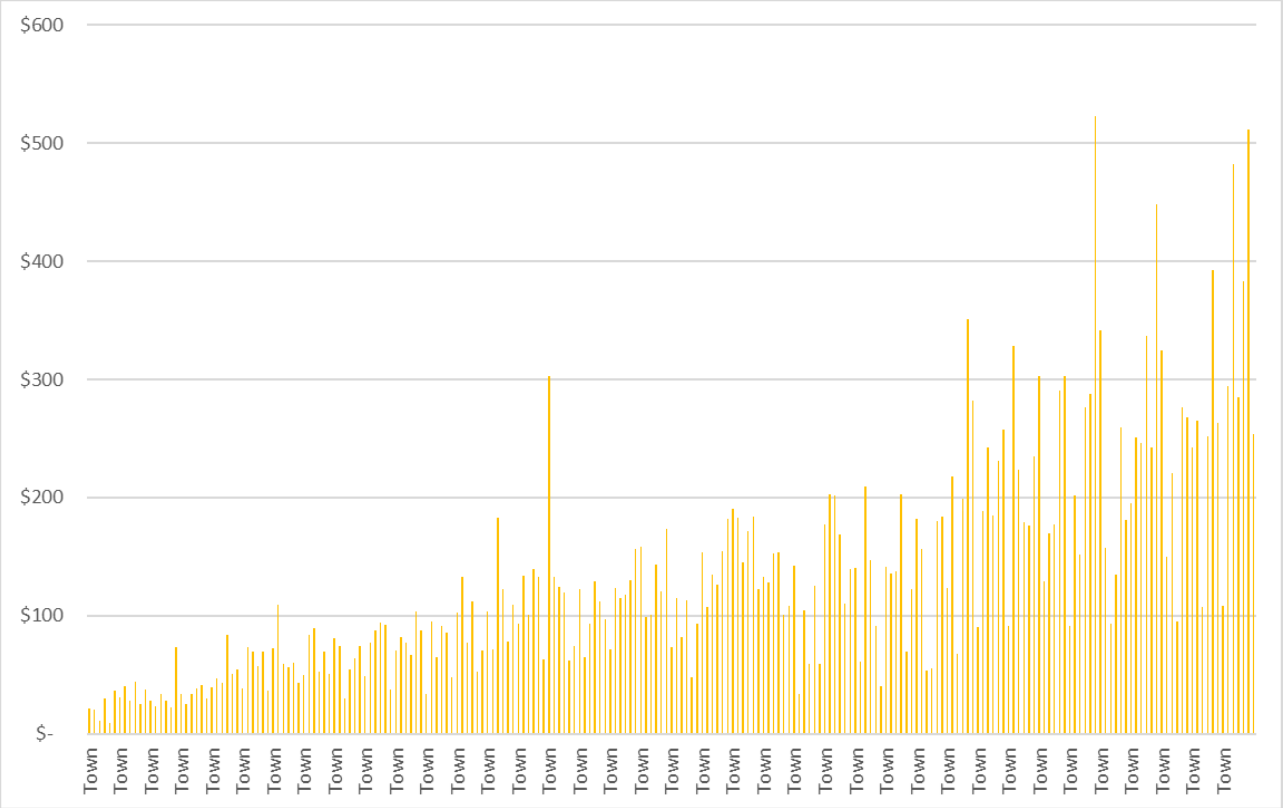
Weighting the responses on cost now by lane miles per capita, Figure 8 shows that there is a large range in winter maintenance costs, ranging from a low of $0.04 to $10. We have truncated the full range of costs at $10 per lane mile (per capita), which eliminates displaying about 20 municipalities with *very large* per lane mile costs because they skew the figure and compress the variation among most of the respondents.

Figure 8: Total Costs per Lane Mile per Capita



Nor is the variation in costs between municipalities due only to their size of population. Figure 9 shows total winter maintenance costs per capita among towns with population greater than 100 people. For comparison purposes, we order the towns by cost per lane mile per capita, as in Figure 8. Per capita costs differ even among towns with similarly low or high lane-mile-per-capita costs.

Figure 9: Winter Maintenance Costs per Capita for Municipalities > 100; ordered by Cost per Lane Mile



We conclude that both the number of road miles maintained and the population size strongly affect municipal winter maintenance costs. Some of this variation may be explained by municipal-level decisions to clear sidewalks, schools and parking lots. Nonetheless, there remains significant variation in costs. This suggests that a closer examination of municipal practices could reveal opportunities to reduce winter road maintenance costs. Unfortunately, we do not have any objective measure of the quality of winter maintenance efforts or the speed and thoroughness of activities by which to rank outcomes that could help explain cost differences.

