# Adoption of best practices for the environmental management of road salt in Ontario

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## ABSTRACT

There are increasing concerns regarding the adverse environmental impacts of chloride from road salts. A web-based survey was conducted to determine how the Code of Practice for the environmental management of road salts has influenced the adoption of best practices in Ontario, Canada. The majority of large Ontario municipalities have salt management plans that adequately address safety and the environment. Most municipalities train a high percentage of permanent staff but only half of seasonal workers and 21% of private contractors are trained. Most training programs cover key learning goals defined by the Code of Practice. There is little improvement in the management of salt-vulnerable areas. Many existing snow disposal sites are poorly designed and do not manage snowmelt quality. The Code has strongly contributed to the adoption and improvement of salt management practices in Ontario by helping to standardize practices and advance the rate of implementation of best practices. Barriers to further implementation of the Code include understanding the Code, institutional will, liability, limited technical/financial resources and public expectation of high service levels. Further benefits can be achieved by aggressively promoting the Code and improving education and training programs for the public, private contractors and staff of road authorities.

**Key words** | Code of Practice, road salt management, salt management plans, salt-vulnerable areas

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## INTRODUCTION

The necessity to keep highways safe and fully operational in cold regions has led to the development of advanced winter road maintenance plans, which include applications of chemical deicers (mainly road salt, sodium chloride) and traction agents (sand and grit). The release of road salts to the environment has been estimated at 18 million tonnes/year in the USA (Corsi *et al*. 2010) and 5 million tonnes/year in Canada (Environment Canada and Health Canada 2001). In addition to annual use, temporal trends in road salt use are also of interest and indicate a continuing growth, driven by increasing population. Historically, increases in salt applications contributed to environmental effects of deicing salts and the first reports of these effects were reported in the 1970s (Field *et al*. 1974; Hanes *et al*. 1976). Similar concerns about road salt effects in Canada (Howard & Hayes 1997; Marsalek 1997; Rokosh *et al*. 1997; Mayer *et al*. 1998; Oberts *et al*. 2000; Williams *et al*. 2000) led to a comprehensive five-year scientific assessment of the environmental impacts of road salt to provide a state-of-the-art synthesis of scientific literature regarding the effects of road salt on the environment (Environment Canada and Health Canada 2001). The assessment concluded that, under the road management practices prevalent at that time, significant discharges of chloride from road salt were having adverse impacts on freshwater ecosystems, groundwater quality, drinking water supplies, soil, vegetation, wildlife and urban infrastructure in many regions of Canada. Furthermore, road salt impacts in urban areas were reported to be exacerbated by modern stormwater management or low impact development (LID) practices, including infiltration of chloride-laden runoff, use of storage in ponds, constructed wetlands, and oil and grit separators (Marsalek 2003).

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To address and mitigate the environmental impacts of road salt, a multi-stakeholder working group was formed to develop a risk management protocol for winter road maintenance. Accordingly, under the *Canadian Environmental Protection Act (1999)*, the Government of Canada published a document entitled a *Code of Practice for the Environmental Management of Road Salts* (Environment Canada 2004). This document was designed primarily to help municipalities and other road authorities better manage road salt use and reduce the adverse environmental impacts of chloride, while maintaining road safety. The document was intended for use in conjunction with the Salt Management Guide and Syntheses of Best Practices (SOBPs) developed by the Transportation Association of Canada (TAC) and related Federal, provincial, territorial or municipal maintenance standards. Specifically, the Code recommended that, on a voluntary basis, road authorities applying more than 500 tonnes of road salt per year develop salt management plans and implement best management practices for salt application, salt storage and snow disposal as reported in SOBPs. The nine SOBPs include TAC 1 *Salt Management Plans*, TAC 2 *Training*, TAC 3 *Road and Bridge Design*, TAC 4 *Drainage and Stormwater*, TAC 5 *Pavements and Salt Management*, TAC 6 *Vegetation Management*, TAC 7 *Design of Road Maintenance Yards*, TAC 8 *Snow Storage and Disposal* and TAC 9 *Winter Maintenance Technologies* (Transportation Association of Canada 2003). The Code recognizes the existence of 'salt-vulnerable areas' (SVAs) (Environment Canada 2004). These areas represent environments particularly sensitive to road salts that require additional salt management measures to mitigate the environmental effects of road salt in such areas. However, the Code does not address the use of road salt on parking lots and private property or its use as a dust suppressant (Environment Canada 2004).

