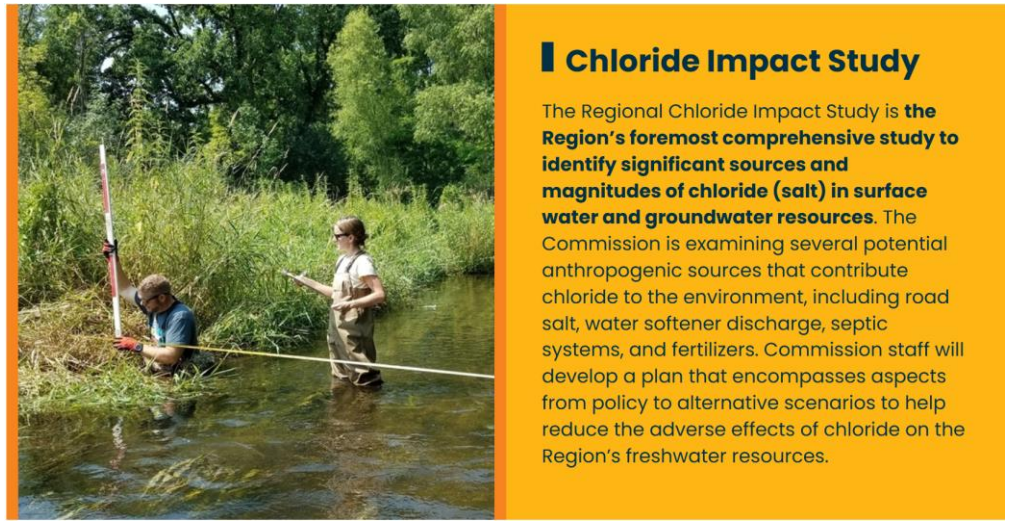
Southeastern Wisconsin

Regional Planning Commission

https://www.sewrpc.org/Regional-Planning/Chloride-Study



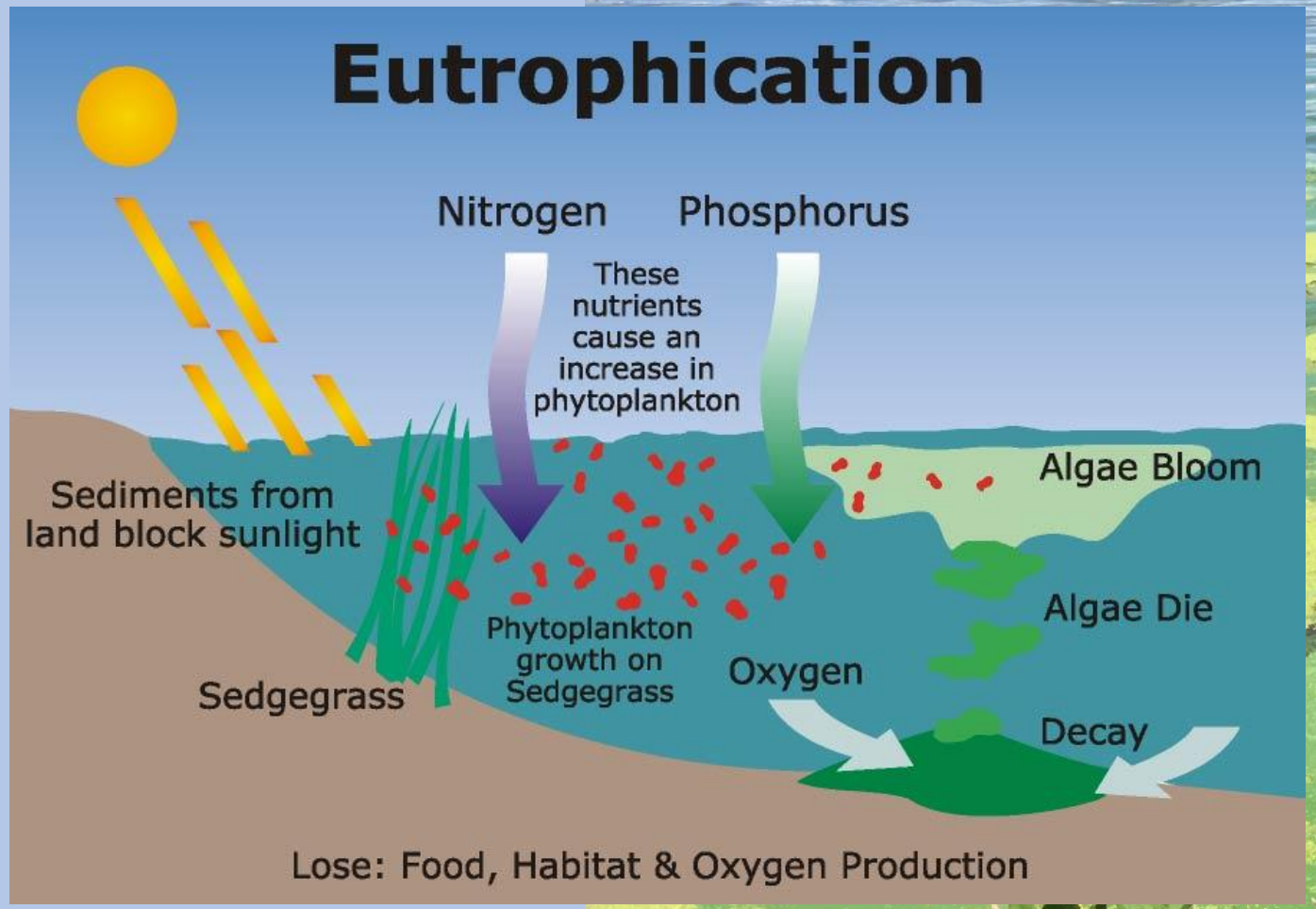
Chloride Study Update-Lake Trends

High Quality Waters Workshop

Retzer Nature Center
May 3, 2025

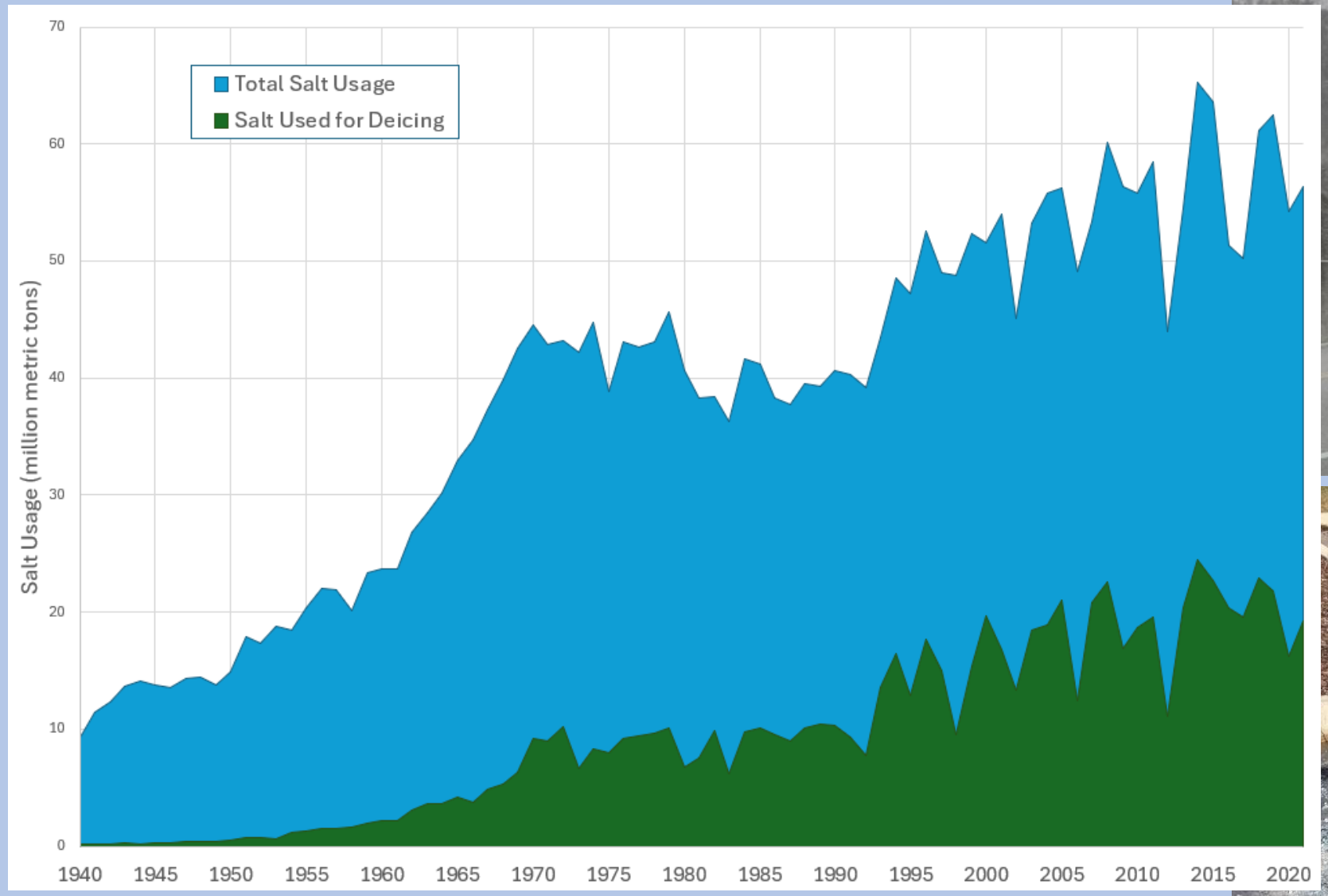
Thomas Slawski | Chief Biologist

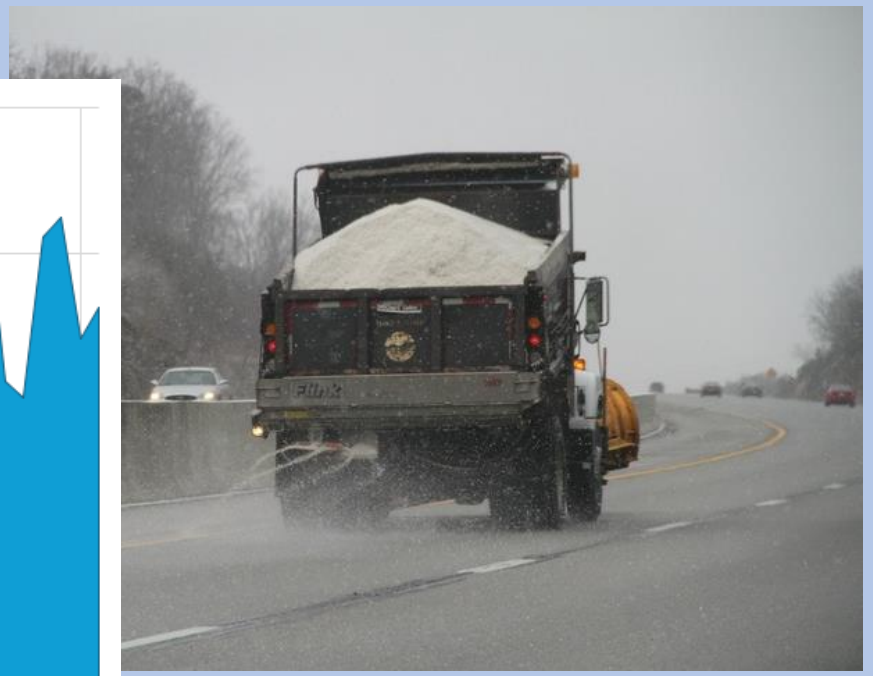
tslawski@sewrpc.org | 262.953.3263