Figure 10: Winter Road Maintenance Costs per Lane Mile per Person-Mile by Municipal Population Size

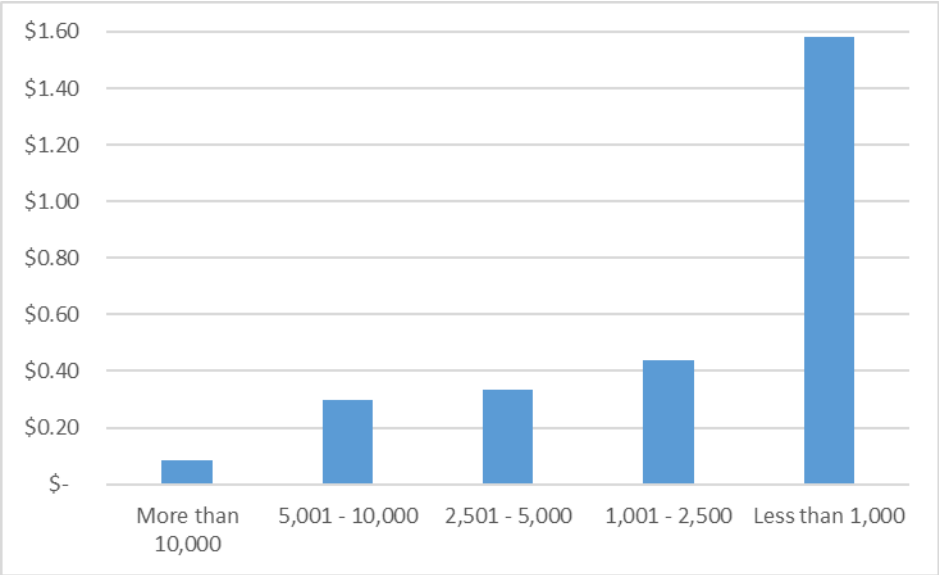


Figure 10 splits the distribution of maintenance costs (per lane mile, per person-mile) by population size of municipalities. The smallest towns bear the highest burden of cost to residents, while municipalities with population above 10,000 show the lowest costs, considering both lane miles and population size. This shows that population, while not the sole factor, heavily influences total costs at a town or city level.

Survey Results: Response rate and weighting

The 246 municipalities responding to the survey represent about 51% of all municipalities and constitute about 65% of Maine's total population of 1.34 million. To extrapolate the winter maintenance costs and practices for the entire state, we scaled or weighted the observations in our sample. All municipalities across the state were placed into bins based on their DOT region, population, and number of winter lane maintenance miles. There are 125 different bins representing combinations of DOT region, population, and lane mile categories. We examined the frequency of responses in each bin (for example, the number of municipalities that exist in *DOT region* 1, *population category* 3 and *lane mile category* 4) compared to the state as a whole.[5] Responding municipalities were then assigned a weight so that our survey sample is reflective of the state as a whole.[6] For total winter maintenance costs and total salt and sand purchases, we

[5] For example, if a survey respondent within DOT region 1, population group 2, lane mile group 3 did not answer the total cost question, we assigned them a total cost equal to the average cost reported by all of the communities who fall in the same bin.

[6] By "state as a whole," we mean all municipalities that have winter road maintenance miles; our scaling does not take into account communities that either do not have any winter road maintenance miles or are unorganized and thus have decisions made at a county level.

took into account *question-level* missing data (non-responses). If a responding municipality did not answer a particular question, we assigned them the *average value* for their bin, using the same categories as the weighting factor described earlier. Finally, though we asked municipalities to report their total centerline winter maintenance miles, not all answered. Instead, we used data provided by MaineDOT on municipal winter-maintained miles by municipality.

Distribution of municipal responses

A higher proportion of the municipalities with larger populations completed the survey, though overall we got more responses from small municipalities due to their larger proportion in the state. We received responses across all size classes. Figure 11 shows the representation of municipalities by size both in the state and in the survey.

