Winter Highway Maintenance Operations: Connecticut

July 2015

A Report By

The Connecticut Academy of Science and Engineering

For

The Connecticut Department of Transportation

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The Connecticut Academy of Science and Engineering

Origin of Inquiry:	The Connecticut Department of Transportation
Date Inquiry Established:	June 1, 2014
Date Response Released:	July 31, 2015

This study was initiated at the request of the Connecticut Department of Transportation on June 1, 2014. The project was conducted by an Academy Study Committee with the support of the UConn Transportation Institute, with James Mahoney serving as Study Manager. The content of this report lies within the province of the Academy's Transportation Systems Technical Board. The report has been reviewed on behalf of the Academy's Council by Academy Members John N. Ivan, PhD, Herbert S. Levinson, DrEng, PE, and external reviewer Ron Wright, Idaho Transportation Department. Martha Sherman, the Academy's Managing Editor edited the report. The report is hereby released with the approval of the Academy Council.

Richard H. Strauss
Executive Director

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Technical Report Documentation Page

1. Report No. CT-2289-F-15-1	**2. Government Accession No.**	**3. Recipients Catalog No.**
4. Title and Subtitle Winter Highway Maintenance Operations: Connecticut		**5. Report Date** July 2015 **6. Performing Organization Code** SPR-2289
7. Author(s): Connecticut Transportation Institute, UConn James Mahoney, Study Manager; and Research Engineers: Eric Jackson, Donald Larsen, Timothy Vadas, Kay Wille, and Scott Zinke		**8. Performing Organization Report No.** CT-2289-F-15-1
9. Performing Organization Name and Address Connecticut Academy of Science & Engineering 805 Brook Street, Building 4-CERC Rocky Hill, CT 06067-3405		**10. Work Unit No. (TRIS)** **11. Contract or Grant No.** CT Study No. SPR-2289 **13. Type of Report and Period Covered** Final Report June 2014 – July 2015
12. Sponsoring Agency Name and Address Connecticut Department of Transportation 2800 Berlin Turnpike Newington, CT 06131-7546		**14. Sponsoring Agency Code** SPR-2289

15. Supplementary Notes
Partners: Connecticut Department of Transportation, and the Connecticut Department of Energy and Environmental Protection; Connecticut Academy of Science and Engineering; and the Connecticut Transportation Institute, UConn. Prepared in cooperation with USDOT, Federal Highway Administration.

16. Abstract: This study addresses issues identified in legislation adopted by the Connecticut General Assembly that directed the Commissioner of Transportation to conduct an analysis of corrosive effects of chemical road treatments, determine the cost of corrosion created by road treatments, and to provide an evaluation of alternative techniques and products, such as, but not limited to, rust inhibitors, with a comparison of cost and effectiveness. Primary conclusions of the study include that ensuring the safety and mobility of the traveling public requires the most effective winter highway maintenance practices possible. This is a shared responsibility—to achieve comprehensive and sustainable success, competing factors must be considered including safety, cost, corrosion, operating practices, materials and equipment, environmental and economic impacts, and communication with the general public, stakeholders, and government leaders. Balancing these factors presents a challenge that can be met through ongoing monitoring and continuous improvement based on evolving best practices. While use of chloride-based deicing chemicals for winter highway maintenance has raised concerns regarding impacts on vehicles, infrastructure and the environment, alternative products also have environmental, corrosion and expense impacts. Although corrosion inhibitors are available for use with deicers, evidence of their effectiveness in the field based on literature reviewed was not found. Research is needed to confirm their effectiveness before considering use. Further, CTDOT's participation in national initiatives, and ongoing communication with neighboring states, municipalities, and other stakeholders should continue and be strengthened to help balance the competing factors by using the most effective practices.

17. Key Words Winter highway operations,corrosion, salt, sodium chloride, magnesium chloride, calcium chloride,corrosion inhibitors, snow and ice removal	**18. Distribution Statement** No restrictions. This document is available to the public through the National Technical Information Service, Springfield, VA 22161

19. Security Classif. (Of this report) Unclassified	**20. Security Classif.(Of this page)** Unclassified	**21. No. of Pages** **244**	**20. Price** N/A

MEMBERS OF THE STUDY COMMITTEE ON WINTER HIGHWAY MAINTENANCE OPERATIONS: CONNECTICUT

Paul Brown
Snow and Ice Engineer
District 1, MassDOT

Brian Burne
Highway Maintenance Engineer
Maine Department of Transportation

Sten Caspersson, *(Academy Member)*
Consultant, Nuclear Power

Michael J. Gantick, PE, PWLF
Director of Public Works
Town of South Windsor

Monty Mills
Maintenance & Operations Branch Manager
Washington State DOT (ret.)

