Deicers – Water Resource Threat?

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PRESENTATION OUTLINE

- Safety and Use
- Environmental Impacts
- Deicers
- Technologies/BMP’s
- New Publications
- References and Publications

Deicing

- $2 billion spent annually for snow and ice control
  - $22.7 million average per State

Without Deicing

A pile-up of 100 vehicles during a storm on March 6, 2003, on Interstate 95 just outside Boston, Massachusetts. Ten miles of the interstate were closed while the vehicles were cleared from the road. SOURCE: Boston Globe.

Why Do We Need Deicers?

- In 2001 (Goodwin, 2003)
  - 110,072 crashes on snowy roads
    - 95,000 injuries
    - 1,100 deaths
  - 183,377 crashes during snowfall
    - 62,000 injuries
    - 790 deaths

Deicers and Water Quality

- States report chloride conc. increases of up to 100x in surface waters from road salting during peak seasons, however, in most cases dilution keeps levels were below WQC.
- When application rates are high and dilution is low, numerous exceedances of EPA criteria and water quality standards (in States with chloride standards)

Water Quality Impacts

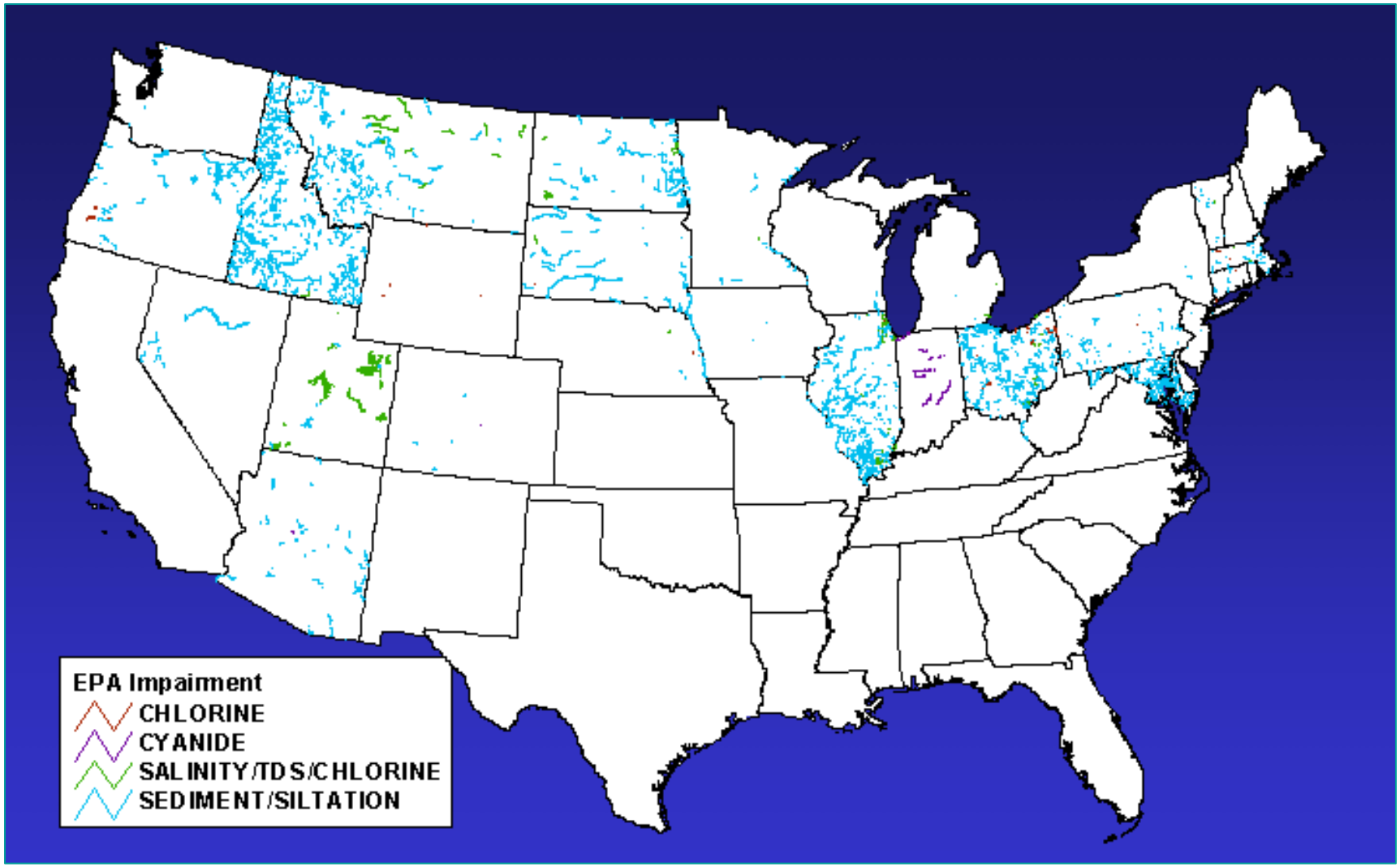
- Chloride EPA Criteria:
- 230 mg/l (96 hours or more)
- 860 mg/l (one hour)
- LC50s with NaCl (conc. 1,440-6,031 mg/l)

