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Beyond Chloride:

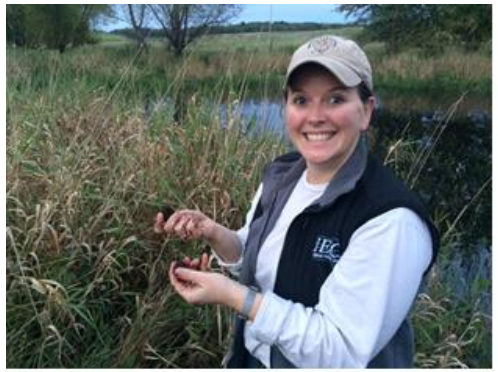
Understanding local impacts of road salts on urban waters

Rebecca Kauten, University of Iowa

Objectives

- Freshwater salinization
- Road salts, metals
- Local conditions

About Me



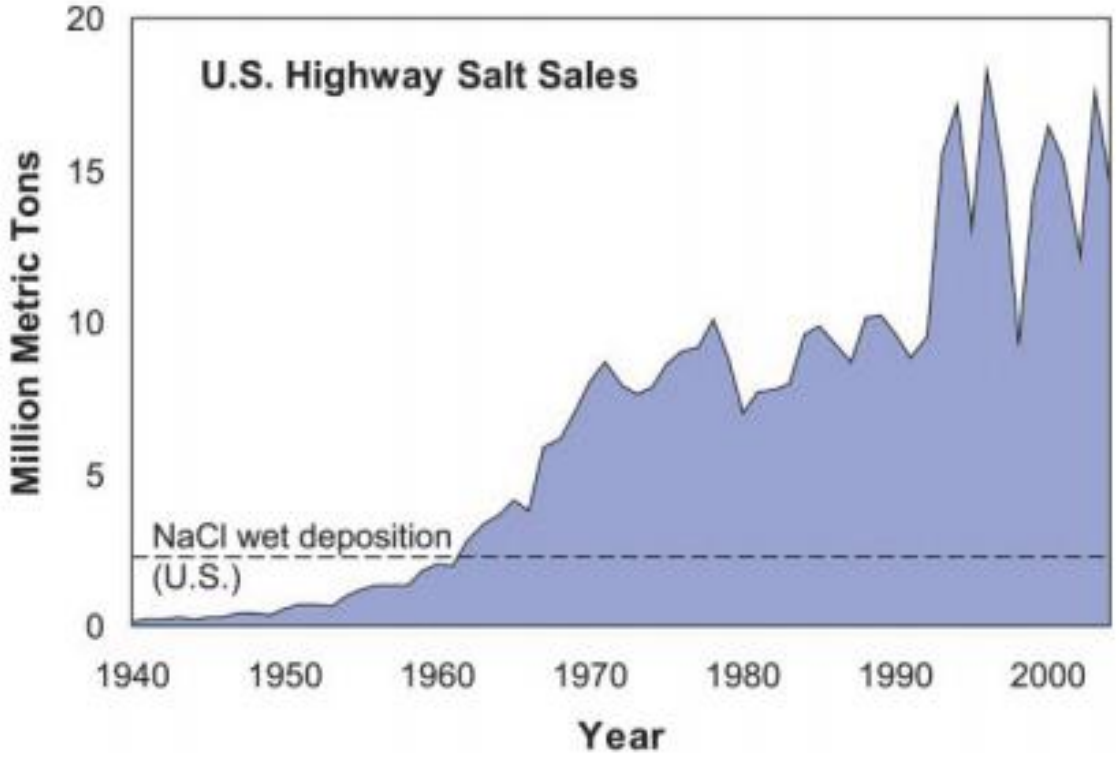
- PhD student, Department of Geographical & Sustainability Sciences
- Previous experience: Iowa DNR/DOT

My research deals with how humans impact water quality.

