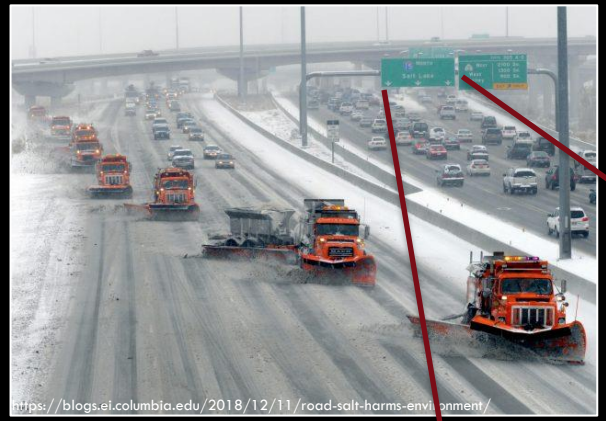
Recent, in progress, and future research on salt pathways, pavements, water softening, and all things chloride



Andy Erickson, Research Associate
St. Anthony Falls Lab, University of Minnesota
2019 Road Salt Symposium
October 24, 2019. Vadnais Heights, MN.

ST. ANTHONY FALLS LABORATORY

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

UNIVERSITY OF MINNESOTA
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Road Salt Use in Minnesota

- Novotny, Murphy, and Stefan (2008)