  - 17 species of fish, amphibians, and crustaceans (7 day exposure)

303(d) Listings

- Chlorides
- Total dissolved solids
- TSS/sediments
- BOD
- Cyanide

303(d) Impaired Waters



303(d) Listings

- Nationwide: 977 listings for Salinity/Chlorides/TDS
- Major Causes: Agricultural return flows, oil field brines
- New Hampshire 2004 list approved June 10th, Region added 5 chloride impaired waters along I-93

Established TMDLs

PARAMETER	# of 303(d)-Listed Segments in Snowbelt States
BOD	62
CHLORIDE	4
CHLORIDES	8
CYANIDE	12
ETHYLENE GLYCOL	2
SALINITY	8
SEDIMENT	167
SEDIMENT/SILTATION	7
SUSPENDED SOLIDS	23
TOTAL DISSOLVED SOLIDS	7
TOTAL SUSPENDED SOLIDS	28

Sodium Chloride

Advantages

- Low cost ($30-40/ton)
- Readily available

Disadvantages

- Impact on the environment
- Corrosivity

Impacts of Road Salt

Soils	Na can bind to soil particles, break down soil structure, and decrease permeability. Cl is not adsorbed on soils but it can form complexes with heavy metals in the soil, releasing them
Vegetation	Salt spray/splash can cause leaf scorch and browning or dieback of new plant growth up to 50 feet from the road. Osmotic stress can be caused by uptake of NaCl. Grass is more tolerant than trees and woody plants. Red and white pines, balsam fir, red and sugar maples, and pin and red oaks are salt sensitive.
Ground water	Mobile Na and Cl ions readily reach groundwater and concentration levels can increase temporarily in areas of low flow during spring thaws. Shallow wells near roadways are most vulnerable.
Surface water	Can cause density stratification in small lakes having closed basins, potentially leading to anoxia in lake bottoms.
Aquatic biota	No effect in large or flowing bodies at amounts expected from current road salting practices. Small streams that are endpoints for runoff can receive harmful concentrations of Cl. Cl from NaCl is generally not toxic until it reaches levels of 1,000-36,000 ppm.

Vegetation

- Proper application has minimal impact
- Excess application causes dieback and browning from 50 ft to 600 ft from roadway.
- Multiple factors
  - Frequency
  - Runoff
  - Etc.

NH I-93 Water Quality Impacts

- Nine streams violate the state's standards for chloride
- Toxic impacts:
  - kills frog and salamander eggs
  - increases metal toxicity in lakes
  - increases health risk for people with high blood pressure
- Standard water quality treatment approaches do little to address the problem
- Existing ground water chloride levels are very high from many years of heavy salt use

EPA Source Water Fact Sheet (August 2002)

- Protect reservoirs and drinking water supplies near treated highways/storage sites
- No MCL or Health Advisory for Na. Equivalent level of 20 mg/l (guidance)
- Cl Secondary Standard (Taste and Odor) is 250 mg/l

Canadian Assessments

- Univ. of Toronto study: 45% of salt applied runs off, the rest goes to shallow aquifers. Trends if continued will exceed safe levels
- Greatest levels from salt storage areas, > 1000 mg/l.
- Aquatic toxicity is of most concern

A Few Well Problems

- New Hampshire, Michigan, from salt storage (One instance each)
- Muskegon from applied road salts

  (sandy, unconfined aquifers)
- No or low risk to human heath is common. Sodium sensitive people?
- We can taste it before it harms us.