Wicked *Water* Problems

- “Wicked Problems” perpetuate because one is a symptom of another (Rittel and Weber, 1973)
- Local management varies across environmental, social/institutional dimensions (Patterson, Smith, & Bellamy, 2013)

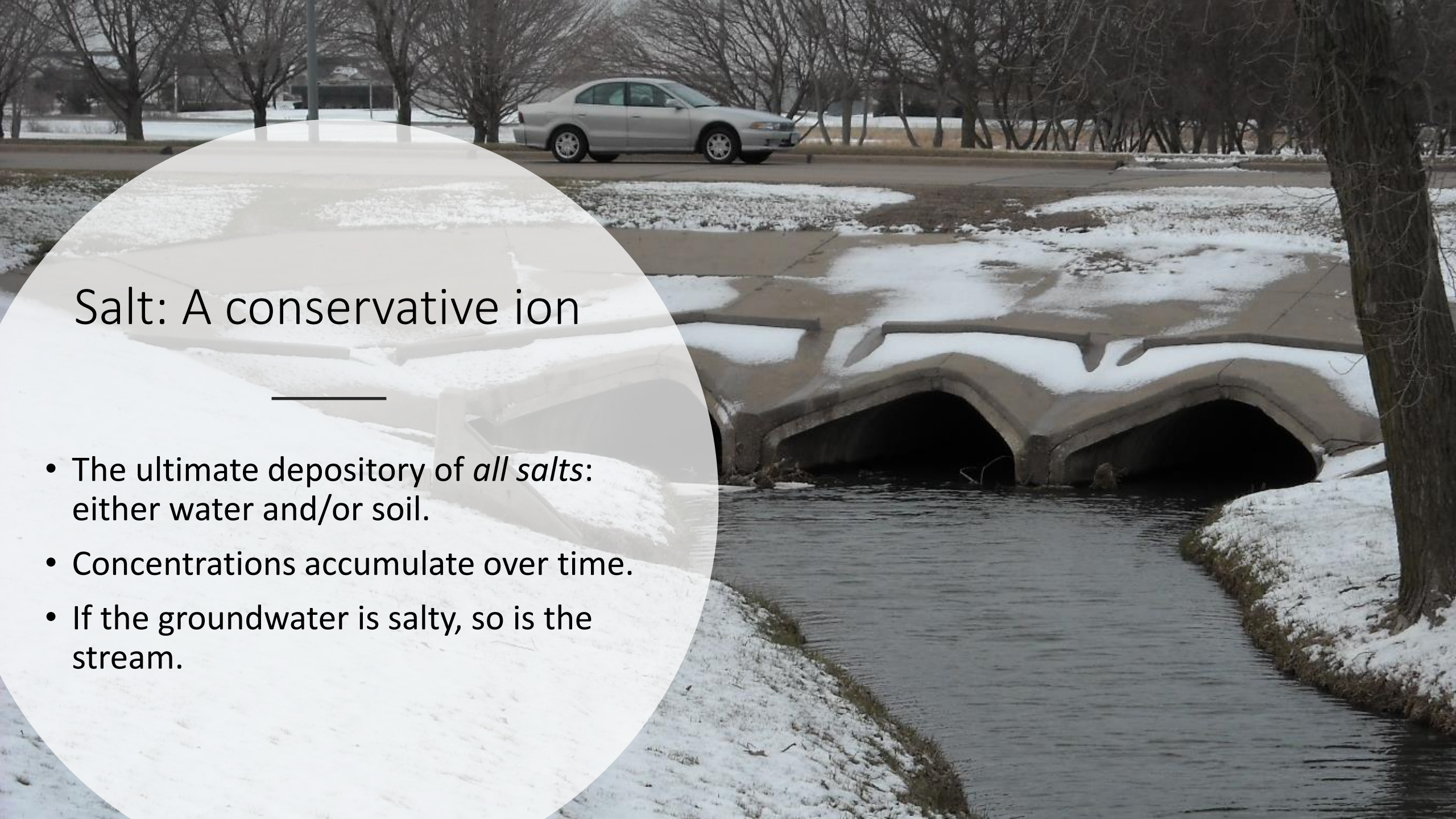
- 21st Century Water Resource Concerns
  - More wicked than tame
  - Not solvable by existing world views/ conditions
  - Non-linear
- Incremental progress means unsolved problems
  - Structure, behavior unchanged, unchecked



