Center for Technology & Training

2020 Michigan Winter Operations Conference

Day 3 – Thursday, October 15th

Michigan Winter Operations Conference

Environmental Impacts of Deicers


www.ci.bellevue.wa.us


Photo courtesy of M. Mills


www.miissoulanews.bigskypress.com

Laura Fay

2020 Michigan Winter Operations Conference

Oct. 15, 2020

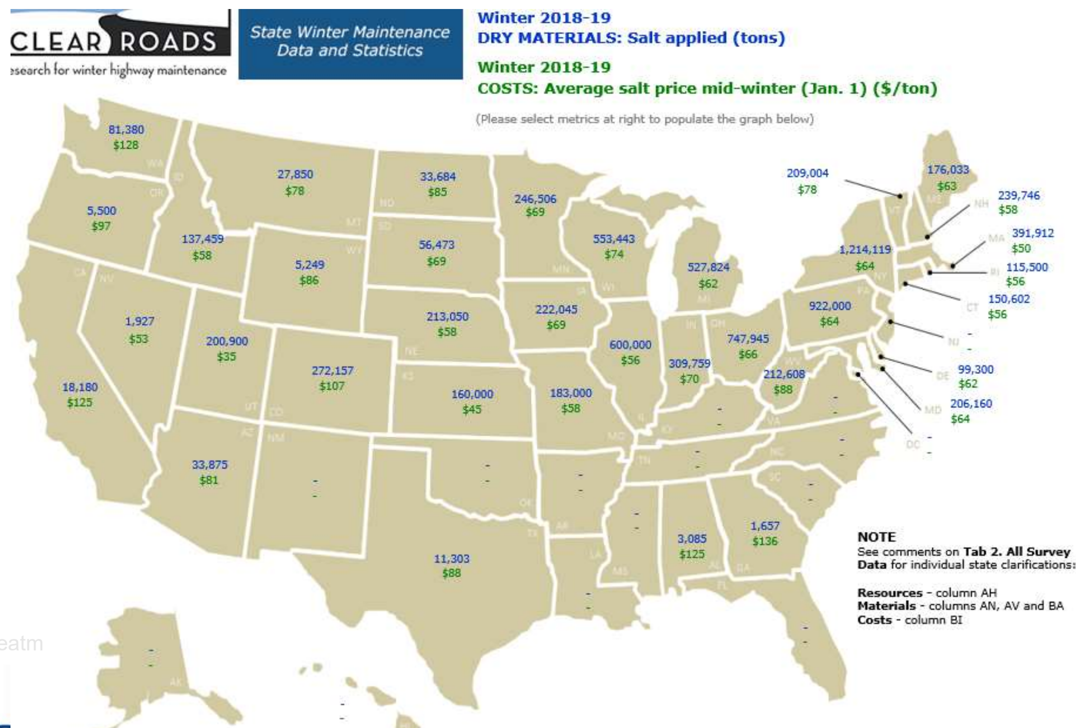
MONTANA STATE UNIVERSITY | College of ENGINEERING

Western Transportation Institute

Why Salt?

1. It is fairly cheap
2. It works
3. It has been proven to create safer road conditions!

https://www.northcountrypublicradio.org/news/images/Winter_road_treatment_using_salt_brine.jpg



What impacts do we see?