THE LATEST STUDY

- Salt, chloride levels in groundwater are increasing in the NE US based on 30 years of data (Sept 20, 2005 Proceedings of the National Academy of Sciences)
- During **some** winter months Cl can be 5 mg/l, which is 25% of seawater concentrations.
- **IF** trend continues many surface water may be unfit for humans and toxic to **SOME** aquatic life

Alternative Deicers

- Chlorides
  - Magnesium Chloride (MgCl
  - Potassium Chloride (KCl)
  - Calcium Chloride ($CaCl_2$)
- Organic Products
  - CMA ($CaMgC_2H_3O_2$)
- Blends of deicers (salts/sands/other)
- Glycols (mostly used in airport/runway deicing)
- Urea, Sand, Soot, Rock Salt, Etc.


PHOTO: RIVERKEEPER

Alternative Deicers

Advantages

- Reduced corrosivity
- Reduced impact on the environment
- $CaCl_2$ can be used in very low temperatures (-20ºF)

Disadvantages

- Higher cost (from hundreds to thousands of dollars per ton)
- CMA starts to act at a slower rate than salt

Impacts of Chlorides

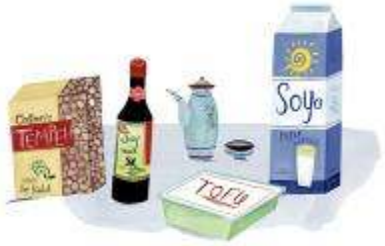
Alternative deicers containing chloride have environmental effects similar to that of salt

Soils	Cl complexes release heavy metals
Vegetation	Leaf scorch and browning or dieback of new plant growth
Groundwater	Mobile Cl ions can reach groundwater and concentration levels can increase in areas of low flow during spring thaws
Surface water	Can cause density stratification in small lakes with closed basins
Aquatic biota	Small streams can receive harmful concentrations of Cl

Rod Frederick, USEPA Office of Water

Magnesium Chloride

- LD 50, Rat, 1000 - 2800 mg / kg
- LC 50, Daphnia, 343 mg / l (Chloride)
- LC 50, Minnow, 1,056 mg / l (Chloride)
- Non-carcinogenic
- GAS by FDA – food additive
- Fertilizer for plants
- Medical treatment for dialysis



Environmental Impacts

	CMA	Sand
Soils	Ca and Mg can exchange with heavy metals. Ca increases soil stability	Gradually will accumulate in soil
Vegetation	Little effect	Can accumulate on and around low vegetation, causing stress
Ground water	Ca and Mg can release heavy metals from the soil into groundwater	No known effect
Surface water	Can deplete oxygen in small lakes and streams when degrading	No known effect
Aquatic biota	Can cause oxygen depletion, leading to anoxic conditions	Particles settling to stream bottoms degrade habitat

Organic Deicer Impacts

- Potential for oxygen depletion through biological oxygen demand (BOD) at concentrations greater than 100 ppm in ponds and lakes (decomposes in 5 days at 20°C, 10 days at 10°C, 100 days at 2°C).
- Potential for nutrient enrichment of surface waters exposed to high concentrations of deicers derived from agricultural products
- May attract wildlife (corn base), increase road kill, and jeopardize public safety
- Color issues when tracked in buildings or splashed on windshields (red or brown residue)

More Deicer Impacts

- Blends of deicers
  - Many incorporate some form of chloride
- Corrosion Inhibitors
  - Most Proprietary
- Ethylene & propylene glycol
  - High BOD, depletes oxygen in water bodies

Best Management Practices

1. Education of road maintenance staff to reduce the quantities of salt used and to prevent the unnecessary use of salt. No pond storage!!
2. Limiting salt application to specific areas that need it the most, such as steep inclines, bus routes, and main thoroughfares.
3. Establishment of buffer zones and filter strips on the sides of roadways to prevent direct spray and runoff from reaching sensitive surface waters and vegetation.

More BMPs

4. Develop programs that promote recycling, minimize salt usage, and protect salt/sand storage.
5. Construction of drainage systems that direct salt-laden runoff away from sensitive areas (more cost-effective in urban areas)
6. Alternative chemicals, more efficient use of salt, reliance on abrasives, and changes to the road surface are possible means of achieving reductions in salt application for identified salt-sensitive areas.