- >**20 million metric tons** applied annually in the U.S.& Canada.
- U.S.: **~$2.3 billion annually**
  - 400-800 lbs per mile, per application.
- Associated **corrosion and environmental impacts: ~$5 billion.**
  - Soil: loss of stability, osmotic stress, nutrient/metal mobilization
  - Water: groundwater contamination, mobilized metals
  - 164,000 miles of highways in the US
  - Most people live in urban areas

Freshwater Salinization & Road Salts

Image credit: Jackson, 2005



Salt: A conservative ion

- The ultimate depository of *all salts*: either water and/or soil.
- Concentrations accumulate over time.
- If the groundwater is salty, so is the stream.

So what?

- Ultra-urban areas – logarithmic relationship
  - ≤15% I.S. ~vegetation impacts
  - >40% I.S.~>4,600 mg/L (500-5000 = “brackish”)
- Localized Impacts
  - Midwest
    - Drinking water wells de-commissioned
    - Saline urban lakes
  - East Coast
    - Stream salinity increase by order of magnitude since 1960s.
    - Also concern re: fracking

Human Health & Safety

- The Salt Institute: “Salt saves lives.”
  - Reduces accidents by 88%, injuries by 85%.
  - Pays for itself in 25 minutes.

- Transportation Agency Implementation Strategies
  - Material Management
  - Vegetation Management
  - Technology & Equipment

Photo credit: mytoba.ca

Research Challenges

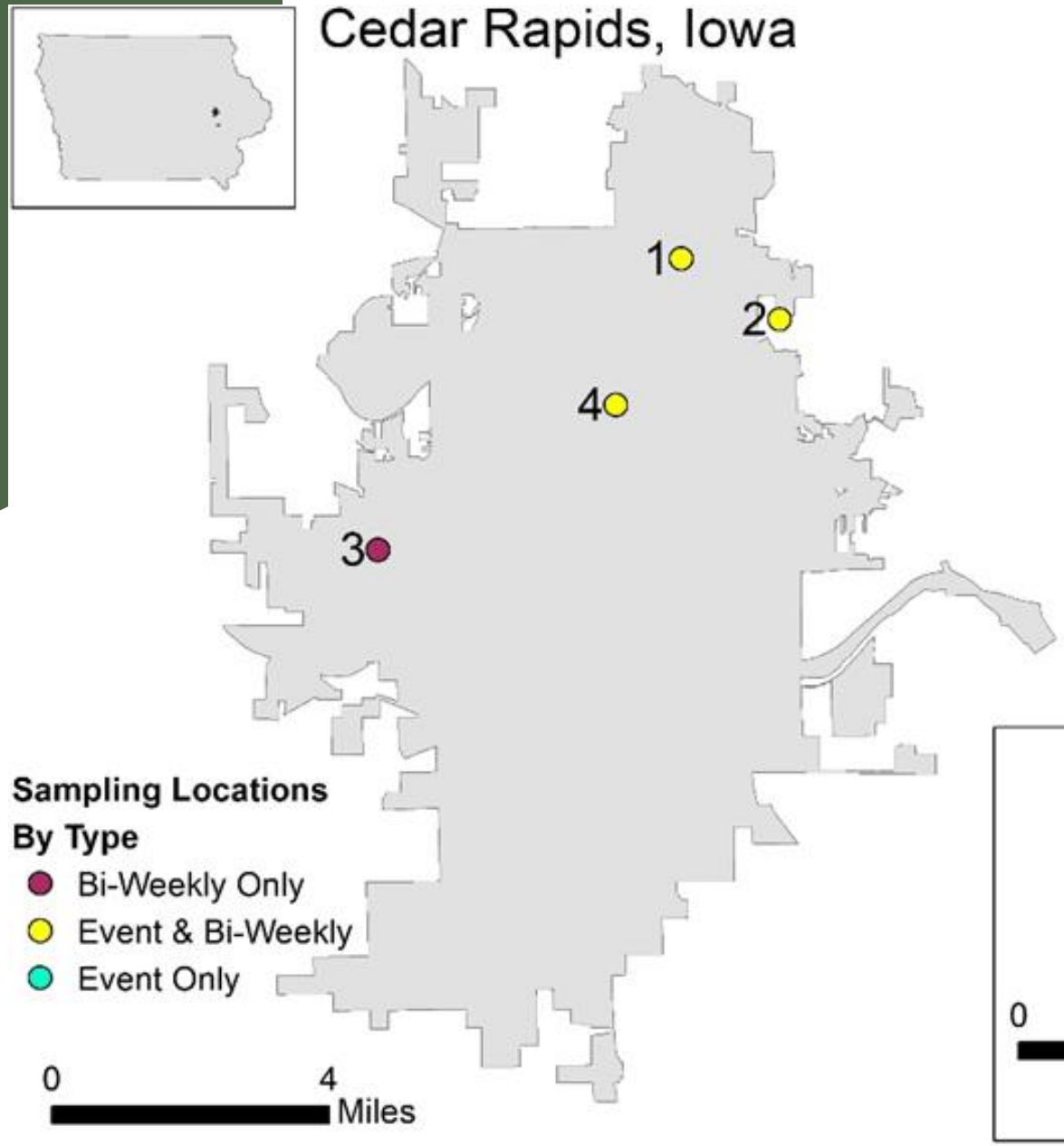
- Impact on soil, water is local and transient.
- Lack of transferable variables: site-specific.
- Winter field studies are challenging!