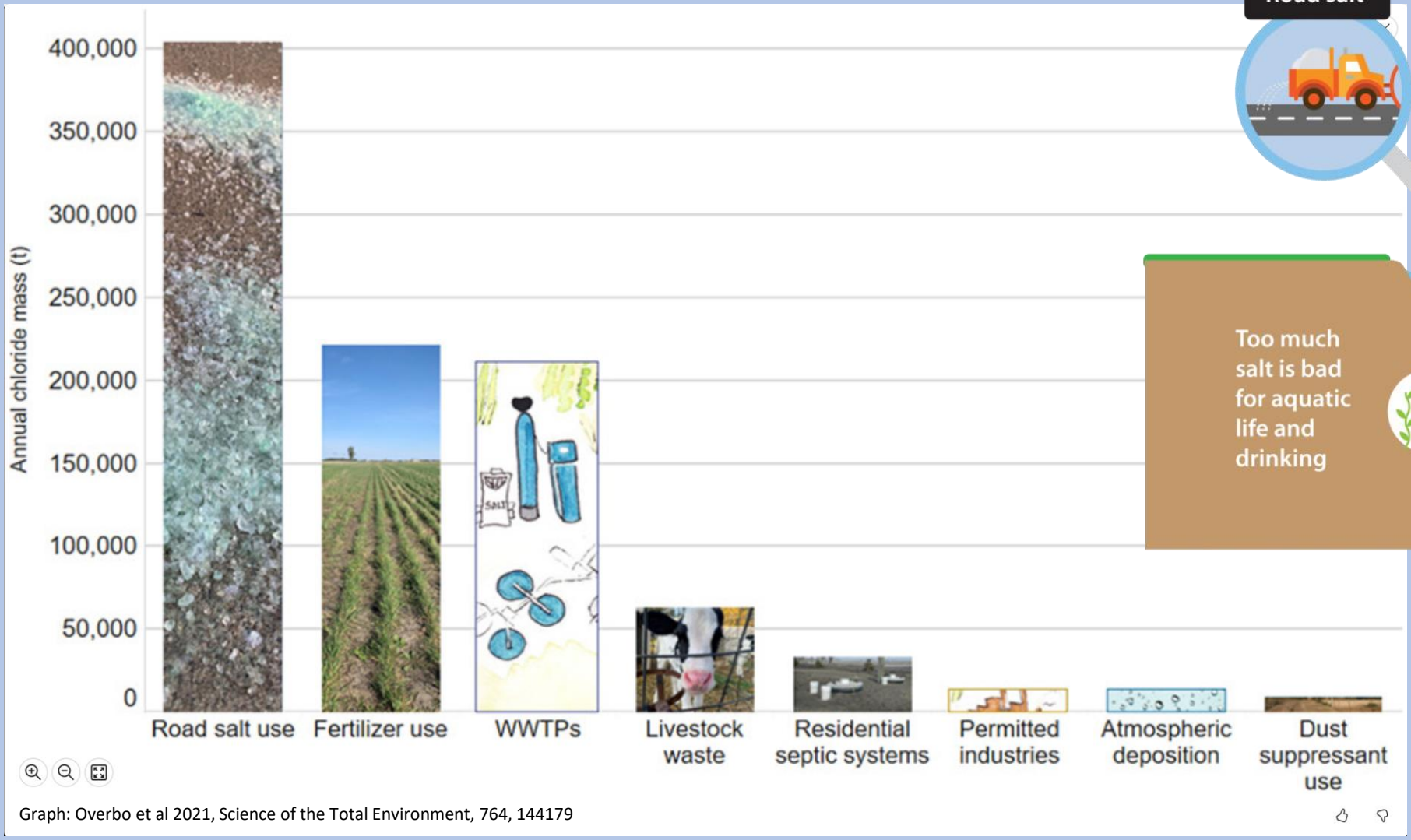
Source: https://www.enviroscienceinc.com/services/laboratory-analysis/harmful-algal-blooms/

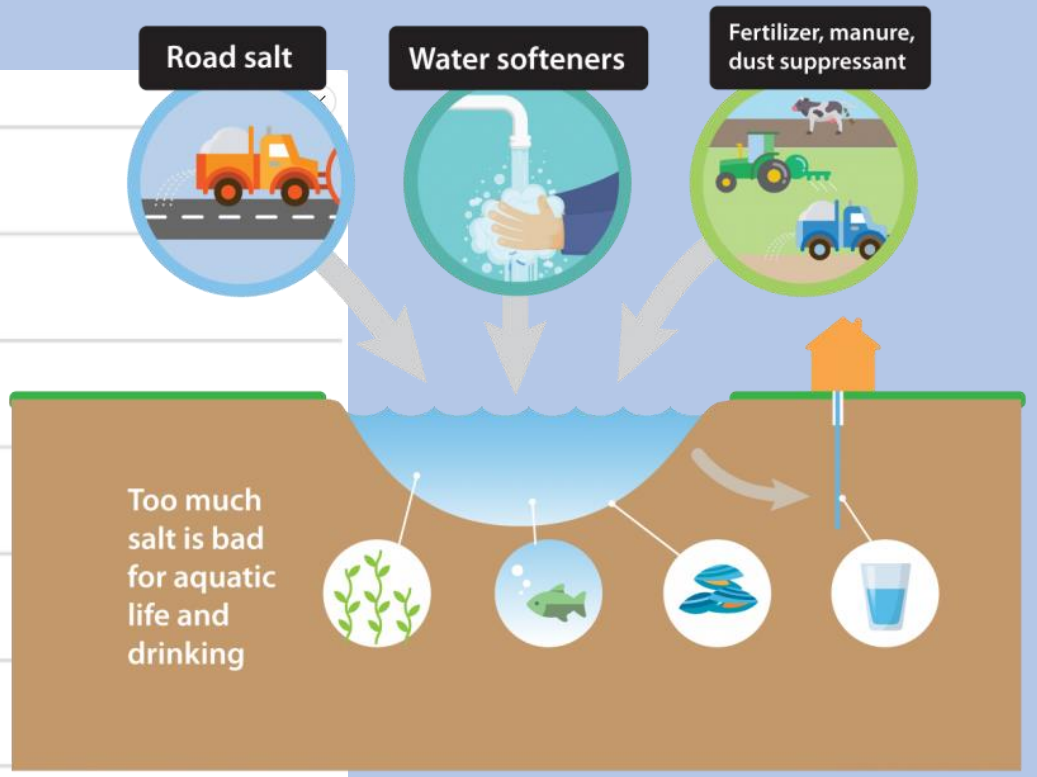
Chloride Trends – Road Salting and Winter De-Icing





Chloride Contributions from Major Point and Nonpoint Sources- within State of Minnesota

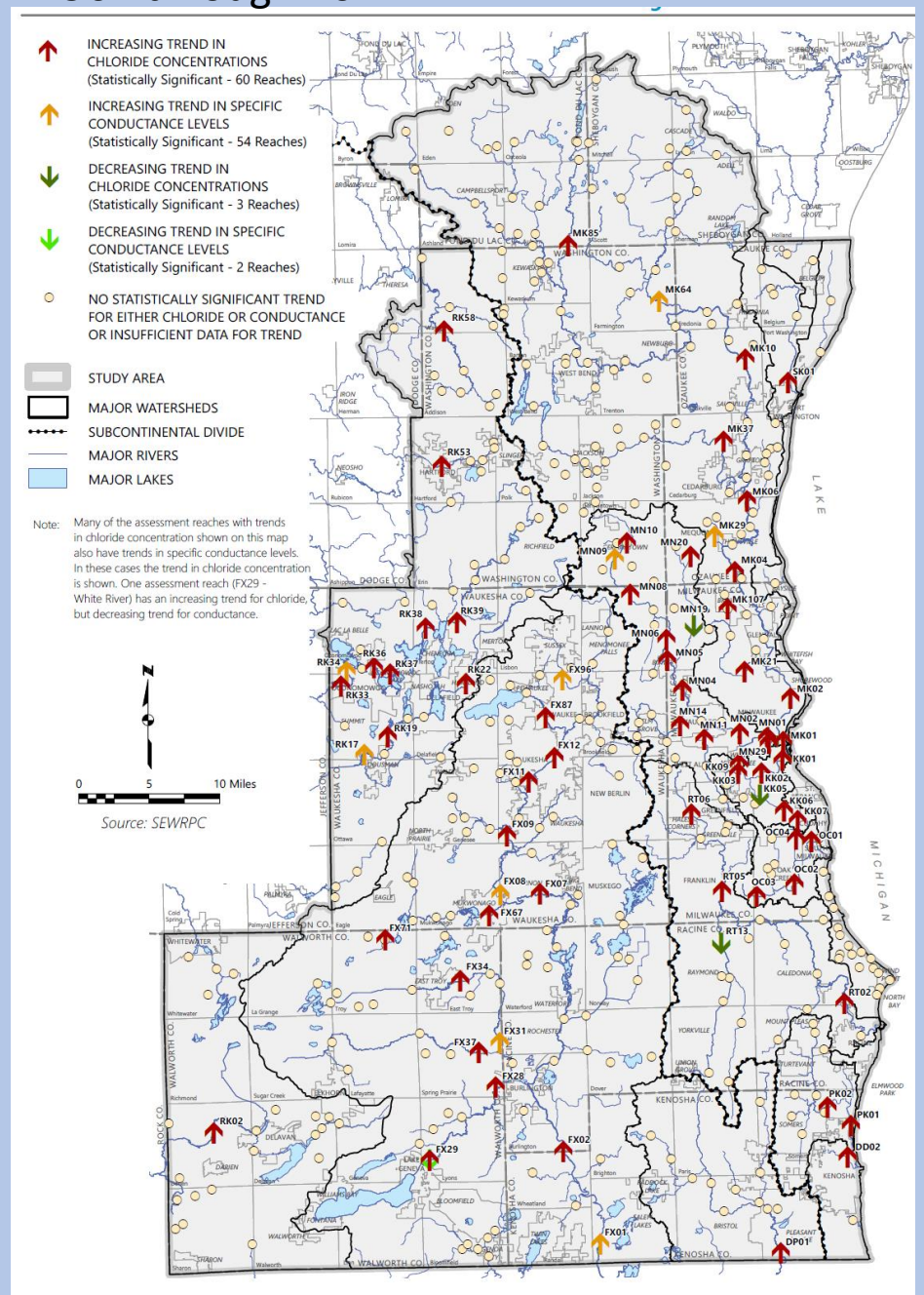




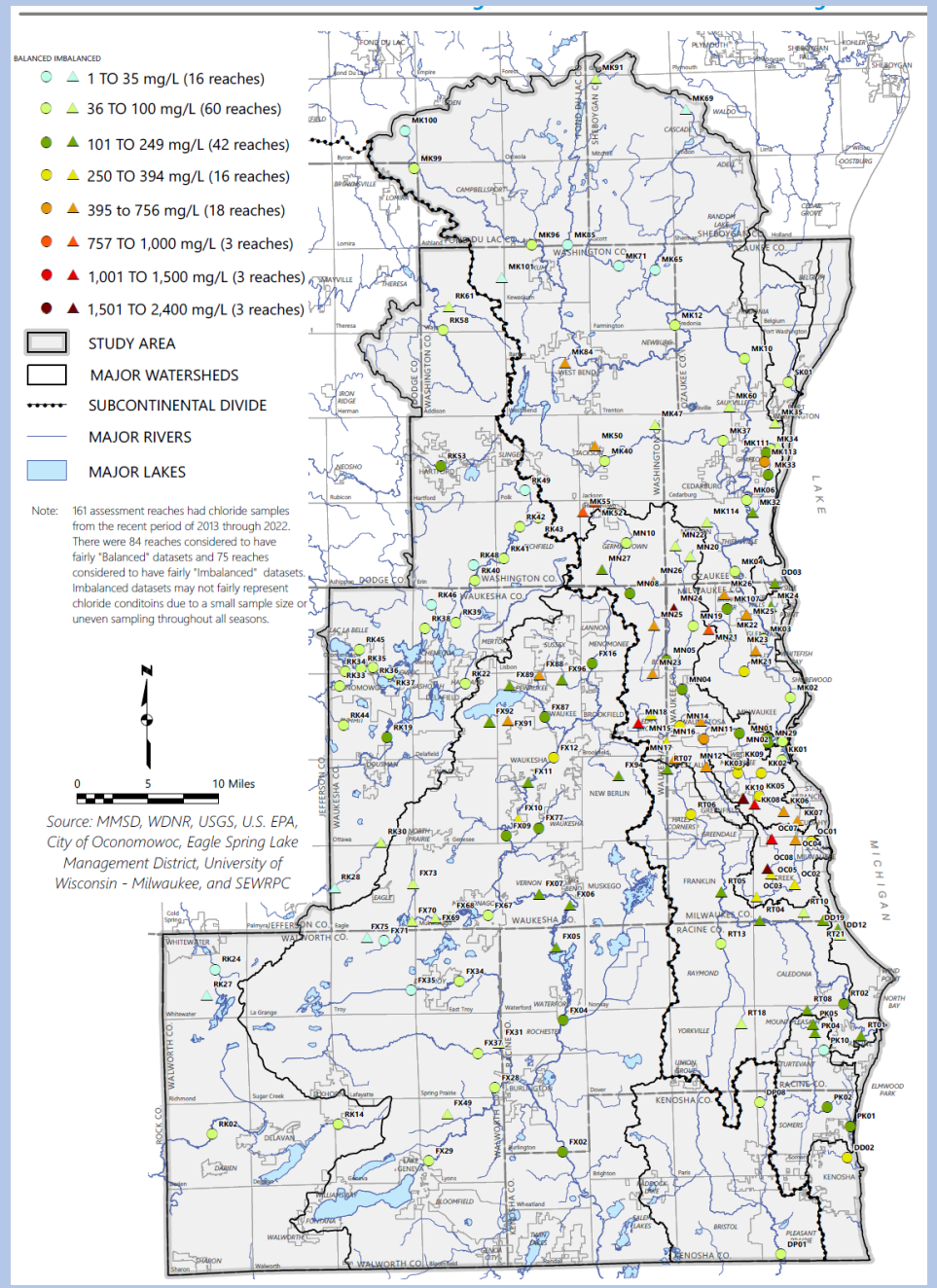
Graph: Overbo et al 2021, Science of the Total Environment, 764, 144179

