Andy Erickson

St. Anthony Fall's Laboratory – University of Minnesota

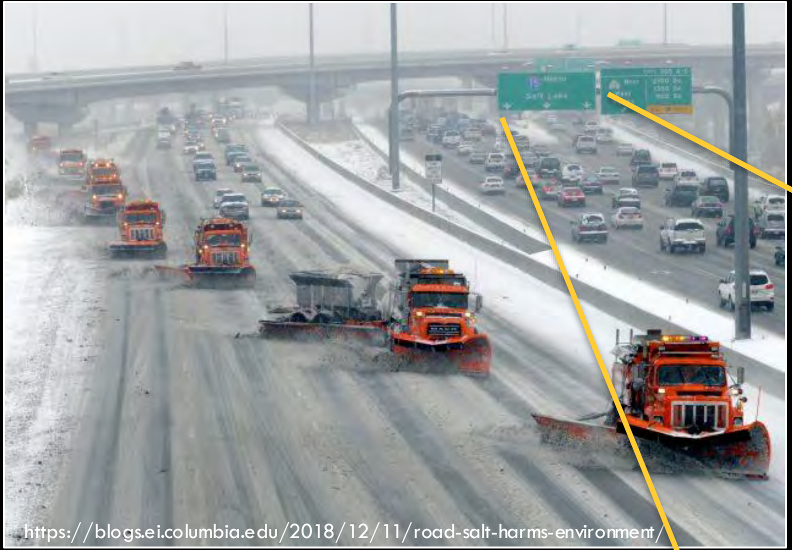
Morning Speaker August 2

Five Things We Learned About Chloride: A Summary of Road Salt Research

SALT SYMPOSIUM

Five Things We Learned About Chloride: A Summary of Road Salt Research

https://www.politicscentral.org/contaminated-water-pipes-crumbling-bridges-roads-culprit-may-road-salt/


https://blogs.ei.columbia.edu/2018/12/11/road-salt-harms-environment/


https://blogs.ei.columbia.edu/2018/12/11/road-salt-harms-environment/

Andy Erickson, Research Manager
St. Anthony Falls Lab, University of Minnesota
2023 Salt Symposium
August 2, 2023

The Issue: Chloride Impacts

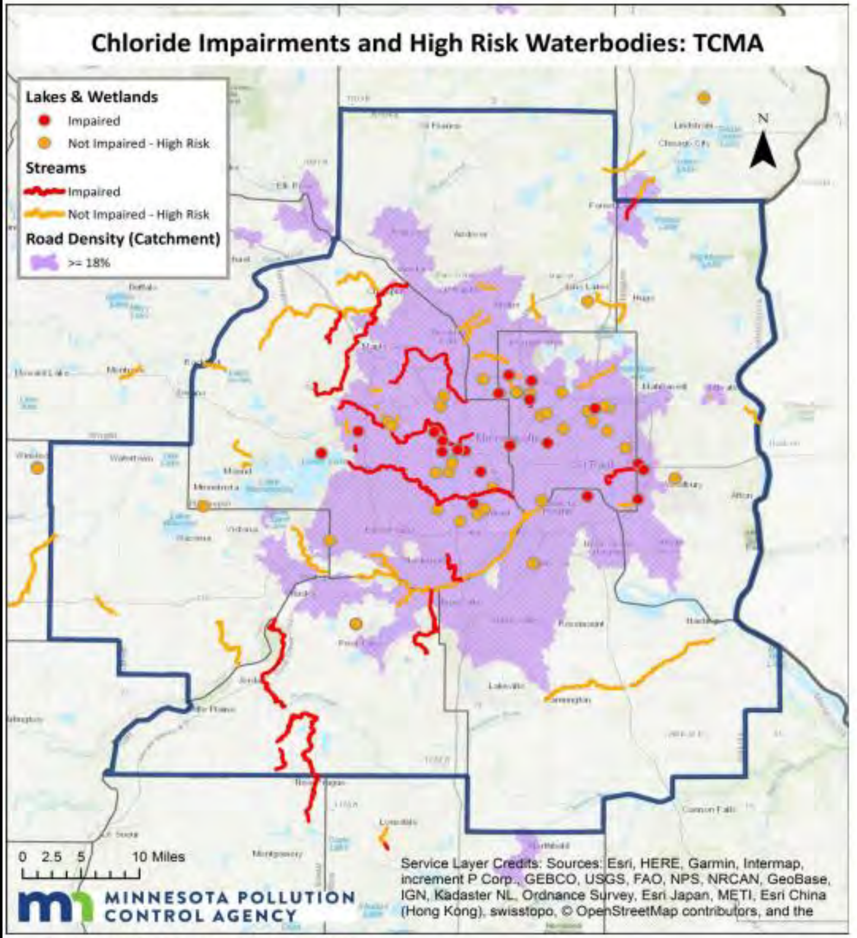


Figure 20: Chloride Condition in TCMA Surface Waters

Minnesota Statewide Chloride Management Plan wq-s1-94

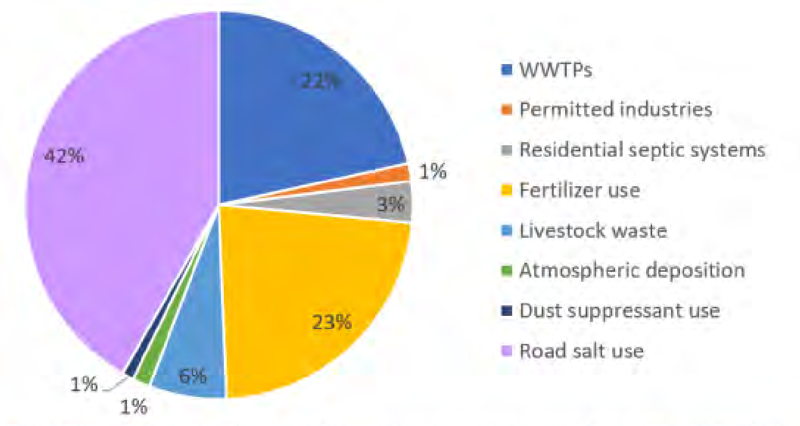


Figure 4: Fraction of annual chloride contributions from major point and nonpoint sources for State of Minnesota (Overbo et al. 2019)
*Please note that Road salt use is actually all de-icing salt applied to roads, parking lots, sidewalks, and trails.

Overbo et al. 2019 in Minnesota Statewide Chloride Management Plan wq-s1-94

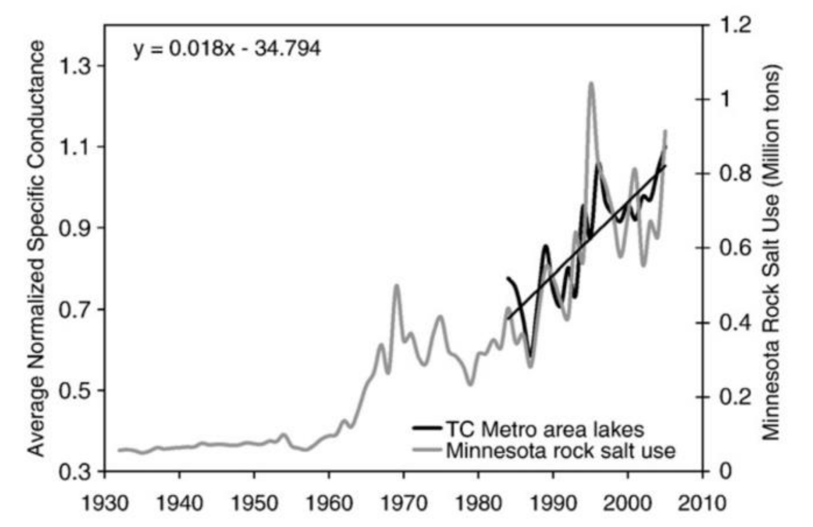


Fig. 8 – Time series of average normalized specific conductance in 38 Twin Cities Metro Area lakes (data set 2) and total rock salt purchases by the State of Minnesota.

Novotny, Murphy, and Stefan (2008)

DRINKING WATER | TESTS SHOW INCREASE OF SODIUM, CHLORIDE

Road salt contaminating Madison water well on West Side as officials look for solutions

BILL NOVAK and BRIANA REILLY Wisconsin State Journal Dec 1, 2016 0

For Immediate Release May 28, 2008

Study Shows Increasing Contamination in Chicago Area Groundwater

Source: Walt Kelly - (217) 333-3729, kelly@sws.uiuc.edu
Contact: Lisa Sheppard - (217) 244-7270, sheppard@illinois.edu

ILLINOIS STATE WATER SURVEY
PRAIRIE RESEARCH INSTITUTE

Since the 1950s, chloride (salt) levels in shallow groundwater have increased significantly in Cook and surrounding counties, ind

Top 5 Things We've Learned…

- Do we have a salt legacy problem?
- Can Permeable Pavements reduce Road Salt?
- Which Anti-icing chemicals work best?
- Do Road Salt Alternatives have Environmental Impacts?
- What Else Can We do?

https://teneoresults.com/blog/top-5-methods-of-prospecting/

Do we have a salt legacy problem?

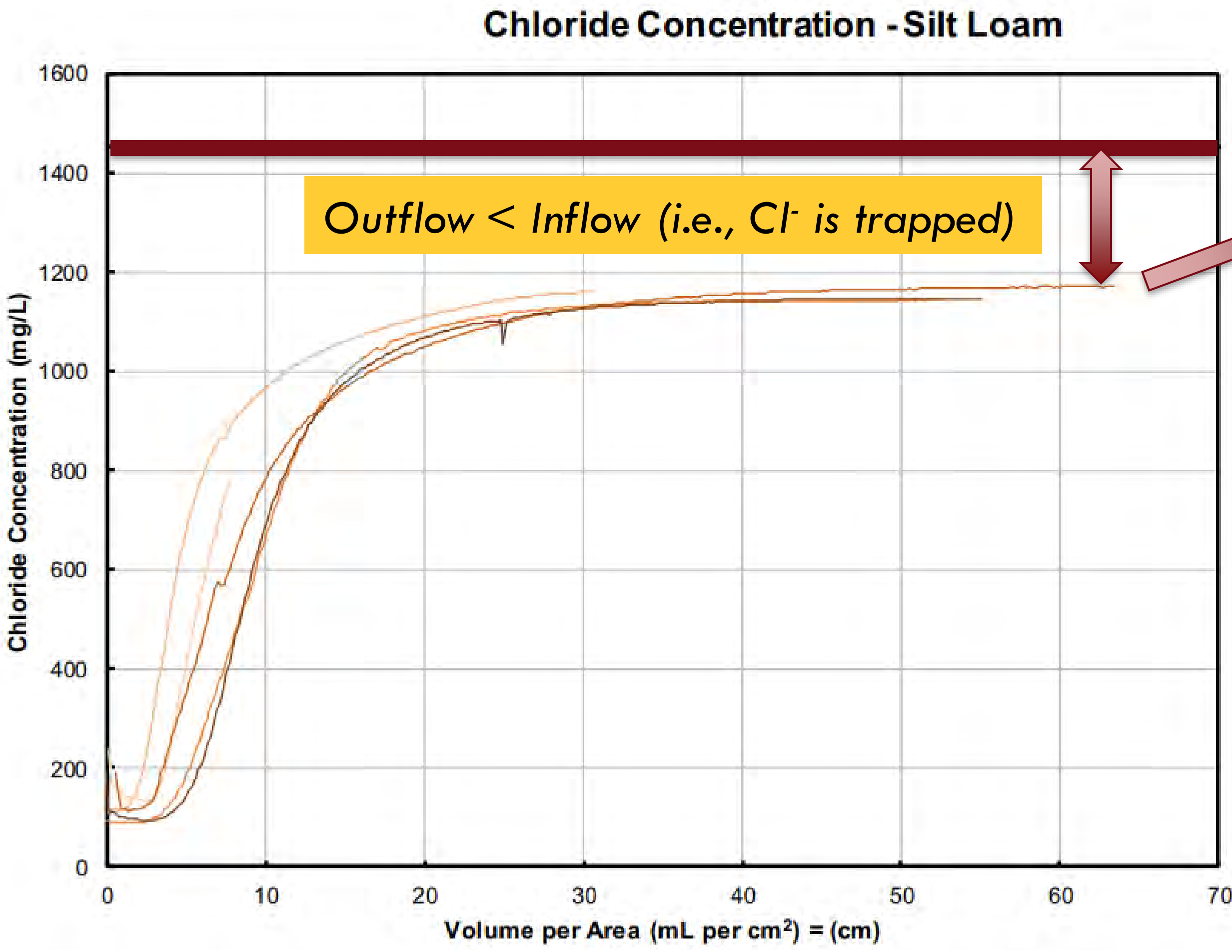
- LCCMR funding (M.L. 2016, Chp. 186, Sec. 2, Subd. 04n) to investigate the transport of chloride from road salt through soils commonly found in Minnesota (silt loam, sandy loam, and sandy loam with 10% organic material)