- Corrosion

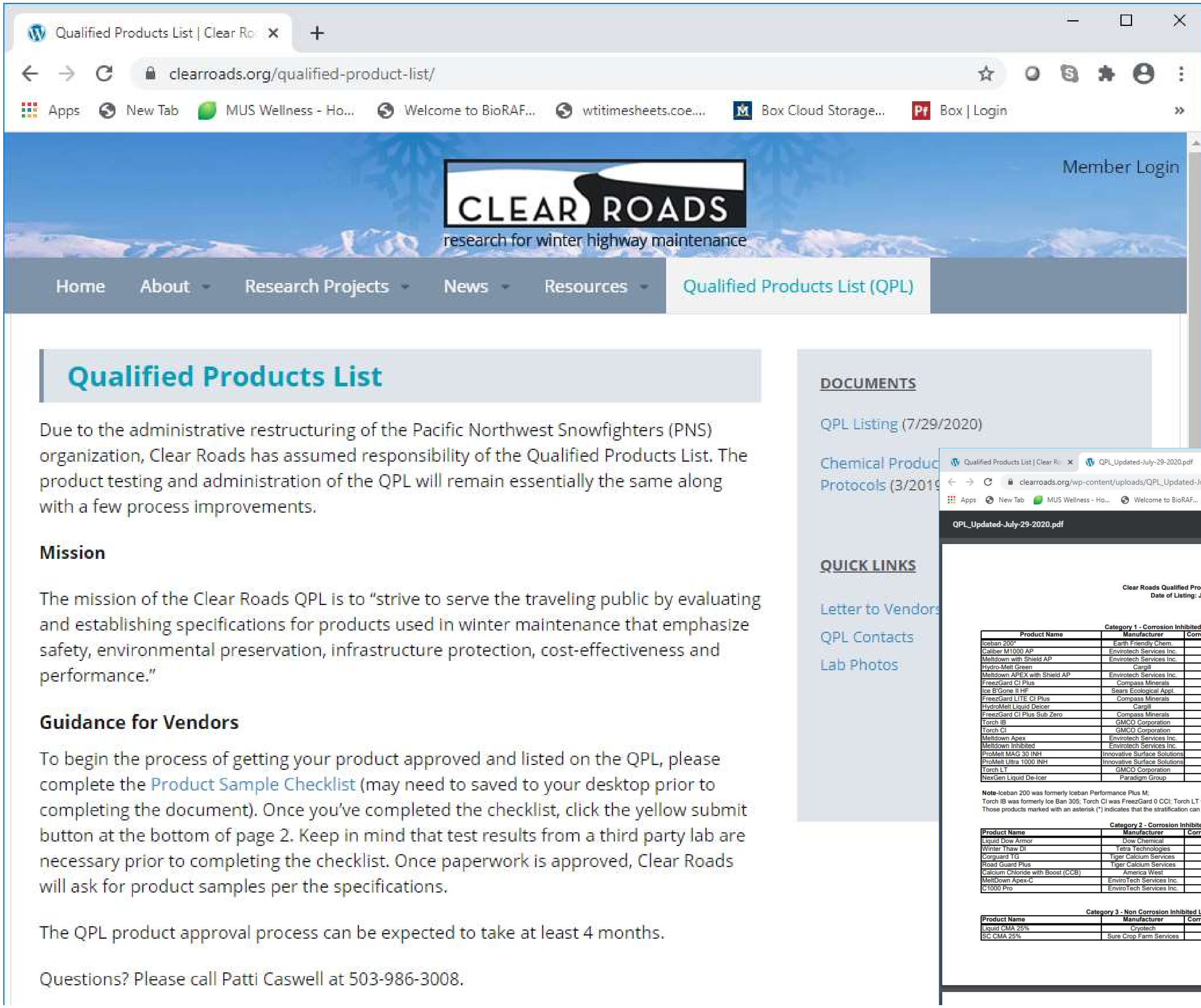
- Scaling

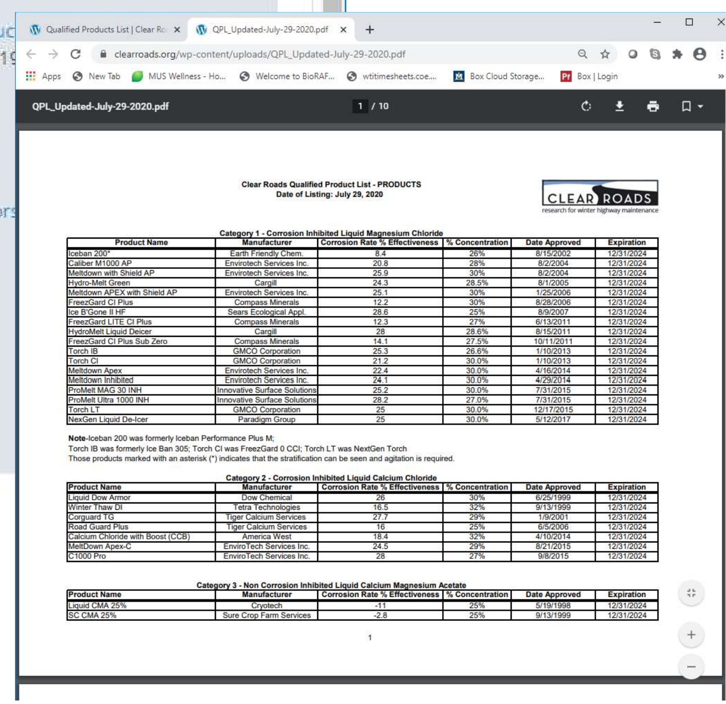
- Damage to rebar

What impacts can NOT see?

Clear Roads QPL

(formerly known as PNS QPL)





Clear Roads Qualified Product List - PRODUCTS
Date of Listing: July 29, 2020

Category 1 - Corrosion Inhibited Liquid Magnesium Chloride

Product Name	Manufacturer	Corrosion Rate % Effectiveness	% Concentration	Date Approved	Expiration
Iceban 200*	Earth Friendly Chem.	8.4	26%	8/15/2002	12/31/2024
Caliber M1000 AP	Envirotech Services Inc.	20.8	28%	8/2/2004	12/31/2024
Meltdown with Shield AP	Envirotech Services Inc.	25.9	30%	8/2/2004	12/31/2024
Hydro-Melt Green	Cargill	24.3	28.5%	8/1/2005	12/31/2024
Meltdown APEX with Shield AP	Envirotech Services Inc.	25.1	30%	1/25/2006	12/31/2024
FreezGard CI Plus	Compass Minerals	12.2	30%	8/28/2006	12/31/2024
Ice B'Gone II HF	Sears Ecological Appl.	28.6	25%	8/9/2007	12/31/2024
FreezGard LITE CI Plus	Compass Minerals	12.3	27%	6/13/2011	12/31/2024
HydroMelt Liquid Deicer	Cargill	28	28.6%	8/15/2011	12/31/2024
FreezGard CI Plus Sub Zero	Compass Minerals	14.1	27.5%	10/11/2011	12/31/2024
Torch IB	GMCO Corporation	25.3	26.6%	1/10/2013	12/31/2024
Torch CI	GMCO Corporation	21.2	30.0%	1/10/2013	12/31/2024
Meltdown Apex	Envirotech Services Inc.	22.4	30.0%	4/16/2014	12/31/2024
Meltdown Inhibited	Envirotech Services Inc.	24.1	30.0%	4/29/2014	12/31/2024
ProMelt MAG 30 INH	Innovative Surface Solutions	25.2	30.0%	7/31/2015	12/31/2024
ProMelt Ultra 1000 INH	Innovative Surface Solutions	28.2	27.0%	7/31/2015	12/31/2024
Torch LT	GMCO Corporation	25	30.0%	12/17/2015	12/31/2024
NexGen Liquid De-Icer	Paradigm Group	25	30.0%	5/12/2017	12/31/2024

Note-Iceban 200 was formerly Iceban Performance Plus M;
Torch IB was formerly Ice Ban 305; Torch CI was FreezGard 0 CCI; Torch LT was NextGen Torch
Those products marked with an asterisk (*) indicates that the stratification can be seen and agitation is required.