Richard Nelson, PE, F.ASCE
Coordinator, Snow and Ice Pooled Fund
Cooperative Program, AASHTO

Laura E. Pence, PhD
Professor, Department of Chemistry
University of Hartford

Leland Smithson
Snow and Ice Pooled Fund Cooperative
Program, AASHTO, Iowa DOT (ret.)

Ex-Officio Member
Robert W. Turner, PE
Safety/Area Engineer
Connecticut Division, Federal Highway
Administration

STUDY REVIEWERS

John N. Ivan, PhD *(Academy Member)*
Professor & Associate Department Head, Civil & Environmental Engineering, UConn

Herb Levinson, DrEng, PE *(Academy Member)*
Professor of Civil Engineering (ret.), UConn

Ron Wright *(External Reviewer)*
Central Laboratory Manager, Division of Engineering Products & Plans,
Idaho Transportation Department

RESEARCH TEAM

CONNECTICUT TRANSPORTATION INSTITUTE (CTI), UCONN

Study Manager
James Mahoney, Executive Director, CTI

Research Engineers
Eric Jackson, PhD, Director, Connecticut Transportation Safety Research Center
Donald A. Larsen, PE, Temporary University Specialist, CTI
Timothy Vadas, PhD, Assistant Professor, Civil and Environmental Engineering
Kay Wille, PhD, Assistant Professor, Civil and Environmental Engineering
Scott Zinke, Research Engineer, Connecticut Advanced Pavement Laboratory, CTI

ACADEMY PROJECT STAFF

Richard H. Strauss, Executive Director
Terri Clark, Associate Director
Ann G. Bertini, Assistant Director for Programs

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LIST OF ACRONYMS AND ABBREVIATIONS

°F	Degrees Fahrenheit
2009/2010	Winter season crossing two calendar years
µS/cm	Electrical Conductivity (micro siemens per centimeter)
10:1	10 parts mixed with 1 part
AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
ACR	Alkali Carbonate Reaction
AOT	Agency of Transportation (Vermont)
ASCE	American Society of Civil Engineers
ASR	Alkali Silica Reaction
ASTM	American Society of Testing and Materials
ATA TMC	American Trucking Association Truck Maintenance Council
AVL	Automatic Vehicle Location
BOD	Biochemical (or Biological) Oxygen Demand
$CaCl_2$	Calcium Chloride
CASE	Connecticut Academy of Science and Engineering
CASHO	Connecticut Association of Street and Highway Officials
CGA	Connecticut General Assembly
COD	Chemical Oxygen Demand
CRCOG	Capital Region Council of Governments
CMA	Calcium Magnesium Acetate
C-S-H	Calcium Silicate Hydrate
CTCDR	Connecticut Crash Data Repository
CTDOT	Connecticut Department of Transportation
CTI	Connecticut Transportation Institute, UConn
CY	Calendar Year
DAS	Connecticut Department of Administrative Services
DEEP	Connecticut Department of Energy and Environmental Protection
DOD	US Department of Defense
DOT	US Department of Transportation (also referred to as USDOT)
DPH	Connecticut Department of Public Health
EMS	Emergency Medical Services
EPA	US Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
F/T	Freeze-thaw Cycling
GIS	Geographic Information System
GPS	Geographic Positioning System
HMWM	High Molecular Weight Methacrylate
IPRF	Innovative Pavements Research Foundation
KABCO	Injury classifications system for crash victims (see Glossary of Terms)
KAc	Potassium Acetate
Lbs.	Pounds

LD_{50}	A lethal dose at which 50% mortality occurs
L	Liters
(LMC/OBPE)	Liquid Magnesium Chloride/Organic-based Performance Enhancers
MaineDOT	Maine Department of Transportation
MAIS	Maximum Abbreviated Injury Scale (see Glossary of Terms)
MassDOT	Massachusetts Department of Transportation
MCL	Maximum Contaminant Level
$MgCl_2$	Magnesium Chloride
MSDS	Material Safety Data Sheet
M-S-H	Magnesium Silicate Hydrate
NaCl	Sodium Chloride
NACE	National Association of Corrosion Engineers
NCHRP	National Cooperative Highway Research Program
NHDOT	New Hampshire Department of Transportation
NHTSA	National Highway Traffic Safety Administration
NJDOT	New Jersey Department of Transportation
NYSDOT	New York State Department of Transportation
OE	Original Equipment
PCA	Portland Cement Association
PCC	Portland Cement Concrete
PNS	Pacific Northwest Snowfighters Association
ppm	Parts per Million
QALYs	Quality-Adjusted Life-Years
Ref.	Reference
RCI	Road Condition Index
RIDOT	Rhode Island Department of Transportation
RWIS	Road Weather Information System
SAE	Society of Automotive Engineers
sq-mi	Square miles
STD	Standard (Volvo)
TMDLs	Total Maximum Daily Loads
TRB	Transportation Research Board
USDOT	US Department of Transportation (also referred to as DOT)
USGS	United States Geological Survey
UV	Ultra-violet light
VAOT	Vermont Agency of Transportation (also referred to as AOT and VTrans)
VMT	Vehicle Miles Travelled
W/D	Wet-dry Cycling
WSI	Winter Severity Index
WTI	Western Transportation Institute, Montana State University