ENVIRONMENT AND NATURAL RESOURCES TRUST FUND

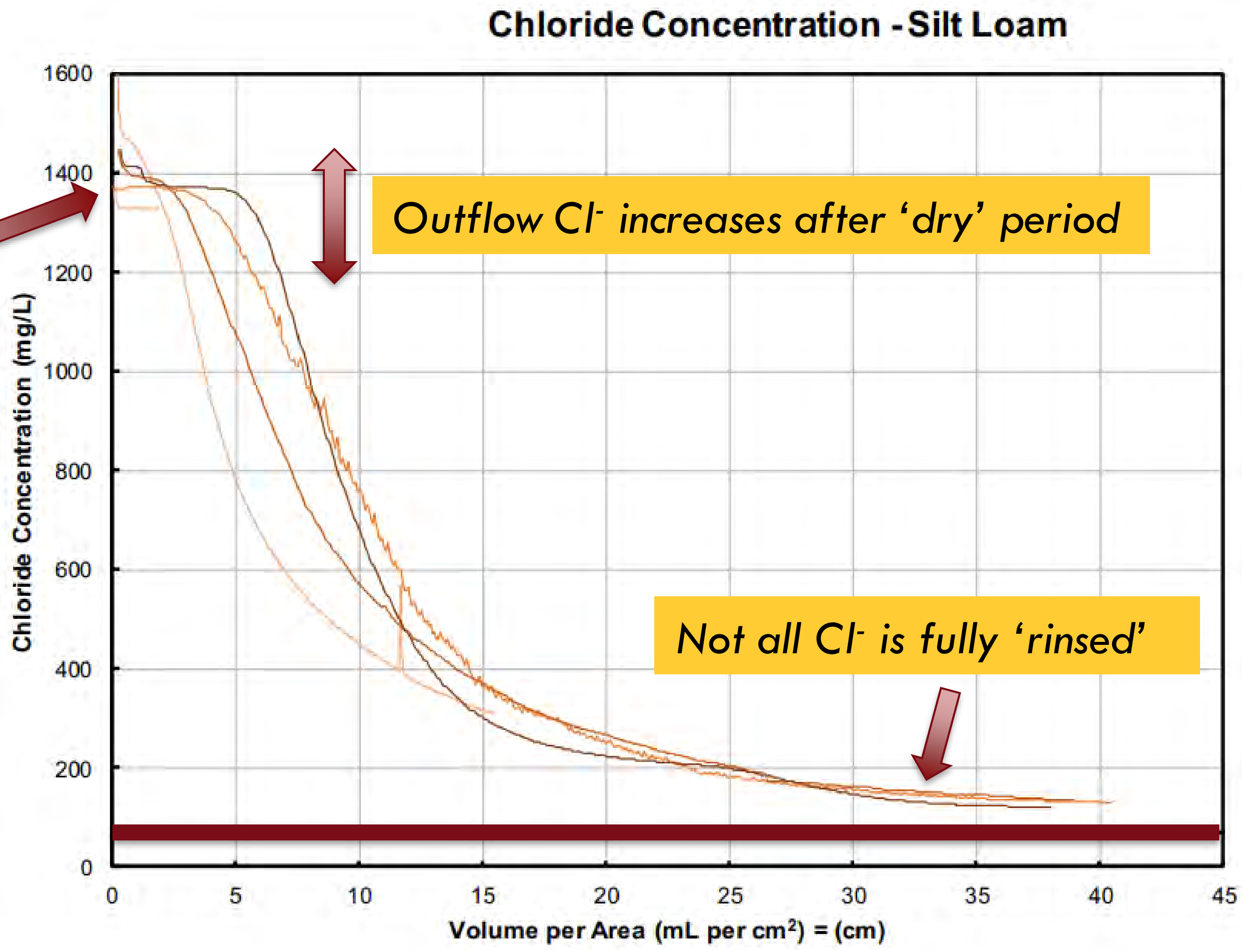
Erickson, A.J., J.S. Gulliver, and P. Weiss. (2019). Transport of Chloride through Silt Loam, Sandy Loam and Sandy Loam with Compost. Report for the Legislative-Citizen Commission on Minnesota Resources & SAFL Project Report No. 590, University of Minnesota. Retrieved from the University of Minnesota Digital Conservancy, http://hdl.handle.net/11299/210228

Column Experiments

Salt Loading



Fresh Water Rinsing



Erickson, A.J., J.S. Gulliver, and P. Weiss. (2019). Transport of Chloride through Silt Loam, Sandy Loam and Sandy Loam with Compost. Report for the Legislative-Citizen Commission on Minnesota Resources & SAFL Project Report No. 590, University of Minnesota. Retrieved from the University of Minnesota Digital Conservancy, http://hdl.handle.net/11299/210228

Cl⁻ along Highway(s)

- Field Measurements indicate Cl⁻ concentration in soils:
  - Varies with location and depth
  - Is greater than zero (i.e., accumulates)

Chloride Content (mg Cl⁻/kg soil)

Depth	Site SB-1: Highway 52 & 67th Street; Sandy Loam Soil type: 896 (Kingsley-Mahtomedi Complex)				Site SB-2: Highway 52 & 75th Street; Silt Loam Soil type: 344 (silt loam)			
(cm)	A	B	C	D	A	B	C	D
0 - 10		23.62		10.62	18.35	18.58		21.41
11 - 20	17.91		64.89				26.9	
21 - 30						16.78		
31 - 40		17.6		7.57	40.2			9.14
41 - 50	11.32		72.47					
51 - 60				7.85	33.56	13.68		
61 - 70		20.01		11.2				
71 - 80								8.87
81 - 90	10.31	18.14						
91 - 100			60.51				43.95	
101 - 110	15.25				12.59	46.9		
111 - 120				10.79				
121 - 130		29.01						8.94
131 - 140	34.24		44.84					
141 - 150					21.43			
151 - 160								
161 - 170		27.98	33.56		65.65	54.33		
171 - 180							52.98	
181 - 190								
191 - 200								12.32
201 - 210								
211 - 220								
221 - 230	111.2			20.78				
231 - 240			37.15					
241 - 250		64.13			69.35	49.67	49.17	
251 - 260								10.66
261 - 270								
271 - 280								
281 - 290								
291 - 300								9.54
301 - 305								

Erickson, A.J., J.S. Gulliver, and P. Weiss. (2019). Transport of Chloride through Silt Loam, Sandy Loam and Sandy Loam with Compost. Report for the Legislative-Citizen Commission on Minnesota Resources & SAFL Project Report No. 590, University of Minnesota. Retrieved from the University of Minnesota Digital Conservancy, http://hdl.handle.net/11299/210228

What Did We Learn?

- Column experiments: chloride is sometimes stored within the soil and is released at other times. This contradicts conventional wisdom for chloride movement and fate in soils → More research is needed
- Field soil cores: chloride is present in the soil along roadways that are treated with deicing road salt (are we surprised?)
- Results: Data demonstrate that chloride is stored within the soil and requires a long period (i.e., years) of freshwater to rinse

Publications:

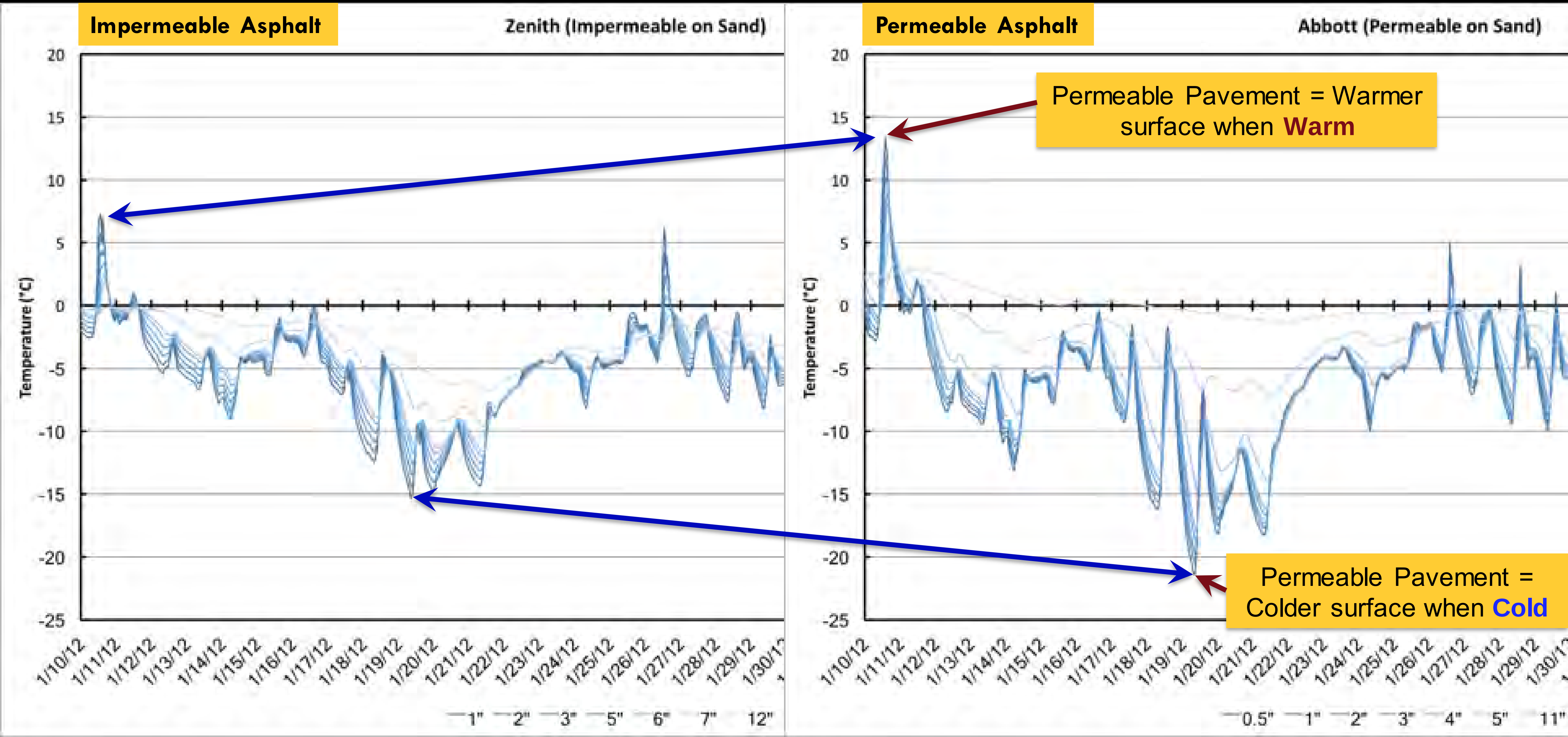
- Erickson, A.J., J.S. Gulliver, and P. Weiss. (2019). Transport of Chloride through Silt Loam, Sandy Loam and Sandy Loam with Compost. Report for the Legislative-Citizen Commission on Minnesota Resources & SAFL Project Report No. 590, University of Minnesota. Retrieved from the University of Minnesota Digital Conservancy, http://hdl.handle.net/11299/210228
- Higashino, M. Erickson, A.J., Toledo-Cossu, F.L., Beauvais, S.W., and H.G. Stefan. (2017). "Rinsing of Saline Water from Road Salt in a Sandy Soil by Infiltrating Rainfall: Experiments, Simulations, and Implications." Water, Air, and Soil Pollution. http://doi.org/10.1007/s11270-017-3256-1

Can Permeable Pavements reduce Road Salt?