FIGURE 1. Location of study sites in Wisconsin and metropolitan areas in the United States used for aquatic toxicity evaluation from road salt.

My Research

- Quantify impacts from winter roadway runoff in two Eastern Iowa communities.
  - Assumption: >I.S. = >concern
- Determine the relationship chlorides: metal ions
  - Compare local results to statewide data, Cu & Zn
- “Frame the Problem” in an agency context
  - Best practices, overall understanding of situation

SA1 Study Area

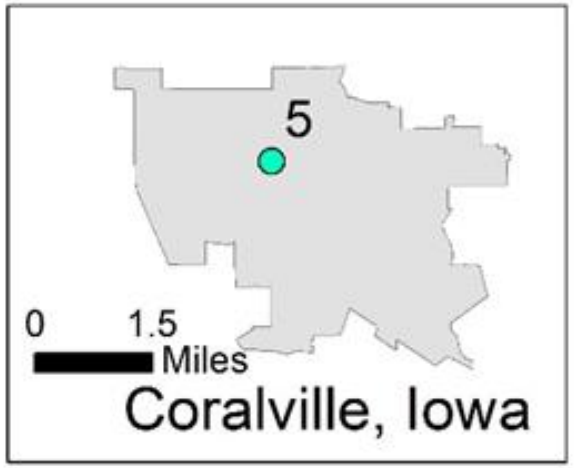


1. Comm/Ind

2. Commercial

3. Residential

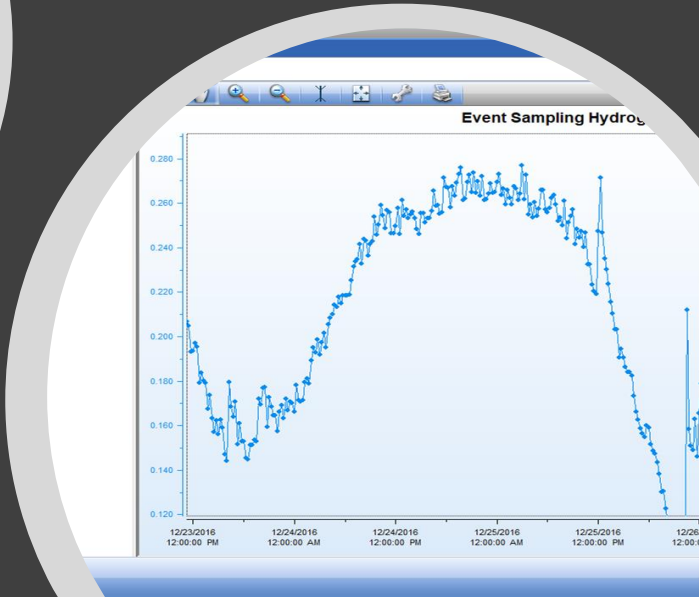
4. Trout Stream



5. Roadway

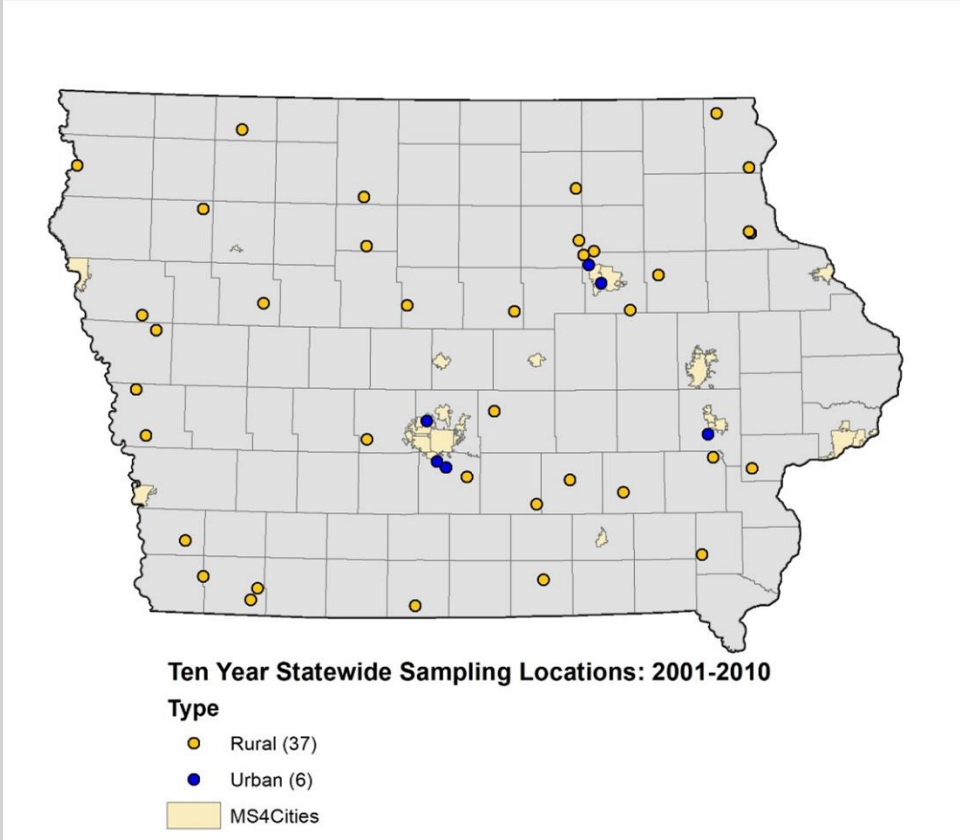
Local Field Data

- Total Metals: As, Ca, Cd, Cl, Cr, Cu, K, Mg, Ni, Na, Pb, Zn
- SO4, Total Hardness, pH
- Conductivity, Total Dissolved Solids (TDS) Total Suspended Solids (TSS)