EXECUTIVE SUMMARY

At the request of the Connecticut Department of Transportation (CTDOT), the Connecticut Academy of Science and Engineering conducted this study on Winter Highway Maintenance Operations. The study addresses the issues identified in Section 6 of Public Act 14-199 that directed the Commissioner of Transportation to *conduct an analysis of the corrosive effects of chemical road treatments on 1) state snow and ice equipment vehicles, 2) state bridges, highways and other infrastructure, and 3) the environment; The analysis shall determine the cost of corrosion created by road treatments, and shall include an evaluation of alternative techniques and products, such as, but not limited to, rust inhibitors, with a comparison of cost and effectiveness.*

BRIEF STATEMENT OF PRIMARY CONCLUSION

Ensuring the safety and mobility of the traveling public requires the most effective winter highway maintenance practices possible. This is a shared responsibility—to achieve comprehensive and sustainable success, competing factors must be considered, including safety; cost; corrosion; operating practices; materials and equipment; environmental and economic impacts; and communication with the general public, stakeholders, and government leaders. Balancing these factors presents a challenge that can be met through ongoing monitoring and continuous improvement based on evolving best practices.

CTDOT winter highway maintenance operations are consistent with the practices of other states with similar weather conditions. Additionally, the department engages in an ongoing process of monitoring current practices, identifying areas for improvement, and instituting improvements based on best practices to increase mobility, safety and overall roadway conditions while reducing the amount of deicing chemicals used. CTDOT has been proactive by testing new technologies and implementing those shown to be effective. Additionally, municipalities can benefit from CTDOT's experience with implementation of state-of-the-art technologies shown to be effective—providing opportunities for achieving higher levels of service to the traveling public.

It is noted that while use of chloride-based deicing chemicals for winter highway maintenance has raised concerns regarding impacts on vehicles, infrastructure and the environment, alternative products also have environmental, corrosion and expense impacts. Although corrosion inhibitors are available for use with deicers, evidence of their effectiveness in the field based on literature reviewed was not found. Research is needed to confirm their effectiveness before considering use.

Further, CTDOT's participation in national initiatives, and ongoing communication with neighboring states, Connecticut municipalities, and other stakeholders, should be continued and strengthened to help balance the competing factors by using the most effective practices.

OVERVIEW

The study report includes the following chapters:

- Chapter 1: Background and Introduction – presents the purpose for the study and an outline of the report.
- Chapter 2: Overview of Snow and Ice Control Operations on Connecticut Roadways: CTDOT and Municipalities — includes a summary of a CTDOT report (Appendix C) providing information on the mission and operations of the department's winter highway maintenance program, practices, types and quantity of materials used, operational coordination, training and outreach, advances in technology, and operational improvements. Additionally, an analysis of responses from a survey of municipalities (Appendix D) on their winter highway maintenance practices is provided.
- Chapter 3: Deicing Chemicals Currently in Use in North America — provides a summary of deicing chemicals primarily used in North America, including their advantages and disadvantages, and approximate costs.
- Chapter 4: Winter Highway Maintenance Practices in Surrounding States — provides a five-year summary of winter highway practices that are used in neighboring New England states, New York and New Jersey, including a comparison of these practices to those used in Connecticut.
- Chapter 5: Environmental Impacts and Mitigation of Deicing Chemical Applications for Winter Highway Maintenance — discusses environmental impacts of deicing chemicals on soils, surface waters, groundwater and biology, as well as techniques to mitigate the impact of these materials.
- Chapter 6: Effects of Deicer Corrosion on Infrastructure and Vehicles — provides a technical overview and assessment of corrosion due to use of chemical deicers. The costs of corrosion, prevention options, and the condition of Connecticut's infrastructure and winter highway maintenance equipment are included. State of the art techniques for reducing and preventing vehicle and infrastructure corrosion are also addressed. Further, corrosion inhibitors and their advantages and disadvantages are also discussed.
- Chapter 7: Best Practices and New Technologies — presents new technologies and best practices as found in the literature and/or practiced in Connecticut and other winter-weather states.
- Chapter 8: Winter Highway Safety Analysis and Overview of Economic and Societal Impacts —includes information regarding highway safety, statistics and analysis of crash rates in Connecticut during winter weather conditions, economic impacts of winter weather events, and societal impacts of mobility during and after events.
- Chapter 9: Summary of Findings -- provides a summary of findings for winter weather practices.
- Chapter 10: Conclusions and Recommendations -- provides conclusions and recommendations for consideration to help guide effective and efficient winter highway operations.

