

Highway Salt: Bargain of the Century

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Winter ice and snow threaten to impede highway transportation less than ten percent of the total time roadways are used to deliver people and goods to their destinations. Maintaining roadway access and safety during those weather-impacted hours, however, can consume as much as half the entire maintenance budget for highway agencies. Even so, the investment in effective snowfighting – featuring use of sodium chloride for anti-icing and deicing to preserve or restore safe surface conditions – is repaid more than 80 times over as crashes and injuries are avoided, emergency vehicles respond in timely fashion, school buses deliver students safely, workers and shoppers reach their destinations and businesses and industries remain in productive operation.

Because the winter maintenance budget is so large – an estimated \$1.5 billion annually in the U.S., for example – it is frequently the target of budget-cutting scrutiny. This compendium of evidence describing the benefits of snowfighting efforts – and the enormous costs inflicted by inadequate snow removal and ice control – provides a useful tool to transportation system decision-makers as they allocate resources in their communities. If public administrators understand the benefits of effective winter maintenance, they will support snowfighting and reap for the traveling public the safety and mobility benefits and economic security for their community. Furthermore, informed transportation system decision-makers will realize the benefits of improving the level of winter roadway maintenance service, further enhancing the benefits derived from the use of highway salt.

1. INTRODUCTION

Winter ice and snow threaten to impede highway transportation less than ten percent of the total time roadways are used to deliver people and goods to their destinations. Maintaining roadways access and safety during those weather-impacted hours, however, can consume as much as half the entire maintenance budget for highway agencies.¹ Government expenditures face increasing scrutiny. Understanding why winter maintenance is performed and the benefits which accrue through effective snowfighting will not only defend winter maintenance budgets, but create a demand and expectation by the driving public that winter roads be kept safe and passable.

2. VALUING MOBILITY AND SAFETY

Agencies responsible for operating roadway systems are being asked for performance reports on

their stewardships. "Road administration's role is increasingly seen as contributing to quality of life, quality of the environment and to the economic performance of both public and private sectors," concludes a recent summary of the work of a Scientific Expert Group convened by the Organization for Economic Cooperation and Development (OECD) and reported by the World Bank.² Thus, considerations for traffic volume and even gross measures of economic contribution by our highway infrastructure are being replaced by more specific performance measures of access, reliability, congestion and safety. "Consumer-defined service quality" measures focus on delivering customer satisfaction to drivers and highway-dependent manufacturers and businesses. In the realm of snow and ice control, Rod Pletan of the Minnesota Department of Transportation terms the development "Managing Winter Maintenance Through The Eyes Of The Customer."³ His agency has gone so far as to conduct public opinion polls of

Minnesota drivers on their satisfaction with snowfighting effectiveness. Our new road weather information technologies, can be coupled with remote modem communications capabilities. They, are rapidly moving us towards the time when drivers can get real time reports on how well snowfighters are doing their jobs – not just reports of when and how many trucks are dispatched or how many tons of salt are applied, but real time reports on whether the roadway is slippery or traffic is congested.

Performance measurement of snowfighting effectiveness and the general operating performance of our highway infrastructure, in turn, will create an informed constituency demanding high levels of winter maintenance service. This constituency will demand the promised benefits of investing in snowfighting. Those benefits are improved safety and mobility.

3. BENEFITS OF SNOWFIGHTING

3.1 Safety

"It's No Accident" is the theme of the current Roadway Safety Foundation safe roads promotion. Snowfighting is no accident. We do it on purpose. And that purpose is to preserve the benefits of safety and mobility on our roadways. The public – drivers, leaders in both the public and private sector, and taxpayers – need frequent reminders of the critical contributions of roadway safety and mobility and the crucial role of effective snowfighting to combat winter snow and ice.

Safety is the public's top concern. Personal injuries, deaths and the direct property losses from traffic accidents are readily perceived. Total traffic crashes are responsible for more than \$135 billion in losses in the U.S. each year. That untreated winter roads contribute to the toll is intuitive, but often unexamined. Serious studies over a number of years, however, confirm the link. The Chicago Citizens Traffic Safety Board determined snow and ice were associated with 12,628 storm-related crashes in that city during the winter of 1963-64, about 80% of the 15,499 total and that snowfighting prevented 19,620 additional crashes, a 61% reduction.⁴ Likewise, an analysis of data from 9 counties in the State of Michigan, 1964-69, found a strong inverse relationship between salt usage and

the percentage of accidents occurring under icy conditions as illustrated in Figure 1.⁵