Stream Reach Trends

Chloride and Specific Conductance: 1961 through 2022



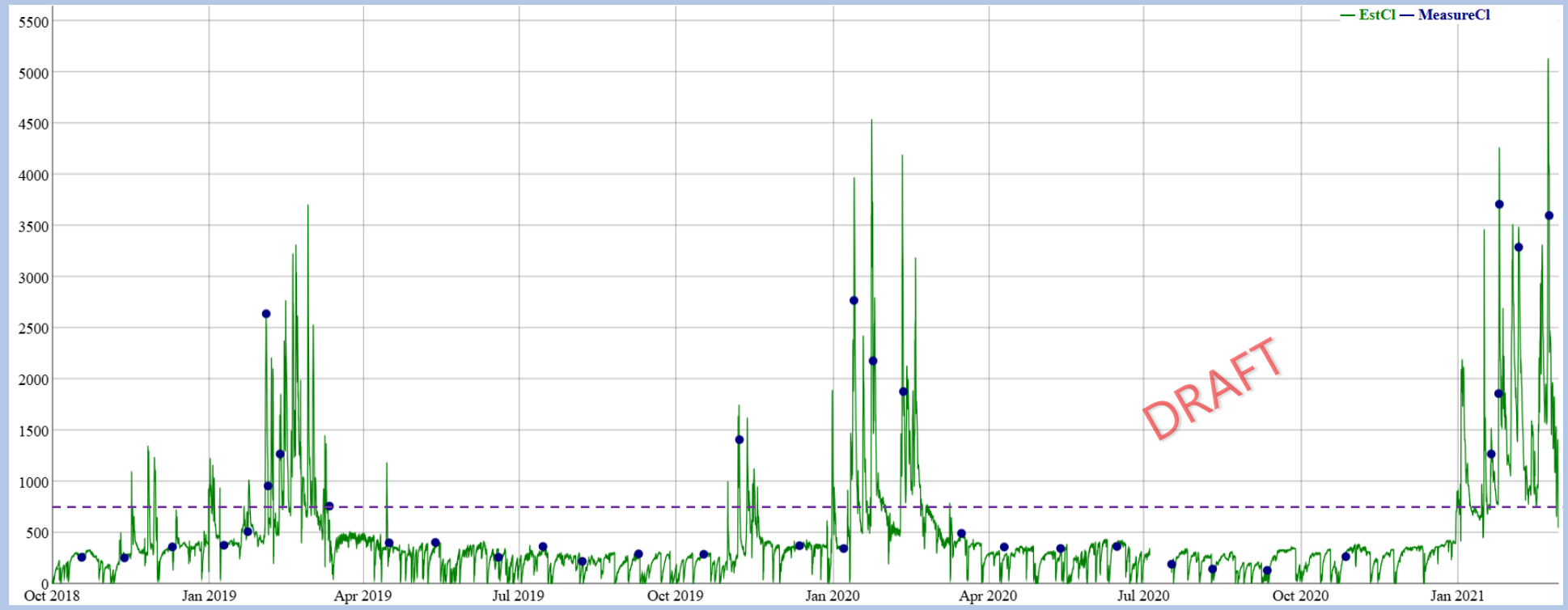
Median Chloride : 2013 through 2022



Realtime Data Analysis

Stream Reach Trends

Site 12: Lincoln Creek Estimated Chloride (Piecewise Regression) compared to Measured Chloride Concentrations



Chloride estimated from Specific Conductance (mg/l)

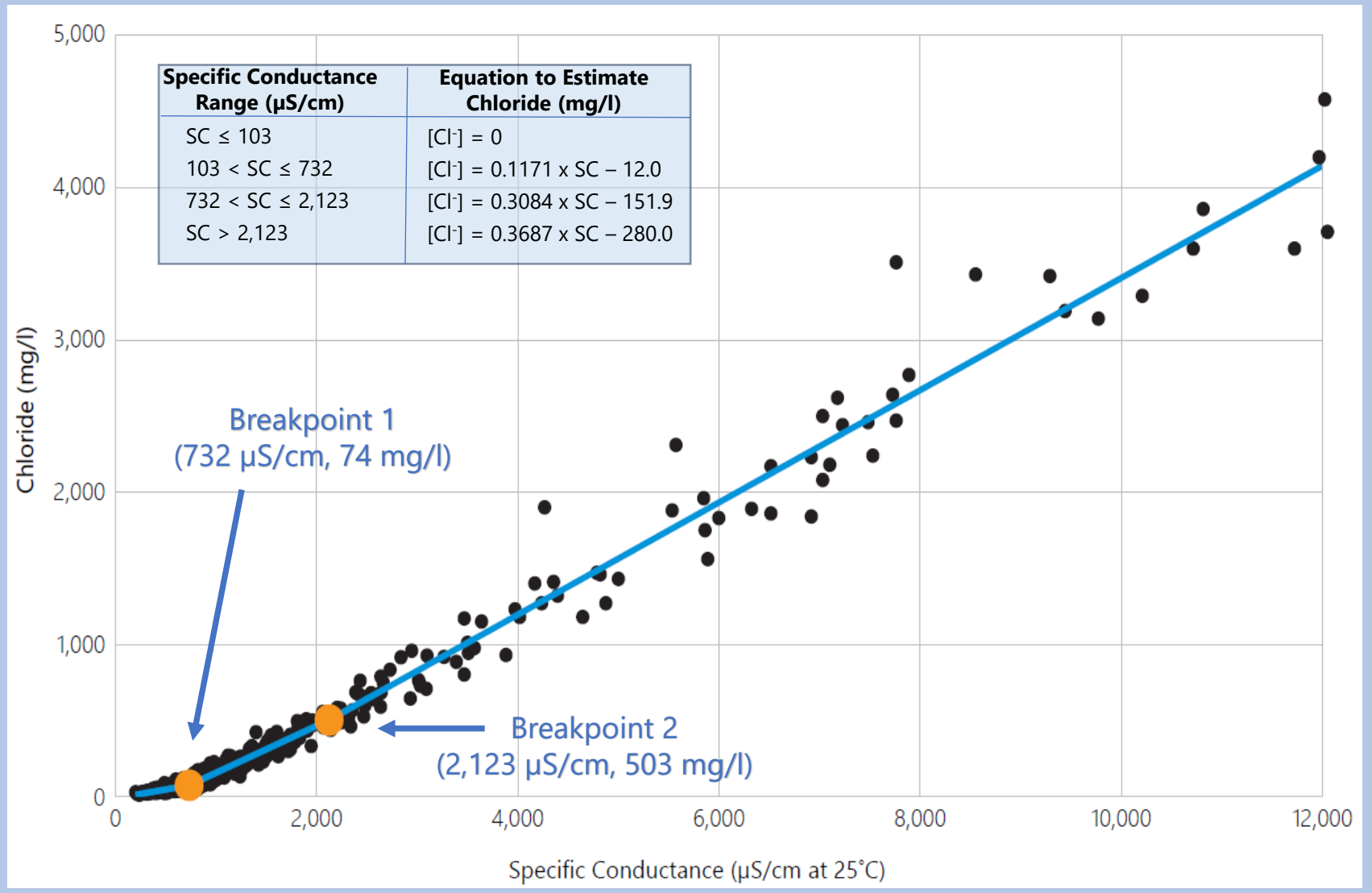
Grab Sample Chloride Concentration (mg/l)

Acute Chloride Toxicity Level (757 mg/l)

Strong Relationship between Chloride and Specific Conductivity

3-Segment Piecewise Regression developed using paired data from 30 sites

Specific Conductance Range (µS/cm)	Equation to Estimate Chloride (mg/l)
SC ≤ 103	$[Cl^-] = 0$
103 < SC ≤ 732	$[Cl^-] = 0.1171 \times SC - 12.0$
732 < SC ≤ 2,123	$[Cl^-] = 0.3084 \times SC - 151.9$
SC > 2,123	$[Cl^-] = 0.3687 \times SC - 280.0$