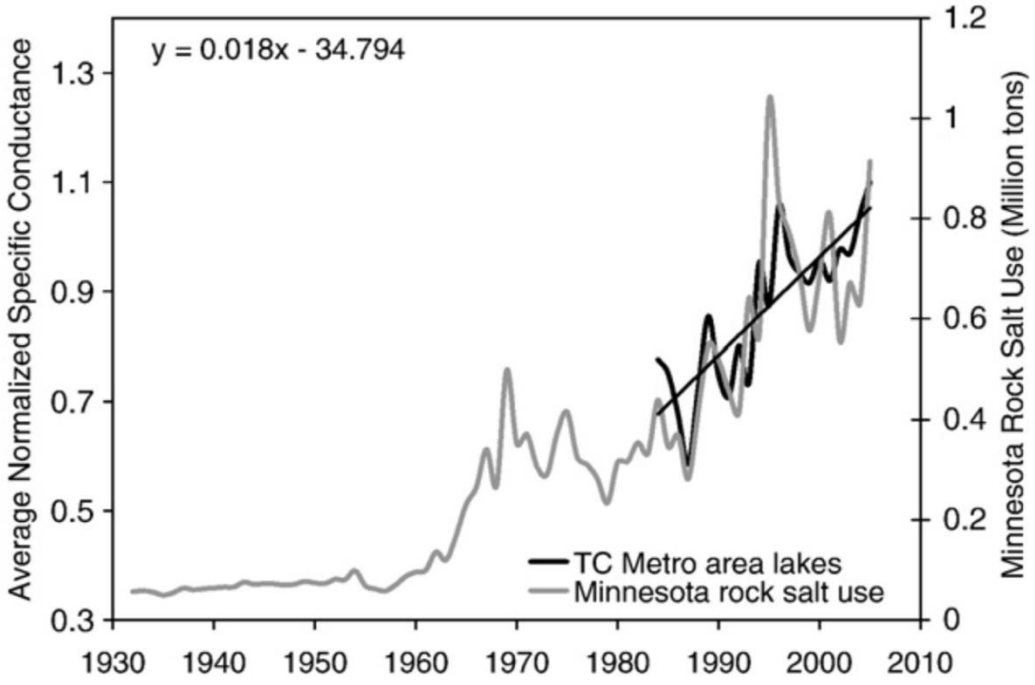
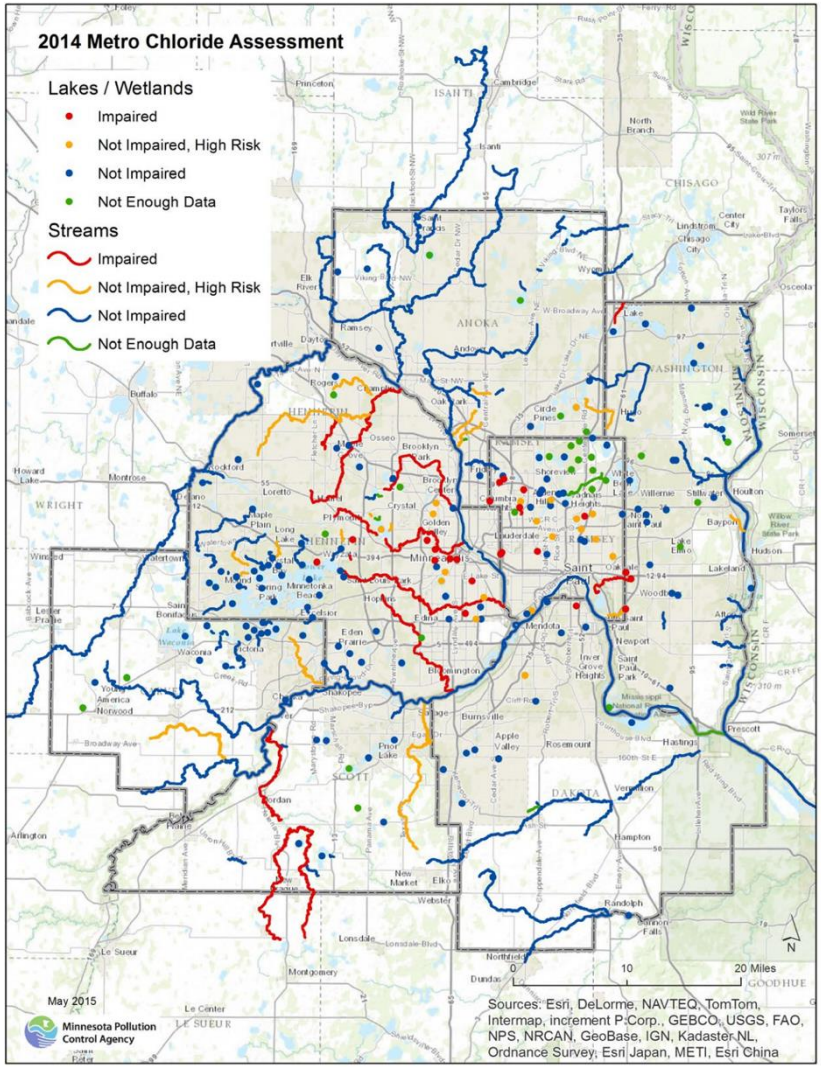


Fig. 8 – Time series of average normalized specific conductance in 38 Twin Cities Metro Area lakes (data set 2) and total rock salt purchases by the State of Minnesota.

Impacts of Chloride on Water Quality

- Impaired = more than 2 values over chronic value in 3 years or 1 over acute value
- 429 nationwide as of 2018
- 50 impairments in MN in 2018
- 39 impairments in TCMA in 2013



Groundwater Impairment

- Minnesota (MPCA, 2013)
  - 27% of shallow wells in TCMA > 250 mg/L Cl-
  - Median Cl^- in TCMA wells 5X that in rural wells

