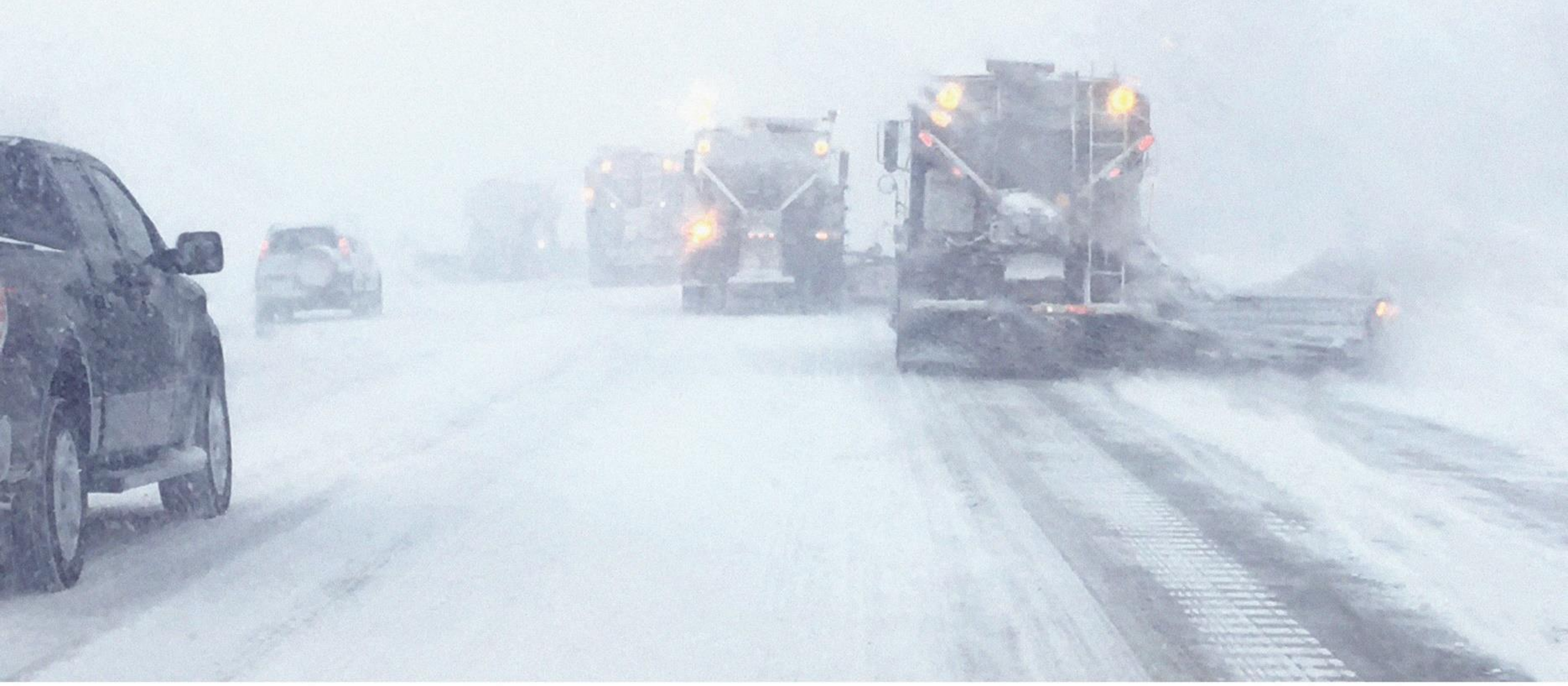
EEA #11202

MassDOT Snow and Ice Control Program

2022 Environmental Status and Planning Report

Executive Summary



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Introduction

This Environmental Status and Planning Report (ESPR) describes the various tools, policies and technologies used by the Massachusetts Department of Transportation (MassDOT) Snow and Ice Control Program (SICP) to maintain reasonably safe travel conditions on state roads during winter weather while minimizing the potential for environmental impacts. The SICP operates as part of the MassDOT Highway Division's Operations and Maintenance Department.

Prior to preparing this ESPR, a Scope of Work (SOW) Plan was developed and posted in the Massachusetts Environmental Monitor on February 10, 2021, for public and agency review (see Appendix A). The SOW Plan outlined major topics and analyses to be included in the 2022 ESPR. The SOW Plan was discussed during a virtual meeting held on February 24, 2021, with representatives from the Massachusetts Department of Environmental Protection (MassDEP), the Natural Heritage and Endangered Species Program (NHESP), MassDOT, and the Nashua River Watershed Association.

Following this meeting, additional questions and comments were submitted by MassDEP, NHESP, the Cambridge Water District, and the WalkBoston organization via separate letters or email to the Massachusetts Executive Office of Environmental and Energy Affairs (EEA). The comments contained in these letters were summarized in the Massachusetts Environmental Policy Act (MEPA) Certificate issued by the EEA on March 19, 2021. This ESPR contains information intended to address these questions and comments. MassDOT prepared similar ESPRs in 2012 and 2017 and, in the future, it is anticipated to prepare an updated ESPR every 5 years, with supplemental Annual Reports submitted and posted in the Environmental Monitor in the intervening years.

The MEPA Certificate (#11202) issued on March 2, 2018, after the 2017 Final ESPR was completed, revised the filing process for this 2022 and future MassDOT ESPRs to a single Final ESPR format to be submitted on a 5-year cycle. The previous format involved submitting Draft and Final ESPR versions for public and agency review. This new single ESPR filing process is consistent with the Special Review Procedures used by MassPort for its ESPR filings related to its airport facilities per MEPA regulations 301 CMR 11.09.

Major Changes Since the 2017 ESPR

The following represents some of the major changes to the SICP since the 2017 ESPR was completed:

» MassDOT now uses over 75 liquid-intensive slurry-spreaders statewide, which are highly effective in preventing hardpack from forming on the pavement and keeping snow in a more plowable form during prolonged winter events. Five years ago, less than a dozen slurry spreaders were being used.

» MassDOT has added over 25 vehicle mounted mobile Road Weather Information System (RWIS) sensors to supplement the over 45 fixed stations across the state.

» Calibration contractors are now required to add visible markings on the rear of the spreader vehicles to indicate the gate opening at the time of calibration, which allows visual inspections of gate openings during the winter season.

» In the last 5 years, MassDOT has reduced its average annual statewide salt usage from 26.9 to 23.0 tons per lane-mile (ln-mi), which approximately 30% less than the 33.4 tons per ln-mi used on an average annual basis between FY01 and FY10 under similar winter weather severity conditions.

Executive Summary

The following Executive Summary provides a synopsis of the information contained in each of the chapters included in the Final 2022 Snow and Ice Control ESPR posted on the MassDOT's web site. Readers are encouraged to review the entire Final 2022 ESPR for more detailed information on MassDOT's various practices and policies, as well as the data sources, methods, and assumptions associated with the various analyses and the studies reviewed and referenced as part of the literature review. The full ESPR also provides a summary of various agency comments following review of the 2022 Scope of Work Plan.

Chapter 1: Operations

MassDOT continues to add new tools and technologies into its SICP including more widespread use of liquid deicers for pretreatment and pre-wetting, new pavement sensors, flexible plow blades, tow plows, AVL/GPS technology, to name a few.

Equipment Calibration Policy

Prior to each season, state-owned and hired material spreaders are inspected and calibrated to ensure the spreader components are functioning properly, and the controllers are appropriately set to apply materials within MassDOT's application policy. Hired contractors are required to have their material spreaders calibrated by an approved, third-party calibrator prior to each winter season. The calibration vendors provide a signed certificate certifying that the spreader controller is working and can be set to apply materials in accordance with MassDOT's application policy. Contractors must also have additional spreader gate opening markings to allow visual inspections of gate openings throughout the winter.

In 2019, more than 900 contractors attended MassDOT's annual snow and ice training.