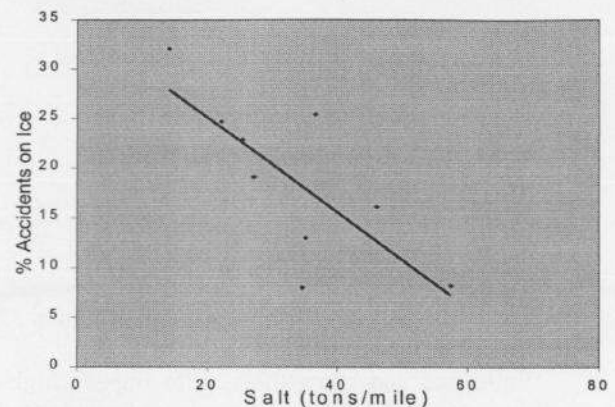


Figure 1

Insurance companies certainly took notice of a 1977 Utah study that estimated a \$200 million in annual property damage losses in a state which then had about a million population.⁶

Broader, more rigorous studies have been undertaken in the past 15 years, first in Germany and then in the United States. In Germany, Horst Hanke and Christoph Levin studied 4,700 accidents on four roadway segments totaling 650 km; the accidents produced 1,900 injuries and about \$90 million (US) in property damage.⁷ Comparing accident data with records of more than 7,000 winter highway maintenance operations, their analysis identified trends in the 12 hours immediately preceding and following the application of salt. Unsurprisingly, application of salt led to a 73% reduction in accidents and a 78% drop in serious injuries and fatalities.⁸ That severity as well as incidence improved with winter maintenance contradicted conventional wisdom that accidents on snow and ice were minor "fender bender" incidents. In the U.S., the Salt Institute commissioned David Kuemmel and Rashad Hanbali to do a study following the Hanke-Levin methodology. They studied 4,599 accidents on 111 randomly-selected segments totalling 800 km of roadways in four states.⁹ Their findings confirmed the German study; in fact, the accident reductions they found were even more impressive – an 85% reduction in overall accidents and 88.3% drop in injury-causing crashes. Figure 2 shows how closely the German and American studies tracked during the twelve hours before and after salt was

applied. The Kuemmel-Hanbali peak is immediately before the salt application.

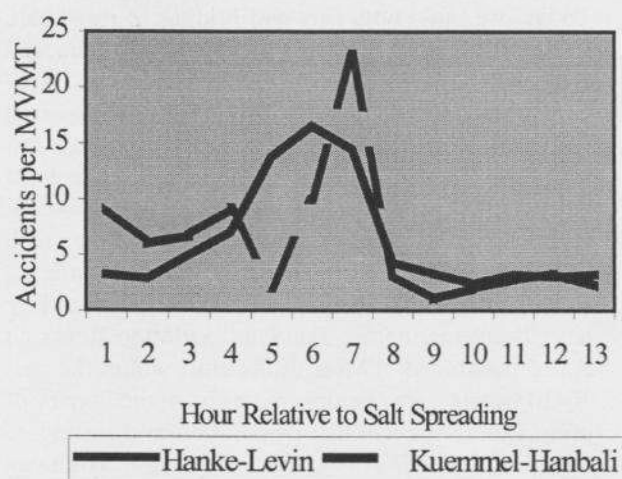


Figure 2

Of course, *how* winter maintenance is performed also has safety implications. The safety benefits of road salting were confirmed in a study in the Kuopio, Finland road district, 1992-94, where the road authority experimented with reduced roadway salting, substituting sand except during "worst conditions" when salt was used. The researchers concluded that slippery surfaces were twice as prevalent and injury accidents jumped 20%¹⁰ and, therefore, recommended against reduced salting. Another Salt Institute-sponsored study by Kuemmel and Quazi Bari, this time of the safety benefits of using sand-salt mixtures during those same two winters on 881 km of roadways in four U.S. states, confirmed the superiority of a straight salt strategy.¹¹ Clearly, the lower "level of service" using sand translated into more crashes, injuries and fatalities.

3.2 Mobility

Time is money; in some cases, even life itself. Modern economies depend on their transportation infrastructure. Workers need to get to work. Raw materials and finished goods must be delivered, sometimes "just-in-time." And delivery of emergency medical response to victims of heart attacks, burns, poisonings, traffic crashes, and accidents at home and work is critically dependent on access and use of our roadway system. When snow and ice restrict or deny the use of our

roadways, paychecks get cut, retail sales are lost, industrial production and business productivity are interrupted – and people die waiting for ambulances, fire trucks or police response. Inadequate winter maintenance also wastes fuel, an estimated billion gallons each winter in the U.S.¹² The conclusion is intuitive, but the documentation is impressive – and available to establish the foundation for effective management policies balancing costs and benefits.