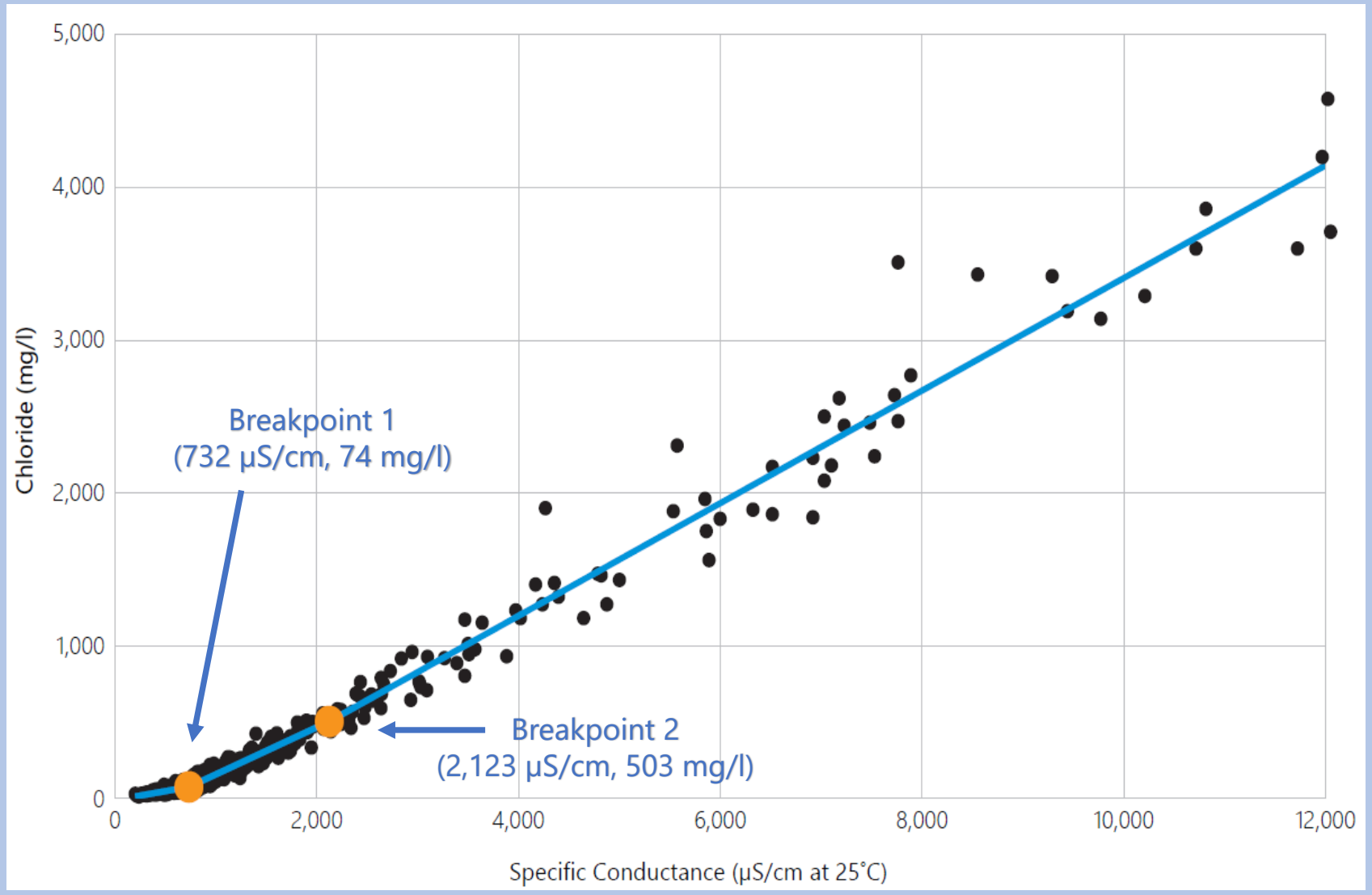


Strong Relationship between Chloride and Specific Conductivity

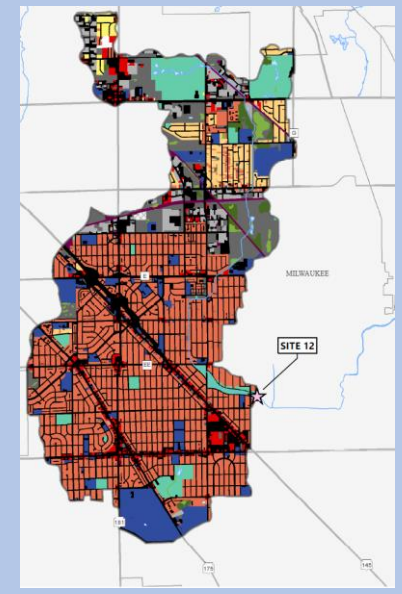
Put into Context

Seawater has a chloride ion concentration of about 19,400 mg/L

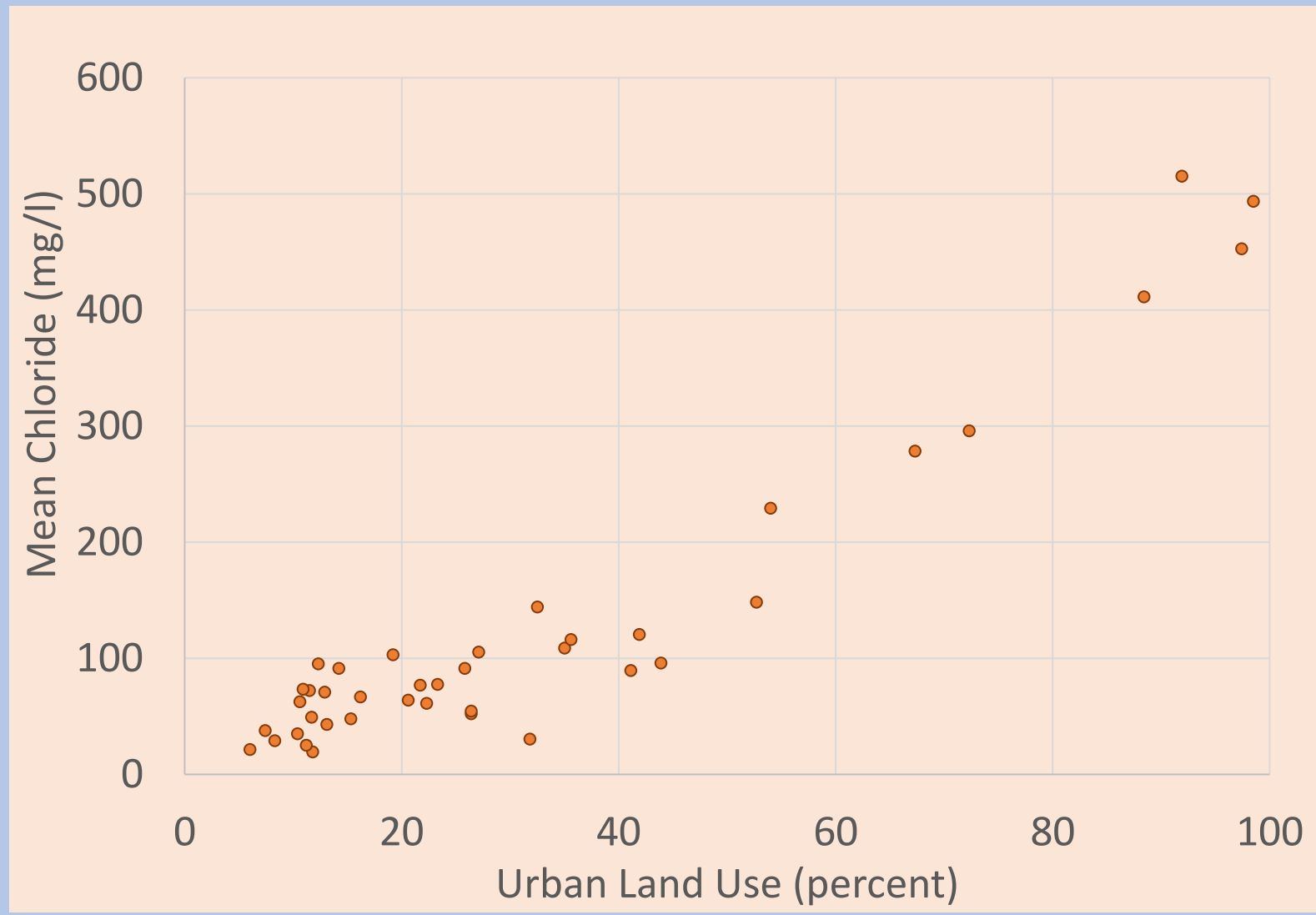
Brackish water in tidal estuaries may have chloride levels between 500 and 5,000 mg/L



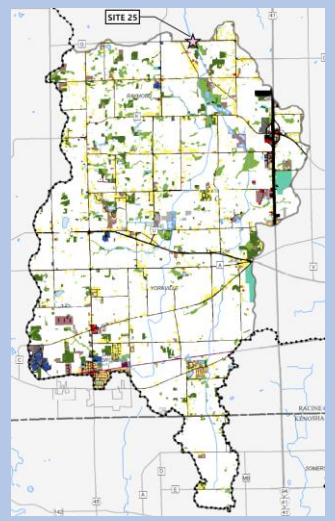
Chloride Concentrations are highly correlated with urban land use and roads and parking lots



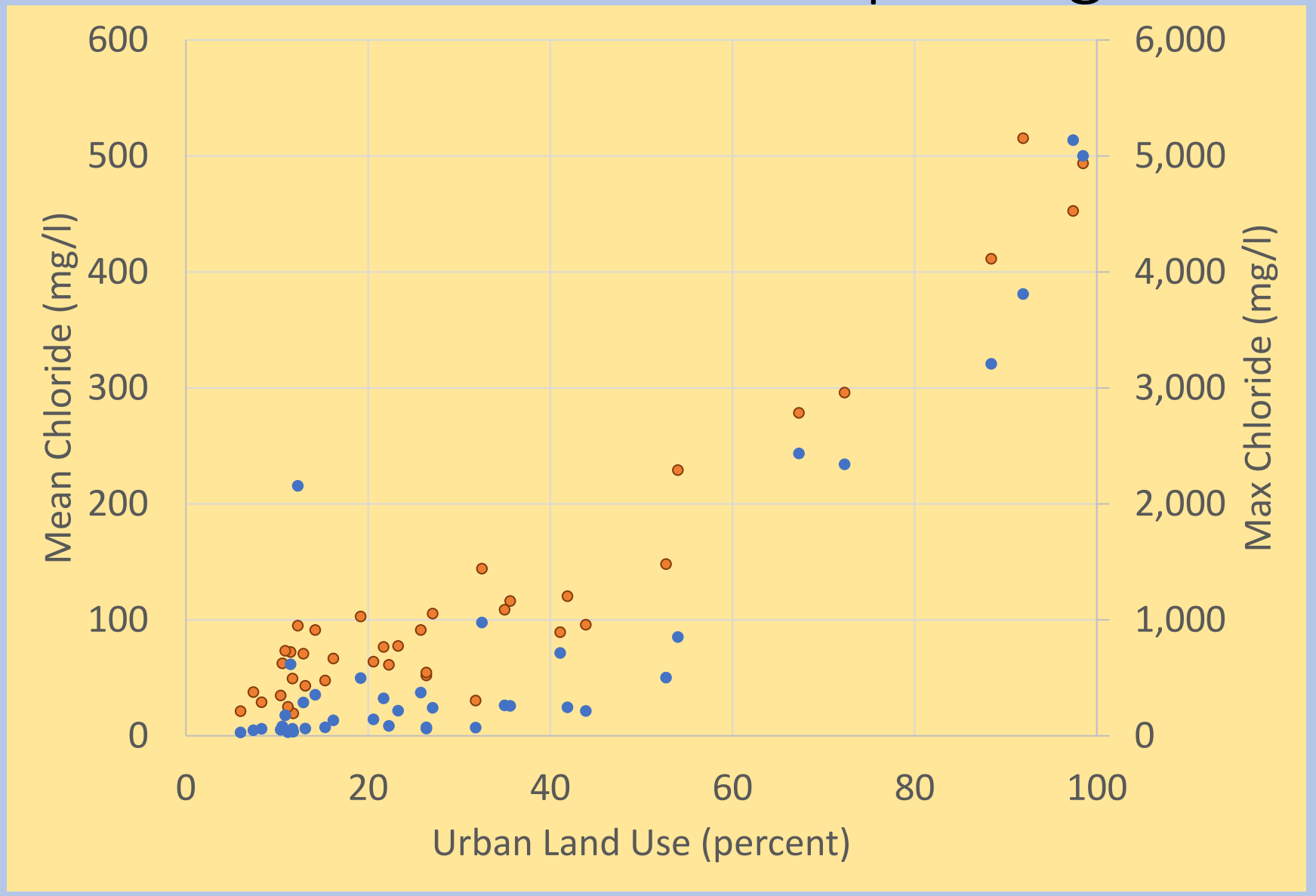
Lincoln Crk



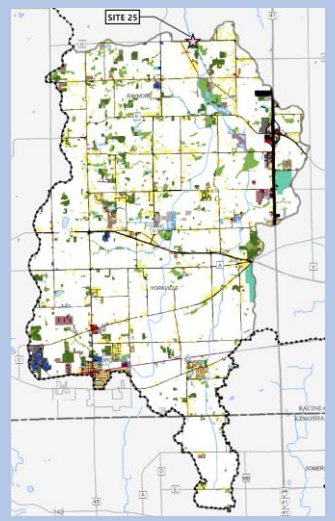
Root River Canal

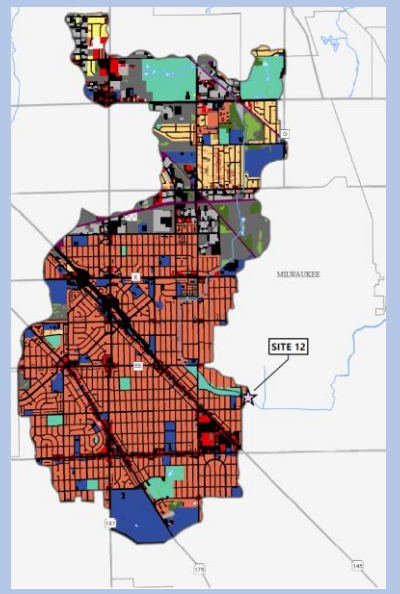


Chloride Concentrations are highly correlated with urban land use and roads and parking lots



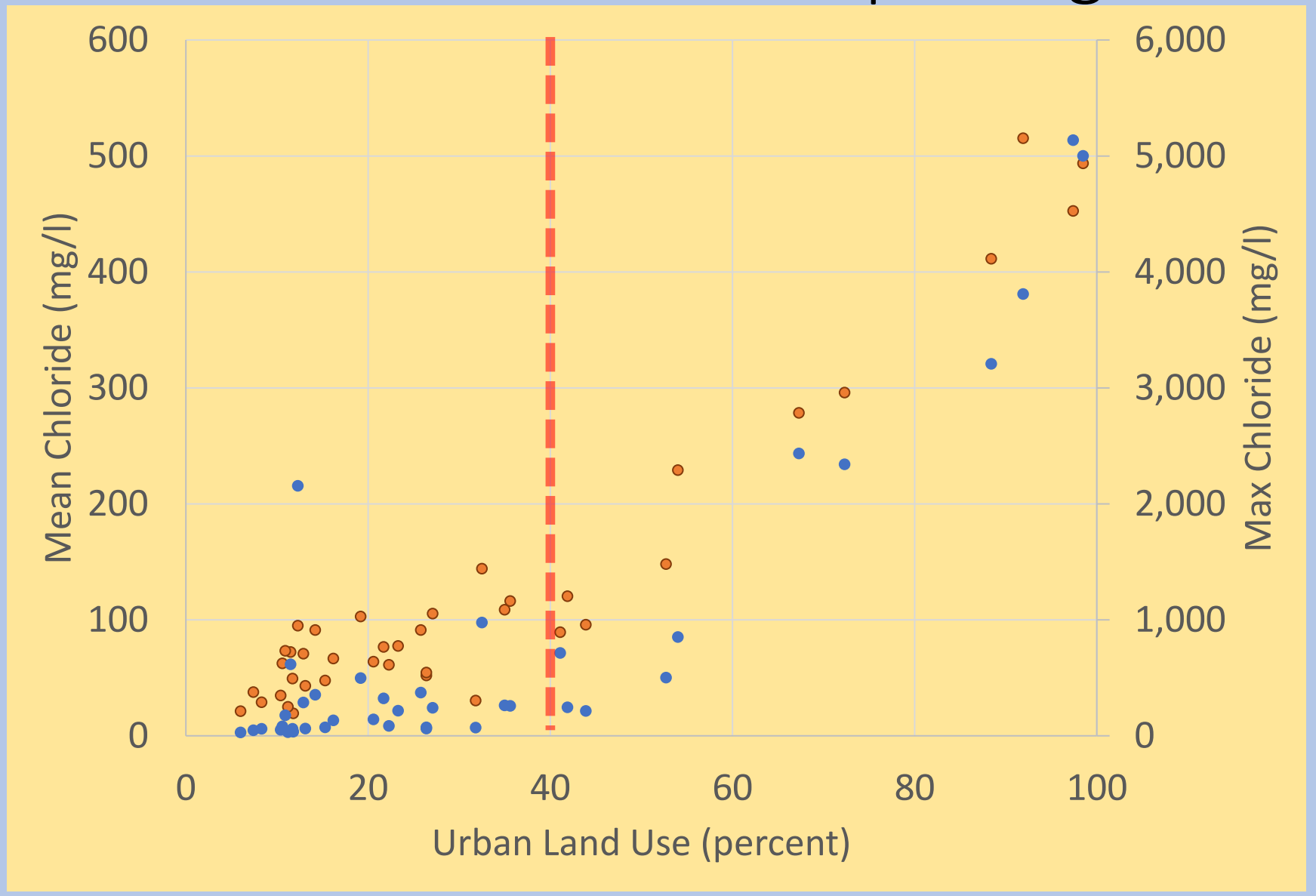
Root River Canal





Lincoln Crk

Chloride Concentrations are highly correlated with urban land use and roads and parking lots