Annual Training

MassDOT requires its SICP employees to participate in annual training using video training modules that provide guidance on various operational aspects including equipment calibration, weather monitoring, and the use of liquid deicers to name a few. MassDOT also provides separate "tailgate" training sessions at various depots in each District for both state personnel and hired contractors. Tailgate training is used to provide updates on any new MassDOT policies and reemphasize the use of current best management practices including spreader calibration, prewetting requirements, application timing, reducing spillage due to overloading spreaders and any specific practices related to environmentally sensitive areas. This training also provides an opportunity to exchange ideas and to discuss challenges and concerns with various practices, environmental stewardship, material tracking and reporting requirement.

Weather Forecast and Road Condition Monitoring

MassDOT relies on multiple sources of weather forecasting and road surface condition data to assist in deciding when to initiate SICP operations and what type and amount of equipment is needed. MassDOT contracts with a commercial weather forecasting service (DTN) to provide area-specific weather forecast information four times a day at 2 a.m., 6 a.m., 2 p.m., and 8 p.m., throughout the year. The weather data is sent to each district, headquarter personnel, and the Highway Operations Center (HOC) located in South Boston.

MassDOT also has added 25 mobile, vehicle-mounted, Road Weather Information System (RWIS) units to supplement its existing 45 stationary stations located across the state that provide pavement and dew point temperatures, friction (grip) data, precipitation type, and roadway surface condition data (i.e., icy, slushy, wet) to inform the decision-making process in deciding when plowing and deicing applications may be needed.

Material Application Policy

MassDOT typically applies road salt at a rate of 240 lb./lane-mile per application, in accordance with their salt application policy, which equates to approximately 4.1 lb. per 1,000 square feet or 0.4 lb per 100 square feet of area (about the size of a small room). This application rate is considered the minimum amount necessary under most weather conditions to prevent snow and ice from freezing to the pavement, especially when air and pavement temperatures are between 25°F and 32°F. As the applied material begins to dilute as snow, rain or freezing rain accumulates and melts, its effectiveness to lower freezing temperatures declines. Thus, repeat applications are often needed with number and timing of repeat applications depending on many factors including precipitation intensity, storm duration, and pavement temperatures.

Road salt's ability to lower freezing temperatures and melt snow and ice declines dramatically as temperatures fall below 25°F and essentially becomes ineffective below 15°F. One pound of salt at 30°F can typically melt approximately 46 pounds of ice but at 20°F the same one pound of salt would only melt 8.6 pounds of ice or is approximately 80% less effective. In other words, it takes nearly 5 times as much salt to melt the same amount of ice at a temperature of 20°F compared to that at 30°F. Thus, just a 10°F difference in temperature can have a major impact in the amount of salt needed to prevent snow and ice from freezing.

MassDOT also instructs operators to use lower application rates closer to 200 lb. per lane-mile during warmer temperatures and/or when temperatures are forecasted to rise recognizing that less salt may be needed at warmer temperatures compared to colder temperatures.

Liquid Deicers for Pre-Treatment and Pre-Wetting

Since 2011, MassDOT has steadily increased its use of liquid deicers for pre-treatment of roads (a.k.a. "anti-icing") and pre-wetting of road salt. Liquid deicers have increased the effectiveness of road salt, which has resulted in substantial reductions in road salt usage over the last 10+ years. MassDOT also uses a blended brine solution to pretreat roads when appropriate weather and pavement conditions allow. MassDOT uses on average approximately 1.5 million gallons of liquid magnesium chloride ($MgCl_2$) per season for pre-wetting purposes. The brine solution costs less than liquid $MgCl_2$ but is not as effective at lower temperatures.

MassDOT is now using more than 75 slurry-spreaders across the state, which has been one of the more impactful pieces of equipment to improve salt use efficiency and enhance road surface conditions. Five years ago, only a handful of slurry spreaders were being used.

Material Use Tracking in Environmentally Sensitive Areas

MassDOT has been using AVL/GPS technology on material spreaders in several key locations to improve tracking and accounting of salt usage including the Dedham-Westwood watershed area, Kampoosa Bog, and Andover's River Road area. MassDOT plans to install newer generation GPS/AVL units on salt spreaders in the Dedham-Westwood area, as well as the Andover area, and the Wachusett Reservoir watershed in District 3. New units will also be installed on state spreaders in the Lee Depot that treat the I-90 roadway section as well as contracted equipment treating State Route 7 adjacent to the Kampoosa Bog.

MassDOT Roadway Lane-Miles

Based on the 2020 Statewide Road Inventory, MassDOT maintains approximately 16,120 lane-miles for winter maintenance purposes, which represents approximately 20% of the total estimated 82,400+/- roadway lane-miles across the Commonwealth. The remaining 80% of roadway lane miles are maintained by various municipalities, private landowners, or federal and other state agencies. MassDOT's lane-mileage has increased somewhat over the last decade, with the last major change occurring in 2010 when MassDOT merged with the Massachusetts Turnpike Authority adding approximately 15% more lane miles. MassDOT also maintains the Tobin Bridge and associated connector roads previously maintained by MassPort, and approximately 726 lane-miles of DCR-owned roads.

Comparison of Recent and Historical Average Annual Road Salt Usage

Since 2011, when liquid deicers and other efficiency measures began in earnest, MassDOT has reduced its average annual statewide salt usage by approximately 26% on a tons per lane-mile basis. In just the last 5 years, or since the 2017 ESPR, the average annual statewide salt usage has decreased from 26.9 to 23.0 tons per lane-mile, which is approximately 30% less than the 33.4 tons per lane-mile that was used between FY01 and FY10 on an average annual basis under similar winter weather severity conditions. As a result, this reduction translates to a savings of approximately 74,150 tons of salt on an average annual basis compared to what was used prior to

FY11. The differences in recent salt usage compared to the prior usage are even greater during more severe winters like in 2015, when MassDOT used approximately 125,000 tons less road salt compared to what was used in similar severe winters of 2003 and 2005 prior to the use of efficiency measures.

MassDOT Pedestrian Transportation Plan

In 2019, MassDOT developed a Pedestrian Transportation Plan[1] to identify initiatives and priorities to improve pedestrian facility access and safety throughout the Commonwealth. The Plan was developed through an extensive stakeholder process and continues to be updated through monthly stakeholder meetings. These meetings provide a forum to review action item updates, identify future initiatives, and exchange comments/ideas from individuals or towns involved with the Plan. Maintenance of sidewalks and other pedestrian facilities is a shared responsibility between MassDOT, municipalities, and other organizations depending on jurisdiction, funding sources, and maintenance agreements. The number of sidewalk miles and separate bicycle facilities has increased considerably over the last decade or so.

Like roads, MassDOT relies mostly on hired contractors to clear snow and ice on sidewalks and other pedestrian facilities. Sidewalk winter maintenance may involve different types of equipment and maintenance practices not used on roads. Since space is limited, smaller equipment and even manual shoveling may be required to clear snow from sidewalks. Since the pool of available contractors is mainly the same as those that sign up to maintain roads, the equipment and personnel needed to maintain sidewalks has been limited. In fact, MassDOT has seen the number of contractors interested in plowing roads recently decline for various reasons.

New for the 2022/23 winter, MassDOT plans to hire more "seasonal' snow and ice employees that report directly to MassDOT to help with sidewalk clearing as well as other activities. MassDOT will continue to evaluate vendor reimbursement rates and pay codes to enlist more contractors for sidewalk maintenance services and better reflect the variable snow removal efforts for large storms versus smaller storms.

MassDOT also provides grant funding of up to $50,000 to help municipalities purchase snow removal equipment for pedestrian and bicyclist facilities through its Shared Streets and Spaces Grant Program. Details on eligible projects can be found at the following link: https://www.mass.gov/shared-streets-and-spaces-grant-program

Snow & Ice Control Program Costs

MassDOT's average annual SICP program cost over the last 5 years was approximately $96.5 million but can fluctuate by as much 50% or more depending on various weather-related factors. These factors include the amount of snowfall, storm durations, and number of winter storms, as well as temperature variability over the course of a winter season. During the unusually mild winter of FY12, the annual program costs were

1 https://www.mass.gov/service-details/pedestrian-plan

approximately $41.5 million, whereas in an unusually severe winter during FY17 the SICP costs were approximately $133 million.

