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Introduction to Sustainable Winter Road Maintenance

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1.1 Introduction

1.1.1 Motivation for This Book

This book is motivated by the opportunities made possible by leveraging recent advances and significant knowledge accumulated in various aspects related to winter road maintenance (WRM), such as weather forecasting, sensor and equipment technologies, operational practices and materials, and performance measurement, to achieve sustainable winter operations. These opportunities enable new perspectives on and holistic approaches to achieving sustainability of WRM operations by minimizing physical and chemical impacts, economic costs, and societal vulnerabilities and risks of winter storms, and maximizing the synergies across multiple modes and jurisdictions.

Investing in WRM operations is essential and beneficial to the public and the economy. In many northerly countries and regions, WRM operations are essential to ensure the safety, mobility and productivity of transportation systems. The U.S. economy cannot afford the cost of shutting down the transportation system, such as highways and airports, during wintry weather. According to the U.S. Federal Highway Administration (FHWA), “over 70 percent of the nation’s roads are located in snowy regions, which receive more than five inches average snowfall annually ... Nearly 70 percent of the U.S. population lives in these snowy regions” (Figure 1.1). Transportation agencies are under increasing pressure to provide a high level of service (LOS) and to improve safety and mobility in a fiscally and environmentally responsible manner. It is therefore desirable to be able to make full use of best practices in the application of materials, strategies, equipment and other technologies. Such best practices are expected to improve the effectiveness and efficiency of winter operations, to optimize material usage, and to reduce associated annual spending and corrosion and environmental impacts. As described in Nixon et al. (2012), WRM operations include six interrelated components and processes where improvements for sustainability can be made, as illustrated in Figure 1.2.
Figure 1.1 U.S. areas affected by snow and ice (Adapted from: FHWA 2016).

Figure 1.2 Key components and processes in winter transportation operations (Adapted from: Nixon et al. 2012).
WRM operations can greatly contribute to a safe and efficient transportation system and thus facilitate economic development by reducing logistics costs of firms and individuals. The U.S. alone spends $2.3 billion annually to keep highways clear of snow and ice, with another $5 billion estimated damage to the transportation infrastructure and natural environment (FHWA 2005). WRM operations have lasting economic, social and environmental impacts. They offer such benefits to the public and society as: fewer accidents, improved mobility, reduced travel costs, reduced fuel usage, sustained economic productivity, continued emergency services, etc. (Figure 1.3). An example of a winter storm hindering the U.S. economy occurred in 1996 when a blizzard shut down much of the northeastern U.S. for four days. The loss in production and in sales was estimated to be approximately $10 billion and $7 billion, respectively, without taking account of accidents, injuries or other associated costs (Salt Institute, 1999). A recent study for the National Research Council estimated the quantifiable benefits of winter highway maintenance by the Minnesota Department of Transportation (DOT) to be about $220 million per winter season, even without considering the risk of highway closures in the absence of winter operations (Ye et al. 2013).

Figure 1.3 WRM operations are vital to economy and society.
Sustainability in WRM operations has become a growing consideration over the past decade. Since a consensus has been reached that the principles of sustainability should guide all transportation design and operations, a variety of efforts have been conducted to follow this recognition. The U.S. FHWA has developed a practical, web-based collection of best practices that would assist state Departments of Transportation (DOTs) with integrating sustainability into their transportation system practices. Winter maintenance has emerged as a critical area for transportation sustainability (Nixon 2012; Nixon and Mark 2012; Nixon et al. 2012; Shi et al. 2013).

1.1.2 The Need for This Book

Winter road maintenance has always been an integral part of transportation operations for agencies that must deal with the impacts of adverse winter weather. Significant advances have been made in the various aspects of WRM operations, such as deicing/anti-icing materials, maintenance practices, equipment, and road weather and surface-condition monitoring. Most of these developments have been motivated by the need to provide a high level of service (LOS) and improve safety and mobility in a sustainable manner. However, currently there are no professional societies or scientific journals or textbooks dedicated solely to sustainable winter road operations and the key information is scattered across a variety of disciplines and in various forms of publications. As more agencies are exploring the impacts of WRM operations, including voluntary and regulatory controls to reduce their impacts, the development of a comprehensive book is timely to consolidate best practices and recent advances in sustainable WRM operations and to help reduce the cost and environmental footprint associated with WRM operations.