Category 2 - Corrosion Inhibited Liquid Calcium Chloride

Product Name	Manufacturer	Corrosion Rate % Effectiveness	% Concentration	Date Approved	Expiration
Liquid Dow Armor	Dow Chemical	26	30%	6/25/1999	12/31/2024
Winter Thaw DI	Tetra Technologies	16.5	32%	9/13/1999	12/31/2024
Corguard TG	Tiger Calcium Services	27.7	29%	1/9/2001	12/31/2024
Road Guard Plus	Tiger Calcium Services	16	25%	6/5/2006	12/31/2024
Calcium Chloride with Boost (CCB)	America West	18.4	32%	4/10/2014	12/31/2024
MeltDown Apex-C	EnviroTech Services Inc.	24.5	29%	8/21/2015	12/31/2024
C1000 Pro	EnviroTech Services Inc.	28	27%	9/8/2015	12/31/2024

Category 3 - Non Corrosion Inhibited Liquid Calcium Magnesium Acetate

Product Name	Manufacturer	Corrosion Rate % Effectiveness	% Concentration	Date Approved	Expiration
Liquid CMA 25%	Cryotech	-11	25%	5/19/1998	12/31/2024
SC CMA 25%	Sure Crop Farm Services	-2.8	25%	9/13/1999	12/31/2024

1

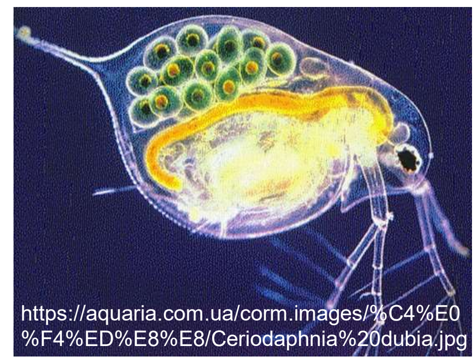
What does it take to be on QPL?

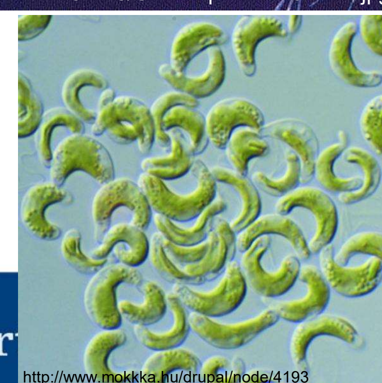
- Elemental Analysis

Arsenic	5.0
Barium	100.0
Cadmium	0.20
Chromium	1.0
Copper	1.0
Lead	1.0
Mercury	0.05
Selenium	5.0
Zinc	10.00
Phosphorus	2500.
Cyanide	0.20

- Other Testing Required

Ammonia - Nitrogen
Total Kjeldahl Nitrogen
Nitrate and Nitrite - Nitrogen
Biological Oxygen Demand
Chemical Oxygen Demand
Frictional Analysis
Toxicity Testing
  - Rainbow Trout or Fathead Minnow Toxicity Test
  - Ceriodaphnia Dubia Reproductive and Survival Bioassay
  - Selenastrum Capricornutum Algal Growth





Where do these numbers come from?

- Your State
- The Environmental Protection Agency (EPA)
  - https://www.epa.gov/wqc/national-recommended-water-quality-criteria-aquatic-life-criteria-table (aquatic life)
  - https://www.epa.gov/wqc/national-recommended-water-quality-criteria-human-health-criteria-table (human health)

Let's talk salt

- EPA water quality standard (*secondary drinking water standard)

250 mg/L = 250 mg Chloride / 1 Liter water

*Maximum contaminant level, causes undesirable taste or odor, undesirable effects to the body, damage to equipment….

What 250 mg/L of salt looks like!

- 250 mg = about 1/10 of a teaspoon of salt

http://home.bt.com/pictures/home-garden/best-kitchen-buys-under-10-11363830268713

That is less than half of this add to a full 1-liter bottle.

Bagels

Photo by Rachel Hartman

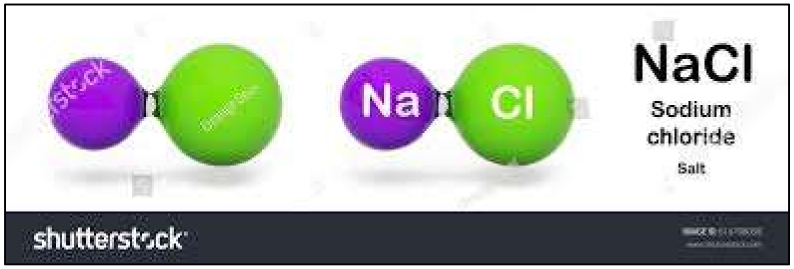
A bagel on average has a salt content of 490mg.

https://spoonuniversity.com/lifestyle/salt-content-favorite-foods-actually-looks-like

A little chemistry

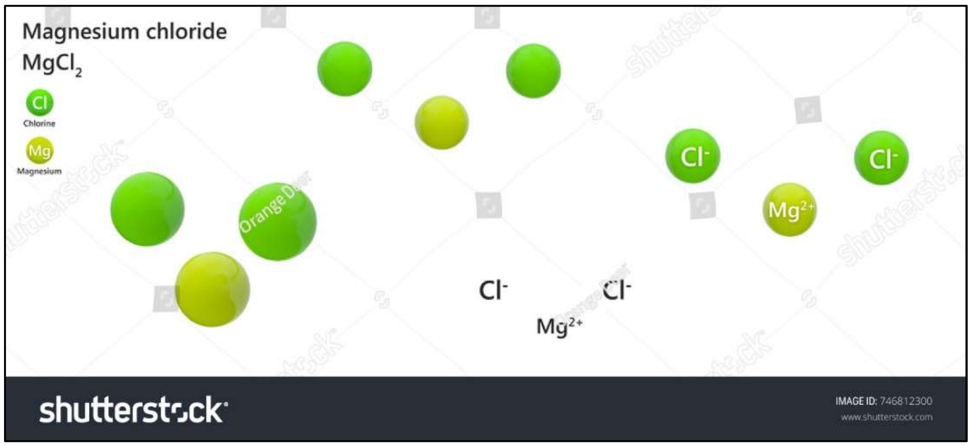
Or salt is 40% Sodium and 60% Chloride!