Based on the overall program costs, MassDOT spends approximately $6,000 per lane mile on an average annual basis to conduct snow and ice control activities on the approximately 16,100 lane-miles. This average annual per lane cost is consistent with that reported by other state transportation agencies in nearby northern New England states including New York at $8,400/lane-mile, New Hampshire at $5,800/lane-mile and Maine at $4,900/lane-mile. These SICP program costs are likely influenced by many factors including roadway types and density, traffic volumes, equipment and materials used, use of contractors, terrain and elevation changes, and differences in winter severity, to name a few.

Chapter 2: Environmental Protection and Remediation

MassDOT has been continuing to take measures to understand the impact of the salt and ice program and address the impacts through its Reduced Salt Zone (RSZ) Program, by performing an analysis of sodium and chloride levels in Public Water Supplies (PWSs) across the Commonwealth, and review of other environmental related issues.

Reduced Salt Zone Program Update

MassDOT plans to phase out the use of sand in Reduced Salt Zone (RSZ) areas and instead focus its efforts on expanding the use of other efficient application practices currently being used statewide, which involve pretreating roads and prewetting salt with liquid deicers. The previous RSZ application practice of using a 50:50 sand/salt mix was often ineffective in preventing snow and ice from bonding to the pavement and keeping snow in plowable form especially at colder temperatures near and below 25°F. As a result, additional repeat applications were often necessary to compensate for the reduced effectiveness of the applied material. The amount of salt used in these RSZs over the course of a season could often be as much or even more than that used on adjacent roads particularly during severe winters. Thus, the RSZ practices were not only less effective in reducing salt use or maintaining safe road conditions but also added additional annual labor and equipment costs to perform post-season cleanup of sand along the roadways.

The more recent salt reduction of approximately 26% on a tons per lane-mile basis over the last 12+ years is far better than that achieved using sand as part of the previous RSZ application practices .Eliminating sand would also likely result in less environmental impact, with respect to phosphorus loading to lakes and ponds.

Salt Remediation Program

The Environmental Services Section of MassDOT’s Highway Division administers a Salt Remediation Program, which processes and investigates complaints from private well owners and public water suppliers whose water supplies are experiencing elevated sodium concentrations. MassDOT has been spending approximately $1.5 million per year, on average, for technical services provided by the UMASS Engineering Department to investigate and remediate complaints as part of this program. The annual costs vary depending on the number of cases, the geographic extent of affected areas, and the type of remedial measures used to address the complaints.

Remediation measures typically include replacement or rehabilitation of an existing well, connecting the property to a Public Water Supply system, or, as a last resort, installing a reverse osmosis (RO) treatment system. Installing a whole house RO system requires more space and operations and maintenance on the part of the homeowner and are much more expensive. Connecting homes or businesses to a municipal water supply is generally the preferred long-term solution when it can be done cost effectively within a reasonable distance and without major disruptions. However, this option is subject to available supply, system capacity, and the discretion of the water supply utility.

Most salt remediation cases are in Districts 1, 2 and 3 where more homes and businesses are served by private wells. In the last 5 years or since 2017, MassDOT received 76 remediation claim applications related to elevated sodium and/or chloride levels in private drinking water wells. MassDOT typically receives 12 to 15 claims per year and has a total of 277 remediation claims received since 2000. Twenty-two cases remain open and under investigation or in the process of remedial measure implementation.

Overall, the Salt Remediation Program has successfully provided potable water with reduced sodium levels for over 250 private water supply complaint cases using various remedial measures. In a few instances where remediation measures were not initially successful in reducing sodium concentrations, MassDOT continues to work with the affected homeowner or PWS to identify the primary sources and potential solutions that MassDOT could implement to reduce sodium concentrations.

MassDOT is currently working with MassDEP and representative from the Town of Boxboro and the Littleton Light and Water Department to evaluate the feasibility of extending municipal water service to an area in Boxboro where several Public Water Supplies (PWSs) have elevated chloride levels as well as other water quality issues.

Sodium Concentrations in Public Water Supplies

Consistent with MassDEP's comments on the 2022 ESPR SOW Plan, MassDOT analyzed the reported sodium and chloride data in PWSs located within and beyond a 0.5-mile of a MassDOT. The 2017 ESPR conducted a similar evaluation for community and non-community PWSs. The analyses compared the percentage of PWSs with sodium levels above MassDEP's drinking water health guideline level of 20 mg/L and the EPA health guidance level of 60 mg/L, based on reported sodium data contained in MassDEP's database through October 18, 2021. Regression analyses were also conducted to assess the relationship or correlation between PWS sodium levels and distance to a MassDOT roadway.

MassDEP set a health guidance level of 20 mg/L for sodium (see MassDEP Drinking Water Regulations, 310 CMR 22.16A), which is an advisory level for individuals on a physician prescribed "low-salt" diet of no more than 500 mg sodium per day. This health guidance level was based on EPA's original guidance of 20 mg/L established in 1980. However, in 1988, EPA removed sodium from the list of contaminants to be regulated under the National Drinking Water Regulations.[2] In 2003, EPA updated the health guidance level for sodium in drinking water in recognition that the daily sodium intake from food consumption is typically much higher than that from water consumption. The revised guidance recommended sodium level of no more than 60 mg/L to avoid aesthetic taste effects. Drinking water with 60 mg/l would comprise 5% of the recommended dietary goal of no more than 2,400 mg of sodium per day if two liters of water were consumed each day.

As of October 18, 2021, MassDEP's database contained reported sodium data from 1,713 different PWSs with approximately 930 PWSs identified as having at least one supply source within the 0.5-mile of a MassDOT roadway, and the water sources for the remaining 783 PWSs are more than 0.5-mile from a MassDOT roadway. The data base had 37,329 records of sodium sampling results, which is twice the amount of sodium data used in the 2017 ESPR (16,345 records) reported prior to August 2016.

Review of the reported sodium data suggests that approximately 52% of the PWSs located within a 0.5-mile of a MassDOT road have average sodium concentrations above 20 mg/L compared to approximately 34% of the PWSs located beyond a 0.5-mile of a MassDOT road. A similar finding was reported in the previous 2017 ESPR, where 52% of the PWSs located within a 0.5 mile had average sodium concentration above 20 mg/L compared to 38% of the PWSs outside a 0.5-mile of a MassDOT road.

Approximately 28% of the PWSs located within a 0.5-mile of a MassDOT road have average sodium concentration above 40 mg/L compared to approximately 15% of the PWSs located outside of a 0.5-mile radius, a difference of 13.0 percentage points. The differences between the two groups narrows considerably when comparing average sodium concentrations above 60 mg/L. Approximately 15% of the PWSs located within a 0.5-mile of a MassDOT road have an average reported sodium concentration above 60 mg/L compared to approximately 8.4% of the PWSs located outside of a 0.5-mile radius, a difference of less than 7 percentage points.

Historically, the sodium data suggest that sodium levels have increased over time for both PWSs that are within and beyond a 0.5-mile of a MassDOT road. Based on data from 1991 to 1996 and that from 2017 to 2021, the percentage of PWSs located within a 0.5-mile of a MassDOT road with an average sodium concentration above 25 mg/L increased from approximately 25% to 50%, compared to an increase of approximately 10% to 25% for PWSs located beyond a 0.5-mile of a MassDOT road.

Regression Analysis of Sodium Concentrations in PWSs and Distance to a MassDOT Roadway

Regression analyses of PWS sodium concentrations and distance to a MassDOT road over 5-year increments indicate a very weak correlation with the highest correlation

2 U.S. Environmental Protection Agency. Sodium Requirements for Public Water Supplies. https://nepis.epa.gov/

coefficient (R^2) value of 0.053. This suggests that distance to a MassDOT roadway explains only 5.3% of the differences in sodium concentration in PWSs. The data suggests that sodium concentrations are increasing in PWSs that are both close to and more distant to a MassDOT road is perhaps due in large part to increased urbanization as well as the fact that more PWSs are reporting data in recent years.