The primary assumption of the Code of Practice is that, if state-of-the-art salt management practices are applied on a voluntary basis as per Code recommendations, both the environment and road authorities (i.e. more efficient operations, improved roadway safety and reduced costs) will benefit. While it is assumed that the best salt management practices are being applied and will result in environmental benefits, there is little information regarding the extent to which best practices designed for salt application, salt storage and snow disposal have been adopted and applied across the province of Ontario. Given this information need and its relevance to evaluate and optimize the environmental management of road salt, the objectives of this study are to: (1) determine the extent to which best practices as stated in the Code of Practice have been implemented since 2004 and are currently being used by Ontario road authorities, and (2) to identify barriers to their implementation. The reporting of this information extends beyond the scope of the voluntary annual reports submitted by Ontario municipalities as requested by the Code and provides additional documentation to the 2010 report on *Review of Progress Code of Practice* (Environment Canada 2010).

## METHODS

An online survey administered through the Ontario Good Road Association (OGRA) was developed to examine the extent to which specific best practices focusing on road salt management (TAC 1, 2, 7 and 8) have been systematically adopted and applied in Ontario since 2004 when the *Code of Practice for the Environmental Management of Road Salts* was released. Part of the survey was designed to identify barriers that prevent full implementation of best practices by road authorities. The survey was sent to 432 Ontario public works authorities that included 40 cities, 6 regional municipalities, 25 counties, 85 towns, 1 district and over 260 townships/villages and municipalities. Complete details of the survey are presented in a report entitled 'Assessing the efficacy of current road salt management programs' (Stone *et al.* 2010). The survey response rate was 16.3% (70/432) and reflects opinions from a range of officials including regional municipalities (20%), cities (19%), counties (13%), townships (19%) and towns (29%). The survey results are not normalized and hence give more weight to responses that reflect the opinions and concerns of larger municipalities that manage a significant proportion of road salt application in Ontario.

## RESULTS AND DISCUSSION

### Code of Practice

The Code of Practice identifies several critical elements that should be addressed and included in a salt management

plan (SMP). Respondents were asked to rate their plans with respect to the level of attention given to each of the nine underlying principles in the Code. Responses indicating a high level of attention given to the individual principles in SMPs are listed in Table 1. Four primary principles (safety, environmental protection, accountability and knowledge and skilled workforce) are considered to provide an adequate level of detail for analysis and decision-making. However, three secondary principles contributing to the sustainability and improvement of efforts (continual improvement, measurable progress and communications) were identified as requiring more attention. These principles are critical to ensure that SMPs remain current and are properly executed and sustained. Regular systematic reviews are required to implement these principles in SMPs.

## Salt management plans (SMPs)

On a voluntary basis, the Code of Practice recommends that all road authorities conducting winter road maintenance and using >500 tonnes of salt annually and applying salt in the vicinity of SVAs should prepare a SMP. Although the Code was published in 2004, the framework for SMPs was developed earlier and some road authorities began to implement best practices including salt management plans before 2004. Almost 30% of the respondents indicated they had developed a SMP to 2004. Nearly half of respondents had prepared plans in 2004–2005 but 18% had no plans until 2007–2009. The survey suggests that the Code effectively encouraged SMPs to be produced in Ontario and that many municipalities were proactive by developing plans before they were required. However, 5 years after the Code was published, several road authorities had not adopted nor implemented a SMP. The survey does not specify whether some authorities decided not to have a plan or whether they lacked the capacity to do so. When asked whether SMPs are being or will be reviewed, 43% of the respondents had not reviewed their plans but the remaining 57% had done so at least once or more than once. The majority of respondents reviewed their SMPs in 2007–2008 and over 90% indicated they intend to review their plans in the future.