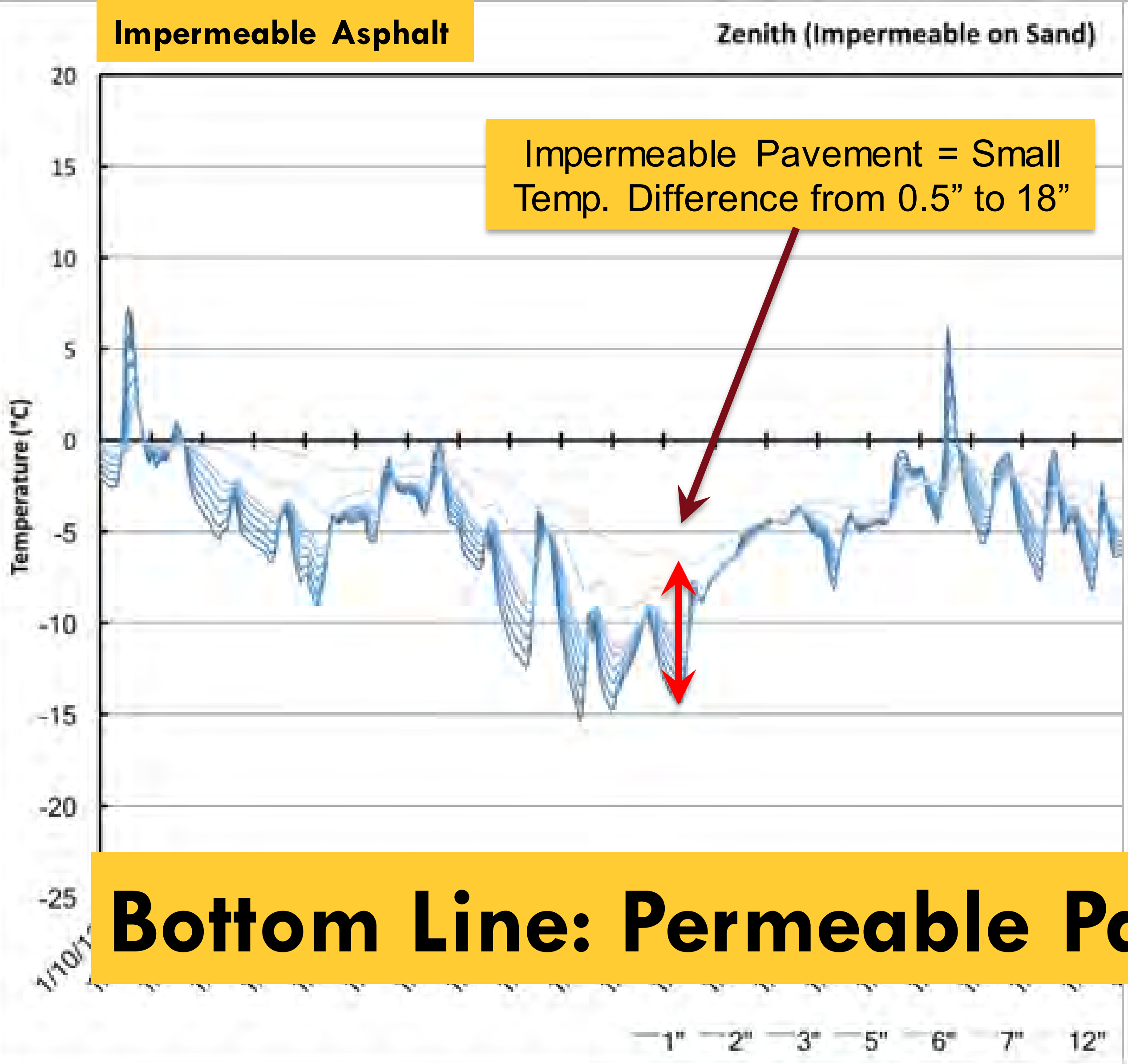
- Runoff Volume Reduction
- Improved water quality
- Smoother riding surface
- Hydroplaning resistance
- Les spray / increased visibility
- Noise reduction
- Less winter salt application (???)

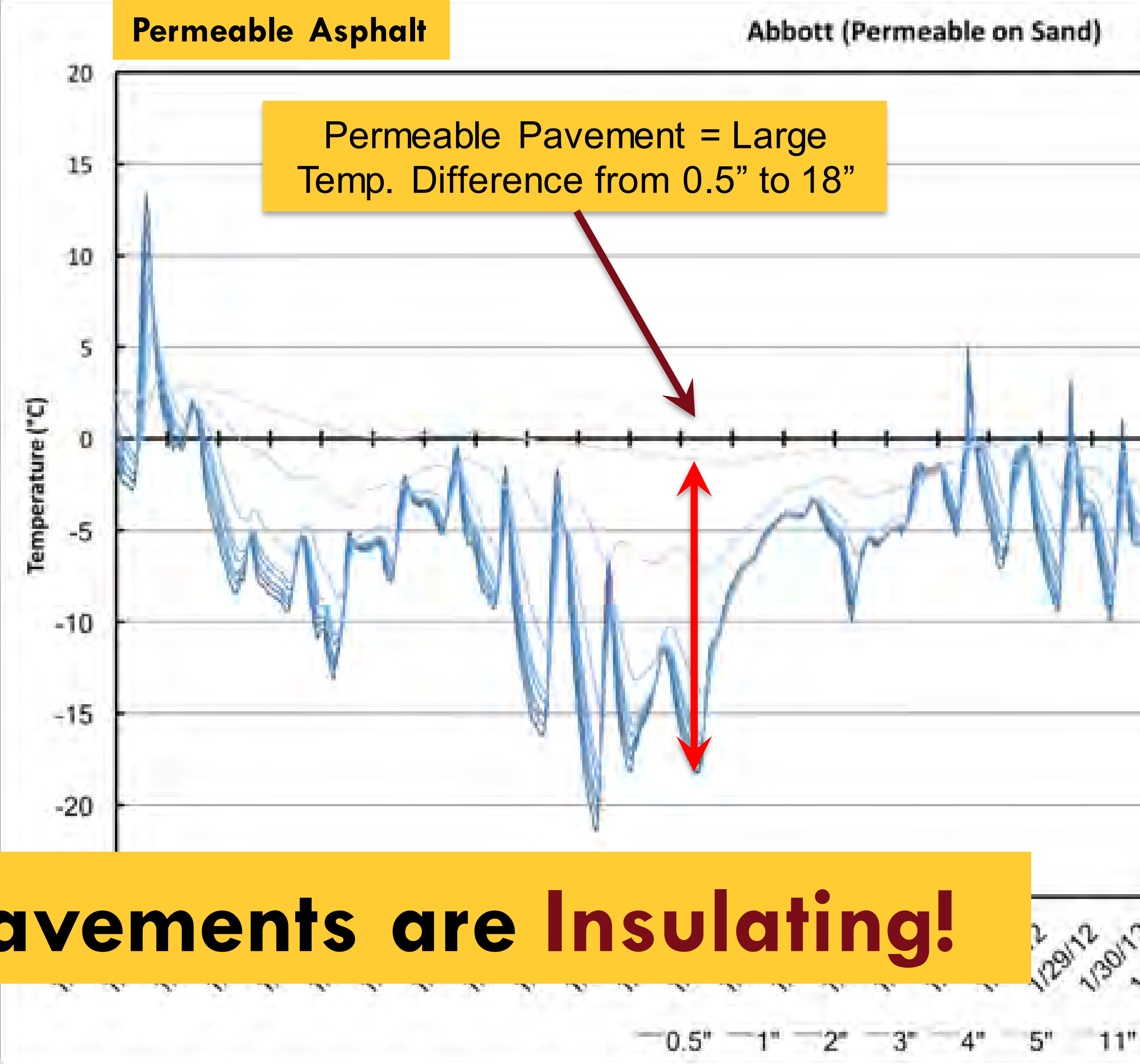
Erickson, A.J., J.S. Gulliver, W.R. Herb, B.D. Janke, and N.K. Nguyen (2020). Permeable Pavement for Road Salt Reduction. MnDOT Project Report No. 2020-15, Research Services and Library, Office of Transportation System Management, Minnesota Department of Transportation. June 2020. http://mndot.gov/research/reports/2020/202015.pdf