RECOMMENDATIONS

CTDOT should continue to participate in groups such as Clear Roads, the American Association of State Highway and Transportation Officials (AASHTO), National Cooperative Highway Research Program (NCHRP) and Transportation Research Board (TRB) to remain current on best practices for snow and ice control. Participation in these groups will enable CTDOT to be aware of emerging best management practices and to adopt those that provide improved strategies that lead toward optimizing the department's winter highway maintenance operations (i.e., maximize impact of chemicals and minimize excess use of chlorides). CTDOT should also work to ensure that successful technology and operation improvements are shared with municipalities for their consideration and implementation. CTDOT should seek assistance from organizations such as the Connecticut Technology Transfer Center at UConn and the Connecticut Association of Street and Highway Officials, Inc. (CASHO), among others, for sharing winter highway operations practices and advancements with municipal transportation agencies.

The following recommendations are provided for consideration by CTDOT and Connecticut's municipalities. Some of the suggested recommendations have already been implemented by CTDOT and some municipalities.

Deicing Chemicals and Application Techniques

DEICING CHEMICALS

Currently, chloride-based snow and ice control chemicals are the most effective and economical treatments readily available, and will be the most commonly used deicing chemicals for the foreseeable future.

a. CTDOT should continue to use sodium chloride as the primary deicer; it remains the most economical inorganic chemical and is an effective deicer under most conditions above 20°F. While typically temperatures in Connecticut under most winter weather conditions are above 20°F, for lower temperatures, materials application rates may be varied due to conditions.

b. CTDOT should continue to mix brine (sodium chloride in solution with water) in-house, rather than purchase mixed materials containing unspecified additives.

c. While organic chemicals (i.e., potassium acetate, sodium formate and propylene glycol, among others) can potentially be used in very specialized circumstances or unique situations for snow and ice control, availability, cost and unintended environmental consequences from the breakdown of organics may be problematic.

PRE-WETTING

Pre-wetting is an effective practice that is used to moisten salt or sand (where still in use) prior to application. It reduces the tendency of these materials to bounce off the road and activates faster melting. CTDOT should continue, when feasible, to use sodium chloride solution for pre-wetting at the beginning and end of seasons and magnesium chloride solution during the

coldest months, to assist in lowering the temperature at which the solid sodium chloride is effective.

a. The chloride-based chemical selected for the pre-wetting solution ideally should be determined based on forecasted temperatures during periods within the winter season. For example, sodium chloride solution can be used for pre-wetting during the warmer months at the beginning and end of the winter season, with magnesium chloride solution used generally mid-December through the end of February.

b. If uninhibited liquid calcium chloride solution is available and cost-effective, it should be considered for the pre-wetting solution in lieu of liquid magnesium chloride solution; while all chlorides are corrosive to metals, calcium ions are less damaging to Portland Cement Concrete (PCC) than magnesium ions.

PRE-TREATING

CTDOT should continue the use of sodium chloride solution for pre-treatment of bridges and known problem areas. Pretreating bridge decks, hills and shaded, north-facing roadways is an effective strategy for enhancing safety and reducing callout of maintenance personnel after hours, resulting in a reduction of overtime costs.

a. CTDOT's strategy of using sodium chloride solution as pre-treatment appears to be successful. Switching to a calcium chloride or magnesium chloride-based pre-treatment does not appear to be warranted in Connecticut's climate.

b. CTDOT should promote the use of sodium chloride solution pre-treatment in larger municipalities for problematic areas.

c. CTDOT should promote the use of solid proprietary salt or pre-wetted salt for pretreating in smaller municipalities.

ANTI-ICING STRATEGY

CTDOT should continue with the anti-icing strategy that was initiated during the winter of 2006/2007 to shorten the period of time that roads are snow or ice covered, to ease removal of snow and ice, and to assist in reducing winter weather-related vehicle crashes.

CORROSION INHIBITORS

Corrosion inhibitors may assist in delaying the onset of corrosion for spreading and plowing equipment. However, for proprietary salts that include a corrosion inhibitor, in many cases the additive is not disclosed, and therefore its effect on the surrounding environment is not known. Based on the reviewed literature, evidence of effectiveness of corrosion inhibitors outside of the laboratory is inconclusive, and it is noted that the dilution of concentration of a corrosion inhibitor occurs rapidly with the melting of snow and ice. As the effectiveness of corrosion inhibitors for the motoring public was not found, the practice of introducing additional chemicals to the environment is questionable, especially when their exact composition is unknown. Additional study regarding the effect of the use of corrosion inhibitors to reduce corrosion to infrastructure and vehicles is suggested. CTDOT should continue to monitor the findings of other agencies and future studies on effectiveness of corrosion inhibitors before implementing their use.