Figure 11: Responding Municipalities by Population Size as Percentage of Total

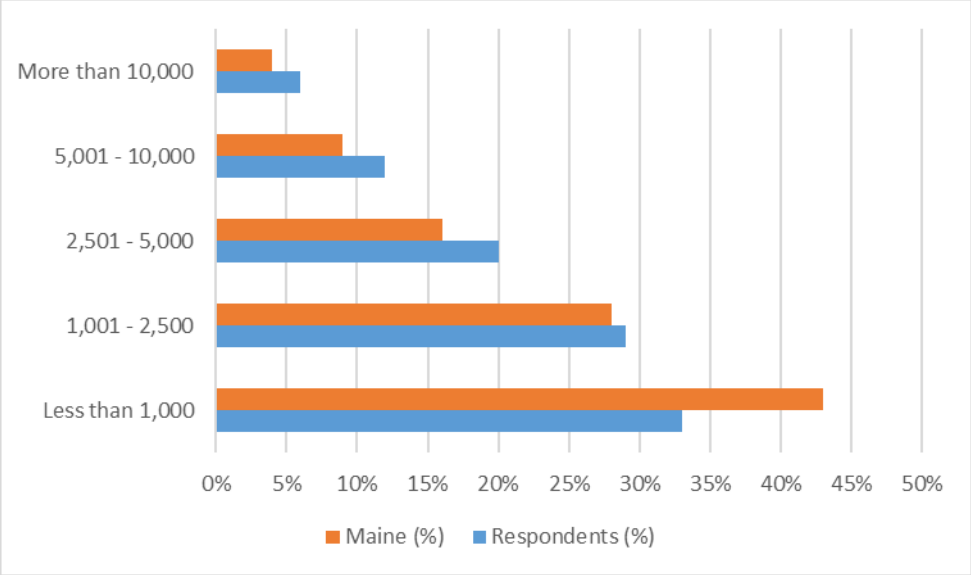
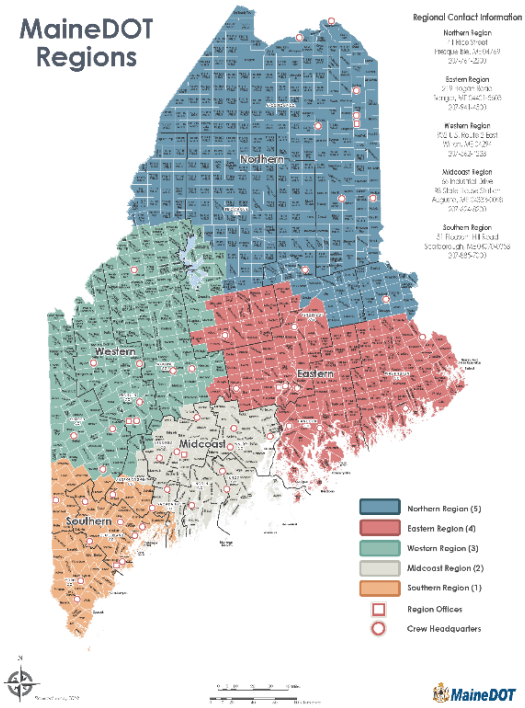


Figure 12: Regions Used to Compare Results of Municipal Survey



MaineDOT uses five zones across the state for reference (Northern, Eastern, Western, Midcoast, Southern), shown in Figure 12. Using these same zones to examine response rate, the number of responses from the Southern and Midcoast regions are higher than proportional compared to the Northern region where there are fewer than proportional, Figure 13.