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

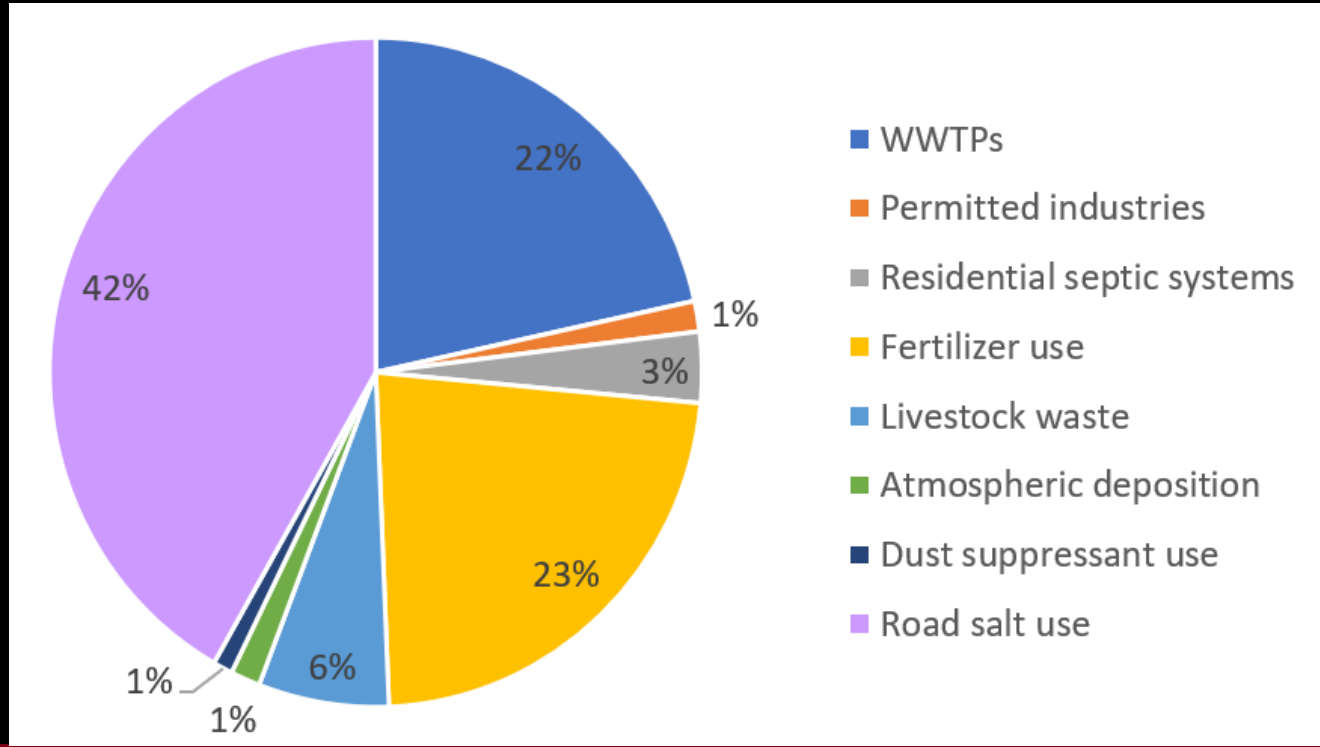
ILLINOIS STATE WATER SURVEY
PRAIRIE RESEARCH INSTITUTE

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

NaCl Salt Use in Minnesota

Road Salt = 42%
Fertilizer Use = 23%
WWTP = 22%
Livestock Waste = 6%

Data from Overbo et al. (2019)



The True Cost of Chloride

- *"Costs for salt and its application are only about $225/ton, but when one considers the damage to infrastructure, automobiles, vegetation, human health and the environment, costs are much higher.* ***Estimates of costs for damage due to road salt, range from $803 to $3341/ton and a $2,320 per lane mile per year reduction in environmental value.***"

Source: "The Real Cost of Salt Use for Winter Maintenance in the Twin Cities Metro Area" by Fortin Consulting, Inc. and the Minnesota Pollution Control Agency. 2014.

Slide and Images Courtesy: Peter Weiss

Adaptation to Reduce Chloride Impacts

- Management by runoff capture/diversion?
  - Ponds: an opportunity for chloride mitigation?
  - First-flush treatment at street level?
  - Disconnect infiltration BMPs during winter?