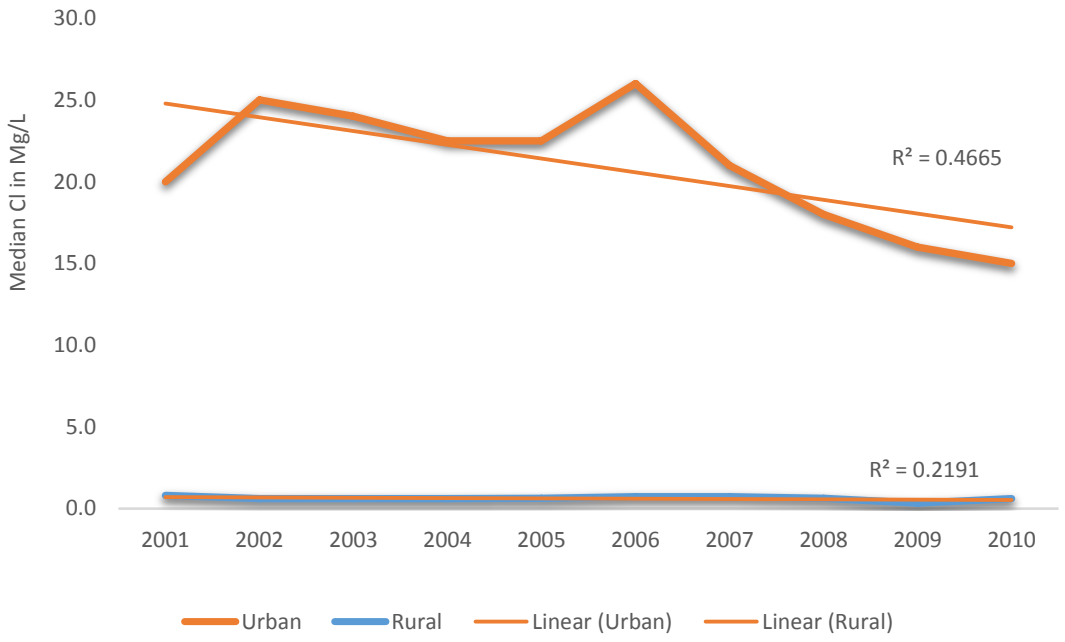
Ten Year Trend Analysis

- 43 sites: “Urban” vs “Rural”
  - Chloride concentrations in mg/L
  - 3 Corrosiveness Indexes
- Mann-Kendall S Statistic *($p < 0.05$)*