Figure 13: Responding Maine Municipalities by DOT Region

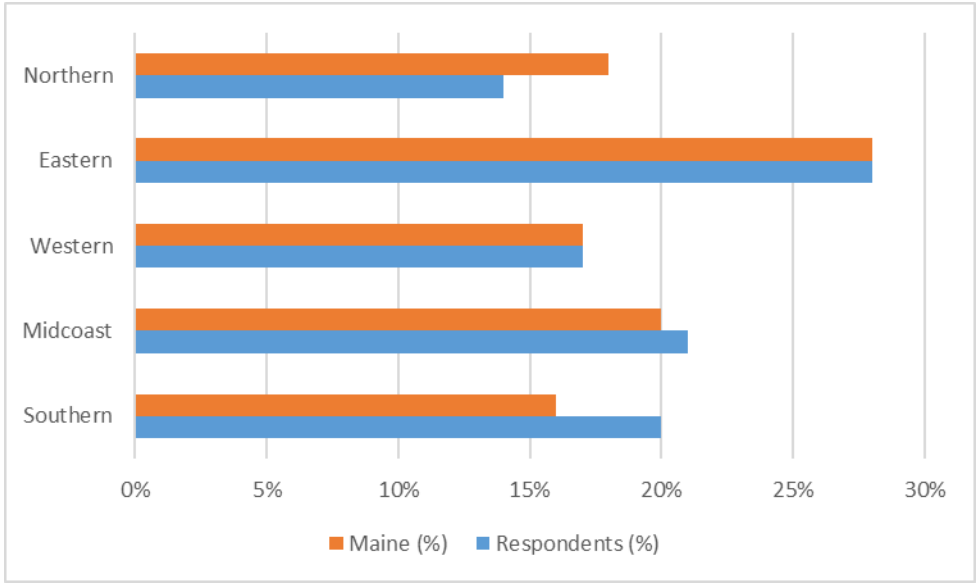


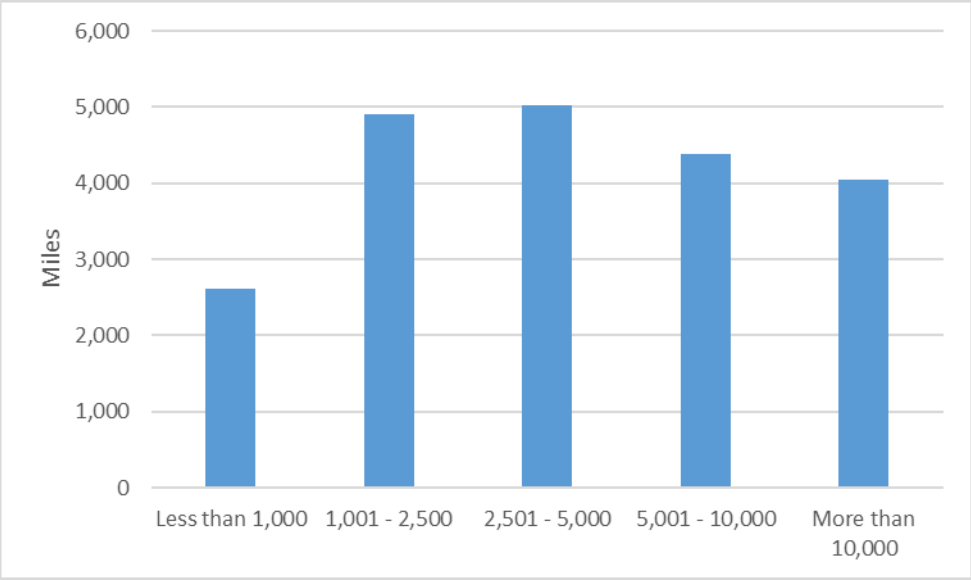
Table 8: Maine Municipal Winter Miles by Region

By MaineDOT Region	Centerline Miles	Lane Miles
1	5,722.41	11,562.06
2	4,010.54	8,030.96
3	2,840.90	5,686.36
4	3,772.93	7,566.96
5	1,935.80	3,882.62
State Total	18,282.58	36,728.96

Source: MaineDOT, August 2021

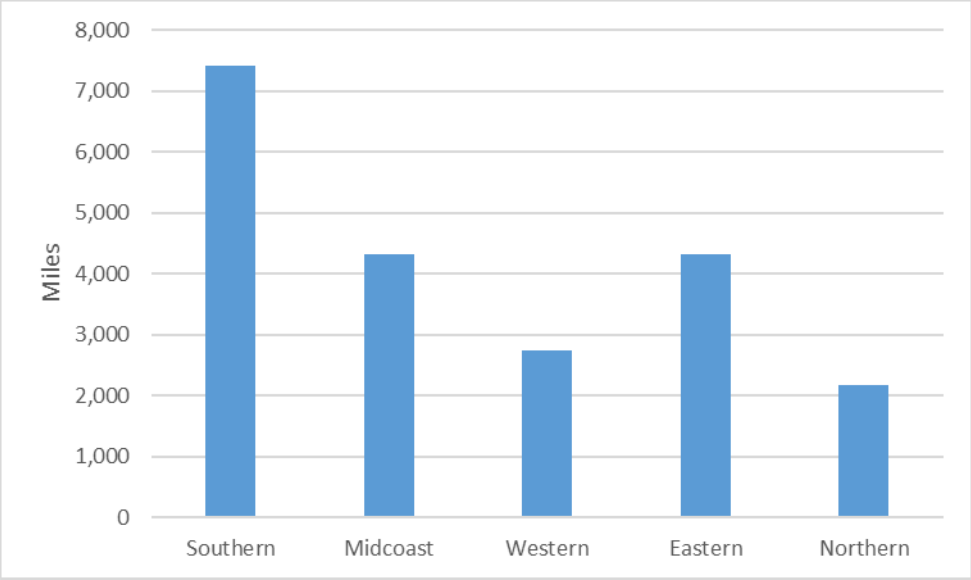
The survey respondents are responsible for a total of 20,960 winter lane miles, or 57% of the winter lane miles maintained by all municipalities statewide. Given their greater number, the responding small and mid-sized municipalities maintain the most lane miles, Figure 14.