Previous Work – Wenck & Robbinsdale



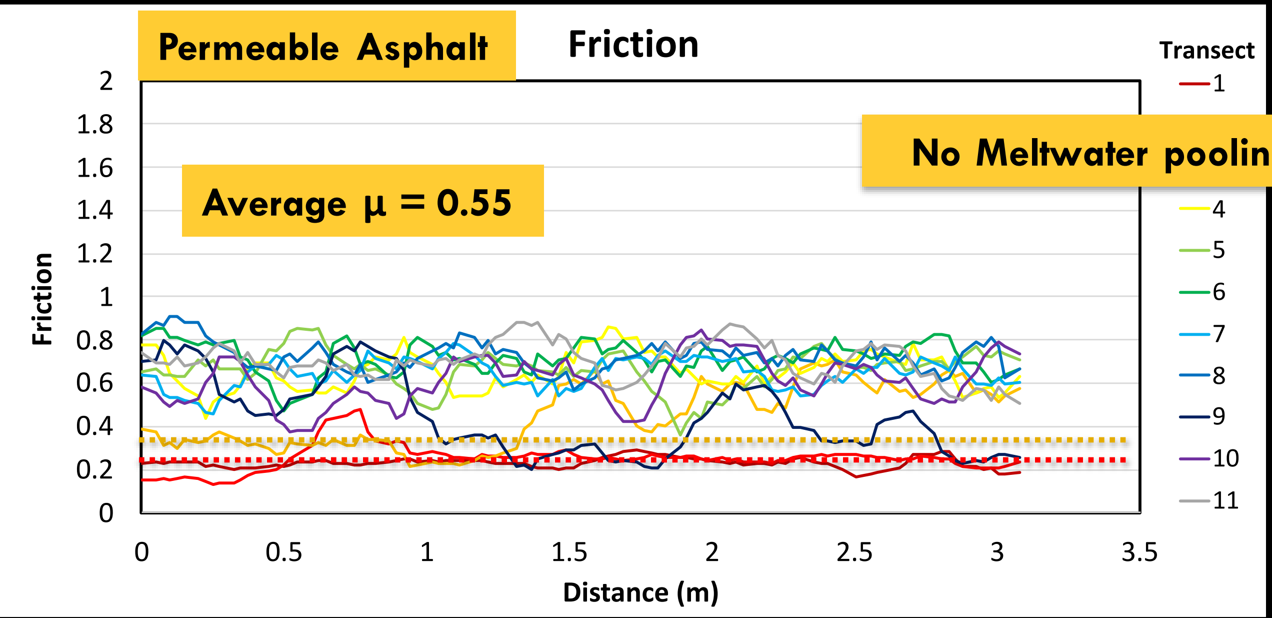
Previous Work – Wenck & Robbinsdale

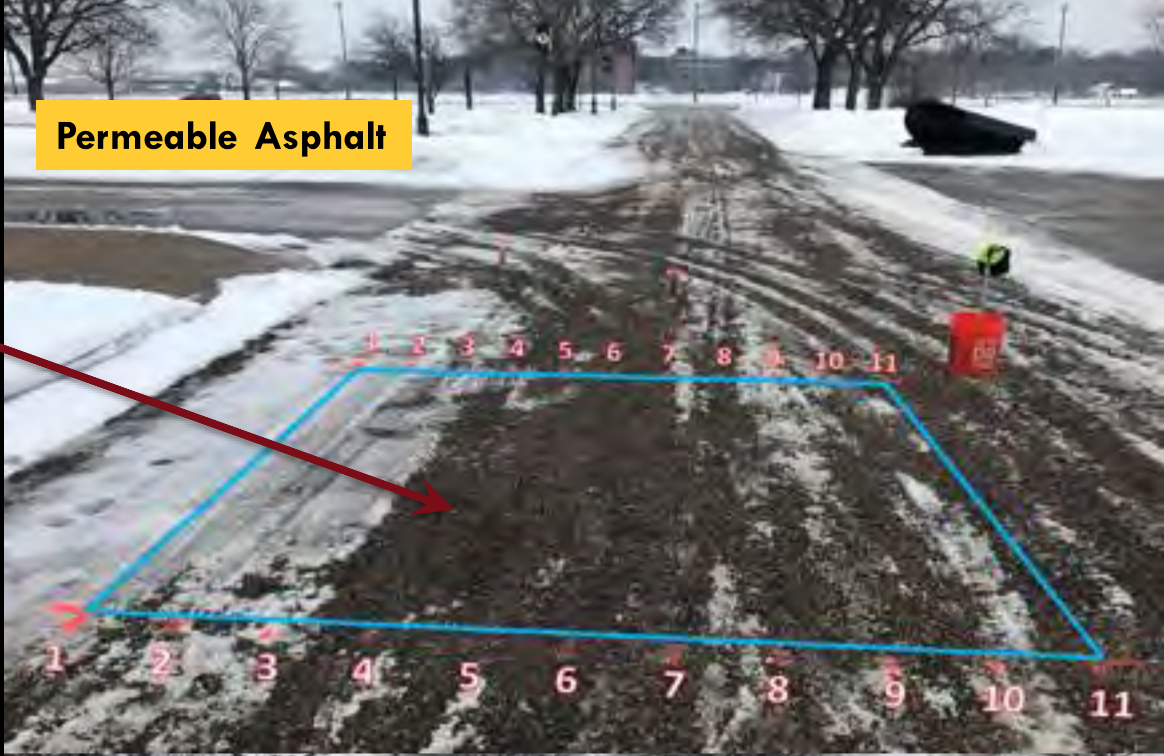


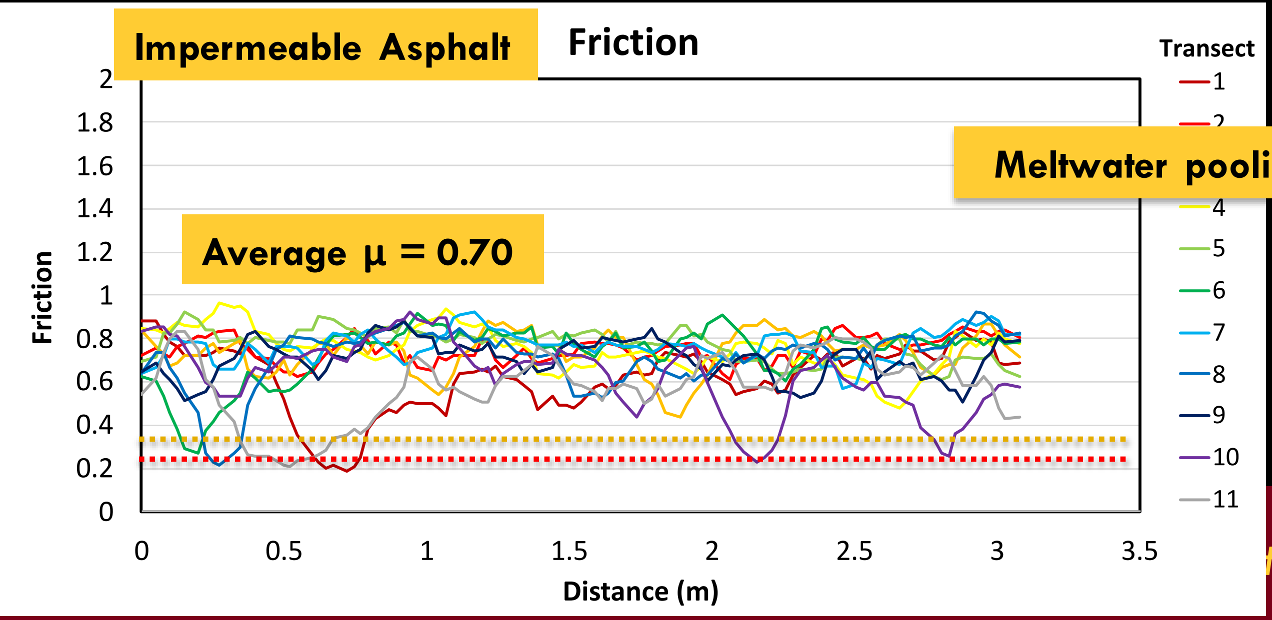


Bottom Line: Permeable Pavements are Insulating!

Example of Friction Results







ttp://s

What Did We Learn?

- Permeable pavements and the porous subbase beneath them function as **thermal insulators**, preventing heat transfer from the surface to below and vice versa;
- Permeable pavements that are **clogged** due to sediment accumulation or collapsed pores provide **no benefit** compared to impermeable pavement;
- The primary winter benefit of permeable pavements is that **meltwater can infiltrate through permeable pavements and prevent refreezing**.

Erickson, A.J., J.S. Gulliver, W.R. Herb, B.D. Janke, and N.K. Nguyen (2020). Permeable Pavement for Road Salt Reduction. MnDOT Project Report No. 2020-15, Research Services and Library, Office of Transportation System Management, Minnesota Department of Transportation. June 2020. http://mndot.gov/research/reports/2020/202015.pdf

Which Anti-Icing Chemicals Work Best?

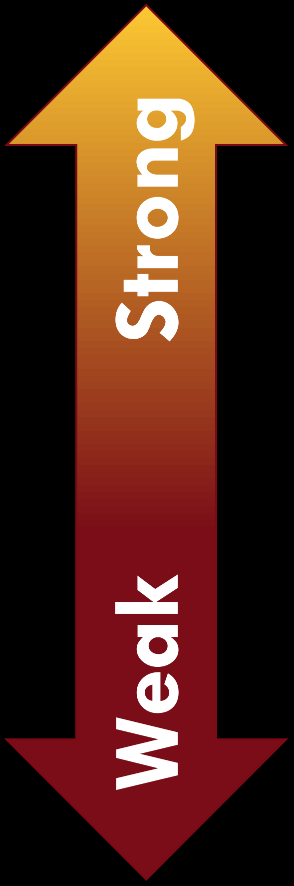
Anti-icing = pre-storm treatment to weaken the bond of snow and ice to pavement

Deicer	Low Temperature Effectiveness (°F)	Relative Cost	Relative Toxicity	Environmental Impacts	Infrastructure Impacts
Chlorides	NaCl: 15 $MgCl_2$: -5 $CaCl_2$: -15	Low	High	Accumulates in the environment. Impacts water quality and aquatic flora and fauna	Pavements and metals
Acetates	Kac: -26 NaAc: 0 CMA: 0	Moderate	Moderate	Moderate BOD	Pavements and galvanized steel
Formates	NaFm: 0 KFm: -20	High	Moderate	Moderate BOD	Pavements and galvanized steel
Glycols	-20	Moderate	High	High BOD	Limited

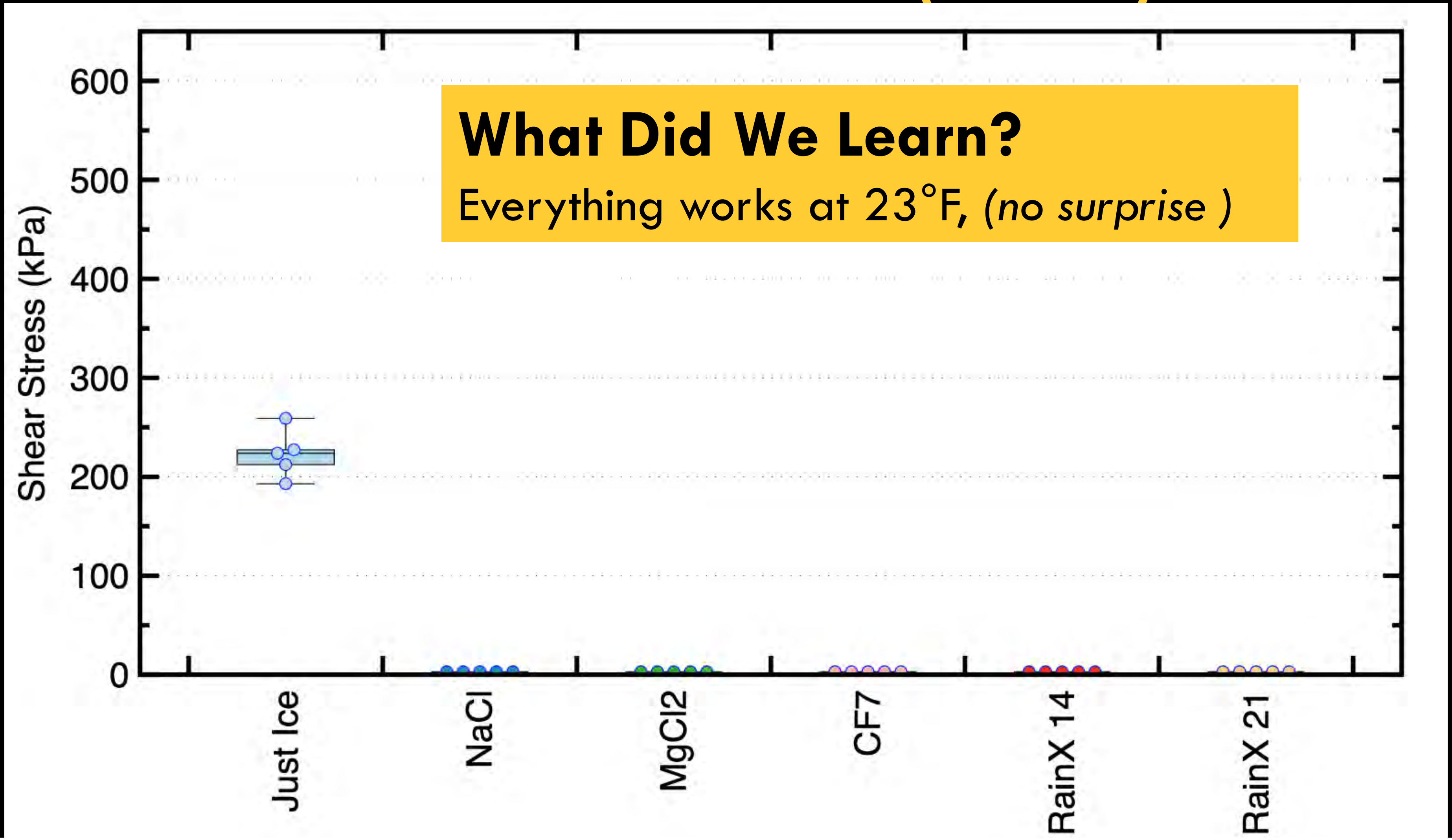
Modified from Western Transportation Institute 2017

Results at -5°C (23°F)

Bad



Good

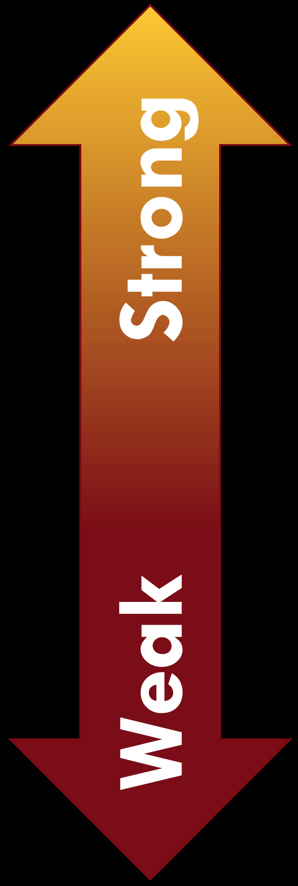


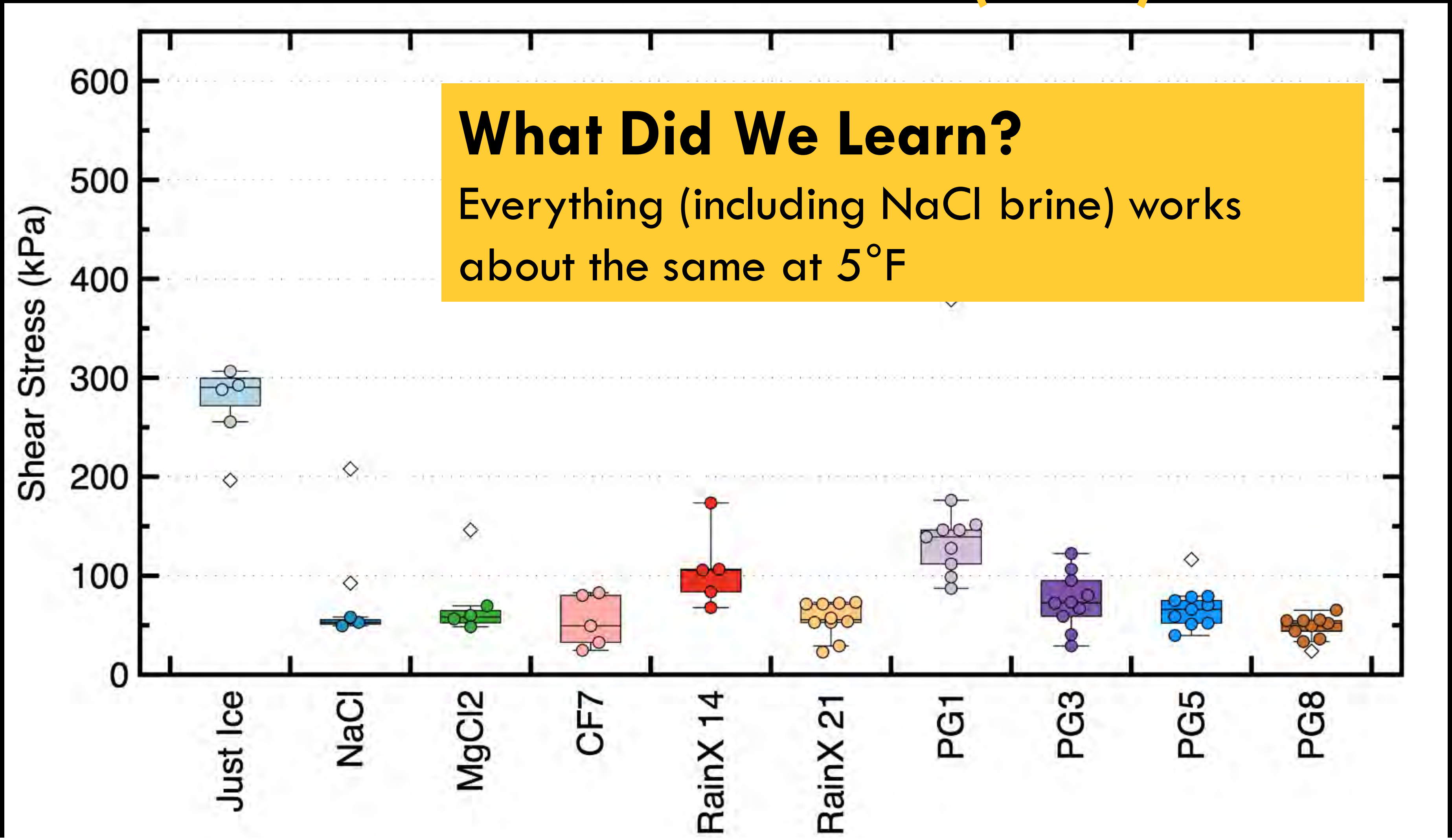
What Did We Learn?