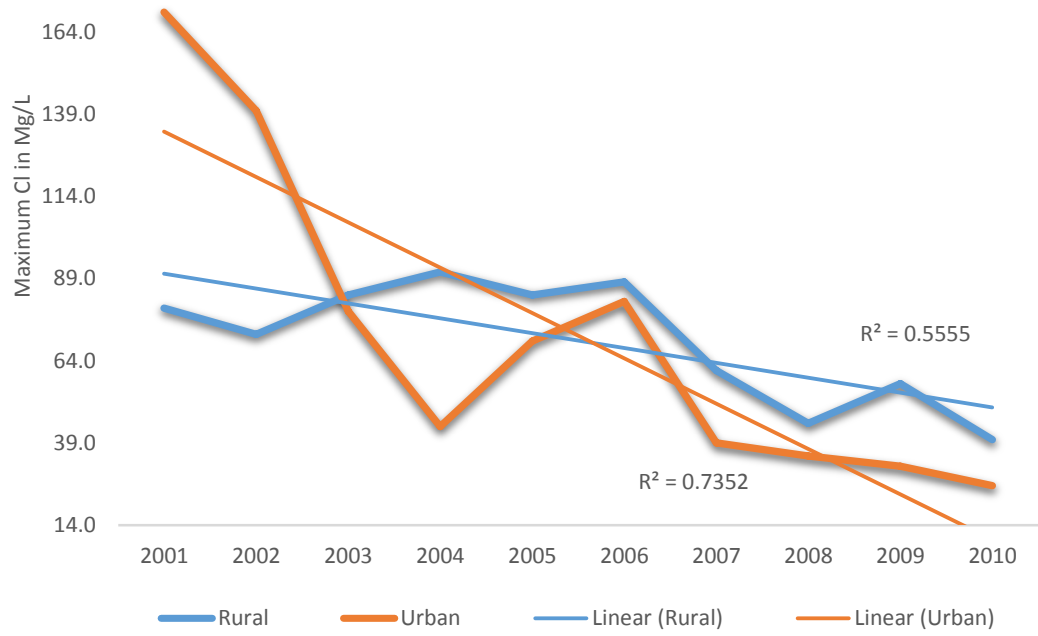


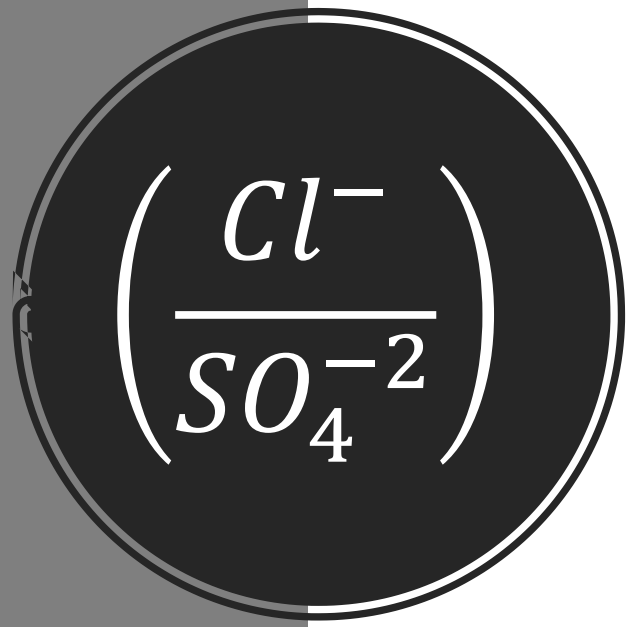
2001-2010 Data: Chloride Concentrations

Median Cl Values: Rural – No Trend
Urban - Decreasing