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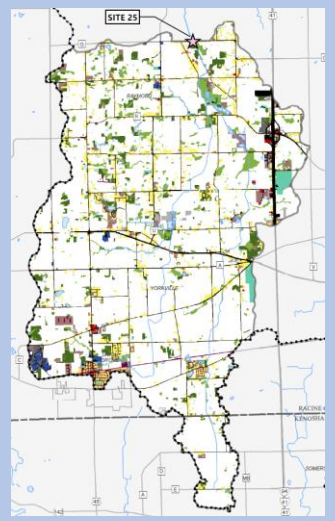
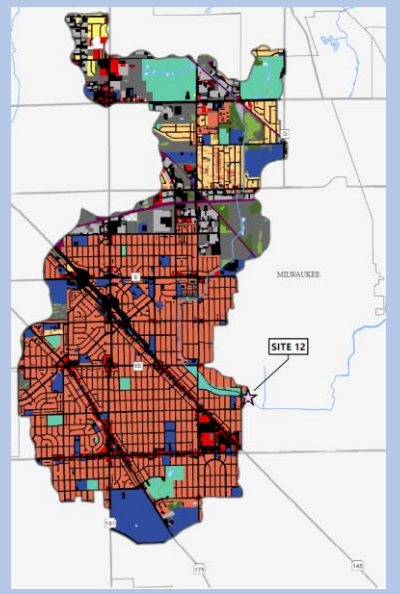
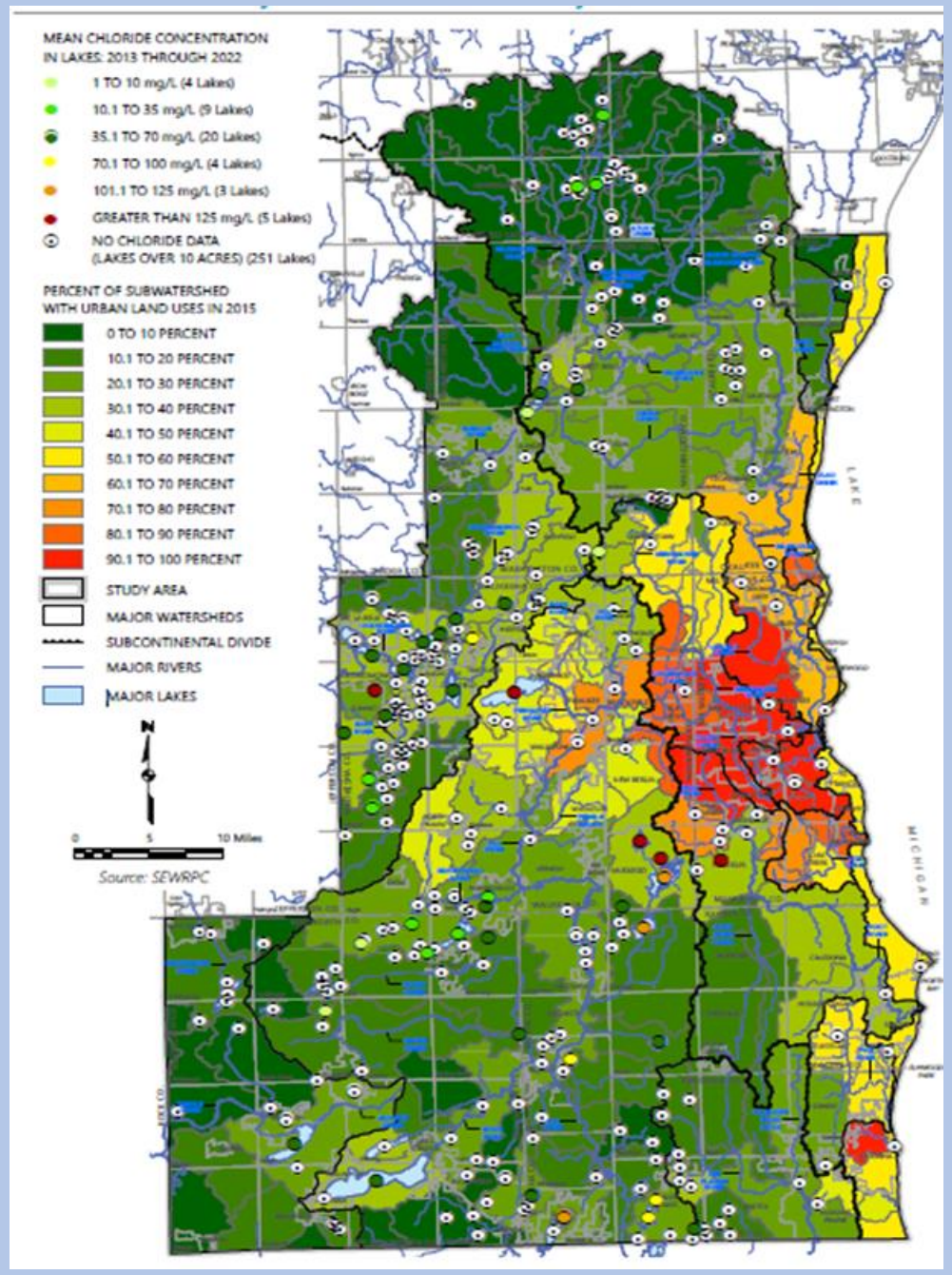