TRB Publications

TRB NCHRP Synthesis Topic 34-10, Winter Highway Operations. Alternative application methods. Includes specialized road temperature sensors on trucks, pre-storm application, performance standards for safety.

TRB NCHRP Project 06-16 for the Selection of Snow and Ice Control Materials to Mitigate Environmental Impacts. Performance of snow and ice removal materials and their impact on the environment , infrastructure, and vehicles.

TRB Synthesis 344

- The Transportation Research Board (TRB) National Cooperative Highway Research Program (NCHRP) Synthesis 344 on Winter Highway Operations is now available at the Transportation Research Board Business Office, 500 Fifth Street, Washington, D.C. 20001 or at http://www.national-academies.org/trb/bookstore. $17.00.

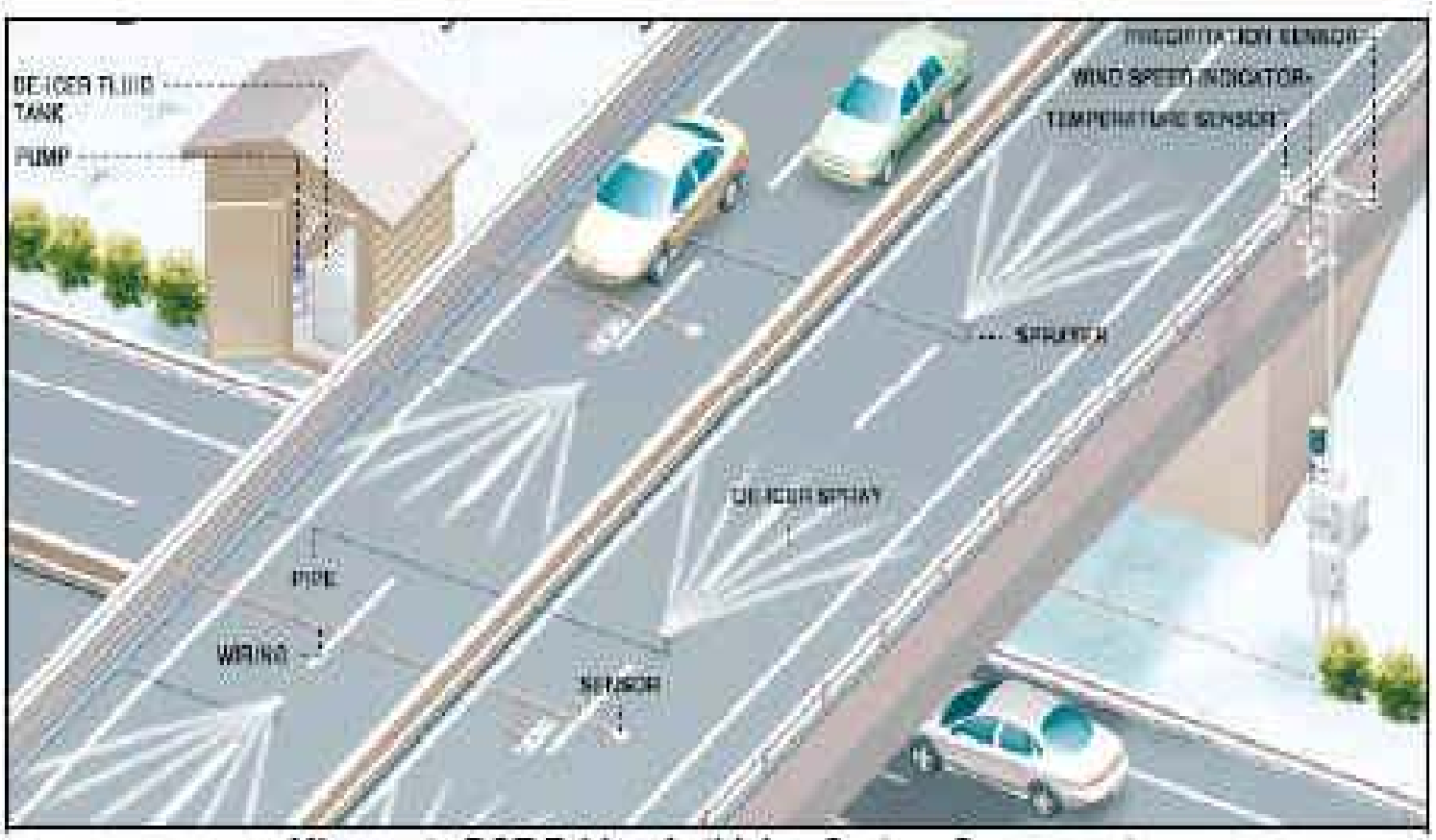
Cost/Benefit Comparison

- Human health/safety
- Aquatic life
- “No-Brainers”
  - Cover and floor the piles
- Tooling the Fleet
  - Gradual Improvements
- Common sense
  - Where, when, how

Emerging Technologies

- A “zero velocity” application device is being used in Wisconsin and Pennsylvania.
- The Institute of Snow Research at Michigan Tech University is developing a system called “Anti-Icing Smart,” which is a permanent coating that acts as a sponge for liquid deicers.
- A high technology “Highway Maintenance Concept Vehicle” is being developed at Iowa State’s Center for Transportation Research and Education. The “Concept Vehicle” uses infrared sensors to detect the temperature of the roadway and air.

Risk-Based Bridge System



Minnesota DOT Bridge Anti-icing System Components

ANTI-ICING

Idaho DOT Winter Maintenance Performance Measures
(Annual Averages)

	1992 to 1997 (Without Anti-Icing)	1997 to 2000 (With Anti-Icing)	Percent Reduction
Abrasive Quantities	1,929 cubic yards (1,475 cubic meters)	323 cubic yards (247 cubic meters)	83%
Labor Hours	650	248	62%
Number of Crashes	16.2	2.7	83%

Idaho DOT
Maintenance Vehicles

Minimize Road Salt Impacts

- Apply less salt
- Apply alternate deicers
- Use additives to reduce deicer application
- Change timing of application
- Modify spreaders
- Implement salt storage regulations

Minnesota Example