The Chicago study calculated over \$5 million in "excess costs" to the public due to icy and snowy roads in 1964.¹³ Further north, the City of Milwaukee, in 1979, estimated the cost of a week of immobilizing snow and ice at \$39 million.¹⁴ The Town of Markham, Ontario studied the impacts of snow and ice on the Metro Toronto area in 1991 and reported a \$59.5 million (Canadian) economic impact.¹⁵ The German study estimated ice and snow increased travel delay costs by 30% and vehicle operating costs by over 10%.¹⁶ Nationwide in the U.S., a 1976 study by Brenner and Moshman, commissioned by the Salt Institute, put the losses during an average winter at \$18.4 billion.¹⁷

A new, late 1998, study in the North American snowbelt,¹⁸ conducted by the consulting firm Standard and Poor's DRI for the Salt Institute, is the best available documentation of the economic value of snowfighting. S&P concluded that failure to get snowplows out and salt on the roads **during a single day** of a winter storm costs almost three times more in lost wages than the total **annual** costs for snowfighting. In fact, a blizzard blanketing just 12 U.S. states¹⁹ could cost federal, state and local tax collectors \$526.4 million, more than the total annual snowfighting cost in those states, \$518.7 million. A crippling snowstorm costs \$1.4 billion per day in unearned wages and \$600 million per day in lost retail sales. In the harsher Canadian environment, the **daily** loss in wages, lost retail sales and federal and provincial tax revenues would total \$417 million (Canadian) in Ontario and Quebec compared to **annual** snowfighting expenditures of \$282.3 million (Canadian). Keep in mind, that is a comparison of **daily** benefits versus **annual** costs. Then do the math: there are 20-30 storms in Chicago each winter which require snowfighting response, 40 in New York and winter weather seems never-ceasing in Toronto and Montreal. Table 1 illustrates the

benefits versus costs (in billions) in these 12 states and 2 provinces.

Annual Costs	Daily Benefits	Annual Benefits (20 storms)
\$ 0.701	\$2.942	\$58.84

Table 1

Even these dramatic figures are conservative. They do not include the safety-related vehicle crash costs discussed earlier: fatalities, injuries and property damage, and increased health and insurance costs. They confirm an independent analysis by First Union Corporation²⁰ assessing the economic costs of the Blizzard of 1996 which shut down the Northeast corridor of the U.S. from Virginia to Massachusetts at about \$4.8 billion per day in goods and services produced by factories, offices, shops, and other enterprises. Standard & Poor's DRI agreed. They calculated that the four-day blizzard shutdown cost the Eastern states as much as \$10 billion in lost production and \$7 billion in lost sales.²¹ This is an important study by a prestigious group of economists. The full results and detailed methodology are available on the Salt Institute's website at <http://www.saltinstitute.org>.

4. COSTS OF SNOWFIGHTING

Each year, American highway agencies spend about \$1.5 billion in their snowfighting programs.²² About one-third of these direct costs is for chemical deicers and 95% of that for sodium chloride.²³ The remaining costs are labor, equipment and administration.

In addition, there are significant "indirect" costs – corrosion impacts on vehicles, pavements and bridges, parking garages and underground utilities and environmental damage to vegetation, soil and surface water.²⁴ In 1976, direct costs were estimated to be about one-fourth the indirect costs.²⁵ Today, estimated corrosion damages would likely a much larger portion of a much smaller total due to enormous progress in "salt-proofing" vehicles and the roadway environment.

4.1 Corrosion

In 1976, vehicle corrosion represented 80% of the total indirect costs of using highway salt; virtually all the rest was damage to highway bridge decks.²⁶ Today, we build both cars and bridges to resist salt. In 1976, for example, 90% of 6-year-old cars had corrosion damage. By 1997, less than 1% were corrosion-damaged.²⁷ Of course, some of this cost has been "privatized" by car owners washing and otherwise caring better for their more-expensive vehicles. Roads and bridges are more corrosion-resistant too. Use of epoxy-coated reinforcing steel, cathodic protection, membranes, and mixing concrete with admixtures to reduce permeability have been important. The Transportation Research Board concluded: "Most decks built within the past 10-20 years are equipped with some type of protection to prevent salt penetration and rusting of rebars."²⁸ The (U.S.) Federal Highway Administration forecasts that new bridges and parking structures will endure 75-100 years.²⁹ Nevertheless, there are many older bridges that require repair and maintenance with an estimated annual cost of \$125 - 325 million.