Infrastructure

PROTECT STRUCTURES

All chloride-based deicing chemicals cause corrosion. Therefore it is very important to promote the use of materials that reduce or prohibit chloride penetration into concrete and steel structures. This includes the following:

a. Use low-permeability concretes for new bridge decks
b. Use sealers and crack sealers on new bridge decks and appropriate components to slow chloride penetration
c. Ensure proper curing of concrete to minimize micro-cracking that results in pathways for the chlorides to penetrate into a structure
d. CTDOT should re-establish a bridge painting (coatings) program for steel structures

BRIDGE CLEANING

It seems obvious that the removal of salt deposits from bridge structures would be beneficial for minimizing the impacts of these chemicals. It is noted that the literature reviewed for this study did not provide consistent conclusive evidence that cleaning bridge decks and structures is cost-effective. This may be due both to the difficulty in quantifying the benefits of removing the salts and the long-term study periods required to validate the benefits. Therefore, the following focused approach for bridge cleaning is recommended.

a. Develop and fund a long-term bridge rinsing/cleaning program to remove chlorides as well as any debris that may hold moisture, particularly for steel portions of structures. Particular attention should be paid to parts of the structure most prone to corrosion such as joints, support ends, fasteners, drainage structures and steel components.
b. Remove a majority of the chlorides during the spring, when stream flows are typically higher than other times of the year, to minimize environmental impacts.

BRIDGE MAINTENANCE

CTDOT and municipalities should continue to utilize best management practices for bridge maintenance, including the following:

a. Maintain bridge joints to limit water infiltration into bridge structures.
b. Minimize runoff containing chlorides from penetrating the bridge structures.
c. Perform periodic bridge inspections in accordance with the National Bridge Inspection Standards 23 CFR 650 and schedule maintenance to address deficiencies such as cleaning, minor repairs, and maintenance of proper coatings on bridge steel in a timely manner.
d. Encourage use of bridge preservation and preventive maintenance strategies. CTDOT should provide technical guidance to municipalities to assist with implementing bridge preservation programs.

CORROSION-RESISTANT DESIGNS

During the design of bridges and for bridge rehabilitation projects, consider the use of anti-corrosion materials such as

a. epoxy-coated reinforcing steel in structure elements coming in contact with deicing materials such as bridge decks, concrete barriers, and drainage structures;
b. stainless or galvanized steel rebar in critical concrete structures; and
c. corrosion-resistant materials in curbs, median barriers, catch basins.

Vehicles

VEHICLE WASHING

An April 2015 National Highway Traffic Safety Administration (NHTSA) Safety Advisory recommended that vehicles older than the 2008 model year be washed as soon as possible after exposure to salt and chemicals. This safety advisory was considered in developing the following recommendations.

a. Vehicle washing be performed on all classes of vehicles, from commercial trucks to motorcycles, to dilute the effects of residual deicing chemicals. Washing should assist with the prevention of corrosion for all vehicles, regardless of age.
b. If salt neutralizers are used to wash vehicles, select products that have proven to be effective. Caution should be exercised in product selection, as research reviewed for this study found that some neutralizers used at the manufacturer's recommended concentration actually increased corrosion of some metals.
c. An emphasis should be placed on rinsing/washing the undercarriage of the vehicle.

COMMERCIAL CAR WASHES

Commercial car washes should be encouraged to voluntarily disclose/post information regarding whether recycled water or fresh (clean) water is used for the car wash, particularly for undercarriage washes. If recycled water is used, then the percent of recycled water used, what cycles the recycled water is used for, and any additives used should be disclosed. Additionally it is suggested that the Connecticut General Assembly and/or Connecticut Department of Consumer Protection and Connecticut Department of Energy and Environmental Protection (DEEP) consider regulations requiring the disclosure and posting of information on the use of recycled water for car washes.

a. Use of fresh water is encouraged for the final rinse – both on the surface and undercarriage washes.
b. Research is needed to identify acceptable salt concentrations of recycled water – that which would not be detrimental to vehicles.

Additionally, the development of additional commercial large truck/vehicle washing stations open to the public should be encouraged, as only one or two commercial large truck/vehicle washing stations are currently available in Connecticut.

CORROSION-RESISTANT TECHNOLOGY

The purchasers of commercial vehicles need to encourage vehicle manufacturers to continue to improve corrosion resistance of vehicles. This includes the use of composites, aluminum, paints and coatings, fasteners, and shrouding of critical electrical or mechanical vehicle components.

a. Use improved coatings for vulnerable components, including undercoating technologies.
b. Improve designs to eliminate known corrosion problems and areas where deicing chemicals can collect.
c. Eliminate areas where dissimilar metals come into contact with each other.

VEHICLE INSPECTIONS

There is a need for periodic voluntary undercarriage inspections of all vehicles (including passenger and commercial vehicles), particularly as vehicles age. This could possibly be performed during oil changes or other standard vehicle maintenance procedures. Other states have safety inspection programs that are required as part of the registration renewal process. Inspections could help prevent vital component failures such as brake lines or parts of the suspension system.