Sodium Level Trends in Municipal Water Supplies

As discussed in more detail in Section 2.3.6 in the full 2022 ESPR, review of reported sodium data in various municipal PWSs reveal that average annual sodium concentration in at least 17 municipal PWSs have increased by more than 50 mg/L over a 30-year period. Based on data from both finished and raw water samples, as many as 10 municipal PWSs have average sodium concentrations at or above 100 mg/L. Municipal PWSs with some of the highest sodium levels are drinking water sources for the Towns of Auburn, Burlington, Cambridge, Millbury, N. Chelmsford, East Chelmsford, Shrewsbury, Weymouth, and Woburn. Although it is unknown to what extent these sources are still used as part of the overall water supply system. These sodium increases occurred despite MassDOT having reduced their average annual salt usage over the last 12+ years, suggesting that the rise in sodium levels in many municipal PWSs may be due to other sources or inputs. As discussed more below, MassDOT has conducted watershed studies for several of these municipal PWSs to assess the relative contributions from various sources.

Reported Chloride Concentrations in PWSs

Chloride in drinking water is regulated as a secondary drinking water contaminant for aesthetic reasons to avoid issues with taste. MassDEP has set a secondary maximum contaminant level (SMCL) for chloride at 250 mg/L. Chloride levels above 250 mg/L may result in a salty taste but are not considered to be a direct human health risk. PWSs are not required to test for chloride levels, but it is recommended, especially where sodium levels are elevated. The MassDEP database had reported chloride levels for 582 PWSs and 1,596 different sources. The earliest reported chloride data appears to be in 2007 and very few data records are available prior to 2010.

Approximately 74% of the 582 PWSs that reported chloride data to MassDEP have estimated average chloride concentrations that are less than 100 mg/L while another 112 PWSs or 19% have average chloride levels between 100 and 250 mg/L. Together, approximately 94% of the PWSs in the database have estimated average chloride concentrations below 250 mg/L or the state secondary drinking water standard.

Approximately 38 PWSs have average chloride concentrations above 250 mg/L including 28 PWSs with average chloride concentrations between 251 and 500 mg/L, six PWSs with average chloride concentrations between 501 and 1,000 mg/L, and three PWSs have average concentrations greater than 1,000 mg/L. Several of the PWSs with averaged chloride concentrations above 500 mg/l have been or are currently being investigated as part of the MassDOT Salt Remediation Program.

Like the sodium data, results of regression analyses indicate a very weak correlation between chloride concentrations in PWSs and distance to a MassDOT roadway. The highest correlation coefficient (R^2) value was 0.039, which suggests that less than 4.0% of the variability in the reported PWSs chloride levels can be explained by distance to a MassDOT road. Many factors might affect chloride levels in PWS, including road salt used in adjacent commercial and residential areas, as well as that added due to treatment chemicals. Therefore, it is difficult to quantify the relative influence of the road salt used on MassDOT roads versus other sources without a detailed site-specific hydrological and source investigation.

Chloride Levels in Drinking Water and the Increased Risk of Corrosion

A more recent issue of concern with respect to elevated chloride levels in drinking water relates to the potential increased risk of corrosion for piping and associated connectors. Researchers have indicated that a chloride-sulfate mass ratio (CSMR) in source water greater than 0.5 can lead to increased potential galvanic corrosion of lead pipe service lines in the PWS distribution system.

As discussed in more detail in Section 2.3.8 of the full 2022 ESPR**,** based on chloride and sulfate data included in MassDOT's drinking water data base, several PWSs were identified as potentially having estimated CSMR values above 50. Facilities with the highest estimated CSMR values include a facility for the Assembly of God of the Southern NE District in the Town of Charlton and a community PWS that services the Henry P. Clough School in the Town of Mendon. These PWS have estimated CSMR values above 200. However, no new data has been reported for these PWSs since 2012 and 2015, respectively, suggesting that these PWS may no longer be used for potable water.

Three other facilities with estimated CSMR values above 100, include the PWS wells serving the Groton-Dunstable Regional High School, the Millstone MIT Laboratory in Westford, and a PWS well used by the Peabody Water Department. The sampling details for the first two facilities indicate that the chloride concentrations represent finished water or post-treatment conditions and thus it is unclear to what extent treatment chemicals might be affecting the chloride levels. The MIT Millstone Lab is located at least 1.5 miles from the nearest MassDOT road in a rural, wooded area in the Town of Westford with no adjacent development and thus, the source of the elevated chloride levels would seem to be not related to road salt use.

Specific Watershed Studies of Salt Usage near Municipal PWS

MassDOT has recently worked with several municipal PWS to evaluate the relative salt contributions from various sources and uses within the watershed or to track salt usage within the Wellhead Protection Area. The municipal PWS include the Auburn Water District, the Cambridge Water District, Dedham-Westwood Water District, and the town of Millbury.

» **Dedham Westwood Water District**: MassDOT has been tracking their annual salt usage on roadways in the Dedham-Westwood Water District (DWWD) Wellhead Protection Area (WHPA) compared to that used on the rest of District 6 roadways since the 2015/16 season. This salt use tracking has indicated that the average annual salt usage on roadways in the WHPA on a tons per lane-mile basis was approximately 30% less than that used on other District 6 roads over the last 5 years due to additional efficiency measures used in the WHPA.

MassDOT plans to continue to track the effectiveness of various efficiency measures in the DWWD area. Despite the recent reductions, no discernable decrease in sodium and chloride levels has been observed in the DWWD wells. This may be due in part to the longer travel time associated with groundwater and/or perhaps due to the influence of other uses of road salt in the area.

» **Cambridge Water District:** MassDOT recently completed a study for the Hobbs Brook watershed in the Cambridge Water District (CWD) for the purpose of updating a 1985 GEI study and developing new estimates of road salt contributions from various sources in the watershed. This study was developed in consultation with CWD personnel and their drinking water consultant. This study involved both the collection of surface water and groundwater quality data and an analysis of road salt usage and treated areas to estimate the average annual salt load contributions from each of major road salt users.

  The study results indicate that in order to reduce future sodium concentrations in the Hobbs Brook reservoir to the MassDEP sodium health advisory of 20 mg/L, the use of road salt would need to be eliminated on all roadways and parking lot areas. This is probably not a realistic scenario unless there was a wholesale change to using a non-chloride deicer. Even with a more realistic potential reduction of 20% or 30%, each of the major road salt users in the watershed would need to invest and adopt various efficiency measures and in equipment upgrades to achieve this potential goal.

  District 4 has already reduced its district-wide average annual salt usage by 40% on a per lane mile basis by utilizing various efficiency measures compared to what was used between 2001 and 2010. As described in the Draft Final Report (Dec. 2022), MassDOT will continue to identify other measures, equipment and technology that can be used as funding allows while prioritizing the Concord and Lexington depots that maintain roads in the watershed. As an initial first step, MassDOT will evaluate whether the Lexington and Concord Depots have sufficient liquid deicer storage capacity to support the expanded use of slurry spreaders and MassDOT's prewetting policy goals. The report also recommends other measures that could initiate a more holistic approach involving other road salt users in the watershed.

» **Auburn Water District:** Through its Interagency Services Agreement with the UMass Engineering Department, MassDOT has been collecting surface and groundwater quality data in Dark Brook and the Auburn Water District well field in the Town of Auburn. The primary purpose of this study was to establish baseline surface and groundwater quality conditions in the wellfield and use the baseline data to assess the potential changes in water quality that may result from future MassDOT road salt efficiency measures. District 3 has recently been using slurry spreaders in this area and the Wachusett Reservoir watershed to increase salt use efficiency.

» **Town of Millbury:** MassDOT also conducted a limited desktop study in the Wellhead Protection Area (WHPA) around the Town of Millbury wells to evaluate how much MassDOT roadway area and related salt use might contribute to the elevated sodium concentrations in the Town's wells relative to other sources and treated areas in the WHPA. Even though two MassDOT roadways (I-295 and 146) are within 1,000 feet of the Town wells, the analysis indicated that MassDOT roads account for only 33% of the pavement area in the WHPA when including municipal and private roads and major commercial parking lots. MassDOT's average annual usage was estimated to account for approximately 60% of the total estimated road salt usage in the WHPA, based on MassDOT's historical average annual salt use and general assumptions on average annual road salt usage on municipal roads and commercial parking lots. Recently, District 3 has reduced its annual salt usage by at least 30% compared to what was previously used under similar winter weather conditions.