- Alternative Road Treatment
  - Non-chloride de-icers
  - Permeable pavements

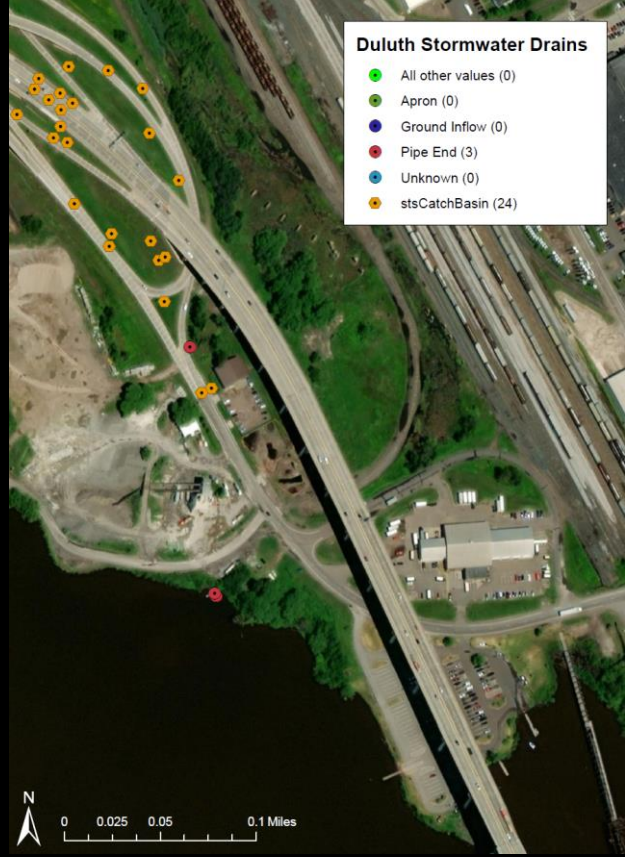
Road Salt Alternatives

- Acetate-based
  - Potassium acetate (KAc) – Favored: Melting ability
    - Lowest of all acetates (-20 to 32 °F)
  - Calcium magnesium acetate (CMA)
  - Sodium acetate
- KAc melts ice at lower temps than salt & RSA's
- High cost
- Less corrosive to metals
- Corrosive to galv. steel, asphalt, concrete
- Increases BOD, toxicity

Environmental Field Evaluation

- Evaluate the decay rate in various environmental conditions.

- Sample collection from MnDOT sites:
  - Upstream, meltwater, road runoff and downstream
- Water quality measurement:
  - Major ions, dissolved oxygen, pH, and conductivity
  - Biochemical oxygen demand and coliforms/E. coli
- MnDOT is especially interested in Potassium Acetate