Environment

GENERAL CONSIDERATIONS FOR CHLORIDES

The use of deicing materials for winter highway maintenance has a variety of environmental impacts, some of which are more manageable than others. Some impacts are short term or seasonal, such as sudden spikes of chloride levels in soils, shallow groundwater or streams due to the flushing of deicing materials from those environments over time. Some impacts from chlorides are longer term, such as the increasing levels of chloride observed in groundwater over the past several decades. The impacts on roadside vegetation are very difficult to mitigate. Therefore any plantings (preferably native) along roadsides should have a tolerance for salt.

CHLORIDE-SENSITIVE ENVIRONMENTS

CTDOT as well as local municipalities need to periodically consult with the Connecticut Department of Public Health (DPH) and DEEP to identify sensitive environments or drinking water sources that are at risk of impairment due to chlorides. After identifying these locations, CTDOT and the local municipalities can work to reduce the application rates of chlorides in these areas. In these identified areas, it is suggested that signs be posted for safety purposes that identify areas where application rates of deicers will be reduced for environmental or public health reasons.

MULTI-CHEMICAL APPLICATION

Although other states such as Minnesota have developed the capability to switch chemicals on the fly, typically for applying alternative chemicals in environmentally sensitive areas, no current need for this was identified in Connecticut. This technology, however, should be monitored for possible future implementation in specifications for purchase of new winter maintenance vehicles.

SALT STORAGE

Covered salt sheds have been implemented statewide by CTDOT and virtually all municipalities. However, commercial salt storage may be an issue that deserves continued attention by DEEP or DPH.

SHARED RESPONSIBILITY

CTDOT in collaboration with DEEP should inform all parties involved with winter weather-related maintenance (i.e., state, municipal, commercial, private, and consumers) of and use best management practices to protect the environment.

REPORTING OF DEICERS APPLIED

Each transportation agency within Connecticut responsible for applying deicing chemicals should be required to report the quantity of materials applied during each winter season, and this information should be made available to the public. This will enable the public to better understand the types and quantities of materials being applied. By making this information public, it will allow municipalities to see how they compare to other municipalities that they would consider comparable in both size and climate. Disparities can be identified and used as a guide to improve practices and performance.

Outreach and Education

PUBLIC INFORMATION CAMPAIGN

CTDOT should develop a public service campaign that utilizes web-based and social media tools along with printed materials to educate the motoring public about winter highway maintenance operations and practices. This information would help explain

a. anti-icing procedures
b. chemicals in use (and why they are used)
c. level of service goals by road type (drivers typically have an expectation that roads will be clear several hours after a storm ends, but there are conditions for some winter weather events when this is not possible)

Additionally, CTDOT, with assistance from DEEP, should develop a handbook that provides guidance for best practices for winter maintenance of sidewalks and parking lots for the general public, businesses, and private winter maintenance service companies. Consideration should also be given to limiting liability for property owners when they have followed the established best practices pertaining to slip and fall accidents. Currently, the financial cost for applying copious amounts of deicing chemicals is far less than the costs associated with a single slip and fall injury claim.

MEDIA

The media is a source of information for the general public. However, the information shared with the public needs to be accurate. Informal information indicates that the general public believes that pre-treatment chemicals applied on roadways prior to winter weather events by CTDOT contain something other than what is actually used — a 23% solution of sodium chloride in water. Both natural processes and events cause corrosion to vehicles

and infrastructure as well as chemicals used for winter highway maintenance by CTDOT, municipalities, and private winter maintenance activities.

Annual informational sessions conducted in advance of the winter season for the media about winter maintenance practices, and materials that will be used for pre-treatment and anti-icing, would help to dispel misconceptions. Informational sessions with the media, along with the availability of public information, will be useful in assuring factual information is distributed to the public. This will help to inform and clarify misconceptions regarding winter highway maintenance practices and materials that are used by CTDOT and municipalities.

RECORDKEEPING AND TRANSPARENCY

CTDOT and municipalities should each prepare an annual summary that accurately documents winter maintenance practices and the type of materials and quantities used for each winter season. The annual summaries should be publicly available and easily accessible.

a. CTDOT should make winter maintenance information readily available to the public via CTDOT's website. Other states, such as Maine, Minnesota, and Vermont, should be used for examples of best practices for transparency and information dissemination.

b. CTDOT should provide technical assistance and guidance to assure that the state's municipalities implement winter maintenance best practices for the 82% of the state's road network that is maintained by the municipalities.

c. Accurate recordkeeping is paramount to optimizing the use of deicers. Municipal data collected as part of this study indicates that it is possible that the towns are using greater amounts of magnesium chloride per ton of solid deicer than CTDOT. However, since there is no single repository or common format used for data collection, total material usage is not readily available. A repository for the collection of winter maintenance practices and material usage using a common reporting format should be developed.

d. Annual CTDOT and municipality winter maintenance information and data will provide an opportunity for comparisons and benchmarks between agencies for the purpose of continually improving operations throughout the state.