The study suggests that MassDOT may be one of the main contributors, but not the only source affecting sodium and chloride levels in the Town wells. During low flow periods, much of the river flow was found to be comprised of treated effluent from the Upper Blackstone Water Pollution Abatement District Wastewater Treatment Plant in Worcester and was a major contributor to the elevated specific conductance and chloride levels in the Blackstone River as well as the Town wells. The hydrologic connection was evident based on elevated levels of boron detected in the wells. Boron is a common element in laundry detergent and treated wastewater and not abundant in the natural environment. Based on these findings, it appears the sodium and chloride levels in the wells are also influenced by water quality conditions in the Blackstone River during low flow periods as well as other activities within the WHPA.

Chloride Impaired Water Bodies in Massachusetts

MassDEP's 2018/2020 Integrated (305(b)/303(d)) List of Waters identified 24 water bodies or assessment units throughout the state as being chloride impaired. This represents 11 additional water bodies that were not included on the 2016 Integrated List and 18 additional water bodies that were not included on the 2014 Integrated List, which was used in the 2017 ESPR. These water quality impairments are primarily based on ambient water quality data collected by MassDEP. These impaired water quality assessment units are largely located in the more urbanized areas in the central and eastern regions of the state.

Recently added chloride impaired water bodies include Gates Brook, Scarletts Brook and two unnamed tributaries in the Boylston and West Boylston areas that drain to the Wachusett Reservoir. In the Mystic River watershed, segments of the Aberjona River, Alewife Brook, and the Little River have been added to the 2018/2020 list. These water body segments are near major MassDOT roads of I-95 and I-93 but are also in the relatively densely developed areas of Cambridge, Somerville, and Medford. In the Cambridge River watershed, Hobbs Brook is a tributary of the impaired Cambridge Reservoir. The Sawmill Brook watershed includes a section of the VFW Parkway in Newton owned by DCR, but MassDOT provides winter maintenance of the road. In the Blackstone River watershed, Dark Brook and associated unnamed tributaries are located near the Interstates 90 and 290 in Auburn.

Potential Effects of Road Salt Use on Other Environmental Resources

Other sensitive environmental resources including Areas of Critical Environmental Concern (ACEC) and Priority Habitats and Natural Communities, as designated by the Massachusetts Natural Heritage and Endangered Species Program (NHESP),. Other road salt related environmental effects discussed include the potential effects on roadside vegetation, cranberry bog and maple syrup production, and the use of winter sand, although state or site-specific data pertaining to these issues is limited.

Areas of Critical Environmental Concern and Priority Habitat Areas

ACECs are designated environmental resource areas that are protected and regulated under state regulations §301 CMR 12.00 and are considered to have a unique set of natural and human resource values worthy of protection. Priority Habitats as identified by the NHESP represent another significant ecological area regulated within the state of Massachusetts. Each of MassDOT's maintenance districts, except District 2, have at least one designated ACEC that borders or is traversed by a MassDOT roadway. Districts 1, 3, and 6 have five designated ACECs, while District 4 has 4 ACECs, and District 5 has sixteen ACECs that are near or traversed by a MassDOT highway.

Kampoosa Bog, located adjacent to Interstate 90 in the Towns of Stockbridge and Lee in District 1 has been the subject of extended research relative to the potential road salt effects on vegetation. Approximately 2 miles of I-90 directly as well as a portion of Route 7 borders the northerly and easterly limits of Kampoosa Bog maintained by MassDOT. A recent 2021 study provides updated sodium (Na+) and chloride (Cl-) levels in the Kampoosa Bog. Although the overall effect of road salt use on MassDOT roadways is still not fully understood given the various hydrologic variables, higher Na+ and Cl- levels in groundwater were generally observed near the I-90 roadway. Recent findings suggest that existing vegetation communities can be maintained if chloride levels in the bog stay below 77 to 95 mg/L, which is higher than the previously recommended limit of 54 mg/L. MassDOT continues to provide financial support for this research on Kampoosa Bog through its agreement with NHESP.

Chapter 3: Best Management Practices for Improving Salt Use Efficiency

MassDOT has adopted various practices, equipment upgrades, and the use of innovative technologies to improve its snow and ice control operations. The principal means of clearing snow and ice from roadways is by plowing, particularly during major snow events with colder temperatures and the snow remains in plowable form. Advancements in plow types, design and materials in just the last 5 to 10 years have made plowing much more effective in clearing snow compared to older plow models.

Segmented Plow Blades

Segmented blades consist of a series of blade sections along the plow edge that move independently and conform better to uneven road surfaces, allowing for improved snow removal that typically results in less reliance on deicers. MassDOT currently uses Kuper Tuca SX Wave segmented blades for its own plows, have an ultrahard tungsten carbide core and vulcanized rubber/ steel cover. Segmented blades also cause less damage to roadway markings, crack sealing or other obstacles, and reduce noise and vibrations resulting in less operator and equipment fatigue. Each blade segment can be replaced individually, which saves time and money for blade replacement. Although they are more expensive than traditional and other comparable alternative blades, MassDOT has found the Kuper Tuca SX to be cost effective for its performance and durability.

MassDOT plans to add more segmented blades for its fleet and, in the future, will evaluate whether the added performance may warrant revising vendor agreements to require contractors to have segmented blades. Some contractors are already using these plows given the improved operator experience and they are easier to repair.

Pre-Treatment of Roads

Since 2011, MassDOT has been using liquid brine to pre-treat roads. Pretreatment, also known as anti-icing, involves direct applications of brine to the road surface prior to or in the early stages of a winter storm. This initial coating or application to the pavement helps prevent snow and ice from bonding to the roadway, much like how anti-stick spray is used for cooking. Pre-treatment is performed using a tanker truck outfitted with a spreader bar and nozzles. Liquid deicer is applied via nozzles from the rear of the truck at approximately 20 to 50 gallons per lane-mile. Like most state transportation agencies, MassDOT uses salt brine at a 23% concentration of sodium chloride dissolved in water to pretreat roads.

Pre-treatment has played a major role in MassDOT's ability to reduce its average annual salt use and will continue to expand its pre-treatment capabilities by adding more brine production and storage facilities, A new production facility was completed in 2020 at the Deerfield Depot in District 2, which can provide 60,000 gallons of brine storage for Districts 1, 2, and 3. A similar facility was built in District 5 in 2015 and another brine generator facility is planned in the near future for the Sterling Depot in District 3. Additional brine-production capabilities are also planned for District 4.

Pre-Wetting Salt

The practice of pre-wetting salt is a key aspect of MassDOT's strategy to making road salt more effective. Pre-wetting involves coating dry granular salt with a liquid deicer that typically consists of a magnesium chloride ($MgCl_2$) solution or brine. This coating usually takes place at the end of the spreader chute during regular salt applications, but if equipment for this process is not available, pre-wetting can also be performed by spraying the salt pile at the depot or by purchasing pre-wetted salt. The purpose of pre-wetting is two-fold. First, pre-wetting salt initiates the dissolution process and helps salt become effective sooner after application. Pre-wetted salt also adheres to the roadway better and minimizes material loss due to dry salt particles bouncing and scattering off the pavement. As a result of these benefits, pre-wetting has been reported to reduce salt use by 25 to 30%.[3]

Since 2011, MassDOT has required all contractors to have pre-wetting equipment (i.e., saddle tanks and spray nozzles) in order to be called in to service. MassDOT has also outfitted its own trucks with pre-wetting equipment and has increased its liquid deicer storage capacity at various depots. MassDOT's preferred liquid deicer for pre-wetting is ProMelt Mag 28 INH, which consists of 28% liquid magnesium chloride in water with a corrosion inhibitor comprising less than 1% of the solution. MassDOT instructs operators to apply 8 to 10 gallons per ton of salt applied which is the general standard of practice for conventional spreaders.