- Minnesota Statute 160.215 restricts the use of salt and other harmful, corrosive chemicals on roadways. These chemicals are only permitted in areas where traction is critical, such as on hills, at intersections, or on high-speed or principal roadways.

Npdes Stormwater Permit Example

- California DOT (CALTRANS) permit requirements:
  - Submit information about the location, source, and chemistry of abrasives and deicing chemicals, as well as volumes used on individual highway segments
  - Develop a monitoring program that measures the effectiveness of BMPs used to recover abrasives and deicing materials on surface waters

Pollution Prevention/Good Housekeeping for Municipal Operations

- Train maintenance staff at a State university to employ pollution prevention techniques

- Examples:
  - routinely pick up trash from the university grounds
  - use less salt on the parking lots and access roads in the winter
  - perform any maintenance of university vehicles under shelter only
  - limit pesticide use to the minimum needed
  - keep dumpster lids closed

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3. Lombardo, L. 2000. Overview of US Crashes and Environment. Presentation at the WIST II Forum, December 4-6, 2000.
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6. Peters Chemicals Company: http://www.peterschemical.com/Seven%20Things%20-%20Facility%20Managers.htm
7. CDPHE, Health Effects of Deicing Application in Colorado, 4300 Cherry Crk Dr. S., Denver, CO. March 2000.

DOT Publications

- Effect of Magnesium Chloride on Asphalt pavements
  (Werner Hutter, CDOT) February 1999
- Studies of Environmental Effects of Magnesium Chloride De-icer in Colorado
  (Professor William M. Lewis) November 1999
- Preliminary Environmental Evaluation of Caliber M1000 De-icer for Use in Colorado
  (Professor William M. Lewis) December 2000
- Evaluation and Comparison of Three Chemical De-icers for Use in Colorado
  (Professor William M. Lewis) August 2001
- Evaluation of Selected De-icers Based on a Review of the Literature
  (The SeaCrest Group) October 2001
- Corrosion Effects of Magnesium Chloride and Sodium Chloride on Automobile Components
  (Professors Yunping Xi and Zhaihui Xie) May 2002
- Cost of Sanding
  (Professor Nien-Yin Chang) June 2002
- Roadside Vegetation Health
  (University of Northern Colorado) starts fall 2003

Questions?

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