NaCl

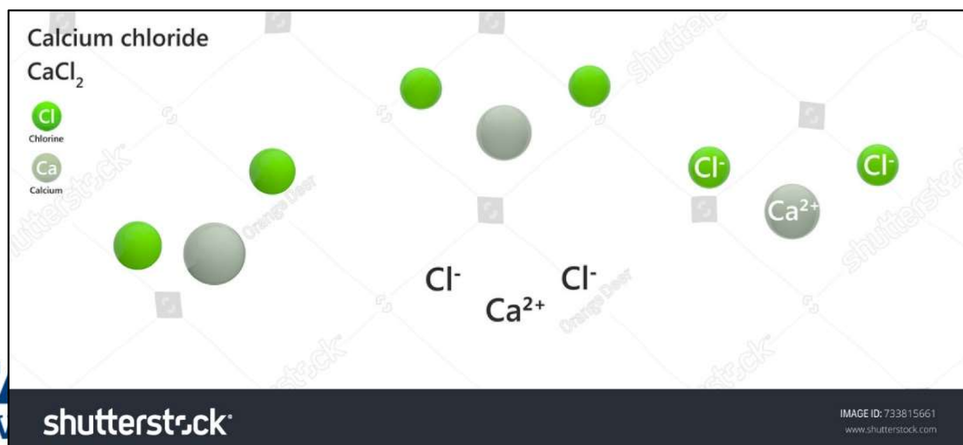


[100 g of NaCl = 39.34 g Na + 60.66 g Cl.]

$MgCl_2$



$CaCl_2$



Both Mag and Calcium chloride have twice as much chloride as NaCl

What does this have to do with winter maintenance?

- Chloride (drinking water standard):
  - 250 mg/L
- Chloride (aquatic life standards):
  - 230 mg/L Chronic (longer term exposure)
  - 860 mg/L Acute (1 time exposure)

Products used by WSDOT and Application Rates

- **NaCl** (32 to 15°F)
  - Solid – 100 to 800 lbs/l-m
  - Liquid – 10 to 40 gal/l-m
  - Pre-wet – 8 to 20 gal/l-m
- **$MgCl_2$** (32 to -5°F) and **$CaCl_2$** (32 to -15°F)
  - Solid – 100 to 500 lbs/l-m
  - Liquid – 10 to 40 gal/l-m
  - Pre-wet – 8 to 20 gal/l-m

Other products?

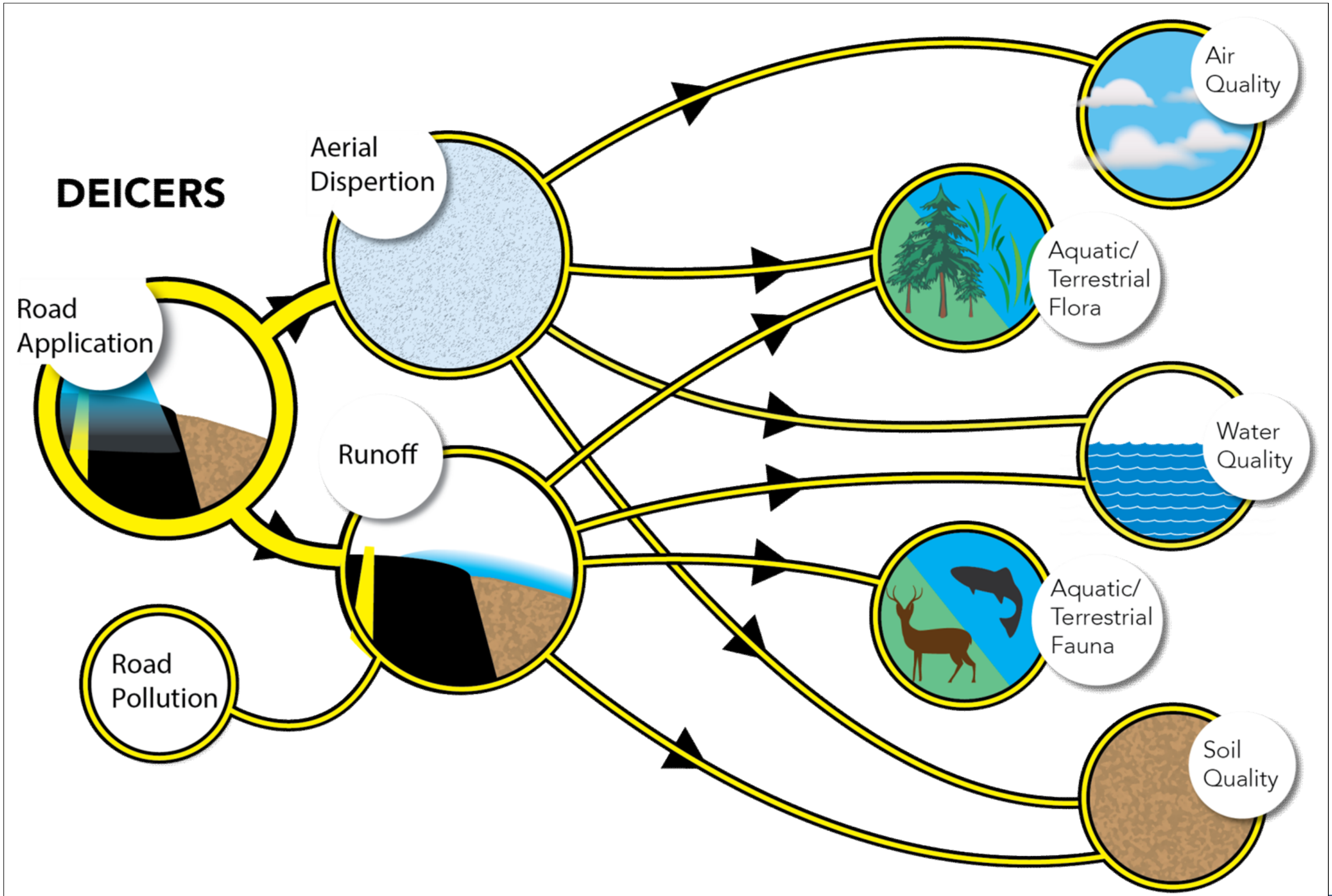
What application rates do you use?