Everything works at 23°F, *(no surprise)*

Erickson, A.J., P.T. Weiss, M. Turos, J.S. Gulliver, and M. Marasteanu. (2022). *Reduce Chlorides in Minnesota Waters by Evaluating Road-Salt Alternatives and Pavement Innovations. Final Report and Literature Review to the Legislative Citizen Commission on Minnesota Resources & the Environment and Natural Resources Trust Fund. Minneapolis, August 2022.*

Results at -15°C (5°F)



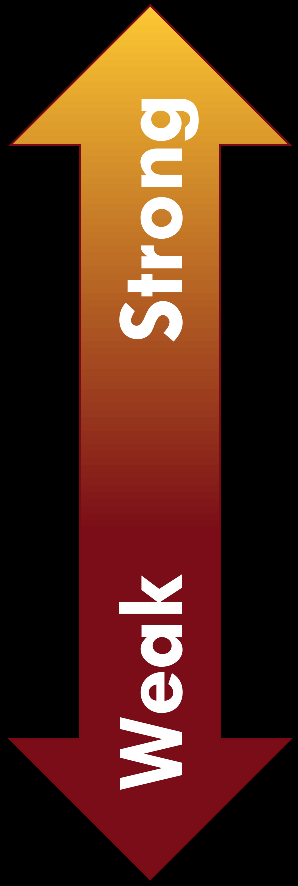


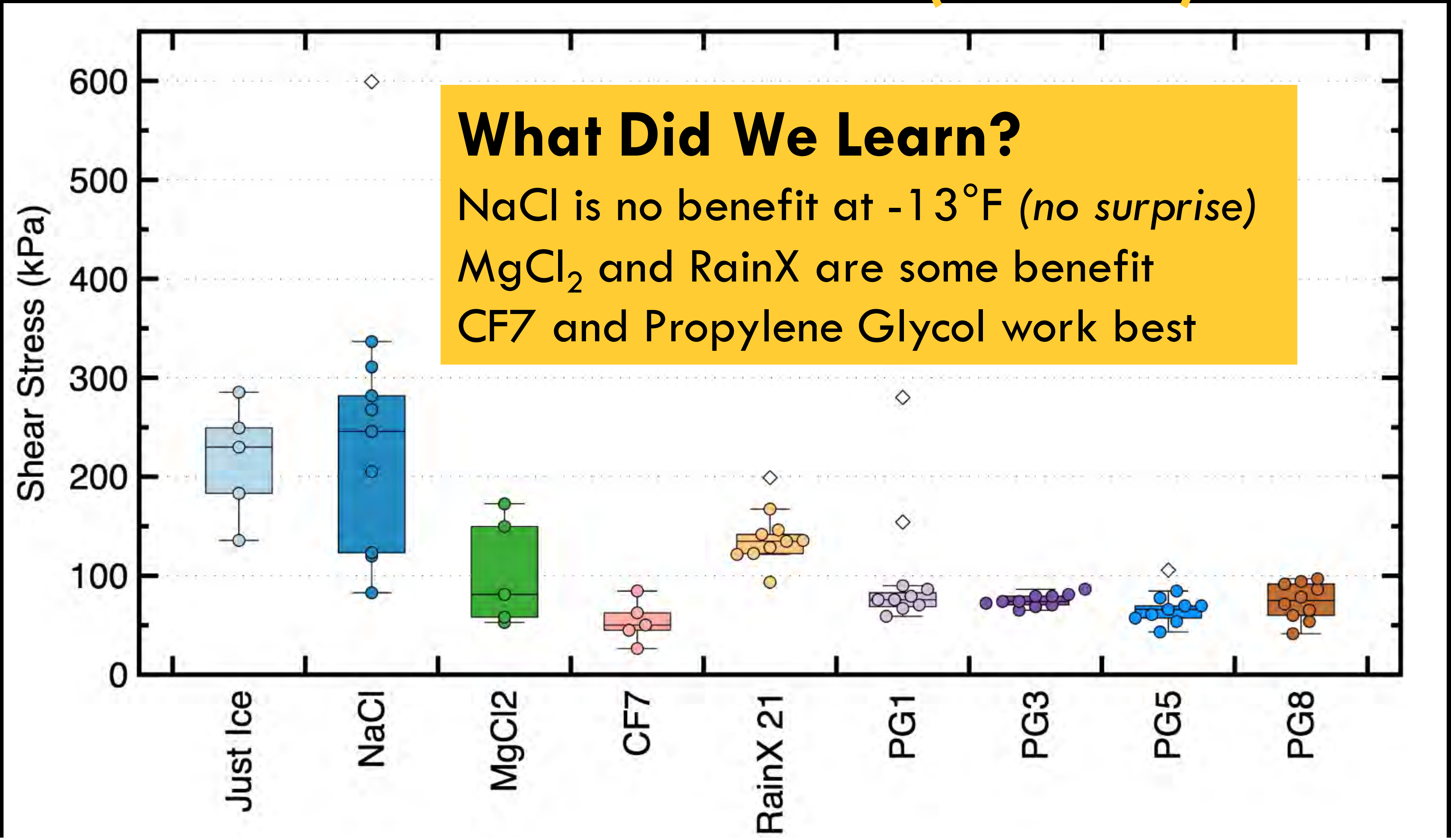
What Did We Learn?

Everything (including NaCl brine) works about the same at 5°F

Erickson, A.J., P.T. Weiss, M. Turos, J.S. Gulliver, and M. Marasteanu. (2022). Reduce Chlorides in Minnesota Waters by Evaluating Road-Salt Alternatives and Pavement Innovations. Final Report and Literature Review to the Legislative Citizen Commission on Minnesota Resources & the Environment and Natural Resources Trust Fund. Minneapolis, August 2022.

Results at -25°C (-13°F)





What Did We Learn?

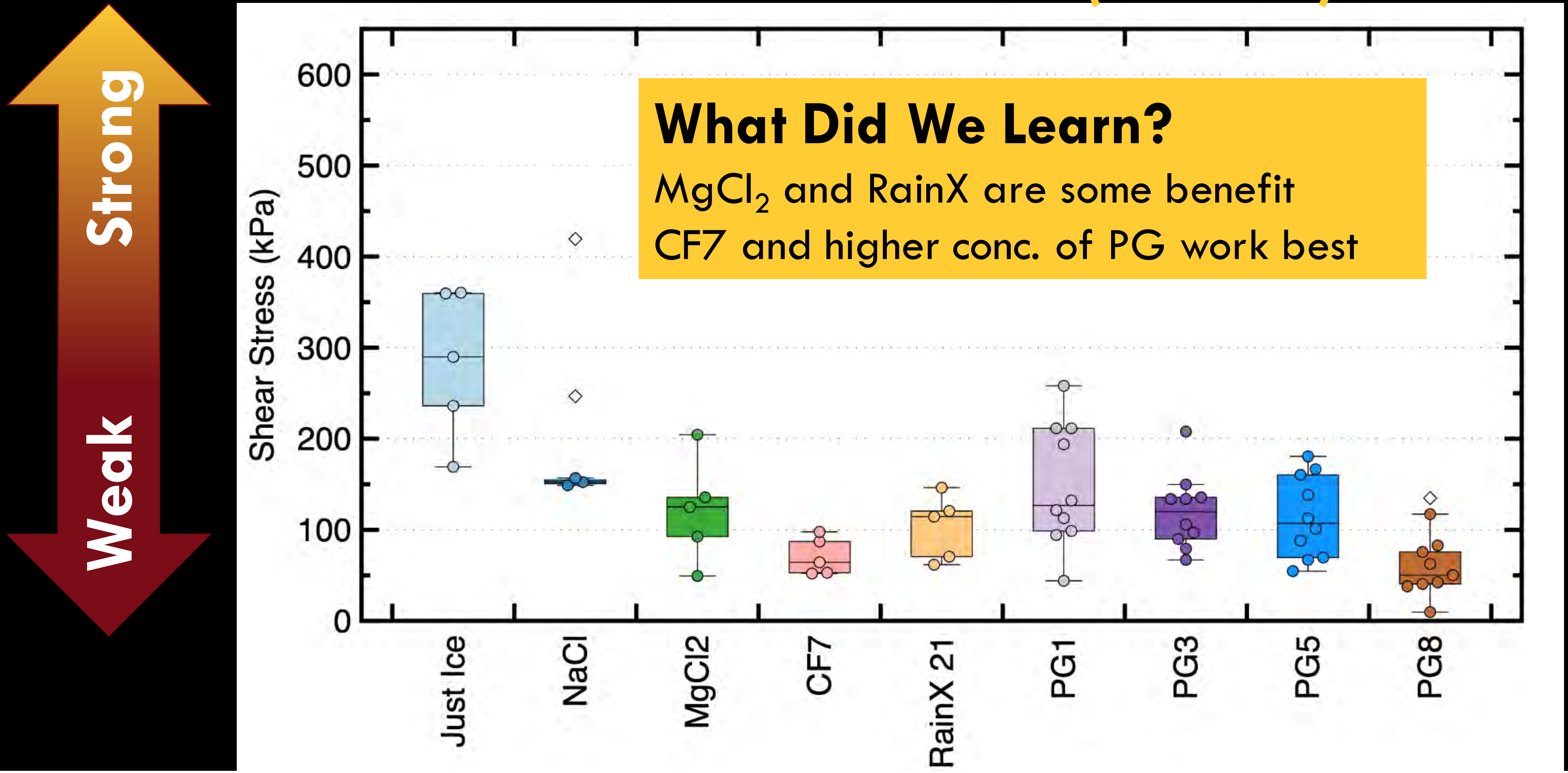
NaCl is no benefit at -13°F (*no surprise*)

$MgCl_2$ and RainX are some benefit

CF7 and Propylene Glycol work best

Erickson, A.J., P.T. Weiss, M. Turos, J.S. Gulliver, and M. Marasteanu. (2022). Reduce Chlorides in Minnesota Waters by Evaluating Road-Salt Alternatives and Pavement Innovations. Final Report and Literature Review to the Legislative Citizen Commission on Minnesota Resources & the Environment and Natural Resources Trust Fund. Minneapolis, August 2022.

Results at -35°C (-31°F)



What Did We Learn?

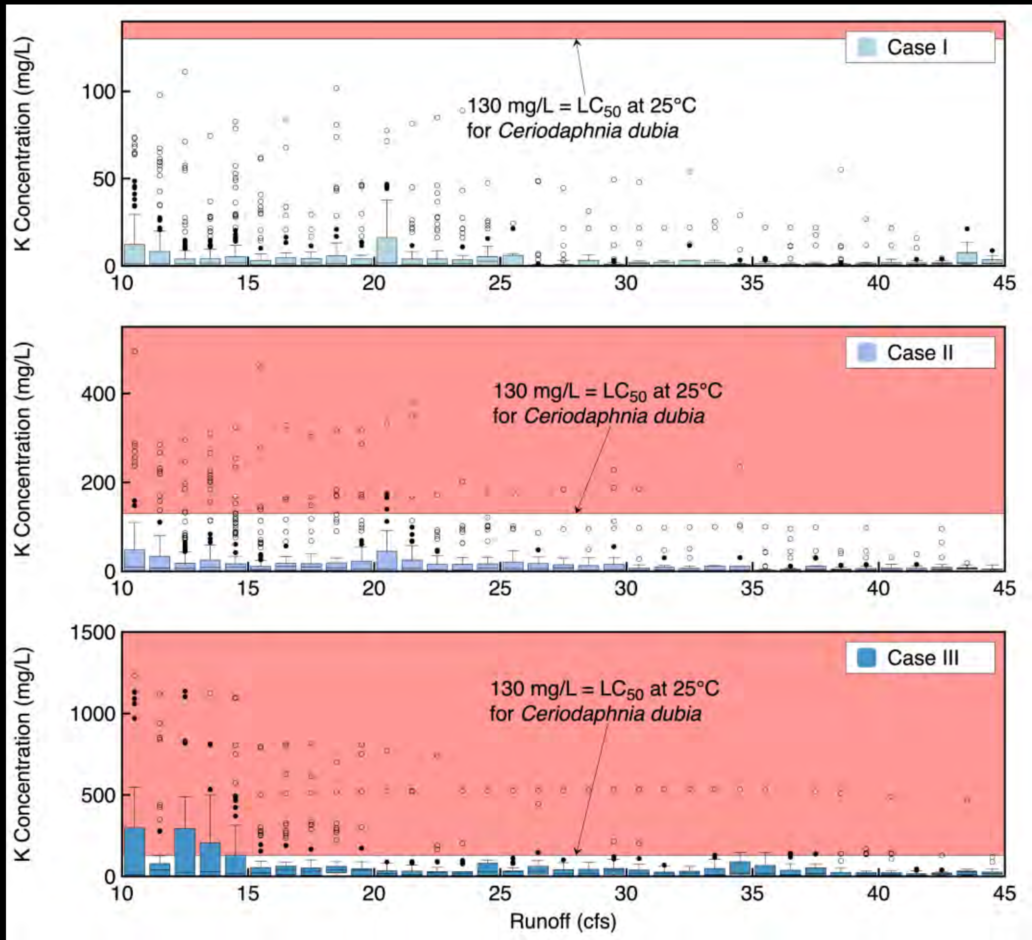
$MgCl_2$ and RainX are some benefit

CF7 and higher conc. of PG work best

Erickson, A.J., P.T. Weiss, M. Turos, J.S. Gulliver, and M. Marasteanu. (2022). Reduce Chlorides in Minnesota Waters by Evaluating Road-Salt Alternatives and Pavement Innovations. Final Report and Literature Review to the Legislative Citizen Commission on Minnesota Resources & the Environment and Natural Resources Trust Fund. Minneapolis, August 2022.