Figure 14: Respondent Winter Maintenance Lane Miles by Population Size



The survey responses from the Southern, Midcoast, and Eastern regions make up a greater proportion of the statewide lane miles than the Western and Northern responses, Figure 15.

Figure 15: Respondent Winter Maintenance Lanes Miles by Region



Recommendations

Maintaining winter mobility while reducing fiscal and environmental costs requires the careful balancing of many factors. In general, we applaud municipal governments for their thoughtful approaches to winter maintenance practices. That said, we do have some suggestions for consideration.

The existing winter maintenance training program for municipalities through the MaineDOT's Maine Local Roads Center should be supported, allowing it to expand and strengthen outreach to municipalities. Funding sources should be identified to help underfunded municipalities upgrade their equipment, training, and winter practices.

Areas of the state with higher salt use, higher percentage of impervious cover, or already identified water quality impairments should be the focus of specific attention for salt reduction strategies, whether through MaineDOT's Local Roads program or a statewide taskforce. Chloride monitoring should be implemented statewide for areas not already known to be affected.

A majority (70%) of the towns responding to our survey reported that they have not defined and communicated a policy on the level-of-service for their roads. This suggests a need to better communicate, particularly at the municipal level and for non-highway state roads, the levels of service on roads and the associated costs of winter maintenance.

Studies have found significant benefits to pre-wetting salt before treating the road. In our survey, only 29% of Maine municipalities report pre-wetting their salt always or sometimes. This low number indicates opportunity for improvement.

Responding towns were relatively evenly split between those using municipal crews and those using private contractors. Municipalities with smaller populations were more likely to use contractors for winter maintenance. Expanding state training options and best practice recommendations to these contractors may be warranted.

This survey study focused on identifying municipal practices. Further effort should be made to identify the practices, salt use, and concerns of private contractors who are hired by municipalities and contractors who maintain non-road areas (parking lots and private roads) in Maine. Then the state could determine if it would benefit from implementing a winter maintenance contractor training program following lessons learned from New Hampshire's and Connecticut's programs. A statewide organization such as the Maine Municipal Association might help facilitate communication statewide, including providing training for town managers on the impacts and tradeoffs of salt application, recent developments, and new policy approaches.

Finally, the public needs to better understand the fiscal, environmental, and infrastructure costs of winter maintenance. All levels of government need to better articulate the tradeoffs for different levels of service. Communities may well make different choices reflecting their own set of values and needs, just as they do with school and police budgets. From this survey we know that towns can have winter maintenance costs per mile that differ substantially. Some of this is explained by population density, geography, sidewalk clearing, and, in urban areas, the need to haul snow, but not all. We suggest that towns take a deliberative approach to re-examine their winter maintenance needs. Savings, both financial and environmental, may be available; there is no one-size-fits-all solution. Choices at the municipal level affect costs, level of service, safety, and environmental and infrastructure impacts.

Glossary of Terms

A. **Anti-icing:** Anti-icing is a philosophy, not a specific practice. It refers to treatment focused on preventing development of a bond between ice and the roadway, as opposed to removing ice and snow after a storm. Anti-icing requires attention to weather information and road conditions. Anti-icing may include pre-wetting salt or pre-treating the roadway.

B. **De-icing:** The winter road maintenance practice familiar to most people – plowing the roads and applying a mixture of salt and sand to break the bond of ice with the pavement, improve traction and promote melting. Plowing is commonly started after an inch of snow has accumulated on the roads, and a salt and sand mixture is spread. Sanding provides temporary traction while salt melts snow and ice so it can be cleared by plows.

C. **Centerline Miles:** The actual length of roadway in one direction of travel. Opposing travel lanes on some state highways are separated by large medians, this can result in the total length of highway differing for each direction.

D. **Lane Miles:** A measurement of roadway distance based on a single lane of travel. For example, one mile of a two lane road would constitute two lane miles.

E. **Pre-treating:** Pre-treating refers to direct application of liquid brine to the road before a storm.

F. **Pre-wetting:** Pre-wetting refers to the wetting of solid salts as they are spread onto the road by the service trucks. Pre-wetting may be performed at the storage area or at the spreader.