For anti-icing?

For pre-wetting?

For deicing?

Once applied, where do deicers go?



Let’s play a game (not really just math)

Pounds (lbs)	Milligrams (mg)	Pond [NaCl]
50	22,680,000	11 mg/L
100	45,360,000	22 mg/L
250	113,400,000	57 mg/L
500	226,800,000	113 mg/L
1000	453,600,000	227 mg/L

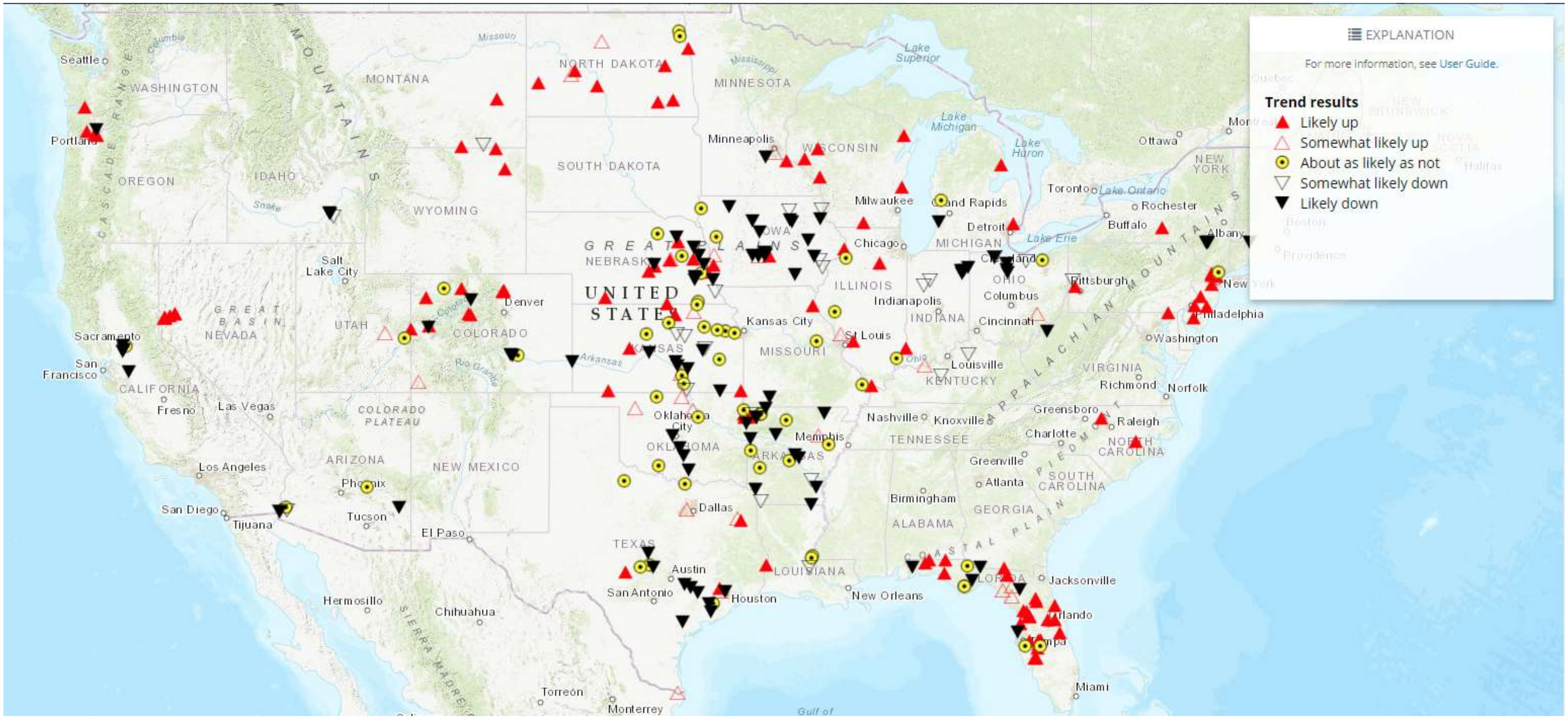
https://www.adn.com/alaska-news/anchorage/2019/06/18/goldfish-are-thriving-in-a-midtown-anchorage-pond-alaska-wildlife-biologists-want-them-gone/
https://dailyreporter.com/2010/12/07/pass-the-salt/

So where do we go from here?

1. What are actual water chloride levels?
2. And what toxicological impacts are being observed?

https://thecolourfulheart.files.wordpress.com/2018/02/where-do-we-go-from-here-e1517805037438.jpg?w=640