Do Road Salt Alternatives have Environmental Impacts?

- The environmental impacts of Potassium Acetate (KAc) were evaluated for a variety of road application scenarios
- In general, Acetate was not toxic to biota for recommended applications rates
- Potassium is predicted to be above toxic concentration limits when applied to only 25% of the roads
- It is recommended that KAc only be used in the most precarious winter driving safety locations on the coldest days
- KAc is not recommended for application on parking lots due to the susceptibility for over-application.
- Acetate could be used in combination with another cation, such as sodium or magnesium. These alternative ions do not, however, possess the low temperature effectiveness of KAc.



Gulliver, J., C.L. Chun, P. Weiss, A. Erickson, W. Herb, J. Henneck, and K. Cassidy. (2022). Environmental Impacts of Potassium Acetate as a Road Salt Alternative (University of Minnesota evaluation). MnDOT Report no. 2022-27A. https://www.cts.umn.edu/publications/report/environmental-impacts-of-potassium-acetate-as-a-road-salt-alternative-university-of-minnesota-evaluation & https://researchprojects.dot.state.mn.us/projectpages/pages/projectDetails.jsf?id=22000&type=CONTRACT. Minneapolis, July 2022.

Do Road Salt Alternatives have Environmental Impacts?

https://www.politicscentral.org/contaminated-water-pipes-crumbling-bridges-roads-culprit-may-road-salt/

- There is economic incentive to alternatives!
- Cost of Road Salt (NaCl) = $100/ton
- Cost of Vehicle Corrosion, Extra Road Maintenance, Tree Damage, & Infrastructure Damage = $3,140/ton
- Ecosystem Impacts = $9,590/ton
- Total Cost = $12,830/ton * 404,000 tons/yr = $5.2B/yr

Gulliver, J., C.L. Chun, P. Weiss, A. Erickson, W. Herb, J. Henneck, and K. Cassidy. (2022). Environmental Impacts of Potassium Acetate as a Road Salt Alternative (University of Minnesota evaluation). MnDOT Report no. 2022-27A. https://www.cts.umn.edu/publications/report/environmental-impacts-of-potassium-acetate-as-a-road-salt-alternative-university-of-minnesota-evaluation & https://researchprojects.dot.state.mn.us/projectpages/pages/projectDetails.jsf?id=22000&type=CONTRACT. Minneapolis, July 2022.

Do Road Salt Alternatives have Environmental Impacts?

https://www.politicscentral.org/contaminated-water-pipes-crumbling-bridges-roads-culprit-may-road-salt/

- There is economic incentive to alternatives!
- Cost of Acetate De-iciers = $1600/ton
- Cost of Vehicle Corrosion, Extra Road Maintenance, Tree Damage, Infrastructure Damage, Ecosystem Impacts = *minimal*
- Total Cost = $1600/ton * (1.5 more KAc vs. NaCl) * 404,000 tons/yr = $0.97B/yr → → **$3.2B Savings/yr**

Gulliver, J., C.L. Chun, P. Weiss, A. Erickson, W. Herb, J. Henneck, and K. Cassidy. (2022). *Environmental Impacts of Potassium Acetate as a Road Salt Alternative (University of Minnesota evaluation). MnDOT Report no. 2022-27A.* https://www.cts.umn.edu/publications/report/environmental-impacts-of-potassium-acetate-as-a-road-salt-alternative-university-of-minnesota-evaluation & https://researchprojects.dot.state.mn.us/projectpages/pages/projectDetails.jsf?id=22000&type=CONTRACT. Minneapolis, July 2022.

What about Abrasives?

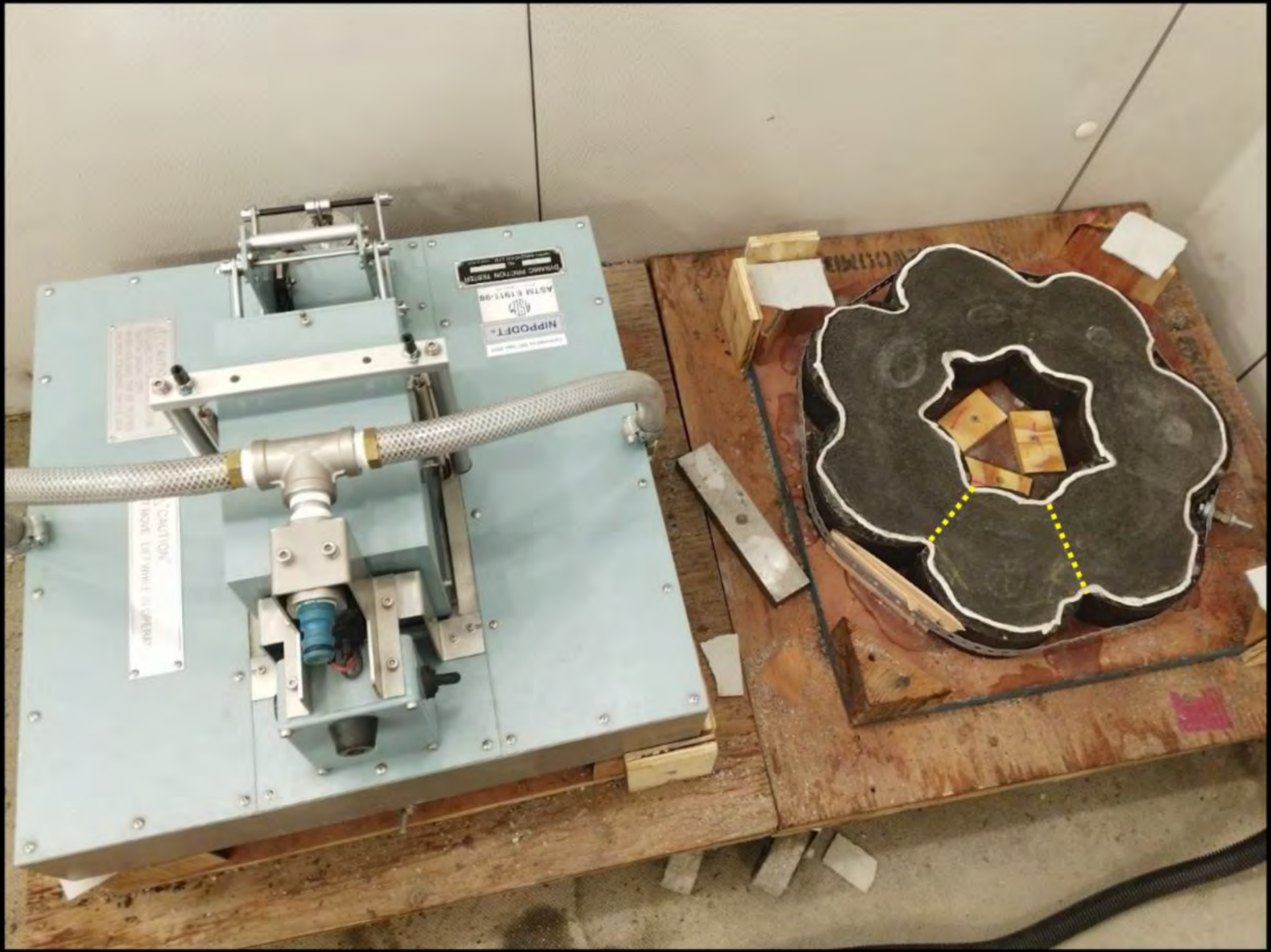
- Bounce or blown off road
- More expensive than salt
- More environmental impact than salt (?)
- Recent Improvements to Abrasive Use:
  - Wetted sand (currently with brine)
  - Heated sand (80-250 °C)
  - Can reduce sand use by 50%

The Friction Maker™ water-heated sand applicator

https://julkaisut.vayla.fi/pdf/3200842.pdf

Measuring Friction Enhancement

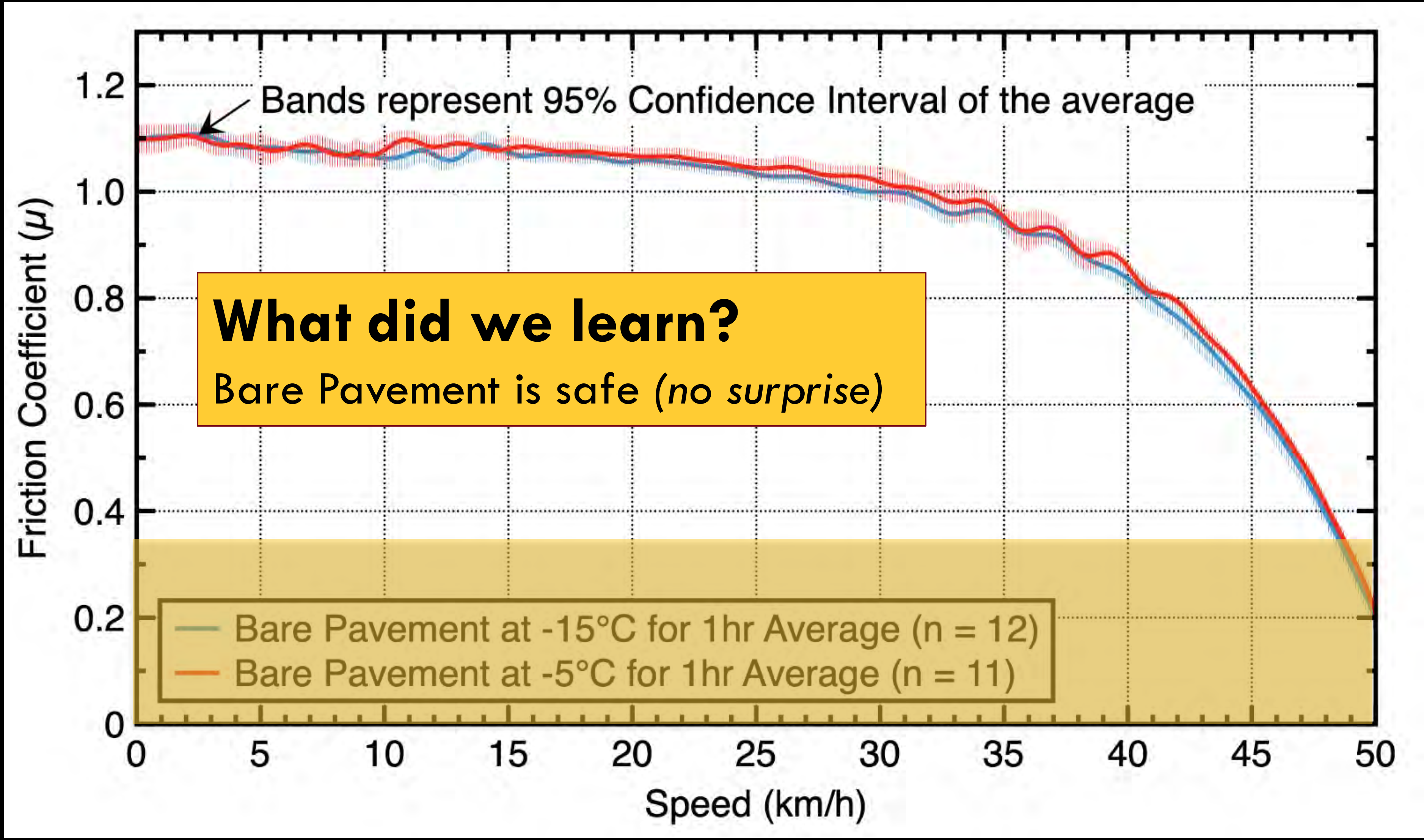
Dynamic Friction Tester
(ASTM E1911-19)
Thanks MnDOT!