**Table 1** | Self-assessment of salt management plans and Code of Practice principles

| Number | Plan principle (element) | Percent respondents indicating a high level of attention paid to individual SMP principles |
|---|---|---|
| 1 | Safety | 89 |
| 2 | Environmental protection | 78 |
| 3 | Continual improvement | 56 |
| 4 | Fiscal responsibility | 68 |
| 5 | Efficient transportation system | 68 |
| 6 | Accountability | 78 |
| 7 | Measurable progress | 46 |
| 8 | Communications | 43 |
| 9 | Knowledge and skilled workforce | 78 |

### SMP – contents

One section of the survey focused on subjects that are addressed in SMPs and examined plan content expectations prescribed by the Code. The survey shows that subjects most often included in SMPs are the amount of salt used, application rates, electronic spreader controllers, material storage, snow disposal, training, record keeping and equipment calibration. Conversely, subjects less frequently addressed included pre-wetting, application of liquid deicers only, use of Road Weather Information Systems (RWIS), identification of salt use in SVAs and monitoring progress in salt management and reporting to senior management and annual reviews.

Good progress is being made regarding the introduction of best practices such as the application of granular road salts but respondents indicate more progress is needed regarding advanced technologies, including pre-wetting (depends on accurate and timely weather forecasts), adjusting practices for SVAs, and applying management rigor to ensure that the intent of the plan is being achieved and that practices are continually being improved.

### SMP awareness

Many road authorities employ seasonal contractors and staff and it is important to ascertain whether seasonal workers are familiar with SMPs. About 55% of respondents hired contractors and seasonal staff but approximately 30% of

contractors and 57% of seasonal staff were aware of the SMPs. This result is not consistent with the expectation of the Code that road authorities should make contractors fully aware of SMPs. The survey suggests that few agencies are fully engaging and informing contractors and seasonal workers of their SMPs, which undermines the intent of these plans.

## Salt management training

The Code of Practice was implemented to promote a change in winter maintenance practices by encouraging the introduction of best salt management practices. Training is a critical component for the adoption of best management practices, particularly when trying to replace well-established conventional practices with the new, less familiar, ones. In Ontario, a number of new training programs have been implemented because of the Code of Practice. Two notable programs are: (1) a program developed by the Transportation Association of Canada, which ran aggressively for a few years (the program is still available on the TAC website for free download by agencies wishing to self-train), and (2) a road school and DVD-based training program developed by OGRA. The survey was designed to examine who is being trained, the extent of training, the topics covered and the preferred timing for salt management training. The following presents the results of the survey with respect to training.

### Who is trained and when?

Approximately 55% of the respondents have annual training programs and 63% of respondents with SMPs have annual salt management training programs. The availability of SMPs does not fully encourage implementation of training programs. While the survey suggests that continued effort is required to improve the quality and frequency of training programs, it is important to note that a considerable amount of training has occurred in agencies across Ontario since the Code was developed.

Respondents indicated that operators (97%), supervisors (79%) and managers (76%) are trained but only 52% of seasonal staff (although not all seasonal staff work on winter road maintenance) and 21% of contractors are trained. Sixty-nine percent of respondents report they monitor compliance with learning goals and 66% reported that performance was in compliance with their learning goals. Most (86%) agencies retrain when performance is not being met and only 31% have a different training program for previously trained personnel. All respondents (100%) conduct their salt management training program in the fall. A variety of learning techniques are used in the training programs, including oral presentations (100%), visual aids (72%), group discussions (79%) and hands on practical applications (76%).

### Topics being covered

The Code encourages training for all personnel that either manage or perform winter maintenance activities. In particular, the *Synthesis of Best Practices – Training* identifies a number of learning goals that should be included in salt management training programs. The survey asked respondents to identify which learning goals are covered in their training program. The respondents (75%) indicated that most of the learning goals are met to a high degree. Over 95% reported that training programs included a review of the environmental effects of salt on the environment and infrastructure.