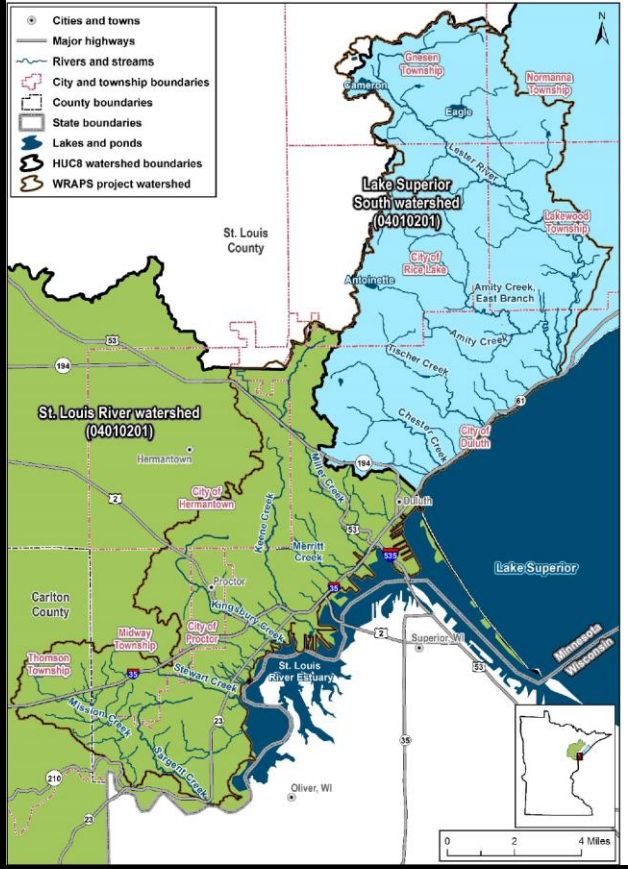


Blatnik Bridge Site

Environmental Modeling

- Simulate the transport of De-icer and Dissolved Oxygen:
  - Road application → runoff and meltwater → soil adjacent to the roadway → to receiving water body

- Calibration and verification with field measurements



Duluth Urban Area Watershed *(adapted from MPCA)*

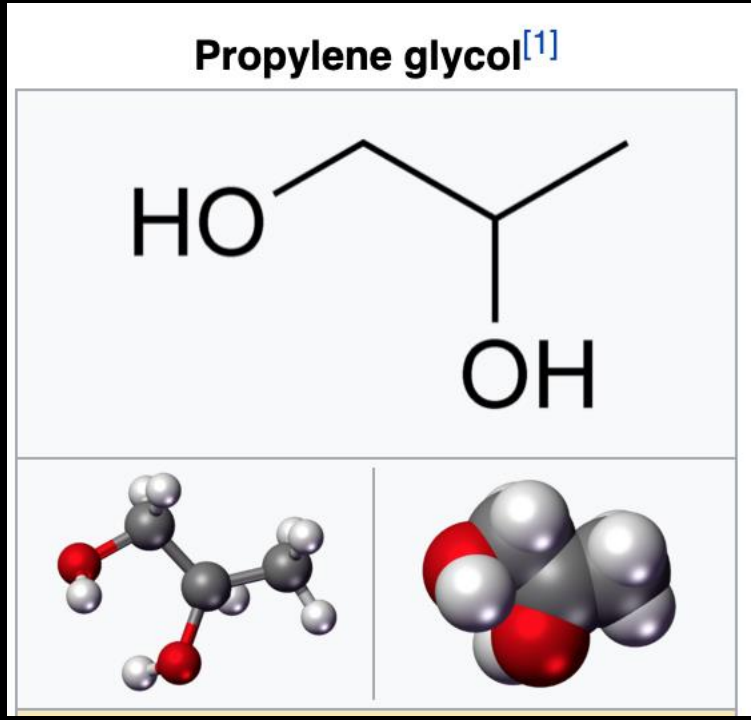
Chemical Toxicity

- Compile De-icer environmental toxicity data
  - ECOTOXicology knowledgebase
- Conduct toxicity tests on select fauna and flora.
  - Species of fauna and flora relevant to Minnesota ecosystem
  - Toxicological endpoints such as LC50, IC50, and EC50
  - With help from toxicology experts at EPA Duluth Laboratory

Image sources from EPA Mid-Continent Ecology Division

Road Salt Alternatives

- Propylene Glycol (used at airports)
- High cost
- Less corrosive to metals
- Negatively impact asphalt and concrete
- High BOD