Slurry Spreaders

MassDOT currently uses over 75 slurry spreaders mostly in Districts 2, 3, and 4 with plans to expand usage in other districts. These spreaders apply a liquid intensive salt-slurry mix with up to 50 to 90 gallons of liquid deicer per ton of granular salt. The liquid slurry distributes more evenly, is retained longer on the pavement surface, and accelerates the melting process and thus is much more effective than granular salt.

District 3 conducted a side-by-side experiment on Route 2 in Westminster during the winters of FY20 and FY21 and found that road sections treated by a slurry spreader had more exposed bare pavement and less snow cover/hard pack than adjacent sections using standard applications. Slurry spreaders can be used during a wider range of weather conditions compared to pretreatment and combine the benefits of pre-treatment and pre-wetting. However, given the higher use of liquid deicer, use of slurry spreaders may be limited to liquid deicer storage capacity. One of MassDOT's planned initiatives is to increase liquid deicer storage capacity in areas where it may be limited to support the expanded use of slurry spreaders as appropriate.

Closed-Loop Controllers

MassDOT requires hired contractors to equip their material spreaders with closed-loop controllers, which are computer-based devices that regulate the rate at which road salt is applied based on vehicle speed and auger speed sensors. The controller is programmed to a desired salt application rate, once adequately calibrated, and can adjust the salt application rate based on detected changes in vehicle and auger speed. Auger speed can change over time due to temperature fluctuations and wear of hydraulics, so the auger sensor feedback helps to ensure consistent applications of road salt as programmed. Controllers are programed to apply at a rate of 240 pounds of pre-wetted salt per lane-mile. Closed-loop controllers can also track and report material usage such as total amount material applied, lane-miles traveled, location of dispensed material, time of application, and average application rate.

3 Michigan Department of Transportation. 2012. Salt Bounce and Scatter Study. https://www.michigan.gov/documents/mdot/Final_ReportNov2012_404228_7.pdf

Road Weather Information Systems

MassDOT has expanded its use of mobile Road Weather Information System (RWIS) unit to add its more than 45 fixed RWIS stations across the state. The mobile, vehicle mounted RWIS units have become as accurate and reliable as the traditional fixed, tower-based RWIS units and are more cost-effective since they are easier to install and provide more geographic coverage. MassDOT is progressing toward using more mobile RWIS sensors, which provide a wide range of critical data (e.g., pavement temperature, moisture, wind speed, pavement grip, and deicer concentrations).

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also outfitted its own trucks with pre-wetting equipment and has increased its liquid deicer storage capacity at various depots. MassDOT's preferred liquid deicer for pre-wetting is ProMelt Mag 28 INH, which consists of 28% liquid magnesium chloride in water with an amine corrosion inhibitor comprising less than 1% of the solution. MassDOT instructs operators to apply 8 to 10 gallons per ton of salt applied which is the general standard of practice for conventional spreaders.

Lower Application Rates

Under appropriate conditions, MassDOT has been instructing operators to use a lower application rate closer to 200 pounds per lane mile rather than the standard 240 pounds per lane mile. The reduced rate typically requires sufficient road monitoring and experience to know when weather and road surface conditions are appropriate and will not compromise safety. Thus, reduced application rates may involve more personnel hours and road sensor data. However, increased availability of weather forecasting and strategically placed road surface sensors can help to support decision-making around the appropriate timing and rates of application.

MassDOT plans to continue its use of GPS/AVL technology to track material usage in select areas. These areas include certain roads maintained by the Andover Depot, roads adjacent to Kampoosa Bog and roads in the Dedham Westwood Water District. MassDOT has recently updated its service provider and AVL/GPS equipment on certain material spreaders with a goal of eventually using this technology statewide.

Alternative Pavements

MassDOT recently partnered with the UMass Transportation Center to investigate how open grade friction course (OGFC) pavement might affect deicing material needs. The study involves a segment of Interstate-95 in Needham, which is a high traffic volume area. The study will compare stormwater runoff and pollutant loads from the OGFC test section to traditional hot-mix asphalt and will monitor deicing material needs and pavement conditions during winter events over a 3-year period.

Pretreated Salt

MassDOT is also evaluating the use of pretreated salt, which is road salt already sprayed or coated with a liquid deicer. Pretreated salt eliminates the need to store liquid deicers where space is limited or have spreaders equipped with saddle tanks to pre-wet salt at the time of application. However, salt suppliers often use an organic, agricultural byproduct such as beet juice as the liquid deicer to pretreat salt. Thus, this material can have a high biological and chemical oxygen demand and possibly elevated levels of nutrients, such as phosphorus and nitrogen. The potential environmental implications of using this material need to be evaluated especially in the watersheds of lakes and ponds, as the oxygen demands and nutrient content may pose as much, if not a greater, concern for downstream water quality in receiving waters. MassDOT plans to get more product information from suppliers and initiate a pilot test to assess the effects on receiving waters based on water quality data.

Chapter 4: Corrosion Effects of Deicing Materials

The corrosive effects of deicing material on roadway infrastructure and motor vehicles are widely known and studied. Various strategies and products are available to mitigate and/or prevent deicer induced corrosion on infrastructure and vehicles.

Measures to Reduce Roadway Infrastructure Corrosion

Approximately 42% of the nearly 620,000 roadway bridges that exist across the nation are estimated to be more than 50 years old, which is the typical design life for most bridges. Approximately 23% are more than 60 years old and 12% are over 80 years old. To fully address the estimated backlog of structurally deficient bridge repairs needed nationwide, the annual spending on bridge rehabilitation would need to increase by nearly 60% from $14.4 billion annually to $22.7 billion. At the current rate of investment, the necessary repairs would not be completed until 2071.

MassDOT is responsible for inspecting approximately 1,500 bridges in the state, and currently has over 30 bridge inspection teams amongst its six maintenance districts, including four underwater "dive" teams. The MassDOT Bridge Inspection Handbook; 2015 Edition provides inspection guidelines on condition assessment criteria, inspection methods, inspection waivers, and bridge inspector qualifications.

As part of an Accelerated Bridge Program (ABP) that extended from 2015 through 2018, MassDOT completed 200 bridge projects at an estimated total cost of $2.4 billion that reduced the number of bridges of classified as structurally deficient to less than 9% of the total number of bridges in the state.

MassDOT has adopted various corrosion protection measures for bridges and other road infrastructure including the use of epoxy-coated steel; spray applied membranes and sealants for bridge decks; as well as applying more effective metal coatings, such as galvanizing and/or metalizing the steel components; and limiting the use of un-coated weathering steel to sites where there is less salt use, such as over railroads.

MassDOT also utilizes sealants and additives in concrete mixtures to slow the rate of intrusion of chloride anions into the concrete or mortar. Common sealants such as siloxane and silane typically last only three to five years and need to be reapplied periodically. MassDOT has listed several types or brands of concrete sealer products that have been qualified for use on the state's concrete mixtures.

Measures to Reduce Motor Vehicle Corrosion

Vehicle manufacturers have made significant progress in the last 20 to 30 years in making vehicles more corrosion resilient by changing the materials used in their design. Vehicles today are made with a variety of corrosion resistant metal alloys, plastics, and resin composites and much less steel. Where metal is still used, coatings, splash guards, and improved drainage are used to limit exposure to trapped water.

Despite these advancements, a 2016 survey conducted by AAA, estimated that U.S. drivers that live in areas affected by snow and ice, paid approximately $3 billion per year in corrosion related repairs linked to deicing chemical usage. Certain vehicle components are more vulnerable to corrosion than others, such as fuel line, brake pads and rotors, and exhaust and electrical systems primarily because of their metal alloy composition and exposure to road spray splashing on or beneath the vehicle. Exhaust systems traditionally were one of the most vulnerable and most expensive vehicle components to replace, but most are now made with rust resistant metal alloys and even stainless steel to provide greater longevity.

Corrosion Effects on Drinking Water Supply Infrastructure

A more recent issue relates to the potential corrosion of drinking water distribution pipes and fixtures due to increased chloride levels as well as other water quality changes drinking in water supply sources. The corrosion issues involving water supply infrastructure are complex as many site-specific factors involved with source water quality and the use of chemicals for treatment and corrosion protection, as well as pipe materials, can affect the corrosion potential of distributions pipes.