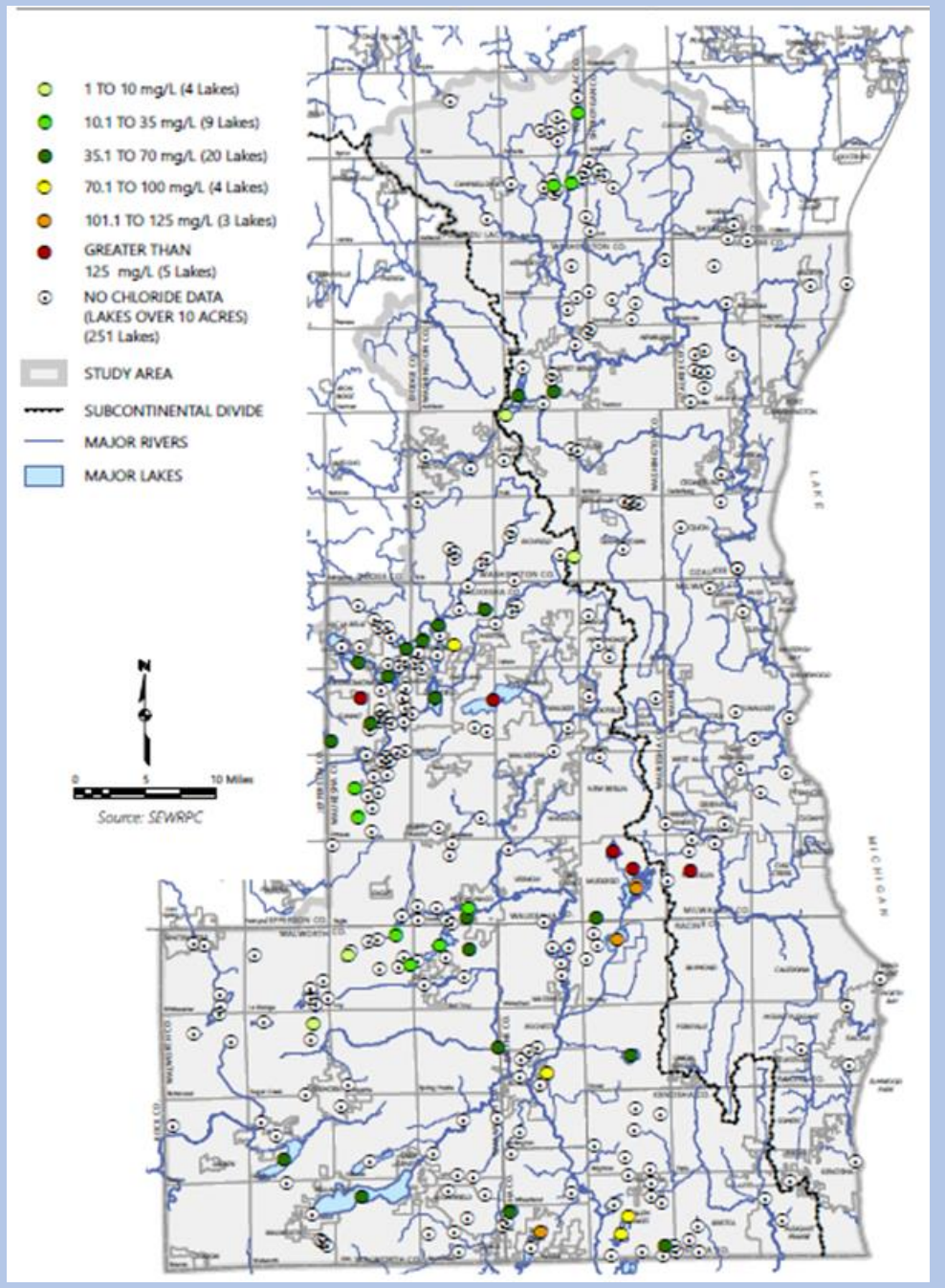
Lincoln Crk

Lake Trends

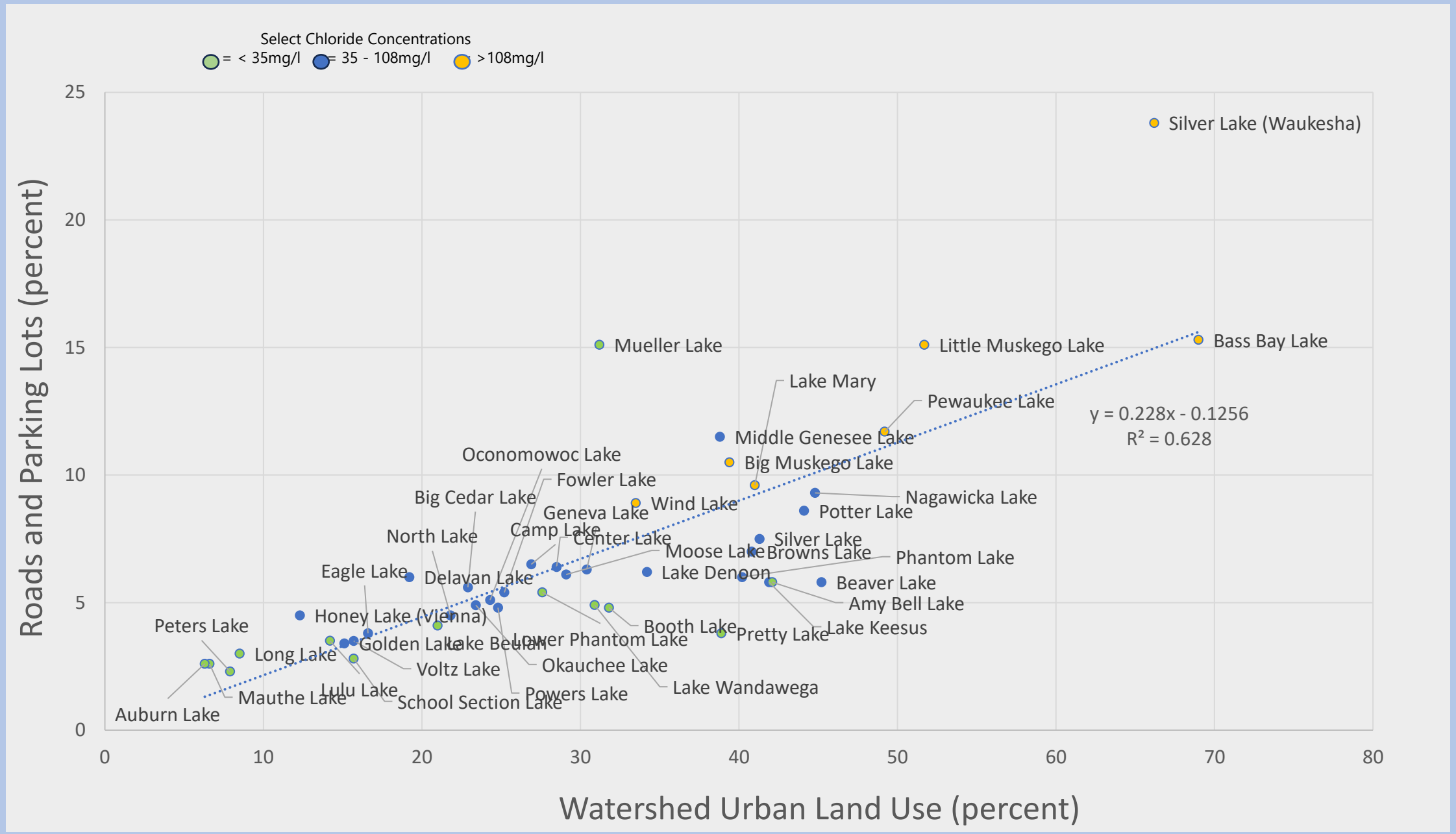
Mean Chloride vs Land Use



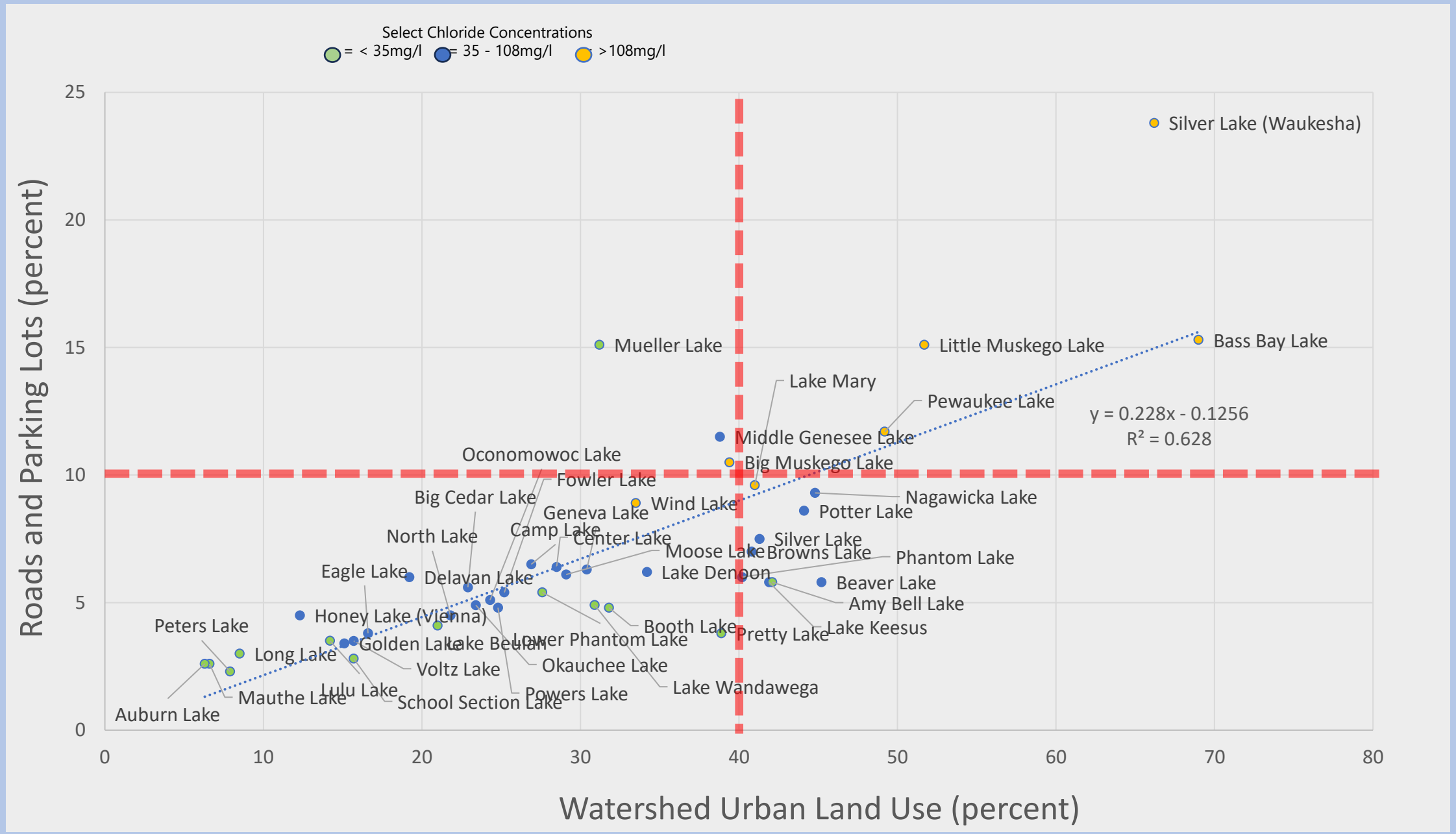
Mean Chloride : 2013 through 2022



Lake Trends


Select Chloride Concentrations
= < 35mg/l
= 35 - 108mg/l
= >108mg/l
Roads and Parking Lots (percent)
Watershed Urban Land Use (percent)
0
5
10
15
20
25
0
10
20
30
40
50
60
70
80
y = 0.228x - 0.1256
R² = 0.628
Silver Lake (Waukesha)
Mueller Lake
Little Muskego Lake
Bass Bay Lake
Lake Mary
Pewaukee Lake
Middle Genesee Lake
Big Muskego Lake
Oconomowoc Lake
Fowler Lake
Big Cedar Lake
Wind Lake
Nagawicka Lake
Potter Lake
Geneva Lake
Camp Lake
North Lake
Center Lake
Silver Lake
Moose Lake
Browns Lake
Phantom Lake
Eagle Lake
Delavan Lake
Lake Denoon
Beaver Lake
Amy Bell Lake
Honey Lake (Vienna)
Booth Lake
Lake Keesus
Peters Lake
Pretty Lake
Lower Phantom Lake
Long Lake
Golden Lake
Lake Beulah
Okauchee Lake
Voltz Lake
Lake Wandawega
Lulu Lake
Powers Lake
Mauthe Lake
School Section Lake
Auburn Lake

Lake Trends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>108mg/l
Roads and Parking Lots (percent)
Watershed Urban Land Use (percent)
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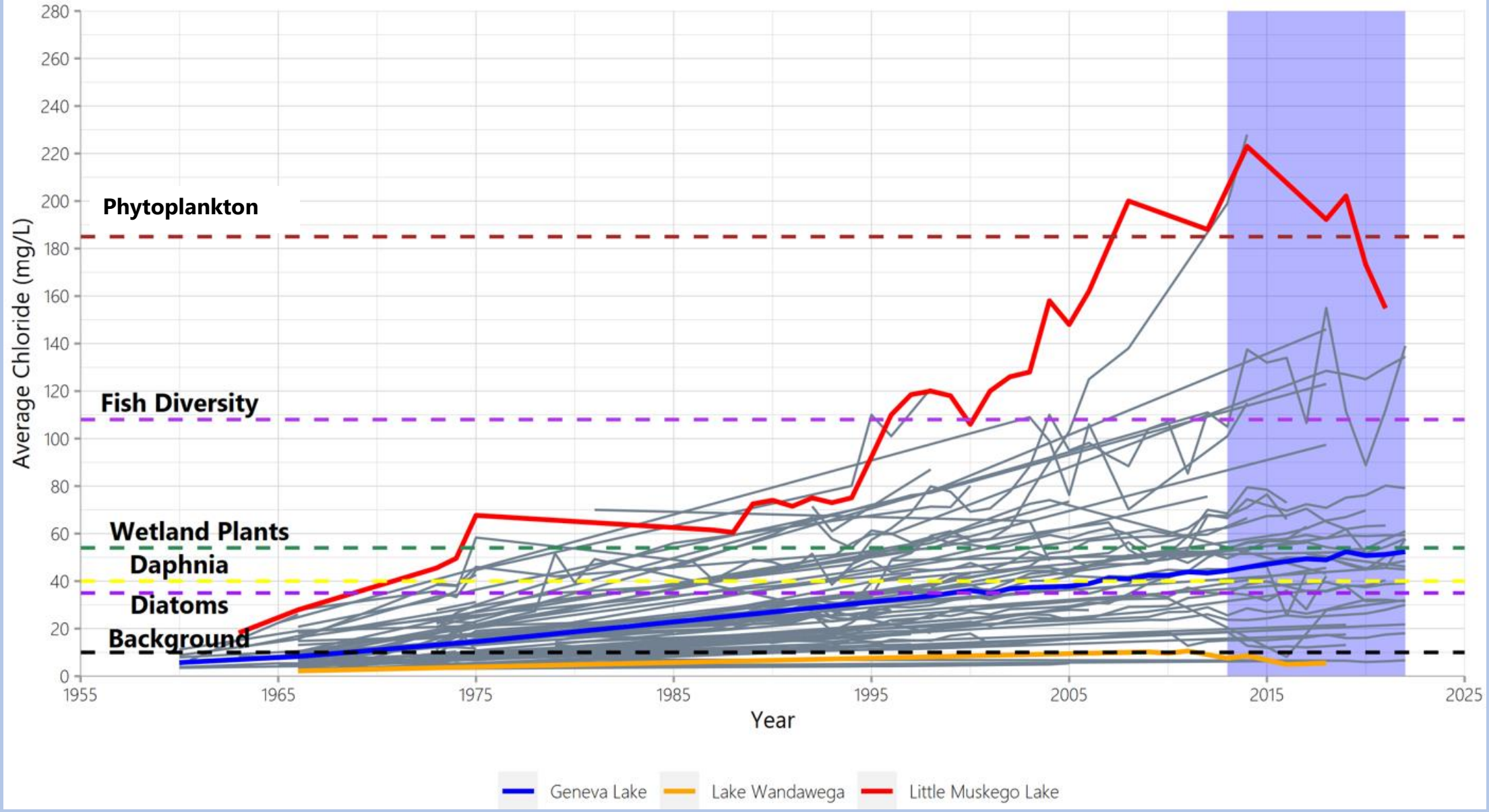
Voltz Lake
Okauchee Lake
Lake Wandawega
Lulu Lake
Powers Lake
Mauthe Lake
School Section Lake
Auburn Lake

Chloride in Regional Lakes: 1960 to 2022

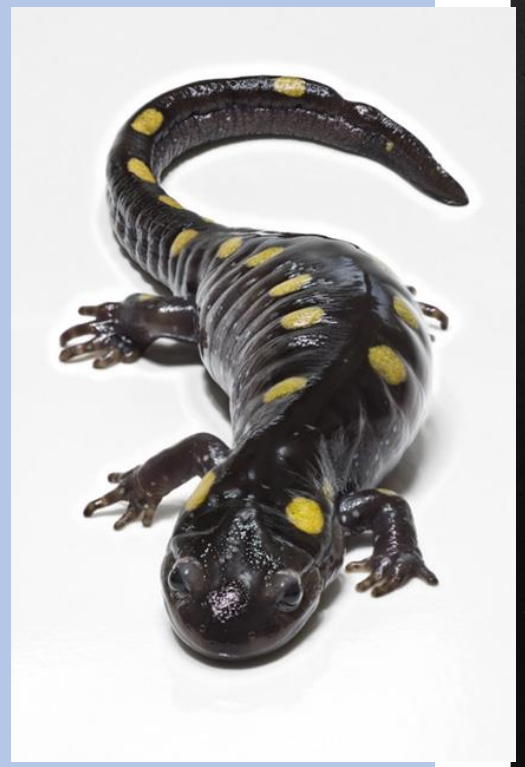
Average Annual Chloride Concentrations and Biological Effects Thresholds



Problem-Chloride Thresholds for Biological Effects Exist at Much Lower Concentrations than the Acute or Chronic Concentration Standards.

Chloride Concentration (mg/l)	Reported Impact	References
5-40	Decreased reproduction and increased mortality in six *Daphnia* Species	Arnott et al., 2020, *Environmental Science and Technology*, 54:9,398-9,407.
16	Reduced bacteria density in biofilms	Cochero et al., 2017, *Science of the Total Environment*, 579:1,496-1,503.
33-108	Reductions in fish diversity	Morgan et al., 2012, *North American Journal of Fisheries Management*, 32:941-952.
35	Substantial changes in composition of periphytic diatom assemblages	Porter-Goff et al., 2013, *Ecological Indicators*, 32:97-106
54	Reductions in wetland plant species richness	Richburg et al., 2001, *Wetlands*, 21:247-255.
100	Decrease in photosynthetic production in common waterweed	Zimmerman-Timm, 2007, In: Lozar, et al., *Water Uses and Human Impacts on the Water Budget*
185	Substantial shift in phytoplankton community composition and reduction in ciliates	Astorg et al., 2023, *Limnology and Oceanography Letters*, 8:38-47.
250	Reductions in zooplankton abundance and diversity	Sinclair and Arnott, 2018, *Freshwater Biology* 63:1,273-1,286.
250-260	Wood frogs and spring peepers stop using ponds for breeding	Sadowski, 2002, *Prairie Perspectives*, 5:144-162; Gallagher et al., 2014, *Wetlands Ecology and Management*, 22:551-564
2,000	Inhibition of denitrification in forested wetlands	Lancaster et al., 2016, *Environmental Pollution*

Source: SEWRPC



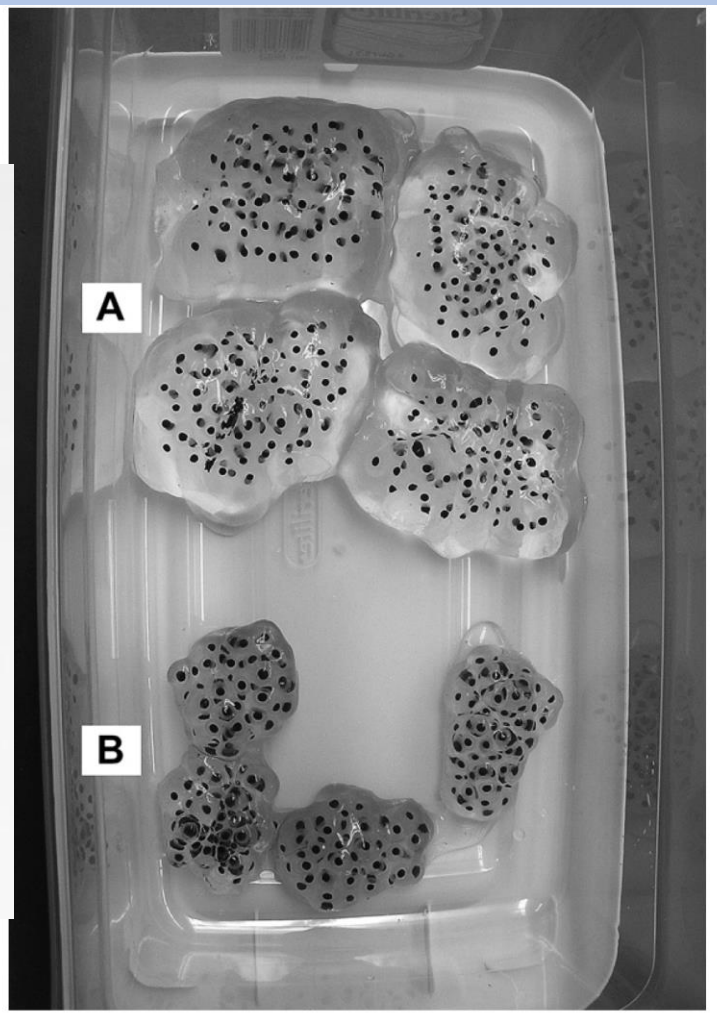


Fig. 1. Photograph of clutches of *A. maculatum* from (A.) pool located >200 m from a highway with chloride concentration of 1 mg/L, and (B.) pool located 11 m from a highway with chloride concentration of 721 mg/L, showing differences in water uptake.