4.2 Environment

Most instances of environmental contamination from the storage and use of highway salt are site-specific. After finishing its vital lifesaving function on the roadway surface, salt enters the roadway environment, usually into groundwater or surface water, as it begins its journey back to the sea. Salt has been implicated in degraded taste of shallow roadside wells, but has not been found to imperil the vitality of any species of plant or animal. Most highway agencies in snowbelt regions routinely select salt-tolerant grasses, shrubs and trees for plantings in rights-of-way; and traffic safety groups are campaigning strongly for removal of roadside trees as a safety hazard. New evidence suggests the likelihood we will soon be able to genetically engineer even more salt tolerant species of vegetation.³⁰ While soil is impacted with 4-5 meters of the roadway, sometimes winds carry airborne salt particles up to 30 meters from the paved surface.³¹ An ongoing environmental assessment of road salt by Environment Canada³² may produce additional relevant data and may be released before the Symposium.

There are other minor "costs" associated with snowfighting including property damage or injuries caused by snowfighters or which they suffer in the course of performing winter maintenance and, of course, the "privatized" cost to homeowners and businesses to shovel out driveways which may be blocked by snow plowed during the course of clearing public roads.

All these costs need to be weighed, then, against the benefits achievable through effective winter maintenance.

5. BENEFIT-COST OF SNOWFIGHTING

Every study comparing the benefits against the costs of applying salt in winter maintenance concludes that snowfighting is well-justified. Brenner and Moshman assign an overall 18:1 benefit:cost ratio for salt-based winter maintenance.³³ Hanke and Levin calculated a 2.16:1 ratio in the first hour after salt was applied; the operation paid for itself by the time 140 vehicles used the roadway.³⁴ Kuemmel and Hanbali calculated a 6.5:1 short term benefit:cost ratio, with costs being recovered within 25-35 minutes after applying salt, depending on type of roadway.³⁵ Kuemmel and Bari, in their comparative study of straight salt and sand-salt mixtures, determined for two-lane roads a benefit:cost ratio for the sand-salt of only 1:0.8 after 12 hours (e.g. sanding did not even recover its costs) compared to a 12:1 benefit:cost ratio at 12 hours using straight salt. For freeways, it took 5-6 hours for the sand-salt operation to generate benefits to cover its costs; highways using straight salt recovered their costs in just 35 minutes.³⁶ Finally, assuming an average of 20 snowstorms per winter, the Standard and Poor's DRI economists conservatively calculate a 84:1 benefit:cost ratio (\$59 billion in benefits against \$700 million in snowfighting costs in their selected states and provinces).³⁷ Quite a bargain!

The benefit:cost ratio can be improved by "Sensible Salting" practices which ensure safe salt storage and application rates. "Just enough and no more" is sound policy. Likewise, the benefit:cost ratio can be further improved as engineers continue to refine the corrosion resistance of vehicles and the roadway environment and we are more diligent in designing roadways to channel saline runoff away

from environmentally-sensitive areas and assure a salt-tolerant roadway environment.

6. CONCLUSION: DEICING SALT: BARGAIN OF THE CENTURY

Winter storms may be unpredictable and unique, but investments in professional snowfighting can keep snow- and ice-storms from paralyzing local economies, keeping children home from school and preventing emergency vehicles from making their lifesaving trips. Good winter maintenance keeps the roads open and saves lives. Snowfighting may be the single most cost-effective investment of our highway tax dollars, returning at least \$70 in benefits for every dollar spent.

The future of transportation infrastructure, particularly roadways, will feature two strong trends: 1) greater attention to customer needs and expectations and, closely related, 2) close management attention to system performance – a concern for outcomes such as how well roadways deliver people and goods to their intended destinations safely, efficiently and reliably on schedule. Intelligent transportation systems will be able to generate mountains of data. Our challenge will be to collect the *right data* in a *timely fashion* enabling us to know when challenges such as ice- and snow-events imperil safety and mobility, allowing us to select and use the most cost-effective countermeasures to protect public safety and assure economic security. Salt will be there, time-tested and available to provide its lifesaving benefit.

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