Bare Pavement (no ice, no sand)

Good

Skid Number = 100 x μ



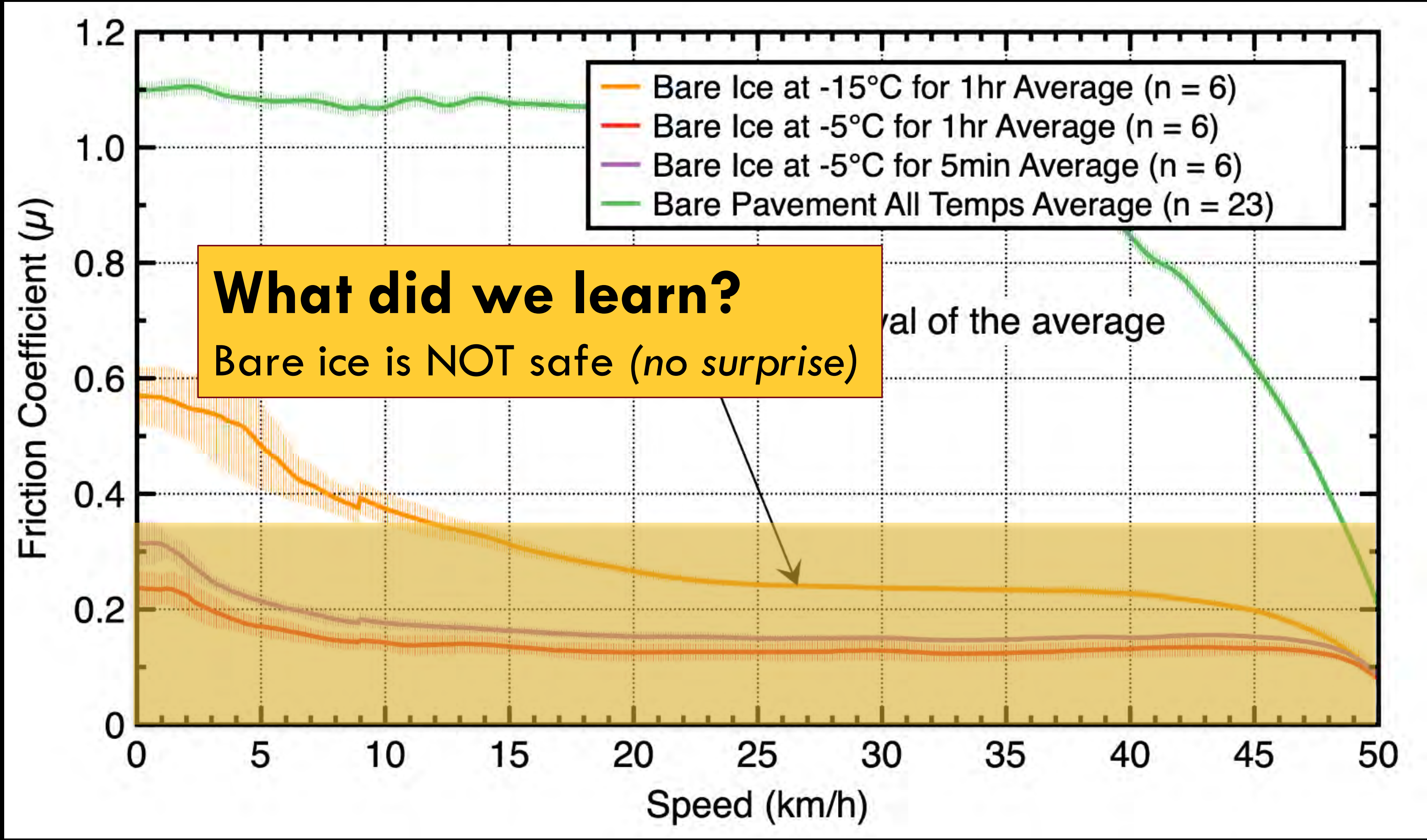
Bad

What did we learn?

Bare Pavement is safe *(no surprise)*

Bare Ice (no sand)

Skid Number = 100 x μ

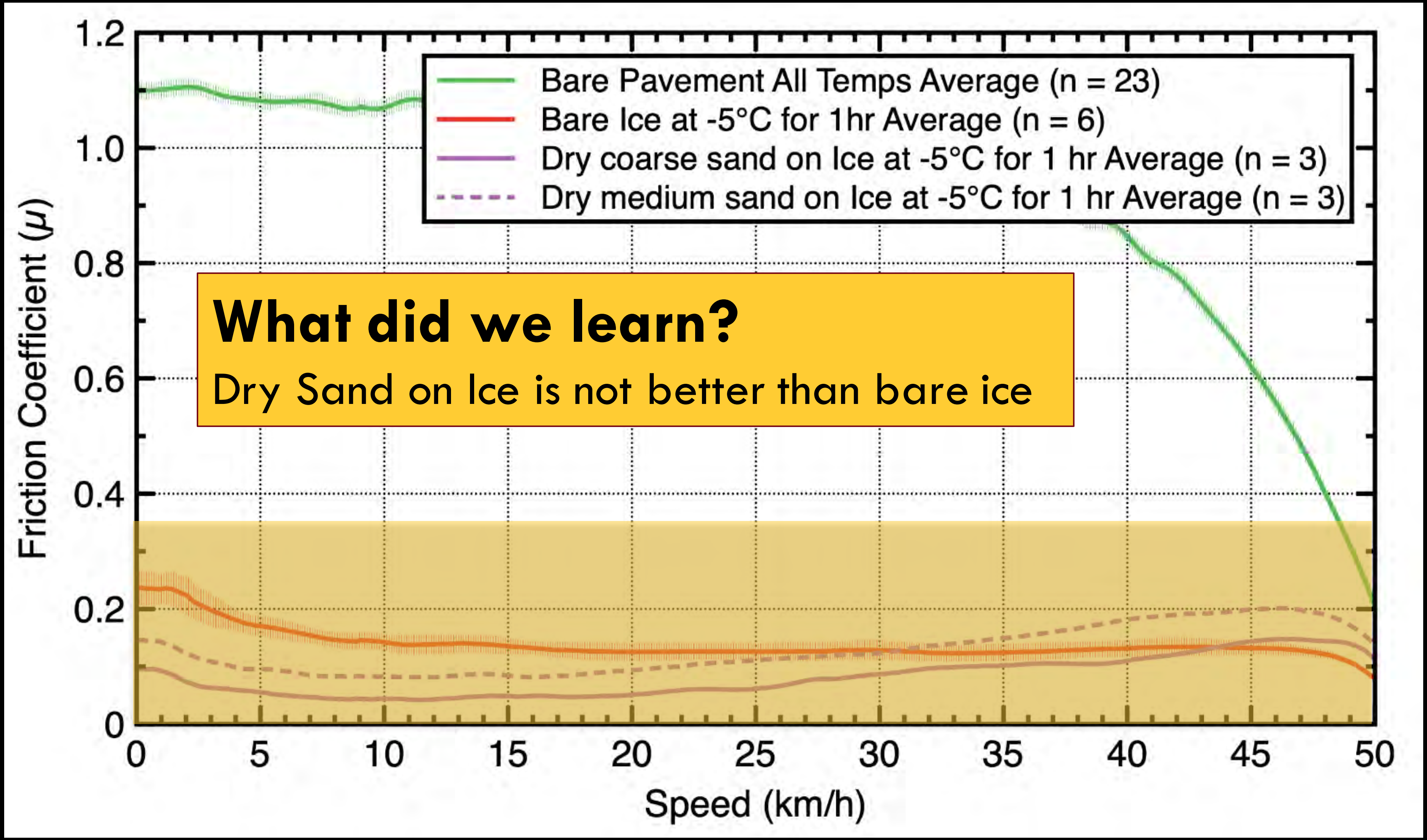


What did we learn?

Bare ice is NOT safe *(no surprise)*

Dry Sand on Ice vs. Bare Ice vs. Bare Pavement

Skid Number = 100 x μ

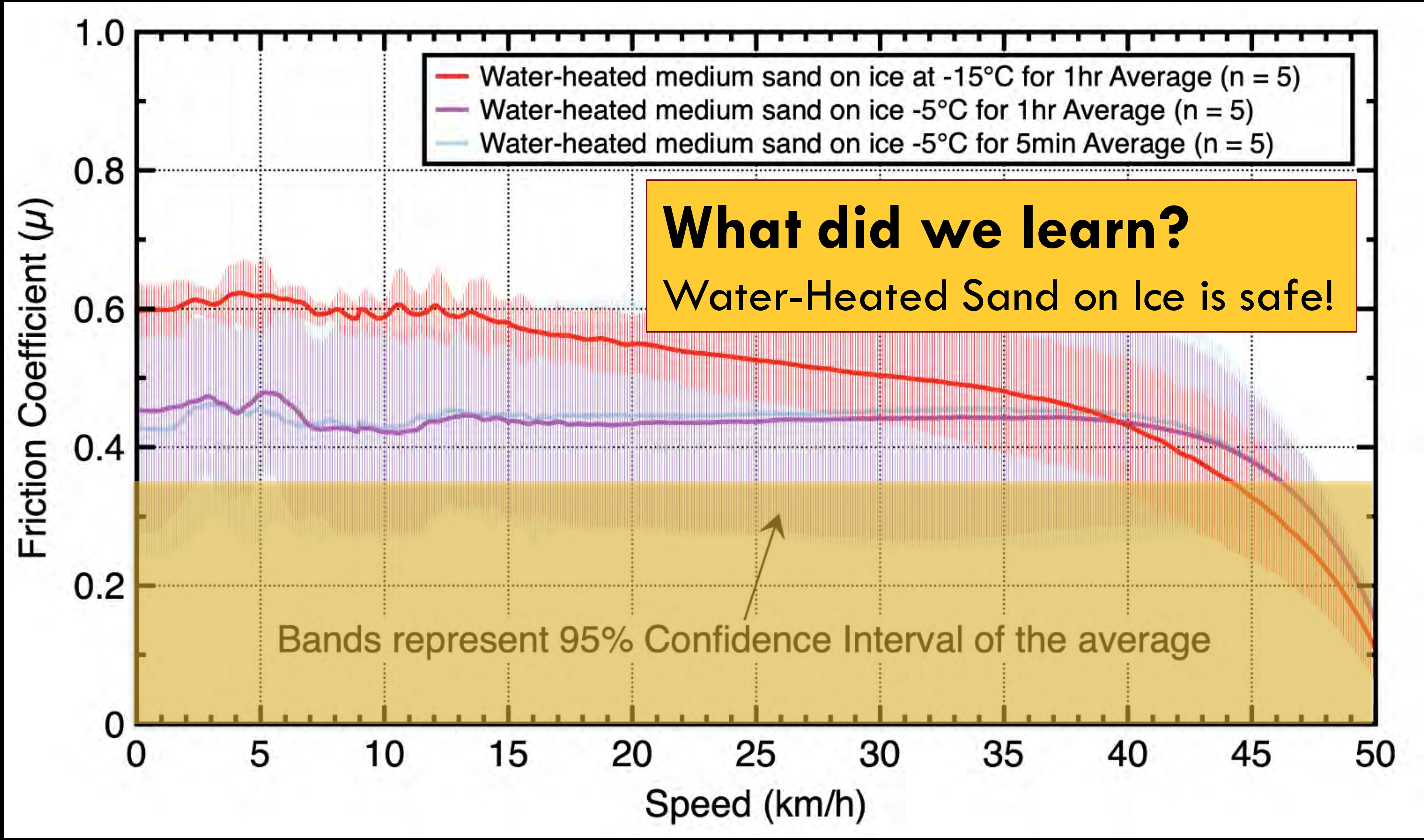


What did we learn?