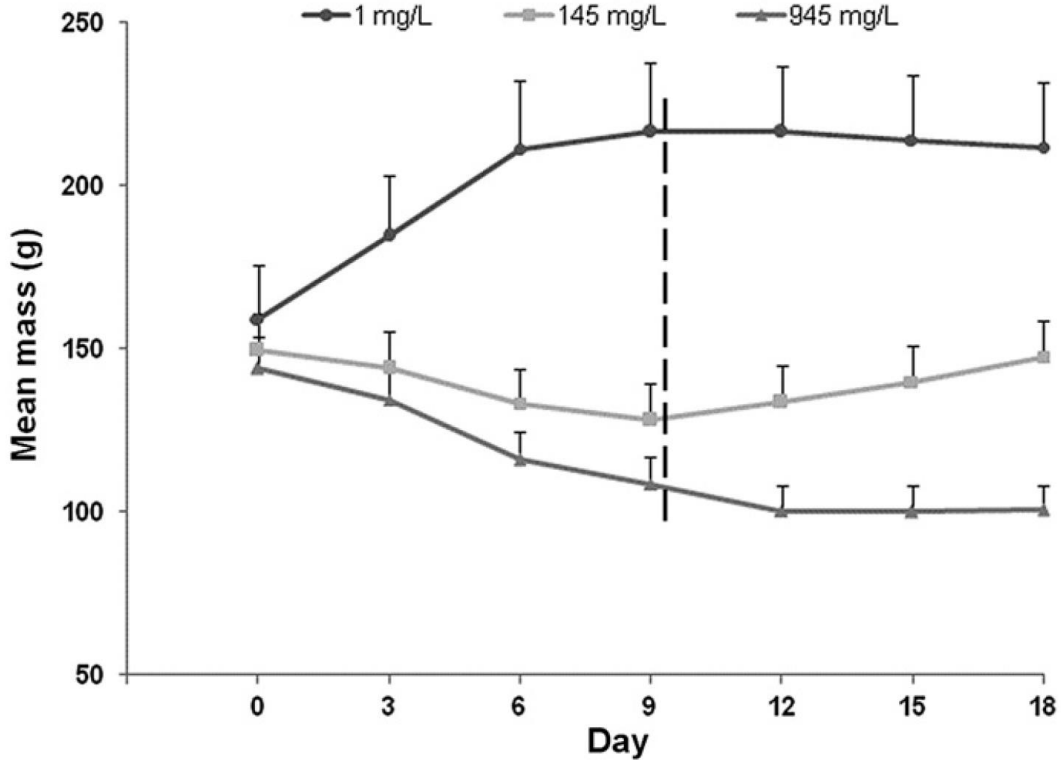


Fig. 2. Mean mass of egg clutches (+SE) of *A. maculatum* by 3-d period in control (1 mg/L chloride), moderate (145 mg/L), and high (945 mg/L) salinity treatments. The dashed line indicates the point at which all clutches were transferred from the salinity treatment (control, moderate, high) to control water.

Our results suggest that clutches of A. maculatum laid in wetlands with high chloride concentrations, associated with road deicing salts from winter application, may experience lower survival and increased frequency of malformations.

N.E. Karraker, J.P. Gibbs / Road deicing salt irreversibly disrupts osmoregulation of salamander egg clutches, Environmental Pollution 159 (2011) 833-835

Chloride Toxicity

	Chronic	Acute
Wisconsin	395 mg/L	757 mg/L
US EPA	230 mg/L	860 mg/L

- As of 2022, 35 waterbodies in southeastern Wisconsin were listed as impaired due to exceeding chloride toxicity thresholds

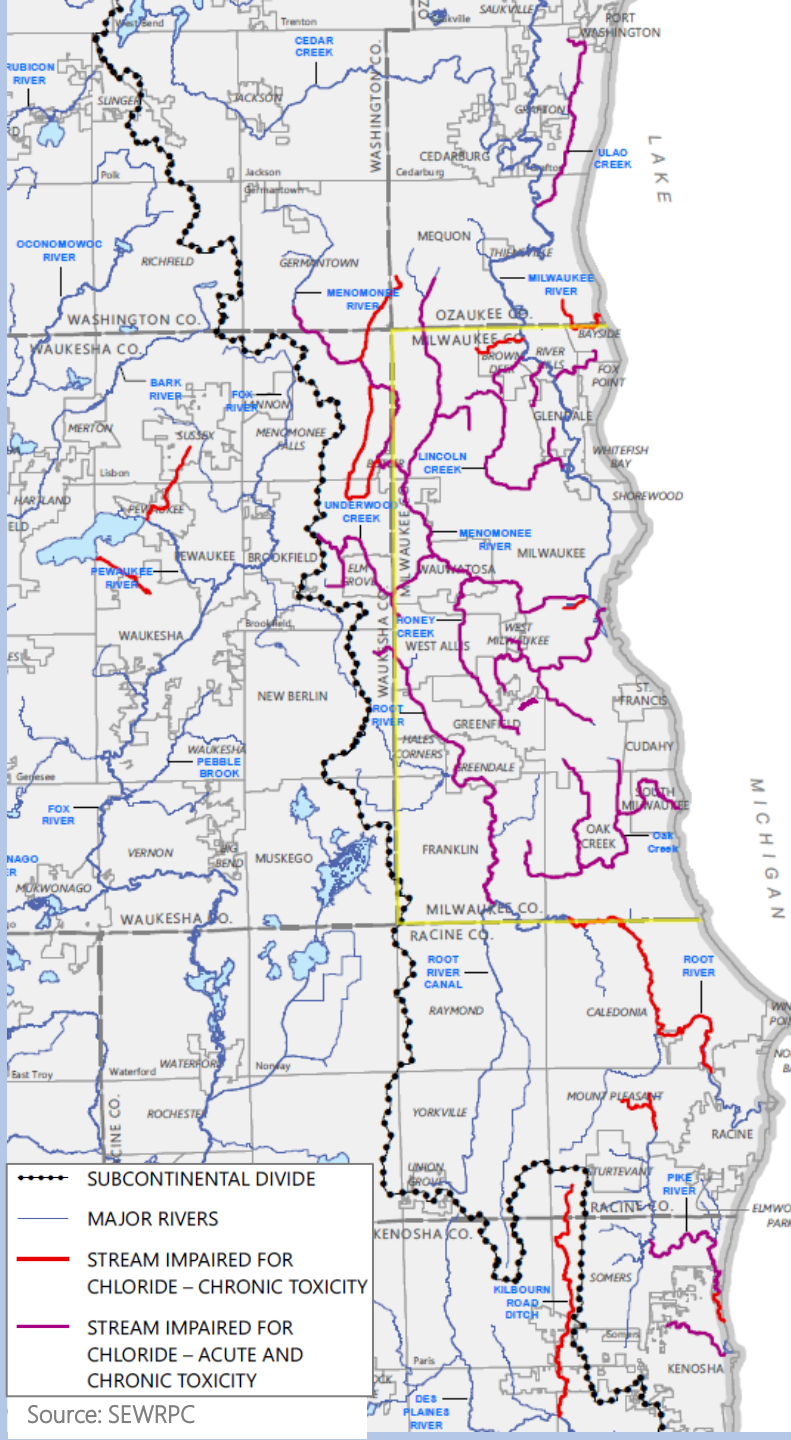
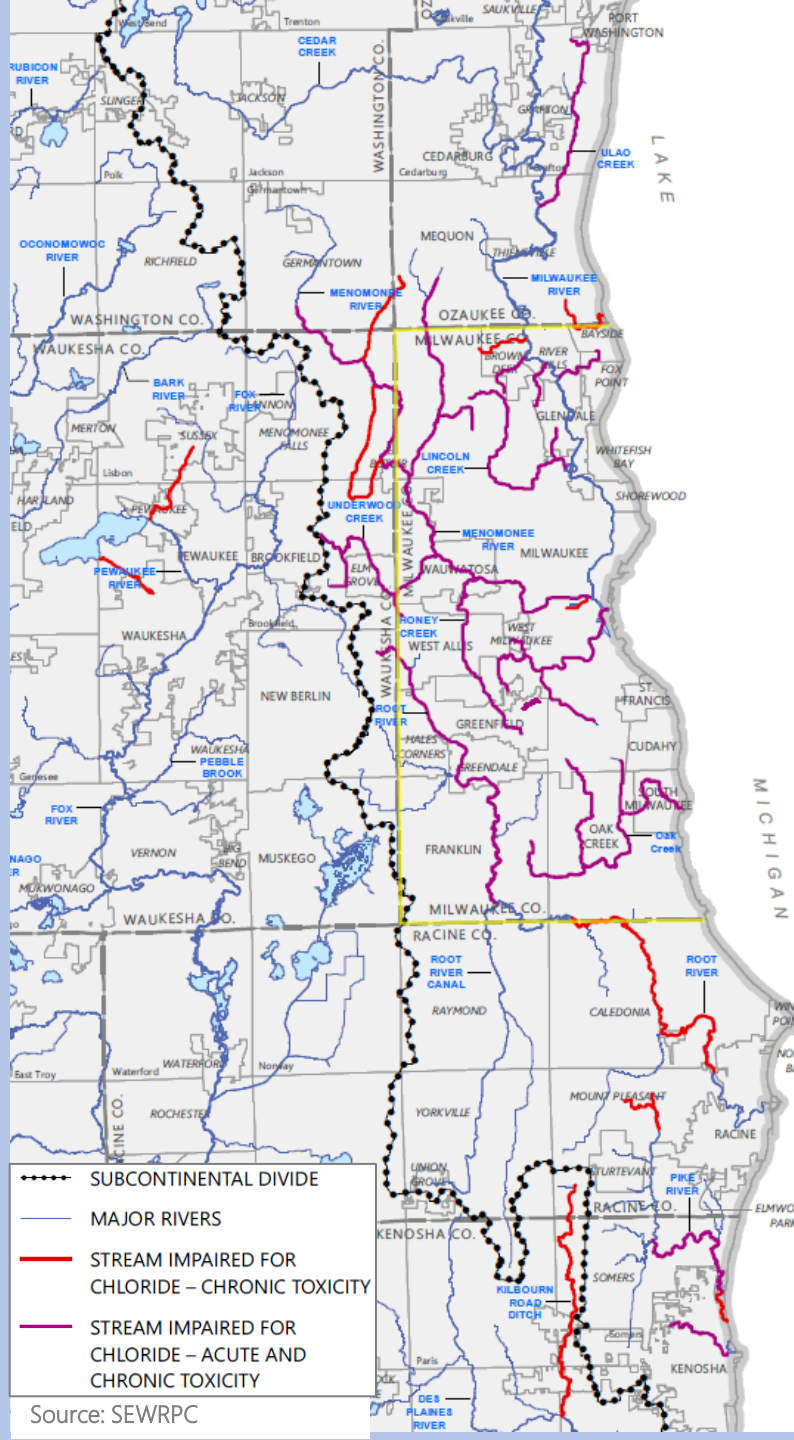


Table 1. Chloride thresholds used for inverse empirical cumulative distribution function and Uniform Continuous Above Threshold (UCAT) analysis. Threshold is measured as chloride concentration (mg/L).

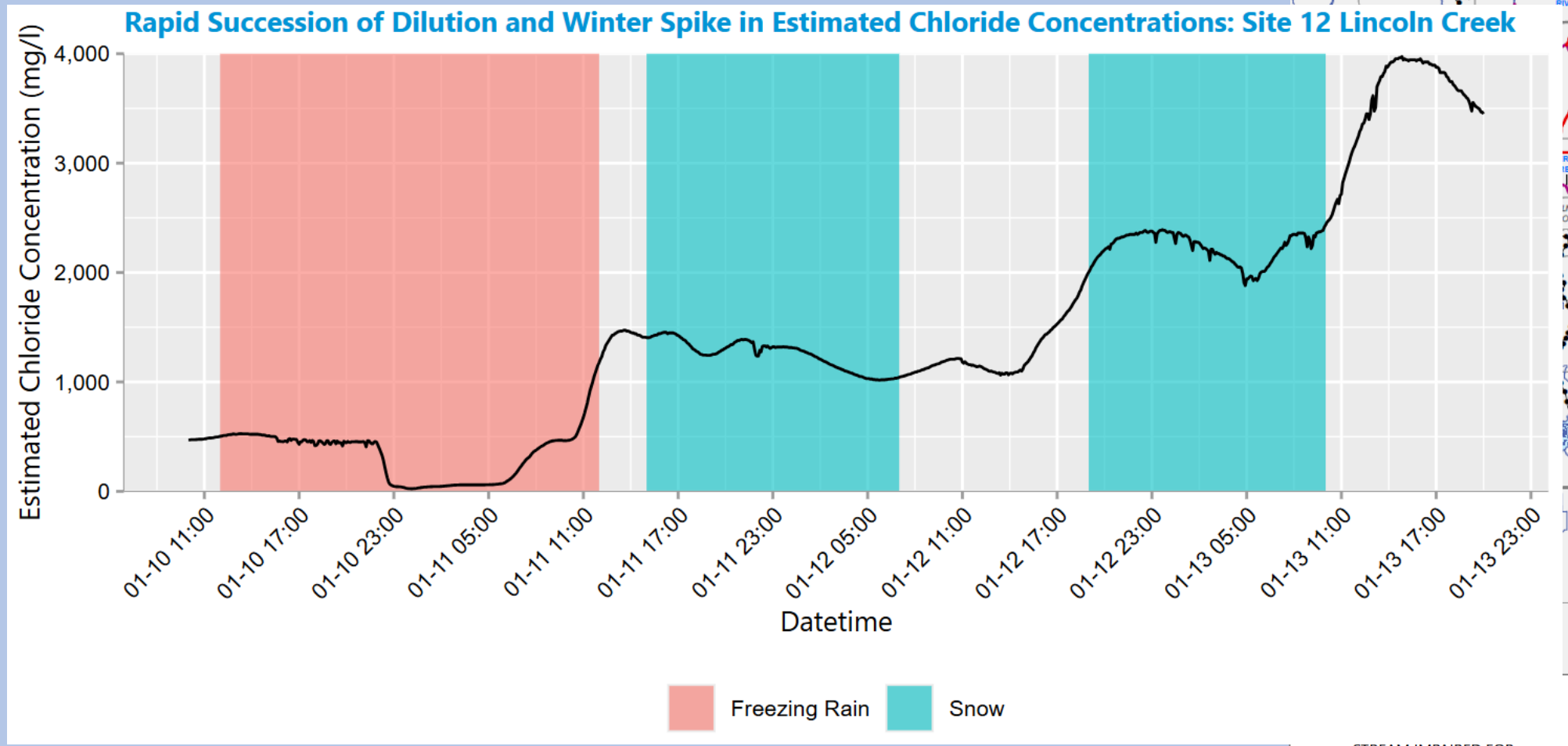
Threshold	Source	Description	Reference
24	Lowest data-point in Canadian Water Quality Guidelines for the Protection of Aquatic Life – Chloride	Wavy-rayed lampmussel chronic	CCME 2011a
120	Chronic Canadian Water Quality Guidelines for the Protection of Aquatic Life – Chloride	7-day exposure – fish and invertebrates	CCME, 2011a, CCME, 2011b
230	Chronic American Ambient Water Quality Criteria for Chloride	"4-day average concentration when associated with sodium should not exceed 230mg/L more than once every three years on the average"	EPA 1988
640	Acute Canadian Water Quality Guidelines for the Protection of Aquatic Life – Chloride	24-hour – 96-hour	CCME 2011b
860	Acute American Ambient Water Quality Criteria for Chloride	"1-hour average concentration should not exceed 860mg/L more than once every three years on the average"	EPA 1988