Some learning goals that are addressed with a moderate frequency (50–75%) include:

- Understanding dew point and the conditions that lead to frost and black ice formation (69%).
- Understanding the concept of freeze point depressant (58%).
- Understanding the use of liquid deicers (69%) which is particularly important for organizations using liquids. Accordingly, not training in this area likely impedes further usage of liquid deicers, which may be particularly important for applying pre-wetting.
- Managing snow disposal facilities (58%). It is not surprising that this percentage is low because few road authorities have properly designed snow disposal sites and any training related to these sites would most likely be directed towards staff that manages these sites. However, 30 respondents indicated that they have engineered snow disposal sites and only 15 indicated they train in this area.

- Two-thirds (66%) of respondents indicated that they make snow and ice control decisions based on pavement temperature. Approximately the same percentage (62–65%) indicated that they include information about pavement temperatures in training. It is important for winter maintenance staff to understand the importance of pavement temperatures when making snow and ice control decisions.

Only three learning goals were poorly addressed in less than 50% of respondents' training programs. They are:

- Understand the phase diagram (42%). Although this concept may be difficult to explain to a non-specialist audience, it is important to understand the science of salt use and should be considered an essential part of training.
- Understand how to measure brine concentration (31%), but 80% of agencies making brine teach how to measure brine concentration.
- Understanding how to read and interpret RWIS data (42%). In Ontario this knowledge is required as a prerequisite to accessing RWIS data and should be part of any training program in which supervisors utilize these data. The OGRA has developed an excellent computer-based RWIS training program.

## Salt handling in maintenance yards

The response rate to questions about construction of new yards (TAC 7 *Design of Road Maintenance Yards*) was low (only seven respondents) and only a brief summary of responses is included here. Respondents expressed the need to conduct environmental assessments as part of the planning process for new yard development and increase general awareness of TAC SOBP 7. Among the limited responses received, most (86–100%) road maintenance materials are covered and stored on impermeable pads. The survey suggests that, at most yards, spreaders are not overloaded, spills are cleaned up, salt is unloaded directly inside salt storage facilities and vehicle wash water is managed. About half of the respondents weighed vehicles to measure salt use. Only 15% of the respondents reported use of salt-impacted water for brine production or were aware of environmental monitoring programs.

## Snow storage and disposal

Among the 49 survey respondents, 30 (61%) reported they operate an engineered snow storage and disposal facility. One respondent operating a recently developed snow disposal facility indicated an environmental assessment of the facility was not conducted during the planning process, nor was the TAC SOBP for snow storage and disposal followed because they were not aware that it existed. Concerning the design of snow storage and disposal facilities, only about one-sixth of the sites were designed with snow storage on impermeable hard surfaces and all but one provided some meltwater treatment in tanks or ponds. Site debris was reportedly cleaned up in 73% of all cases and properly disposed of when snow melting operations stopped in the spring. The survey results indicate that the TAC SOBP on snow storage and disposal should be more strongly promoted so that site operators fully understand the potential environmental effects of snowmelt on groundwater and surface waters. Runoff from snow storage/disposal sites contains a variety of pollutants (Stone *et al.* 2010; Exall *et al.* 2011), that cause environmental impacts such as high levels of total suspended solids (TSS) contributing to the impairment of aquatic habitats, formation of sediment banks by the outfalls, reduced dissolved oxygen levels, toxicity caused by concentrations of chloride and other chemicals (e.g. dissolved metals), and nutrient loads. Hence to mitigate further risk of such impacts, snow storage sites should be properly designed and equipped with a snowmelt/runoff treatment train and considerations should be given to where the treated flow is discharged.

## Salt-vulnerable areas

The Code of Practice applies to '*organizations that have vulnerable areas in their territory that could be potentially impacted by road salts*'. Annex B of the Code provides guidance to identify characteristics of vulnerable areas that include high road salt inputs to receiving waters, formation of densimetric stratification impairing vertical mixing of water, chloride concentrations exceeding chronic or acute toxicity levels, adverse effects on native or agricultural vegetation, harming the integrity of a life cycle, harming habitats of wildlife species at risk, discharge of chloride into sources of drinking waters

and impacting on the groundwater recharge zone. Annex B of the Code also identifies preferred salt management best practices for vulnerable areas. Three questions in the survey were asked to determine how the issue of managing SVAs is currently addressed. Approximately one-half of the respondents indicated they have documentation (policies, procedures and guidelines) for SVAs and that they modify winter maintenance practices in SVAs. Recognizing that the protection of SVAs is the primary objective of the Code, the survey suggests that this aspect of salt management requires significant improvement by road authorities. Suggestions for improvement include increasing awareness of SVAs in existing documentation and training materials, re-designing training programs specifically related to identify and examine winter road maintenance measures in SVAs. Additionally, it will be necessary to more fully measure knowledge of maintenance staff (permanent and temporary) and private contractors to improve environmental protection in SVAs.