Comparison of Road Salt Alternatives

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

Abrasives

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

The Friction Maker hot sand applicator

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

Pavement Innovations

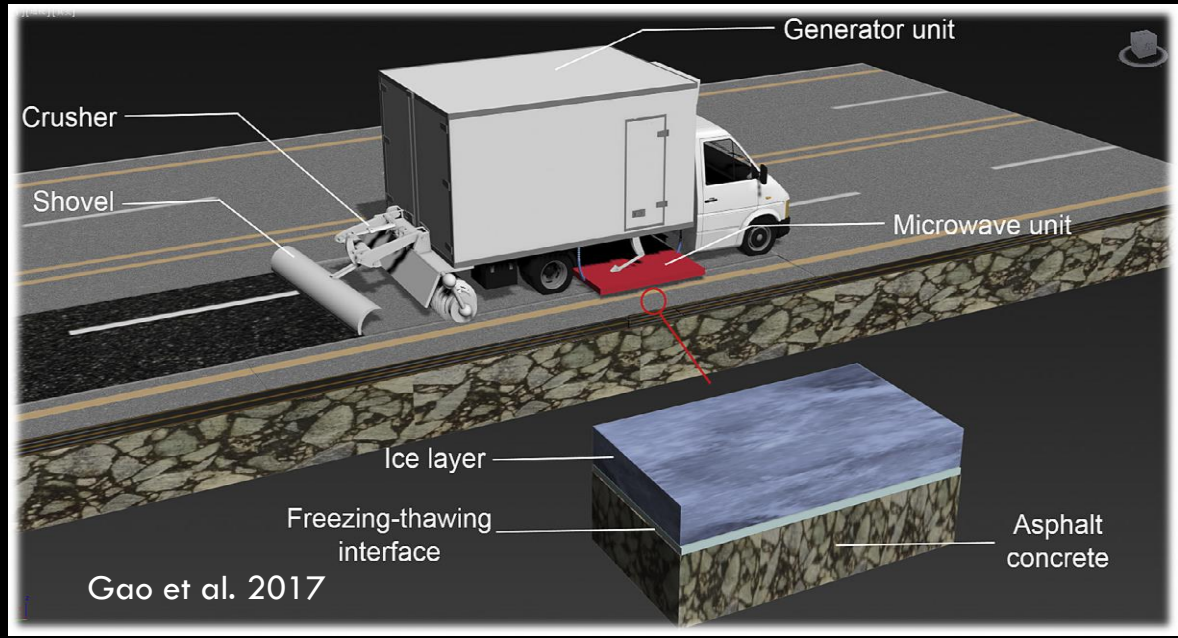
- Adding materials to heat pavement
- Adding deicing agents to pavement mix
- Adding heated pipes to the pavement
- Applying a hydrophobic coating

Electrically conductive concrete tested at Des Moines, IA airport.

Photos courtesy of Halil Ceylan.

Microwave Absorbing Particles

- Ice does not absorb microwaves
- Particles in pavement do (e.g., taconite)
- Weakens ice-pavement bond



Conductive Concrete on Runways

- U of AR experimental runway conductive concrete is solar powered.

Conductive Concrete to Charge E-Vehicles

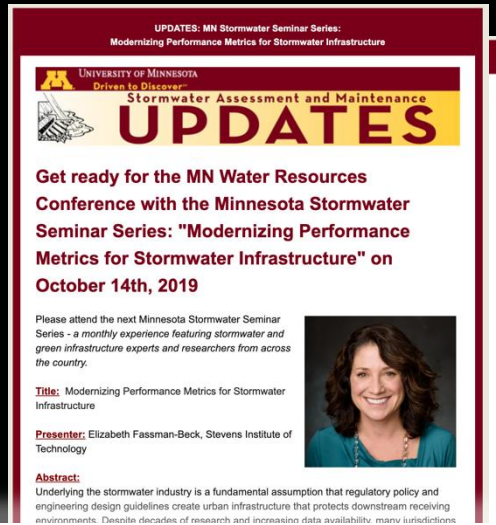
- Talga Resources plans conductive concrete to charge moving electric vehicles.

Gao et al. 2017

Conclusions

- "We have met the enemy and it is us." *Walt Kelly, creator of Pogo*
  - Chloride pollution is one challenge created by expanding cities and population growth.
- We need to apply chloride-based salts more judiciously.
  - MnDOT type of techniques need to be more widely applied.
- Possibly improve management of Spring runoff.
  - Divert to storage tanks or to waste water?
- Eventually replace chloride-based salts with biodegradable alternative salts and/or improved abrasives?