The Flint, Michigan water crisis highlighted the importance of monitoring water quality and how changes in water quality can affect pipe corrosion and the leaching of metals. Studies have reported that drinking water sources with chloride to sulfate mass ratio (CSMR) above a threshold of 0.5 appear to pose an increased risk of pipe corrosion. The elevated CSMR ratios can result from increased salinization of source waters as well as the use of salt-based treatment chemicals. Corrosion protection measures and frequent water quality monitoring are ever more critical as watershed areas of drinking water source become more urbanized.

EPA banned the use of lead-based pipes and solder in new plumping systems in 1986. However, according to a 2016 MassDEP survey, more than 20,000 lead service lines (LSLs), installed prior to the 1986 ban, may still be in use statewide.[5] As part of the cost analysis for the 2021 revisions to the Lead and Copper Rule, EPA estimated that the average cost to replace LSLs was approximately $3,600 but could be as much as $10,000 or more depending on the site complexities and constraints.

The American Rescue Plan Act of 2021 provides $15 billion over the next five years for lead pipe removal. Funds from the bill will be distributed to the states and will be made available through the Drinking Water State Revolving Loan Fund to fund various investments to water and sewer infrastructure, including LSL replacements.

As of July 2022, the Massachusetts Clean Water Trust is offering $20 million in loans and 100% loan forgiveness for all public water suppliers to conduct planning projects to inventory LSLs and to develop LSL replacement plans. PWSs can apply for loans through the State Revolving Loan Fund.

5 2016 Massachusetts Department of Environmental Protection (MassDEP) Lead Service Line Survey https://www.mass.gov/service-details/lead-and-copper-rule-lead-service-line-survey

Chapter 5: Effect of Winter Weather on Public Safety and Vehicle Mobility

Public safety and maintaining vehicle mobility are the two principal drivers behind the various road maintenance activities conducted as part of the MassDOT Snow and Ice Control Program. Consistent with previous ESPRs, the effects of winter weather on vehicle mobility and crash rates were assessed using Massachusetts vehicle crash data and reported seasonal economic data.

Winter Weather and Vehicle Crash Rates

Snowfall is estimated to cause 45,000 injury-related crashes and 150,000 property damage crashes each year in the United States. The National Highway and Transportation Safety Administration (NHTSA) reports that of the 6 million motor vehicle crashes that occur each year nationally, approximately 34% are weather-related crashes occurring mainly during rain events but approximately 10% are due to winter weather which includes sleet, hail, freezing rain, and snow.

In Massachusetts, review of statewide crash data for the last 20 years indicates that each winter day approximately 385 vehicle crashes occur statewide, on average, compared to an average of 352 crashes on a summer day. The additional 33 vehicle crashes per day can add up to1,000 additional vehicle crashes per month and over 5,000 additional crashes over the 5-month winter season. The 2017 ESPR reported a similar finding of 36 additional vehicle crashes occurring on winter days versus summer days, based on vehicle crash data from 2006 to 2014.

The average daily crash rate between 2011 and 2021 was lower than the average daily crash rate in the pre-2011 period, despite the more recent period having a more severe average WSI value. The lower average crash rate suggests that road conditions may have improved with the use of liquid deicers as well as other efficiency practices. At the same time, the average annual salt usage during the recent 2011-2021 period was lower than that used during the 2001-2010 period.

The major traffic backup in eastern Virginia on Interstate 95 on January 3, 2022, highlights the precarious nature of how winter weather can adversely affect vehicle mobility and public safety. Virginia DOT officials were not able to pretreat the roads since the storm started as heavy rain and any applied material would have been washed away by the rain. The inability to pretreat and the buildup of water on the roads combined with a sudden drop in temperature led to icy road conditions that caused a major vehicle backup. The conditions went from bad to worse when the rain turned to snow falling at a rate of 2 inches per hour, causing a tractor-trailer truck to jackknife and block traffic. Motorists were stranded along 50 miles for over 24 hours.

State Economy and Vehicle Mobility

Maintaining safe travel conditions on the Commonwealth roadway system has a vital role in supporting tourism activity and related travel as part of the state's economy. Data published in the 2020 Annual Report of the Massachusetts Office of Travel and Tourism (MOTT) indicates that nearly $25 billion was spent in the State by domestic and international visitors in 2019, an increase of 3% from 2018 and more than $3 billion more than in 2015 and $10.5 billion more than in 2009. In FY20, approximately 92% of these dollars were spent by domestic visitors, and 56.3% of all domestic trips originated in New England and other nearby northeast states. Travel disruptions and reduced vehicle mobility due to weather and poor road conditions can have a major impact on tourism, business commerce and other economic activity in the state.

A IHS Global Insight study estimated that a one-day shutdown in Massachusetts could result in economic losses of $265.1 million. Much of the impact was attributed to lost wages for hourly workers ($194 million), but also estimated losses in retail sales ($40.5 million), and lost federal, state, and local tax revenue ($30.5 million). These cost estimates assumed that nearly all businesses and government agencies would be closed due to impassable roads and the closure of other modes of transit.

The Massachusetts Emergency Management Agency (MEMA) estimated that the severe winter weather of 2015 caused over $300 million in economic losses in the Boston Metro area due to lost revenue, wages and productivity as well as property damage and higher snow removal costs. The MBTA, MassPort, and the Steamship Authority also reported significant losses of approximately $22.4 million, $13.3 million, and $0.4 million, respectively, due to reduced operations and cancelled trips. MassDOT lost nearly $3 million in toll revenue. Boston area hospitals lost approximately $10.3 million in revenue. Retail sales were estimated to decline by 22% and employee payroll dropped by approximately 7%.

Shipping and trucking industries are especially vulnerable to financial impacts caused by adverse road conditions and winter weather. A 2016 U.S. Federal Highway Administration study estimated that weather events cost the freight industry approximately $3.8 million per year in lost time due to delays and decreased speeds.

Potential Economic Impact of Ecosystem Service Declines

A 2010 study estimated the potential economic impact or lost value that road salt use may have on reduced ecosystem services provided by lakes, wetlands, and forests along roadways in the New York Adirondack region. Based on model simulations, the study authors estimated a potential 1% decline in ecosystem services provided by lakes and rivers and a 5% decline in ecosystem services provided by forested areas within 100 feet of roadways.

The study suggests, based on model simulations, the potential loss or reduction in ecosystem services caused by road salt could result in an estimated economic impact of approximately $2,320 per lane mile due to diminished water recharge, soil stabilization, nutrient cycling, and recreation activity. Applying the estimated cost to the 16,100 lane-miles maintained by MassDOT results in an estimated environmental economic impact of approximately $37 million per year. Accounting for inflation, this potential impact could be nearly twice as much. However, since much of MassDOT's road network is in more urban or developed areas of the eastern half of the state, the type and extent of ecosystem services provided by directly adjacent forested or wetland areas along these roadways could be much less than those along the more rural roads of the Adirondack Region. Also, the potential impacts to ecosystem services will depend on the type and extent of deicing chemicals and application practices used as well as many factors.

As discussed earlier, MassDOT has been able to reduce its overall annual road salt usage by using liquid deicers as well as other technologies and equipment upgrades , which has the added benefit of reducing the potential for environmental impacts. Additionally, MassDOT's road network for winter maintenance accounts for only 20% of the roadway lane-miles in the state.

Chapter 6: Current and Future Initiatives

Continuing to research new technologies in addition to progressively updating snow and ice equipment are key aspects of the MassDOT SICP. Consistent with previous ESPRs and the 2021 MEPA Certificate, MassDOT has identified the following current and planned initiatives regarding equipment, polices and research for the foreseeable future, as funding allows. Status updates on the implementation of these initiatives are provided in the MassDOT SICP Annual Reports that will be posted in the EOEEA Environmental Monitor at the end of each intervening year between ESPRs.

The following describes several of MassDOT equipment and material application initiatives that have been recently deployed or are in the early planning stages for future implementation.