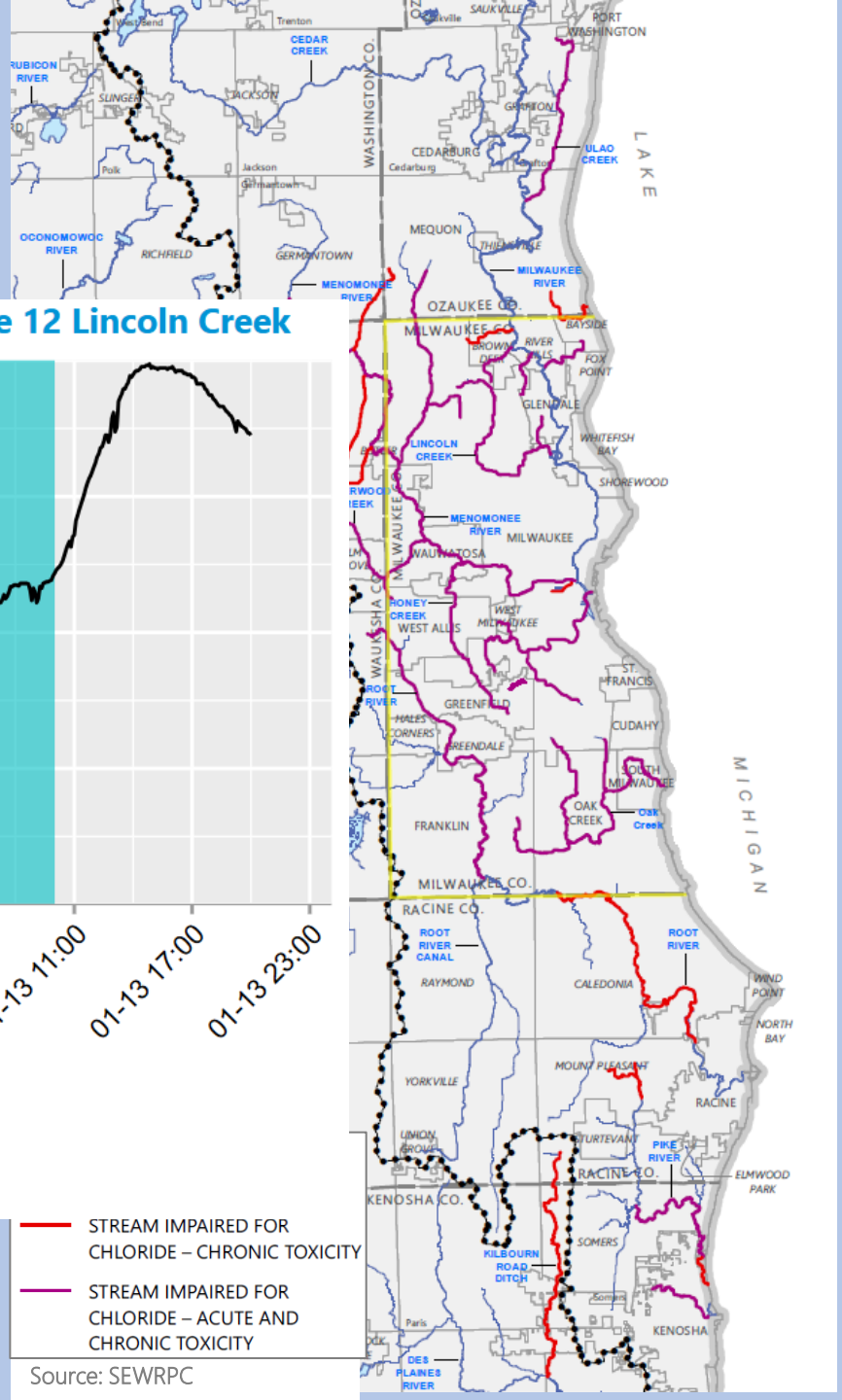
Chloride Toxicity



Source: SEWRPC

Chloride Toxicity





What can you do on your property?

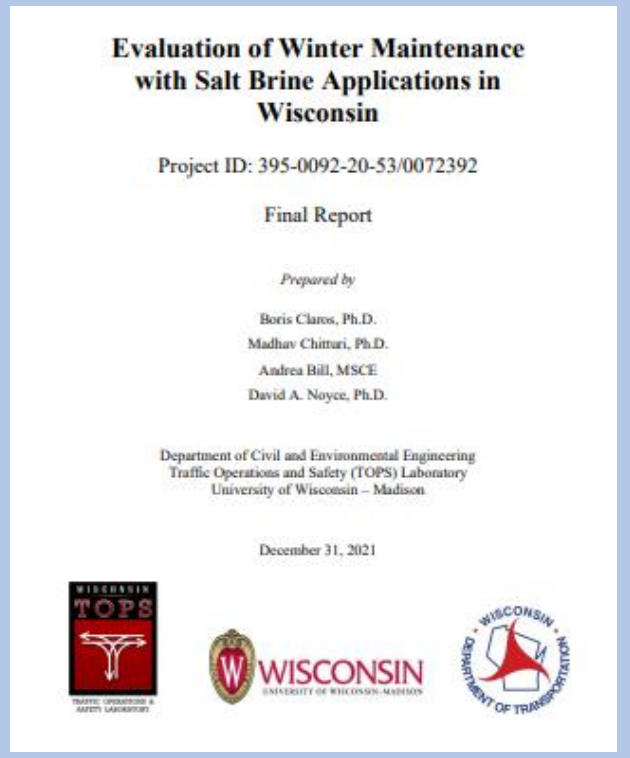
- Snow removal
  - Shovel early and often
  - Use salt appropriately
    - Scatter salt so there is space between grains
    - A coffee mug of salt is enough to treat 20' of driveway or 10 sidewalk squares
    - Switch to sand when temperatures are under 15°F and salt effectiveness is diminished
    - Sweep up excess salt after each winter event
- Water softening
  - Update to on-demand instead of timer-based unit
  - Don't pump brine tank discharge on to lawn
- Consult Wisconsin Salt Wise for ideas/tips or trainings:
  - https://wisaltwise.com/

What are your State and County agencies doing?

- Monitoring chloride in surface waters and groundwater

- Researching alternative de-icing techniques
  - Salt brine application report
    - Less salt used (23%)
    - Better pavement friction
    - Benefits outweigh investment costs

- Applying and incentivizing best practices
  - Using brining and pre-wetting on County and State roads
  - Supporting salt certification courses for winter maintenance professionals



Evaluation of Winter Maintenance with Salt Brine Applications in Wisconsin

Project ID: 395-0092-20-53/0072392

Final Report

Prepared by

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Madhav Chitturi, Ph.D.
Andrea Bill, MSCE
David A. Noyce, Ph.D.

Department of Civil and Environmental Engineering
Traffic Operations and Safety (TOPS) Laboratory
University of Wisconsin – Madison

December 31, 2021

How can your community help?

- Lake districts and associations
  - Chloride monitoring in lakes and rivers
    - Many lakes do not have a recent chloride measurement
    - ~$25 per sample
    - Low to no cost for equipment
  - Educational materials/campaigns to reduce salt usage on lakeshore properties

- Municipalities
  - Implement policies and practices to reduce salt use
    - Brining, calibration, pre-wetting, etc.
  - Hire Salt-Wise certified winter maintenance professionals

Working together to keep Freshwater Fresh!

We rely on salt to keep our roads safe in the winter and to soften water in our homes year-round but using more salt than is needed comes with a heavy price. In Wisconsin and much of the United States, chloride from salt is infiltrating into our lakes, streams and groundwater. Learn more about #thetruecostofsalt and how you can make a difference.

Featured Content

Municipal Champions Story Map
Wednesday Webinars
2025 Workshops
2025 Equipment Open Houses
Home Water Softeners

Events

Webinar: Water Softening Hacks: Blending Valves
5/7/2025

Smart Salting Workshop - Madison
9/24/2025

UW-Parkside Salt Wise Winter

Salt Wise Municipal Champions

Wisconsin Cities, Towns and Villages committed to protecting freshwater through salt reduction.

Allison Madison
February 28, 2023

City of Stevens Point

The City of Stevens Point began calibrating in 2014 after attending American Public Work...

City of Superior

The City of Superior's salt use has decreased significantly since 2014. In the past two yea...

Village of Walworth

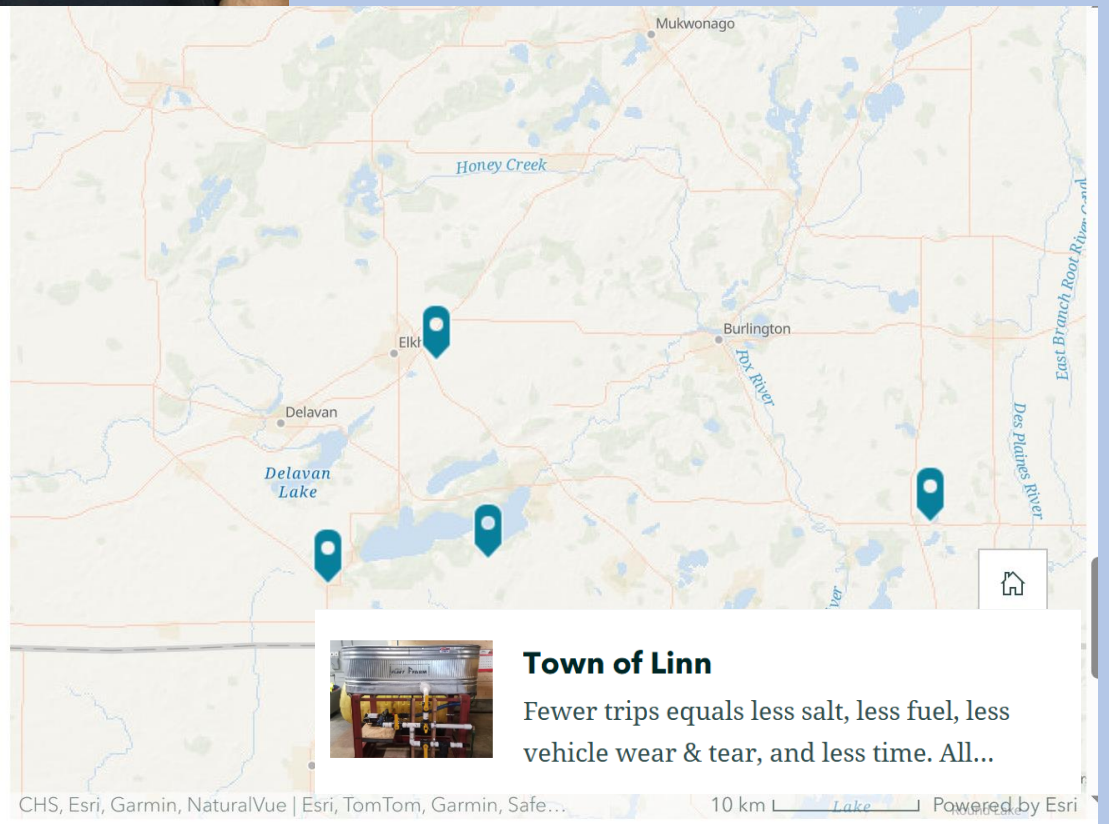
After attending a Salt Wise workshop in Fall 2024, Village of Walworth Public Works staf...

Walworth County

Walworth County has gone big with brine and high pre-wetting rates, which have...

City of Wausau

At the City of Wausau we are committed to reducing salt use and achieving a high...



Town of Linn

Fewer trips equals less salt, less fuel, less vehicle wear & tear, and less time. All...

Thank You

Funding Provided By:

Thomas Slawski | Chief Biologist

tslawski@sewrpc.org | 262.953.3263

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@SEW_RPC