G. **State Aid Road:** These roads connect local roads to the state highway system and generally serve intracounty rather than intrastate traffic movement. With the exception of compact areas, the state aid roads are usually maintained by MaineDOT in the summer and by municipalities in the winter pursuant to State Law 23 MRSA 1003. The state aid highway category generally corresponds with the federal “collector” classification.

H. **State Highway:** A system of connected main highways throughout the state that primarily serve intra- and interstate traffic. With the exception of compact areas, the MaineDOT has responsibility for the year-round maintenance of state highways. The state highway category generally corresponds with the federal “arterial” classification.

I. **Toll Road:** In Maine, these are all roads maintained by MTA.

J. **Townway:** These roads are all roads not included in the state highway or state aid highway classifications that are maintained by municipalities or counties. These roads are classified as federal “local” roads.

K. **Winter Road Chemicals**:
    a. **Sodium chloride (NaCl)**, or road salt, is the most widely used chemical for winter road maintenance. It is used in solid form as rock salt, or liquid form as brine. As brine, it is used for pre-treating.
    b. **Calcium chloride ($CaCl_2$)** is used to lower the working temperature of rock salt. **Magnesium chloride ($MgCl_2$)** is used to lower the working temperature of rock salt. It is used in some states to pre-treat roads.

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Appendix 1: Survey Instrument for Municipal Winter Operations

The University of Maine and the MaineDOT are conducting a statewide survey of municipalities to better understand winter road maintenance practices. The project will also update the 2010 report entitled Maine's Winter Roads: Salt, Safety, Environment and Cost.

A majority of Maine's road miles are maintained by municipalities. Your responses in the following categories will help us create a picture of the winter practices of cities and towns throughout Maine. Even if your town contracts out all winter work, we'd like to hear from you.

Please tell us about your town or city's winter operations:

Municipality name _____ current population _____

Winter road miles you maintain: _____ centerline miles

Do your winter operations include sidewalks or parking lots? Yes___ No ___

Sidewalks: _____miles Schools, municipal lots, other: _____square footage

What percentage of your winter miles are:

1) highest priority _____

2) medium priority _____

3) last priority _____

For winter operations, how much of your town's centerline miles is maintained by the following?

municipal crews/equipment _____

private contractor _____

comments? _____

If you use a contractor for winter maintenance, do their drivers receive any training on snow and ice control practices? _____

If you use municipal crews, do your drivers receive any training on snow and ice control practices?

_____

COST

What was your town's total winter maintenance budget during 2019-2020? $ _____

If known, how does that break down into:

approx. % personnel costs _____

approx. % materials _____

approx. % equipment_____

MATERIALS

In the winter of 2019-2020:

How many tons of salt (sodium chloride) did you buy? _____ What % did not get used? _____

How many cu. yds. of sand did you buy? _____ What % did not get used? _____

Which other de-icers did you buy?

__ Calcium chloride (CaCl2): How much?_____ in gallons or tons?_____

What % did not get used? _____

__ Magnesium chloride (MgCl2): How much?_____ in gallons or tons?____

What % did not get used? _____

__ Other de-icer (which?) _____ How much?_____ in gallons or tons?____

What % did not get used? _____

WINTER PRACTICES

Do you consider your municipal winter operations to be more of

_____ an "anti-icing approach with salt" or

_____ the more traditional method of "sand- with-some-salt-in-it"?

Do you pre-treat your roads (applying liquids before a winter storm)?

____Yes ____ No If yes, how often do you pre-treat? _____

Do you pre-wet your materials? _____ Always _____ Sometimes _____ Never

Does your municipality have a defined Level of Service policy for winter maintenance?

Yes____ No____ How is it communicated to your residents? _____

Are there areas in the road mileage you maintain which are considered environmentally sensitive (wetlands, wildlife management areas, public water supply) or which otherwise require specific/different winter maintenance? Please explain.

_____

Are you familiar with the Maine Environmental Best Management Practices (BMP) Manual for Snow and Ice Control? Yes___ No ____

Do you use this manual in your work or training? _____

Has your town ever had a well claim for salt contamination? _____

Are there any other winter practices you use that we have not asked about here?
Please comment on anything that makes your town's winter maintenance practices or costs unique.

_____

_____

In case we need to follow up on any of these questions, could you please provide a contact for your town?

Name: _____

Email address: _____ Phone number: _____

Thank you for taking this survey! Your response is very important to us.