Dry Sand on Ice is not better than bare ice

Water-Heated Medium Sand (d_{50} = 1.5mm) on Ice

Skid Number = 100 x μ

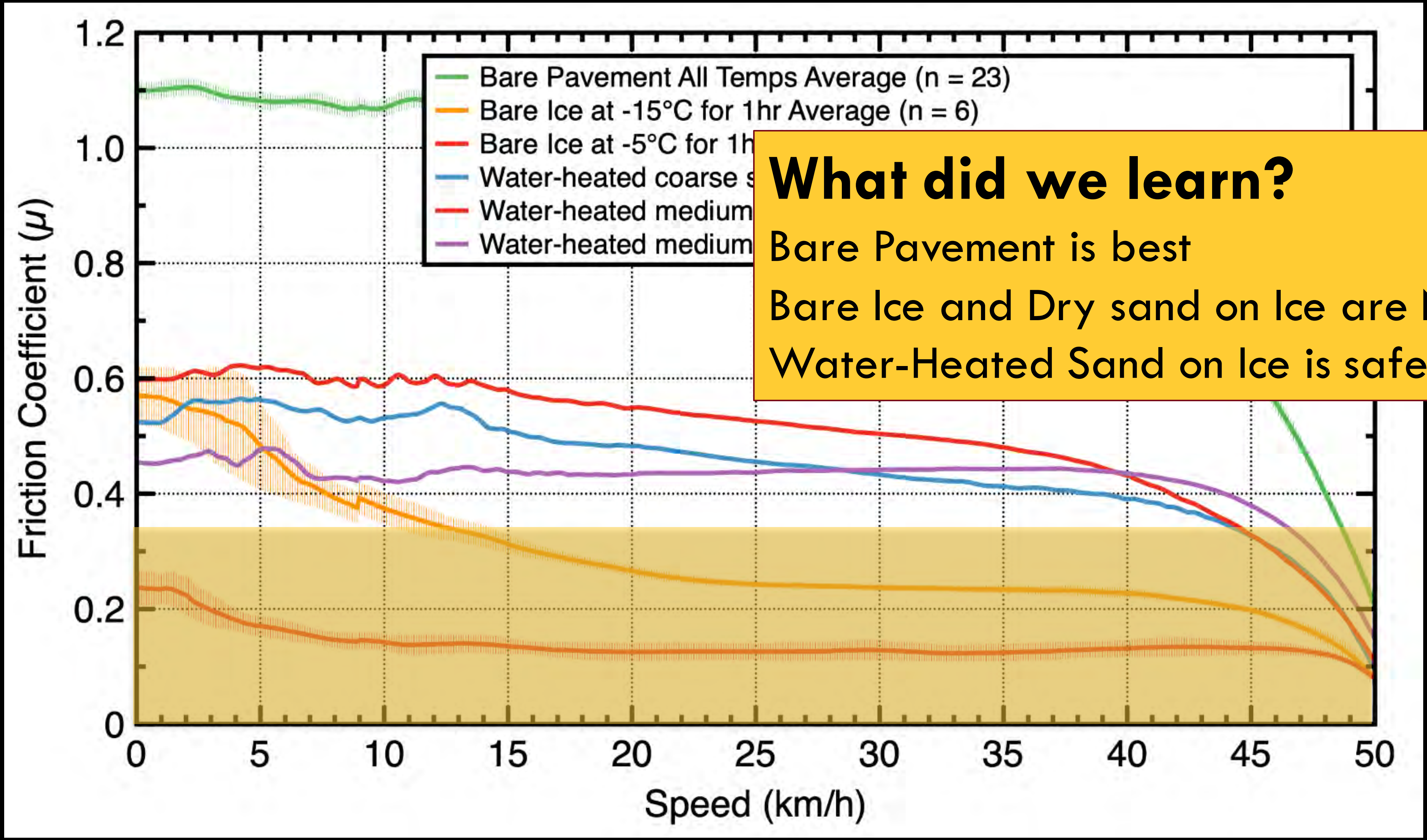


What did we learn?

Water-Heated Sand on Ice is safe!

Summary of Friction Results

Skid Number = 100 x μ



What did we learn?

Bare Pavement is best

Bare Ice and Dry sand on Ice are NOT safe

Water-Heated Sand on Ice is safe

Top 5 Things We've Learned…

- Do we have a salt legacy problem? **YES!**
- Can Permeable Pavements reduce Road Salt? **YES!**
- Which Anti-icing chemicals work best? **KAc & Prop. Glyc.**
- Do Road Salt Alternatives have Environmental Impacts? **Yes, but potentially less overall cost.**
- What Else Can We do?

Water-heated Sand!

https://teneoresults.com/blog/top-5-methods-of-prospecting/

Stormwater UPDATES Newsletter


University of Minnesota
Driven to Discover
Stormwater Assessment and Maintenance
UPDATES

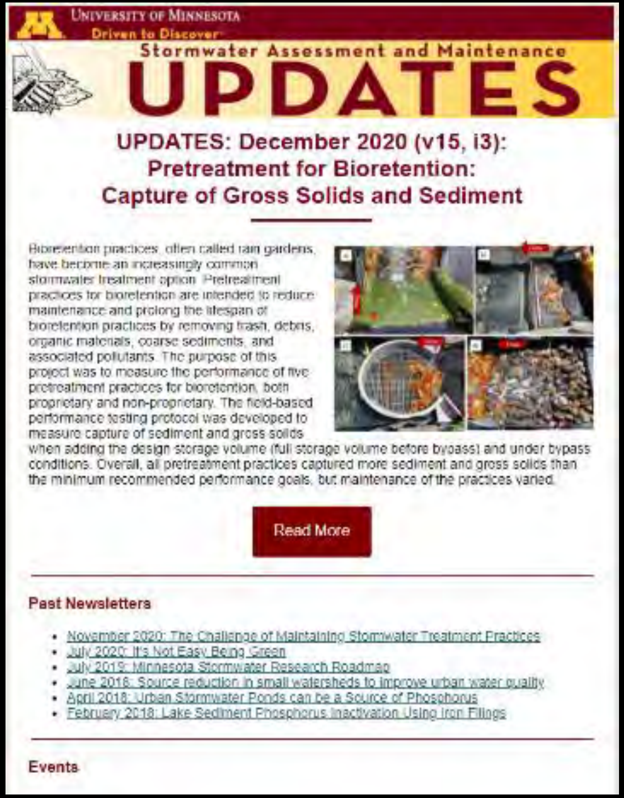
UPDATES: February 2021 (v16, i1):
Optimizing Biofiltration Media for Phosphate Release, Filtration Rates, and Vegetation Growth

Biofiltration has become common in Minnesota's urban landscape because it is one of the most robust stormwater treatment practices available to designers. Stormwater professionals and practitioners, however, still face challenging decisions while designing these practices and often feel as if they are guessing when selecting media components and designing these practices. Our objectives of this research are to **1) identify which local and sustainable biofiltration media are effective** for filtration rate and supporting plant growth and microbial function, while not releasing phosphate, and 2) **document local sources, simple tests or metrics, and/or design specifications** that can be used by practitioners to reliably and repeatably obtain a biofiltration practice that functions as expected. In other words, we intend to partially fill the knowledge gap of the best available biofiltration media components that can be locally sourced in Minnesota and accurately specified. This knowledge will hopefully empower practitioners to design biofiltration practices with the best available knowledge and understanding of media components in Minnesota.

Read More

Past Newsletters

- December 2020 (v15i3): Pretreatment for Bioretention: Capture of Gross Solids and Sediment
- November 2020: The Challenge of Maintaining Stormwater Treatment Practices
- July 2020: It's Not Easy Being Green
- July 2019: Minnesota Stormwater Research Roadmap


University of Minnesota
Driven to Discover
Stormwater Assessment and Maintenance
UPDATES

UPDATES: December 2020 (v15, i3):
Pretreatment for Bioretention:
Capture of Gross Solids and Sediment

Bioretention practices, often called rain gardens, have become an increasingly common stormwater treatment option. Pretreatment practices for bioretention are intended to reduce maintenance and prolong the lifespan of bioretention practices by removing trash, debris, organic materials, coarse sediments, and associated pollutants. The purpose of this project was to measure the performance of five pretreatment practices for bioretention, both proprietary and non-proprietary. The field-based performance testing protocol was developed to measure capture of sediment and gross solids when adding the design storage volume (full storage volume before bypass) and under bypass conditions. Overall, all pretreatment practices captured more sediment and gross solids than the minimum recommended performance goals, but maintenance of the practices varied.

Read More

Past Newsletters

- November 2020: The Challenge of Maintaining Stormwater Treatment Practices
- July 2020: It's Not Easy Being Green
- July 2019: Minnesota Stormwater Research Roadmap
- June 2016: Source reduction in small watersheds to improve urban water quality
- April 2018: Urban Stormwater Ponds can be a Source of Phosphorus
- February 2018: Lake Sediment Phosphorus Inactivation Using Iron Filings

Events


University of Minnesota
Driven to Discover
Stormwater Assessment and Maintenance
UPDATES

Minnesota Stormwater Research Spotlight, December 17, 2020:

Please join us for the next Minnesota Stormwater Research Spotlight Series event - *a bi-monthly experience featuring stormwater and green infrastructure research results from projects made possible through the Minnesota Stormwater Research and Technology Transfer Program in collaboration with the Minnesota Stormwater Research Council.*

Presentation 1: Pollutant Removal and Maintenance Assessment of Underground Filtration Systems (Phase I)

Presenters: Todd Shoemaker & Ali Stone, Wenck Associates, Inc.

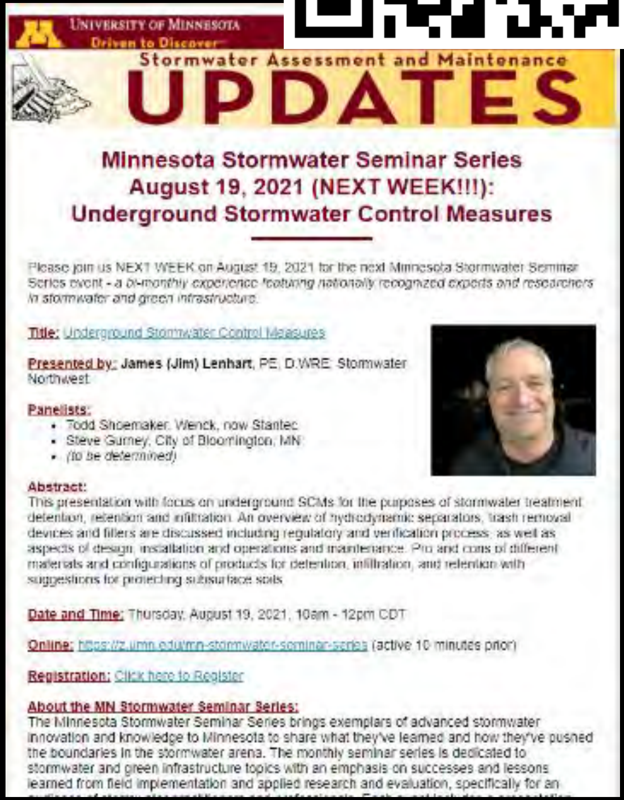
Abstract:
In this presentation, we will present our preliminary data and conclusions from the summer of 2020. We collected samples from six different storm events to evaluate pollutant removal and recorded water levels during the summer of 2020 to measure filtration (drawdown) rates.

The purpose of this study was to evaluate the stormwater management effectiveness of four underground sand filters in the Twin Cities Metro Area. These types of filters do not always offer clear access to the sand media layer and are not included in the Minnesota Stormwater Manual. Therefore, their pollutant removal effectiveness and maintenance frequency are somewhat unknown.

Presentation 2: Temporal Dynamics of Pathogens and Antibiotic Resistance Genes in Raw and Treated Stormwater

Presenter: Satoshi Ishii - Associate Professor, Department of Soil, Water, and Climate, University of Minnesota

Abstract:
Stormwater is considered as an alternative water source for both


University of Minnesota
Driven to Discover
Stormwater Assessment and Maintenance
UPDATES

Minnesota Stormwater Seminar Series
August 19, 2021 (NEXT WEEK!!!):
Underground Stormwater Control Measures

Please join us NEXT WEEK on August 19, 2021 for the next Minnesota Stormwater Seminar Series event - *a bi-monthly experience featuring nationally recognized experts and researchers in stormwater and green infrastructure.*

Title: Underground Stormwater Control Measures

Presented by: James (Jim) Lenhart, PE, D.WRE, Stormwater Northwest

Panelists:
- Todd Shoemaker, Wenck, now Stantec
- Steve Gurney, City of Bloomington, MN
- *(to be determined)*

Abstract:
This presentation will focus on underground SCMs for the purposes of stormwater treatment, detention, retention and infiltration. An overview of hydrodynamic separators, trash removal devices and filters are discussed including regulatory and verification process, as well as aspects of design, installation and operations and maintenance. Pro and cons of different materials and configurations of products for detention, infiltration, and retention with suggestions for protecting subsurface soils.

Date and Time: Thursday, August 19, 2021, 10am - 12pm CDT

Online: https://z.umn.edu/mn-stormwater-seminar-series (active 10 minutes prior)

Registration: Click here to Register

About the MN Stormwater Seminar Series:
The Minnesota Stormwater Seminar Series brings exemplars of advanced stormwater innovation and knowledge to Minnesota to share what they've learned and how they've pushed the boundaries in the stormwater arena. The monthly seminar series is dedicated to stormwater and green infrastructure topics with an emphasis on successes and lessons learned from field implementation and applied research and evaluation, specifically for an

Signup at http://stormwater.safl.umn.edu/

Minnesota Stormwater Seminar Series

YouTube Channel: http://z.umn.edu/swsrecord or
https://www.youtube.com/@MNStormwaterSeminar/videos

Past National Speakers:

Bill Hunt | Bridget Wadzuk | Bill Selbig | Jamie Houle | Marcus Quigley | Elizabeth Fassman-Beck | Scott Struck | Jenn Drake | Jon Hathaway | Allen Davis | Seth Brown | Stephanie Hurley | Jane Clary | Rob Traver | Tom Scheuler & David Wood

Michelle Simon | Nina Bassuk | Ryan Winston | Jim Lenhart | Bob Pitt | Mike Dietz | Harry Zhang | Chingwen Cheng | David McCarthy | Steve Corsi | Ken Schiff | Joel Moore | Bill Hunt

…and more to come!

Thanks for your attention!

Questions?

Andy Erickson
eric0706@umn.edu

Approximate Temp = -20 °C = -4°F