In this context, this book aims to bridge a significant knowledge gap and to address the pressing need for such a book for both education and workforce development. It will be the first book to provide a holistic perspective on the benefits and potential negative impacts of WRM operations while promoting environmental sustainability concepts and practices. This book will serve as essential reading for maintenance professionals in charge of snow and ice control operations on highways, local roads, etc. It will also serve as a textbook for senior elective or graduate-level courses, with outstanding potential for online education. Webinars and training modules could be developed using this book as the blueprint.

1.2 How the Chapters and Topics Are Organized

Following this introductory chapter, the rest of the book tackles the multiple dimensions of sustainable WRM operations. The individual chapters, while covering different topics related to WRM, are interrelated, with some serving as input to the others, as schematically illustrated in Figure 1.4. Chapter 2 provides a framework for assessing the life-cycle sustainability of salt application in winter maintenance operations. The framework integrates the triple bottom line of sustainability, i.e., economics, environmental stewardship and social progress in accounting for the direct and indirect costs, benefits and impacts over the entire life cycle of road salt. Chapter 3 provides a historical perspective detailing the important developments and evolutions in
materials, maintenance strategies, and equipment over the past three decades in advancing sustainable WRM operations. Chapter 4 discusses the societal and user expectations of WRM operations, as well as how agencies establish their LOS standards.

Chapter 5 provides an overview on how road weather services can greatly contribute to sustainable WRM operations. Chapter 6 discusses the fundamentals of plowing, anti-icing, deicing, and sanding operations, laying out the foundation for developing ways to improve the performance and sustainability of various maintenance treatments. Chapter 7 and Chapter 8 provide an overview of the methodologies that can be applied to understanding and quantifying the effects of winter weather and maintenance operations on road safety and mobility, respectively. Chapter 9 discusses the economic benefits of WRM operations and examines how they can be used in cost-benefit analysis of maintenance policies, programs and technology investment. Chapter 10 provides an overview of the environmental risks that some commonly used deicing/anti-icing materials may pose. Chapter 11 and Chapter 12 discuss the risks of WRM operations to the transportation infrastructure and motor vehicles, respectively, as well as the corresponding best practices to manage such risks.

Chapter 13 focuses on planning and management strategies for achieving sustainable WRM, such as network partitioning or districting, fleet sizing and mixing, siting of RWIS stations, and salt management. Chapter 14 discusses sustainability practices in the domain of source control tactics, including innovative snow fences for drift control, anti-icing, deicing and pre-wetting practices, maintenance decision support systems (MDSS), fixed automated spray technology (FAST), equipment maintenance and calibration, advanced snowplows and spreaders, and material and snow storage.
Chapter 15 discusses reactive approaches to reducing the environmental impacts of snow and ice control materials after their application on pavement. Chapter 16 focuses on the decision-making process for selecting the appropriate types of innovative equipment for WRM. Chapter 17 discusses the search for “greener” materials for WRM operations, with a focus on the development and evaluation of deicers. Chapter 18 provides an overview of pavement innovations that can reduce the need for chemicals or abrasives for WRM operations.

Chapter 19 describes the benefit of performance measurement in responsible and sustainable winter maintenance management, an overview of common performance measures, and how to overcome the challenges associated with analyzing winter operations performance. Chapter 20 presents a review of current snow and ice control methods and a guide for selecting an optimal application rate for specific weather, treatment and LOS requirements. Chapter 21 concludes the book with a look into the future in terms of the main challenges and opportunities and future research and development in sustainable WRM operations.

References