## Record keeping

Winter road maintenance practice can only be improved if it is properly documented by monitoring and record keeping. The survey asked the question: 'Does your organization monitor and keep records of winter maintenance activities?' Ninety-six percent of the respondents reportedly keep records but the detail of these records varied considerably. Records that most respondents keep are: annual salt use (87%), road condition (85%), air temperatures (75%), current weather conditions (68%), pavement temperatures (62%), application rates (60%), daily salt use (55%), treatment strategies (21%) and pavement temperature trends (6%).

The survey suggests that detailed salt use records are not being maintained by a high percentage of respondents. Failure to maintain detailed records of winter maintenance makes it difficult to audit existing winter maintenance practices for program improvement and to defend against possible lawsuits alleging neglect of maintenance.

## The Code of Practice: reporting, benefits and challenges

The Code of Practice requests that road maintenance authorities 'should' provide annual reports to Environment Canada. The survey respondents were asked if they had, or intended to, complete and submit their Environment Canada report before the end of June. Seventy-nine percent of the respondents indicated that they would comply with Environment Canada's reporting requirements but 21% did not plan to file reports. Regarding benefits and compliance challenges of the Code, the respondents indicated it had raised the awareness and knowledge of road salting issues with respect to: the amount of road salt being used, the negative impacts of excessive salt on the environment, potential savings on operating expenses achieved by reducing salt use, and the understanding and use of best salt management practices. Furthermore, the Code provided leverage with council and management to obtain the necessary funding and commitment to implement best practices.

The respondents indicated the Code was particularly helpful to design and implement the framework and standardized approach for salt management. This information was considered helpful for the continuous improvement of practices such as: establishing a common benchmark that road authorities can work towards, standardizing the amount of road salts being used and providing guidelines for reducing salt application, providing a common understanding of road salting, providing objectives to serve as a benchmark, providing a tool for tracking salt best practices and undertaking regular reviews of winter control procedures and operations (as required by the Code).

The Code helped to implement improved practices by: requiring road authorities to examine and monitor different methods of winter road maintenance, improving the planning and control of road treatment practices and salt use, encouraging better record keeping that helps road authorities achieve progress, increasing coverage of stored materials and improved salt handling practices, increasing the adoption rate of new technologies, encouraging the greater use and preparation of liquid deicers, encouraging sand/salt mixes reducing salt applications and choosing from a wide variety of road salting methods.

Other benefits of the Code include achieving environmental improvements arising from the reduced amounts of chloride entering the environment without reducing the level of service with respect to road safety and achieving cost savings by optimizing salt application. The Code improved monitoring of salt use and maintenance

procedures in general as well as the annual review and updating of salt management plans.

## Barriers to implementation of the Code of Practice

Forty-eight respondents (69%) commented on challenges related to complying with the Code. The main barriers reported included understanding the Code, institutional inertia and liability, limited resources and public expectation of high levels of services.

### Understanding the Code

Respondents identified the critical need for clear direction and training on what is required by a SMP. They indicated that a considerable amount of time is required to clarify ambiguities which are further exacerbated by continual upgrades to the Code. While the Code provides an effective planning framework, it is considered to be very time-consuming to clarify specific details of strategies required to effectively manage salt and to meet the requirements of the Code. Better planning mechanisms and information sources specifically designed to meet this challenge are required.

### Institutional will

Respondents reported that it can be difficult to convince staff that there are alternative winter maintenance practice solutions and that winter road maintenance procedures must be chosen according to the existing conditions. There appears to be some resistance to changing old practices/habits. Before the Code was introduced, there was no incentive to keep proper snow removal/disposal operation records. Some respondents expressed concerns about the effect of changing snow removal practices on liability for traffic accidents or personal injuries in parking lots. The respondents felt it was important to make politicians and decision-makers fully aware of the benefits of the Code and the need to meet its performance expectations.