USGS Stream and Surface Water Chloride Concentrations from 2002-2012



https://nawqatrends.wim.usgs.gov/swtrends/

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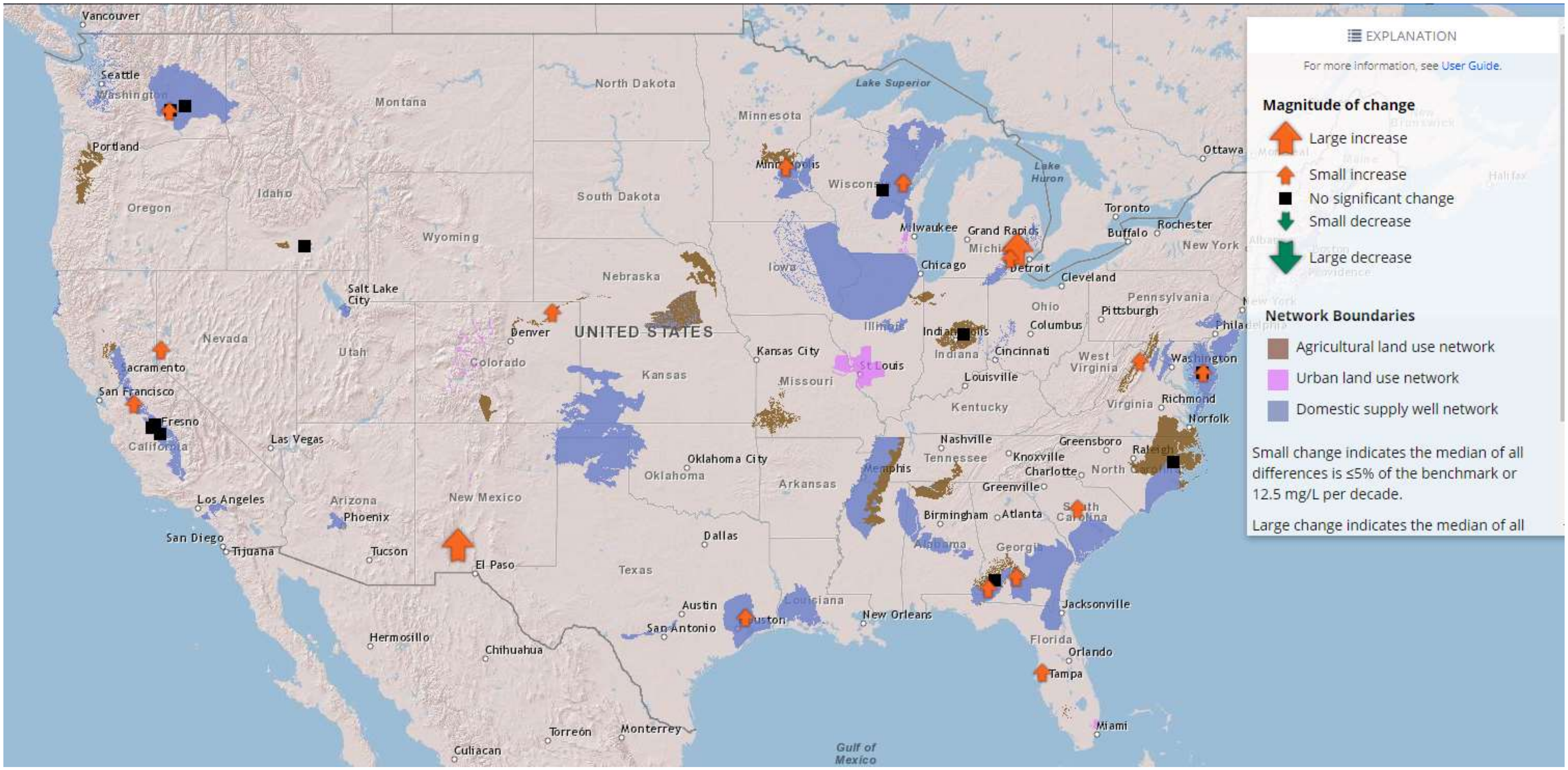
USGS Groundwater Chloride Concentration changes from 1988-2016



https://nawqatrends.wim.usgs.gov/Decadal/

Chloride numbers from the field

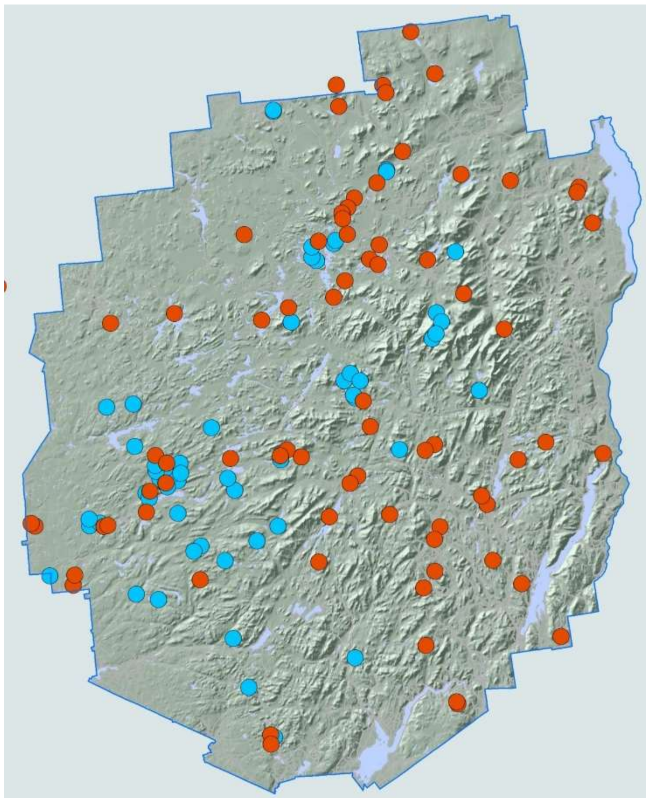
- USGS (Corsi et al., 2014)
  - 29% of the sites exceeded the EPA (230 mg/L)
    - by an average of more than 100 days per year from 2006 - 2011, almost double the amount of days from 1990 -1994.
  - The lowest chloride concentrations were in watersheds that had little urban land use or cities without much snowfall.

https://www.usgs.gov/news/urban-stream-contamination-increasing-rapidly-due-road-salt