VOLUNTARY CERTIFICATION OF PRIVATE CONTRACTORS APPLYING DEICING CHEMICALS

The development of a voluntary certification program for private contractors who apply de-icing chemicals will be an opportunity to provide information and training to private contractors about best practices, including application rates. Certification programs of others such as the New Hampshire Department of Environmental Services' voluntary certification program for private contractors or the American Public Works Association program could be used as models for developing a Connecticut program. This certification could be used by private contractors to promote their business as being environmentally friendly regarding the application of deicing chemicals, and could be useful to businesses and the public in selecting contractors who are sensitive to the environmental issues. This certification could also be a requirement as part of limiting liability associated with slip and fall injury claims, as it is in New Hampshire.

The actual quantity of deicing chemicals applied by private contractors in Connecticut is unknown. However, information for New Hampshire indicates that the quantity of deicing chemicals used by private contractors in New Hampshire may approach half the total deicing chemicals applied in the state. With private contractors representing such a large percent of material being applied, private contractors represent a significant opportunity to reduce the quantity of salt material used in Connecticut.

COMMUNICATION

CTDOT should continue to communicate with neighboring states regarding winter highway maintenance best practices and operations. CTDOT should also continue its practice of communicating with neighboring states with regard to approaching winter weather events in order to provide as much lead time as possible for staging personnel and equipment.

Also, CTDOT should seek to communicate with municipalities with regard to information on weather, equipment, technology and best practices. In addition to CTDOT, organizations that can help to maximize outreach include the Connecticut Technology Transfer Center at UConn, CASHO, and others.

TRAINING

Initial and ongoing annual training on the best practices and methodologies should be provided for all CTDOT and municipal employees, and contractors involved in winter highway maintenance operations. This training should include

a. current state-of-practice
b. information about new technology
c. forums to discuss successes and problems encountered

This training can be provided by the Connecticut Technology Transfer Center at UConn, as well as in-house by CTDOT and others.

General

CTDOT should continue to monitor state-of-the-art techniques for winter maintenance and communicate with surrounding states about their winter maintenance practices. CTDOT should be cognizant of alternative chemicals that become available that might become acceptable substitutes for chlorides. Approaching any changes in the use of deicing chemicals regionally may help vehicle manufacturers design and modify their products to be more corrosion resistant, since each type of deicing chemical may have different effects on the various metals that are used in a vehicle.

LEVEL OF SERVICE

CTDOT should consider revising their definitions of levels of service for winter weather events on the three classes of state roadways that are maintained by CTDOT. Defining the level of service for the different roadway classes provides an opportunity for CTDOT to re-evaluate its policy of using a standard deicer application rate of 200 lbs./lane-mile. Utilizing variable application rates under differing conditions and roadway classifications may ultimately be more

cost-effective and useful in helping to mitigate the negative impacts of using chloride-based deicers. Communicating with the public about road condition expectations following a winter weather event for the different classes of roadways, setting goals, and posting achievements may be useful for maintaining reasonable public expectations.

PERFORMANCE MEASURES

CTDOT should monitor in-process studies being undertaken by NCHRP Project 14-34 "Guide for Performance Measures in Snow and Ice Control Operations" [152] and Clear Roads Project 14-05 "Snow Removal Performance Metrics" for use in developing winter highway maintenance performance measures on mobility, chemical use, and cost similar to that done in some other states. A review of performance measures implemented by other states is also recommended.

WEATHER MONITORING

Road Weather Information Systems (RWIS) are in use and assist CTDOT with storm monitoring throughout Connecticut. CTDOT plans to add an additional 23 RWIS stations to its RWIS network of stations over the next two to five years. CTDOT should

a. continue sharing weather data with/from surrounding states (MA, NY, RI);
b. share RWIS data and other information about weather events with Connecticut municipalities;
c. consider making RWIS data available to the public via a website; and
d. consider working with other states in the Northeast to provide RWIS data online using a system such as the Meteorological Assimilation Data Ingest System (MADIS) maintained by the Federal Highway Administration and the National Weather Service, as this may benefit municipalities that are located near state borders.

WINTER SEVERITY INDEX (WSI)

CTDOT should develop a WSI. While this is a challenging task, it provides a method to compare winter seasons and develop performance measures. States that have developed a WSI, including Massachusetts and Utah, can be used as references for CTDOT.

ROAD CONDITION INDEX (RCI)

CTDOT should consider developing a RCI that would be available on a regional basis during a winter weather event for state roads. This would allow CTDOT to provide information directly to the public. One of the most important and difficult aspects of this would be the need to keep the information current during a winter weather event. Utah DOT has a RCI that could be used as a guide for CTDOT.