» **Expanded Use of Slurry Spreaders:** MassDOT is currently using more than 75 slurry spreaders statewide, up from less than a dozen slurry spreaders used just a few years ago. These slurry spreaders apply a more liquid-intensive salt mixture that acts as an effective anti-icing layer that prevents snow and ice from freezing to the pavement and forming a hardpack. This helps to keep snow in a plowable form, especially at colder temperatures. This enhanced effect can often delay or even eliminate the need for repeat applications during prolonged storms. MassDOT plans to continue to expand the use of slurry spreaders as well as the availability of brine material used in slurry spreaders by acquiring additional brine production and storage facilities.

» **Use of Segmented Plow Blades:** MassDOT has steadily increased its use of segmented plow blades to improve plowing efficiency. Segmented plow blades consist of a series of short, segmented blade sections rather than one long plow blade. The short sections allow for greater road surface contact and improved snow removal effectiveness. Better snow removal can translate to less reliance on deicer applications to keep roads clear. MassDOT has been installing these segmented blades on their own equipment and some contractors are also using them because they are easier to fix and replace, more durable and, depending on the manufacturer, dampen the plow vibrations reducing operator fatigue.

» **Expanded Use of Mobile RWIS and Road Condition Sensors:** Advanced road and weather condition sensor technology developed in the last 5 to 10 years has become more cost-effective, easier to use, and with greater functionality. MassDOT is now relying more on mobile, vehicle mounted Road Weather Information System (RWIS) instruments instead of fixed, tower-based RWIS systems. The mobile units allow for broader coverage and better access to real-time data while on the road. The improved user interface has made the data more readily available and focuses on key data such as pavement grip or traction, available moisture, deicer concentrations, and temperature, which are critical elements in deciding when road treatment may be necessary. Use of this technology enables more data driven decisions in determining when deicing applications may be needed. MassDOT currently has over 25 mobile units and plans to expand on the use of this technology in the foreseeable future.

» **Expanded Training Resources:** In part due to the COVID pandemic, MassDOT has relied on more online training resources that cover a wide range of topics. These online resources provide greater flexibility and perhaps more effective delivery of technical knowledge through visual examples that might not otherwise be achieved through in-person, classroom instructions. MassDOT intends to expand on making online resources more available to its Snow and Ice Program employees.

» **Collaboration with other State Agencies to Develop Regional Initiatives:** Starting in 2022, MassDOT organized an Interagency Salt Working Group and met with representatives from MassDEP and the DCR Water Supply Protection Division and MWRA to discuss possible initiatives to increase awareness on various road salt efficiency measures to a broader audience such as municipal and commercial operators, including the use of brine for pretreatment and prewetting of salt. This Working Group is still in the early stages but is intended to meet quarterly to identify ways to expand the knowledge base to a broader audience on various technologies available to make the use of road salt more efficient and effective.

» **Advance the Use of AVL/GPS on Material Spreaders in Select Locations:** MassDOT will look to expand its use of AVL/GPS equipment to assist in tracking salt usage on key road segments in environmentally sensitive areas. MassDOT recently executed a new contract with a service provider to install newer generation AVL/GPS devices in select locations. These devices will initially be installed in nearly a dozen material spreaders operating out of the Dedham depot as part of a FHWA-funded study to evaluate salt usage on open-graded friction course pavement. Then additional units will be installed on spreaders servicing the Dedham-Westwood area, the Andover area, the Kampoosa Bog area, and then several key areas in District 3.

» **Promote the Use of Lower Application Rates:** MassDOT will continue to use lower application rates when weather and pavement conditions allow. Initial efforts have been positive, but further testing is needed under a variety of storm and temperature conditions to gain greater confidence in the decision process. Appropriate weather conditions that allow for lower applications can be relatively infrequent and only occur during certain types of winter storms. Thus, the overall effect of lower application rates on the annual usage may be relatively small compared to other factors and measures over the course of a season. District personnel closely monitor potential weather changes, especially dropping temperatures, as well as changes in traffic volumes based on time of day and many other factors on a case-by-case basis.

- **Use of Pretreated Salt:** MassDOT plans to evaluate the feasibility, effectiveness, and potential impacts of using pretreated salt (salt with liquid deicer already applied) in key locations, especially in areas where space is limited for brine storage. Pretreated salt avoids or minimizes the need for liquid storage as well as the added equipment such as saddle tanks to prewet salt at the time of application. However, data provided by material suppliers indicate that the liquids used to pretreat salt are often agricultural byproducts such as beet juice, The organic based liquids can have a relatively high biological and chemical oxygen demand (BOD and COD) and nutrient content and thus, the sensitivity of downstream receiving waters to low dissolved oxygen issues must be considered. Based on the limited use of pretreated salt, it appears to be highly effective in keeping roads clear of ice and snow and perhaps minimizing the need for subsequent applications of regular road salt. However, further evaluation of the potential oxygen demand issues needs to be evaluated before widespread use.
- **Potentially Automating Spreader Controllers Using Real-time Data:** MassDOT, as a member of the Clear Roads™ pooled funding research collaborative comprised of snow and ice practitioners working for various state agencies, will be evaluating the results of a recently initiated study to evaluate and develop programming tools to connect onboard spreader controllers with road condition friction or grip data. This technology could possibly lead to spreader controllers automatically adjusting material applications based on real-time weather and road condition data. The goal is to develop methods to be able to adjust and use the right amount of deicing material data based on real-time data collected from the pavement and weather data sensors.
- **Evaluation of Open-Graded Friction Coarse Pavement:** MassDOT is working with the US Geological Survey to evaluate the effects of Open-Graded Friction Coarse pavement on deicing material usage. This pavement type tends to improve driver visibility with less tire spray and increase tire friction during wet weather events, but OGFC pavement's effect on deicing material needs remains unclear compared to conventional asphalt. Anecdotal evidence suggests at times more deicing material is needed and other times less may be used depending on weather and pavement conditions. Although the OGFC open pores appear to limit the amount of water that accumulates on the pavement and available to freeze, the pores also allow cooler temperatures to penetrate deeper into the pavement compared to regular pavement causing freezing to occur earlier in the event or season. MassDOT expects the study to provide better insight as to whether OGFC provides snow and ice control benefits, as well as improved driver visibility during wet weather.

2022 MassDOT Snow & Ice Program ESPR Organization

The following describes the general ESPR Report organization and the general topics discussed in each of the Chapters.

Chapter 1 provides an update on the operational practices, polices, equipment, tools and technologies used to enhance the effectiveness and efficiency of the SICP operations as well as an update on MassDOT's average annual material usage relative to that used prior to the adoption of various efficiency measures while accounting for differences in winter weather severity.

Chapter 1 also provides an update on MassDOT's roadway lane-miles and describes new measures to build capacity to address the snow and ice removal needs on sidewalks and pedestrian facilities consistent with the 2019 Pedestrian Transportation Plan and as requested by the WalkBoston following review of the 2022 ESPR SOW Plan.

Chapter 2 provides updates on MassDOT's Salt Remediation Program, its Reduced Salt Zone (RSZ) Program, an analysis of sodium and chloride levels in Public Water Supplies (PWSs) across the Commonwealth, and other environmental related issues. A discussion of how MassDOT plans to transition away from using sand in RSZs and instead utilize the more effective tools and technologies used statewide to enhance salt use efficiencies and minimize salt use is also included. Also, this Chapter includes a discussion of recent research that links increased chloride levels to potential increased risks of corrosion in drinking water infrastructure.

Chapter 3 provides updates on the various Best Management Practices (BMPs) currently being used in the MassDOT SICP as well as other emerging technologies.

Chapter 4 describes new research findings and data regarding the potential corrosive effects of deicing material on roadway infrastructure and vehicles.

Chapter 5 provides new information on the effect that winter weather has on vehicle accidents, mobility and the local and regional economy based on published data.

Chapter 6 provides a listing of current and future planned initiatives that MassDOT is exploring or testing to further enhance salt usage and program efficiency. Status updates of these initiatives will be provided in subsequent annual reports submitted for posting in the MEPA Environmental Monitor in future years prior to the next ESPR.