Stormwater UPDATES Newsletter


UPDATES: MN Stormwater Seminar Series:
Modernizing Performance Metrics for Stormwater Infrastructure

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UPDATES

Get ready for the MN Water Resources Conference with the Minnesota Stormwater Seminar Series: "Modernizing Performance Metrics for Stormwater Infrastructure" on October 14th, 2019

Please attend the next Minnesota Stormwater Seminar Series - *a monthly experience featuring stormwater and green infrastructure experts and researchers from across the country.*

Title: Modernizing Performance Metrics for Stormwater Infrastructure

Presenter: Elizabeth Fassman-Beck, Stevens Institute of Technology

Abstract:
Underlying the stormwater industry is a fundamental assumption that regulatory policy and engineering design guidelines create urban infrastructure that protects downstream receiving environments. Despite decades of research and increasing data availability, many jurisdictions


UPDATES: MN Stormwater Seminar Series - Using Technology in Water Resources

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UPDATES

Minnesota Stormwater Seminar Series: "Innovation and Technology Evolution in Water Resources Engineering" - September 19th, 2019

Please join us for the next Minnesota Stormwater Seminar Series - *a monthly experience featuring stormwater and green infrastructure experts and researchers from across the country.*

Title: Innovation and Technology Evolution in Water Resources Engineering: Where are we headed and how will we get there?

Presenter: Marcus Quigley, D.WRE, PE, CEO, EcoLucid

Abstract:
The incorporation of new digital technologies into practice has been pivotal to water resources engineerings' ability to continue to improve outcomes for people and the environment. From the digital computer's introduction in the early 1970's followed closely by personal computers in the late 1970's, to ARC/INFO GIS emerging 1981 and AutoCAD's


July 2019 (Volume 14, Issue 1): Minnesota Stormwater Research Roadmap

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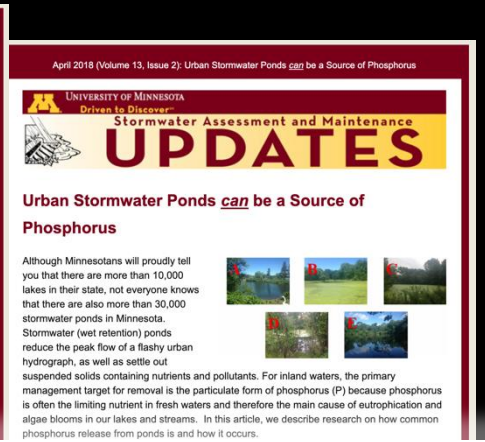
Minnesota Stormwater Research Roadmap

Many of Minnesota's urban waters are impaired. The future cost of meeting Clean Water goals using conventional approaches is likely to be very high - estimated to be $317 million per year (Barr Engineering, 2017). Research to improve stormwater management practices would likely result in improved stormwater management and accelerate progress toward Minnesota's statewide water quality goals. We started by conducting a review of relevant stormwater-related documents; we then developed a statewide survey of stormwater managers, conducted four focus groups, and conducted a number of policy actor interviews with knowledgeable and highly


April 2018 (Volume 13, Issue 2): Urban Stormwater Ponds *can* be a Source of Phosphorus

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Urban Stormwater Ponds *can* be a Source of Phosphorus

Although Minnesotans will proudly tell you that there are more than 10,000 lakes in their state, not everyone knows that there are also more than 30,000 stormwater ponds in Minnesota. Stormwater (wet retention) ponds reduce the peak flow of a flashy urban hydrograph, as well as settle out suspended solids containing nutrients and pollutants. For inland waters, the primary management target for removal is the particulate form of phosphorus (P) because phosphorus is often the limiting nutrient in fresh waters and therefore the main cause of eutrophication and algae blooms in our lakes and streams. In this article, we describe research on how common phosphorus release from ponds is and how it occurs.

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

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

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Questions?

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