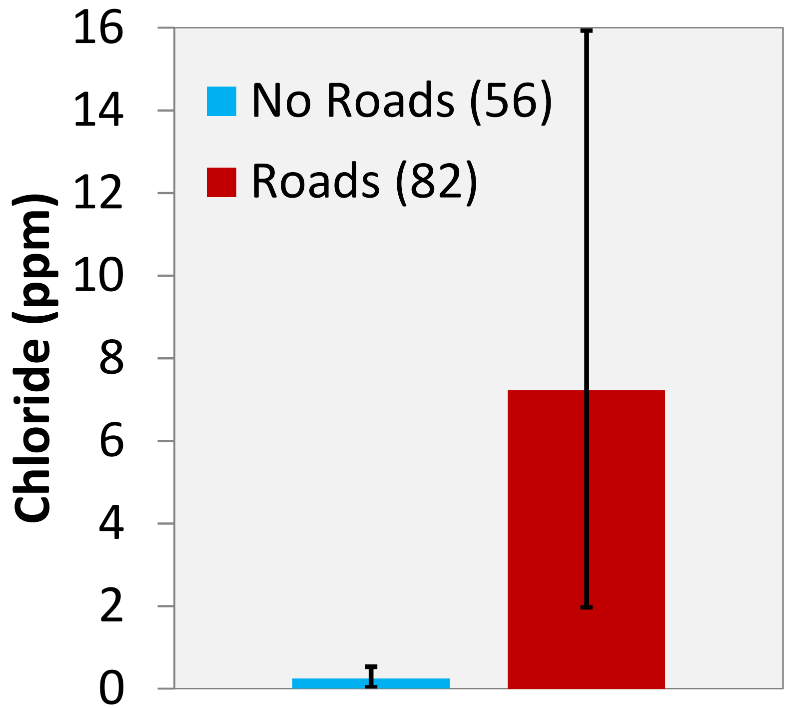
USGS (Corsi et al., 2014)

- In 16 of the streams, winter chloride concentrations increased over the study period.
- In 13 of the streams, chloride concentrations increased over the study period during non-deicing periods such as summer.
  - chloride infiltrating the groundwater system during the winter, then slowly released to the streams throughout the year.

Regional Salinization caused by WMO



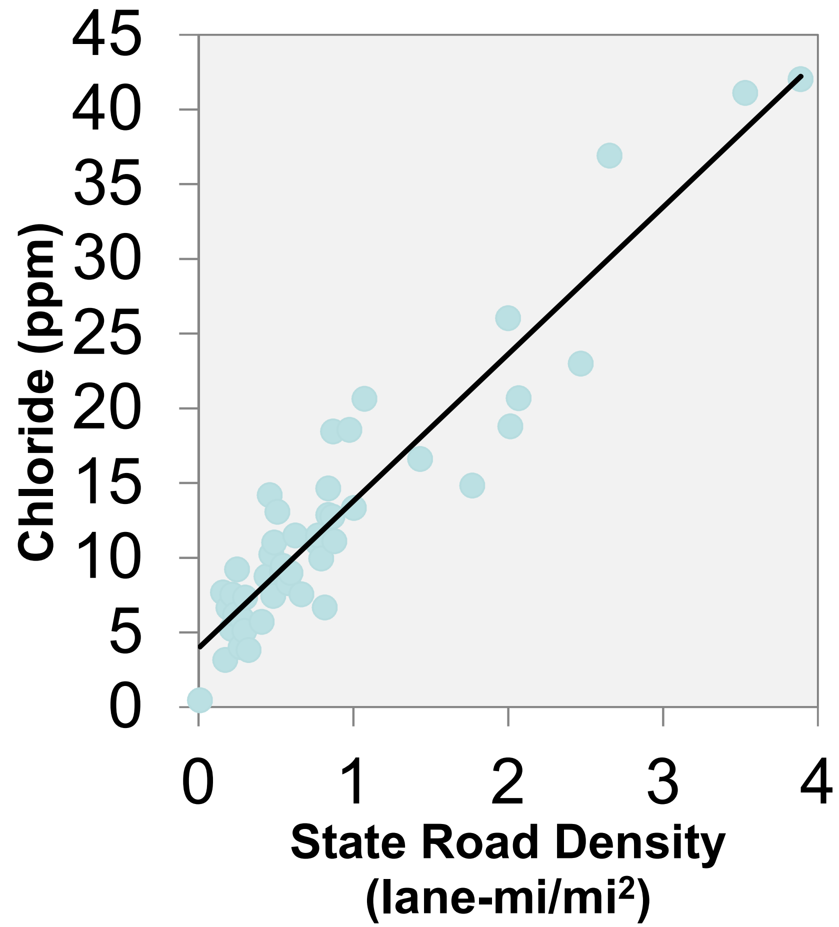
Kelting, D. L., Laxson, C. L., & Yerger, E. C. (2012). Regional analysis of the effect of paved roads on sodium and chloride in lakes. *Water Research*, 46(8), 2749-2758.



- <0.5ppm w/**no roads**
- 14X higher w/**roads**

Lake Chloride Concentrations tied to State Road Density

- Higher state road density equals higher salt load
- No relationship found between local roads and chloride concentration.



Kelting, D. L., Laxson, C. L., & Yerger, E. C. (2012). Regional analysis of the effect of paved roads on sodium and chloride in lakes. *Water Research*, 46(8), 2749-2758.

It is not just surface water; it is ground water too…

- They found the UNEXPECTED
  - Think slow, glacial time scale..

1. Long term increases in concentration
2. High [Cl-] in summer
3. Higher [Cl-] downstream in summer

Stuart Findlay and Vicky Kelly (Cary Institute, 2018)

Stuart Findlay and Vicky Kelly (Cary Institute, 2018)

- Background < 10 mg/L
- Environmental effects (sub lethal) ~ 100 mg/L
- Lethal > 1000 mg/L

- EPA Drinking Water Std. 250 mg/L
- EPA chronic 230 mg/L
- EPA acute 860 mg/L

Summary of Reported Chloride concentrations

Freshwater Ecosystem	Range due to natural sources (mg/L)	Range from road salt contamination
Lakes	0 - 10	6 – 1,000
River/Stream	1 - 20	10 – 7,730
Wetland/Pond	0 - 12	10 – 13,500

Sources of chloride

- 80% from deicing (DOT, local, private)
- 5-10% from water softeners

(Findlay and Kelly, Cary Institute, 2018; Hintz and Relyea, 2018)

The Ecological Perspective

- Salt negatively affects species across all trophic levels – biofilms to fish
- Salt impacts vary by concentration and species
- Typical impacts for species were not death, but reduction in growth and reproduction
- Community level impacts were reductions in biodiversity, and encouragement of salt tolerant species

Hintz, W.D. and Relyea, R.A. (2018) A review of the species, community, and ecosystem impacts of road salinization in fresh waters. Freshwater Biology.