CLEAR ROADS CONSORTIUM

CTDOT should continue their participation in the Clear Roads consortium pooled fund project. Participating in these groups enables CTDOT to be aware of ongoing research and new products. CTDOT should participate in Clear Roads field trials if possible and appropriate.

Equipment

GROUND SPEED CONTROLLERS

The inclusion of ground speed controllers for deicing chemical application on all new equipment purchases should be considered standard practice to ensure that the desired application rates are achieved. Ground speed controllers are installed on virtually all of CTDOT's material spreading equipment, and it is recommended that municipalities do the same.

CALIBRATION OF SPREADERS

The calibration of material spreaders should be performed at least on an annual basis or as required, which is the current practice of CTDOT and many municipalities. Accurate record keeping will be useful for determining if a specific piece of equipment is applying a radically different amount of material than expected. This may be an indication that the spreader needs to be recalibrated. It is also suggested that spreaders should be calibrated two to three times during the winter season, as well as after any repairs are performed.

SALT SLURRY SPREADERS

Salt slurry spreaders have been successful at improving the application of salt materials. CTDOT purchased salt slurry spreaders to test this technology in Connecticut. Initially, the testing involved setting up the equipment to apply the desired amount of material. It is expected that these spreaders will be tested in operation in the winter of 2015/2016.

Similar to the process noted above, an example of a process or steps suggested for implementation of other new technologies is as follows:

- First, demonstrate the product.
- Next, test the product in operation under actual conditions typically experienced.
- Finally, follow with operational implementation and monitoring to assure that the results are those that are expected.

GPS AND MATERIAL DATA LOGGERS

The technology exists to track the location of deicing chemical-spreading vehicles via GPS while at the same time recording spreading equipment settings. This data can be used to develop a very detailed material application tracking system. These types of systems require analysis of the data and can generate a great deal of data depending on how they are configured. Therefore, before implementing this type of system, it is necessary to determine how this data will be managed, as well as how it will be used for monitoring and improving performance, as well as decision making.

MULTI-SECTIONAL PLOWS AND UNDERBODY SCRAPERS

Multi-sectional plows improve plowing performance on uneven roads. Underbody scrapers are useful for maximizing snow removal on roadways with packed snow and ice. These technologies should be considered for plowing operations since plowing is the most environmentally friendly method for snow and ice removal — the more snow and ice that is removed mechanically, the less deicing chemicals needed. Currently, CTDOT uses underbody scrapers on a limited basis, and reportedly underbody scrapers and multi-scetional plows are used by several municipalities.

APPLYING AND VERIFYING APPLICATIONS

Technological improvements that should be considered for winter maintenance operations to maximize deicing chemical application efficiency include:

a. measuring and weighing loads of deicing chemicals and abrasives to accurately track the amount of materials used; and

b. pavement and air temperature sensors for all trucks that can be used for decision making for varying application rates based on current and forecasted conditions.

SUMMARY

Sustainable winter maintenance operations are achieved by balancing the demands of the users, the available budget, and the environment. Chloride-based deicing chemicals will continue to be the most common deicer used for winter highway maintenance operations. While chloride-based deicers are effective at helping transportation agencies remove snow and ice from roadways, which assists in providing the traveling public with safe roadways and mobility as soon as possible following a winter weather event, their use also contributes to increased corrosion of infrastructure and vehicles, as well as possible environmental impacts.

Therefore, under the assumption that safety and mobility of the traveling public are key goals of winter highway maintenance operations, it is necessary for everyone to recognize that minimizing the negative impacts of the use of chemical deicers is a shared responsibility.

- For transportation agencies, this includes achieving the maximum benefit from the least amount of chemical deicer application, and assuring that best practices are utilized for operations.

- For the general public and commercial vehicle owners and operators, this includes washing vehicles after each winter weather event to remove as much deicing chemical as possible; inspecting the undercarriages of vehicles periodically for damage due to corrosion of critical safety components; and having reasonable expectations for the return of roadways to a safe condition following a winter weather event.

As previously noted in this report, the DOTs of the states surveyed for this study are responsible for maintaining different types of roadways, with different levels of service being required. Additionally winter weather events vary from state to state. These factors make state to state comparisons of deicer chemical usage and practices useful only as a frame of reference for use by each state in seeking to continually improve winter maintenance operations. Taking this into consideration, CTDOT's total application of chlorides per lane-mile is typically lower than that of the other surveyed northeastern states.

It is important for CTDOT to continually monitor, review and implement winter highway mainteance best practices including operations, technological advances, and use of improved

deicing chemicals to maximize efficiency and reduce adverse effects on infrastructure, vehicles, and the environment while maintaining public safety and mobility.