### Securing adequate resources

The greatest challenge reported by the respondents was obtaining sufficient resources to fully implement the Code of Practice. Limited funding adversely affected continuous training or retraining of staff and purchase of the most advanced snow removal equipment, while providing the level of service expected by the public. The cost of acquiring new equipment is increasing with advances in technology. Other resources including staff time and operations and management financial support are needed to comply with new requirements introduced by the Code, particularly during the initial implementation. Such resources have to be allocated in competition with many other municipal programs and under uncertain conditions created by broadly varying winter conditions and the associated road maintenance requirements. Respondents indicated that the essential pre-requisite for securing funding to implement the Code was winning the support of politicians (municipal councils) and decision-makers.

### Public expectations for level of service

Expectations of the public to receive the best level of service regardless of the snow event severity and the demand to apply chemical deicers are challenges to fully implementing the Code. In some cases, the implementation of progressive salt management practices resulted in scaling back traditional levels of service which undoubtedly has been extremely difficult for both staff and the public to accept.

### Need for continuous training/education

The Code promotes the use of a variety of winter road maintenance measures to respond to a range of anticipated weather conditions. These measures are continually changing, as new information and equipment become available. Accordingly, there is an ongoing need to initially train and subsequently upgrade permanent staff, as well as contractors and seasonal workers. Many respondents indicated awareness, education and training as the greatest challenges for implementation of the Code. In order for the Code to be effective, it is essential to fully train maintenance equipment operators.

Other challenges listed by the respondents included determining optimal salting rates that effectively maintain traffic safety (there is a tendency to apply more salt, particularly in parking lots, to reduce accident/injury liabilities)

and finding cost-effective ways to monitor salt use. Considerable variation in winter road conditions makes the planning, budgeting and assessing the effectiveness of winter road maintenance very challenging. Some respondents report that their operations have difficulty responding to rapid changes in the weather. A final challenge is related to the proper delineation of SVAs. Such information is required under the *Source Water Protection Act* to identify SVAs and develop an appropriate strategy to reduce the potential impact of chloride from road salt on important recharge areas in the province of Ontario.

## CONCLUSIONS

The *Code of Practice for Environmental Management of Road Salts* has had a major impact on winter road maintenance procedures related to road salting and snow removal/disposal in Ontario. It has been widely adopted by Ontario municipalities and 89% of the respondents which are predominantly larger municipalities have SMPs. Salt management plans include the principles of safety, environmental protection and accountability but often do not include provisions for continual improvement nor measurement of progress and communication. Salt management plans, once in place, are often not reviewed. The level of communication and training for private contractors and seasonal staff regarding SMPs is relatively poor. The Code has improved salt management training of road authority employees responsible for winter road maintenance. In particular, the efforts of the Ontario Good Roads Association and the Ontario Road Salt Management Group in this regard are notable. Although record-keeping has improved since the introduction of the Code and its requirement for annual reporting, many road authorities do not keep records. The Code has increased awareness of the SVAs. Policies for winter maintenance practices in proximity to these areas are slowly being developed but increased technical capacity is required to delineate these areas. Since the Code was developed, the greatest improvement has been in the areas of salt storage and handling. The least improved areas are management of salt-impacted water and environmental monitoring. There is a lack of awareness of this SOBP and more promotion is warranted. Approximately 61% of municipalities have snow disposal sites but most are not designed in accordance with the Code or the SOBP. Concerns and challenges regarding implementation of the Code arise from a lack of understanding or acceptance of the need for salt management. Changes in personnel at the staff, management and political levels may negatively impact the level of commitment to salt management and consequently. Environment Canada is currently completing a five-year review of the progress achieved under the *Code of Practice for the Environmental Management of Road Salts* as described under the 1999 Canadian Environmental Protection Act. The objective of the review is to determine the extent to which the Code has prevented and reduced the environmental impacts of road salts in Canada. The report will provide guidance to identify and implement future actions, if any, that will be needed to achieve environmental protection objectives.

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