Other documented impacts of Deicers


https://rachelcarsoncouncil.org/safe-deicing-products/

- Deicers can cause…
  - Mobilizations of heavy metals
  - Impacts to or death of aquatic & terrestrial species
  - Loss of native species => increase in invasive species (aquatic & terrestrial)
  - Wildlife-vehicle collisions


https://www.hoosier.aaa.com/insurance/wildlife-animal-vehicle-collisions

Impacts of Salt and Chloride Based Deicers


www.witnerservices.net


www.modot.org


Photo courtesy of M. Mills


www.clf.org


www.syracuse.com


www.miissoulanews.bigskypress.co


www.ci.bellevue.wa.us

Impacts of Sand and Abrasives

$ $ $

BOD
(Biological/Biochemical Oxygen Demand)

- "The amount of dissolved oxygen needed by aerobic biological organisms to break down material in water at a specific temperature or a specific time."

https://en.wikipedia.org/wiki/Biochemical_oxygen_demand

https://www.slideshare.net/jamesmacroony/biochemical-oxygen-demand

	BOD Standards (mg/L)
Most pristine rivers	< 1
Moderately polluted rivers	2 - 8
Ordinary domestic sewage	150 - 200
Treated sewage	< 20

BOD Level in mg/liter	Water Quality
1 - 2	**Very Good:** There will not be much organic matter present in the water supply.
3 - 5	**Fair:** Moderately Clean
6 - 9	**Poor:** Somewhat Polluted - Usually indicates that organic matter present and microorganisms are decomposing that waste.
100 or more	**Very Poor:** Very Polluted - Contains organic matter.

https://www.pharmaguideline.com/2013/06/determination-of-biological-oxygen.html

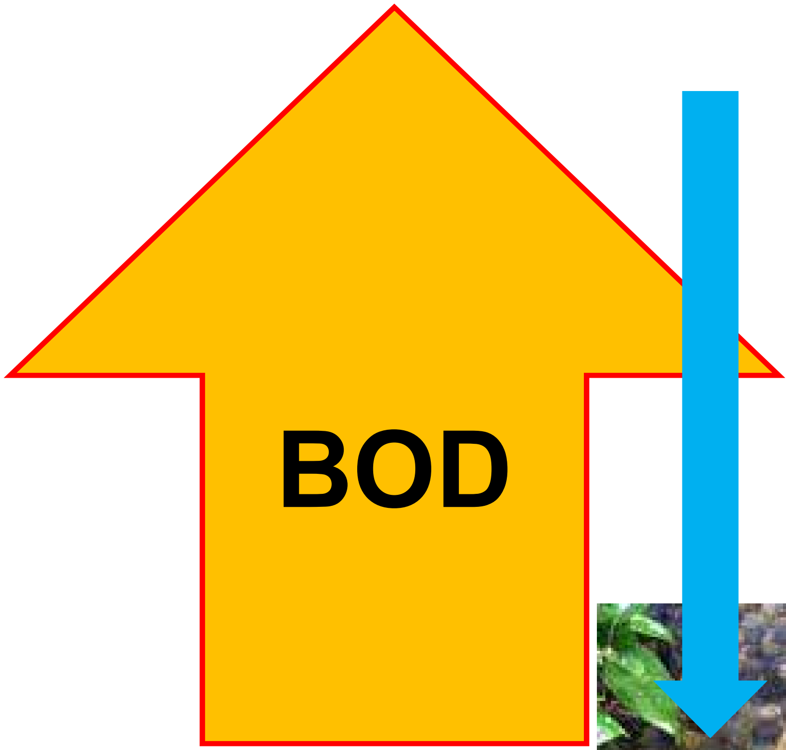
Ag-based, Acetate, Formates & Glycols

<u>Benefits</u>

- Break down in the environ.
- Less corrosive than chlorides

<u>Not so good</u>

- Higher costs
- Exert a higher BOD



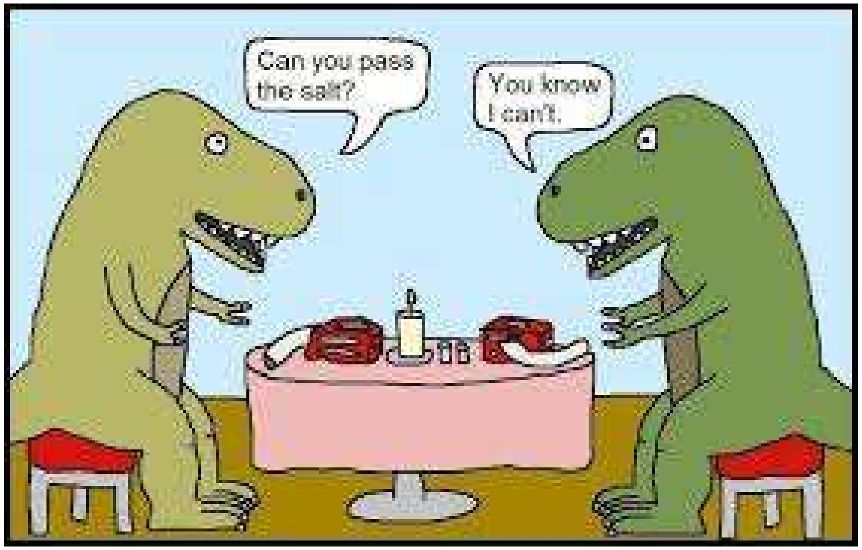
Reduces available oxygen for organisms in the soil and aquatic environments

Where does this leave us…

Where does this leave us…

https://encrypted-tbn0.gstatic.com/images?q=tbn%3AANd9GcR5MGKmoiGc9aoBATLUiXWFIOS-RHeJ9vfu4w&usqp=CAU

- Invent a better deicer



- Invest in a different deicing system

Heated pavements?

Resources

- www.clearroads.org

CLEAR ROADS
research for winter highway maintenance

Questions?

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https://westerntransportationinstitute.org/