Maximum Cl Values: Rural – No Trend
Urban - Decreasing



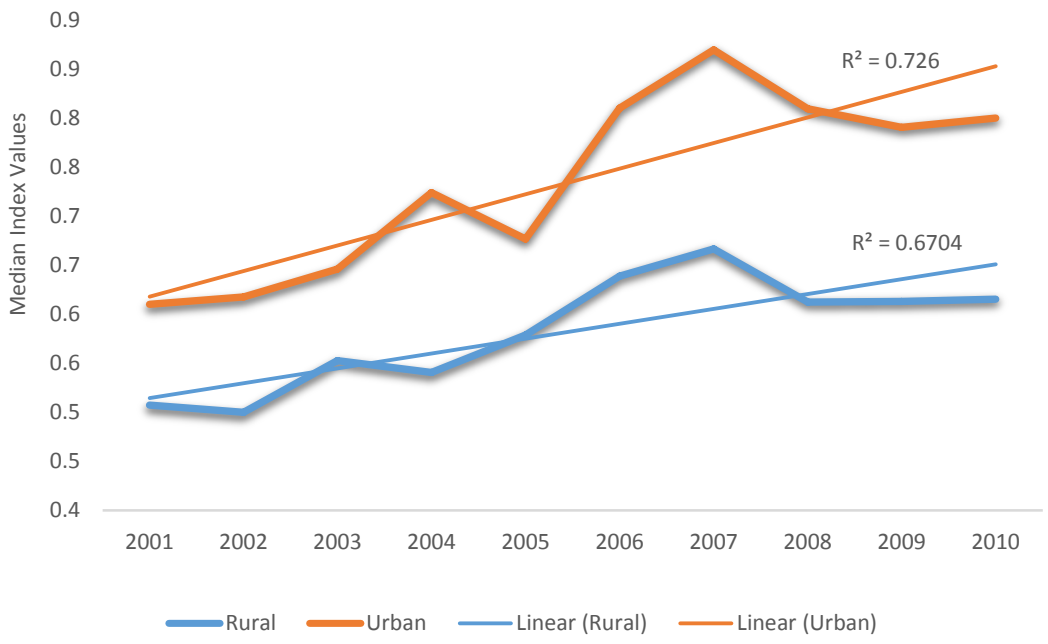


CSMR Value	Alkalinity ($CaCO_3$ in mg/L)	PPGC
< 0.20	<50	Low
0.20 to 0.50	≥50	Moderate
>0.50	< 50	High

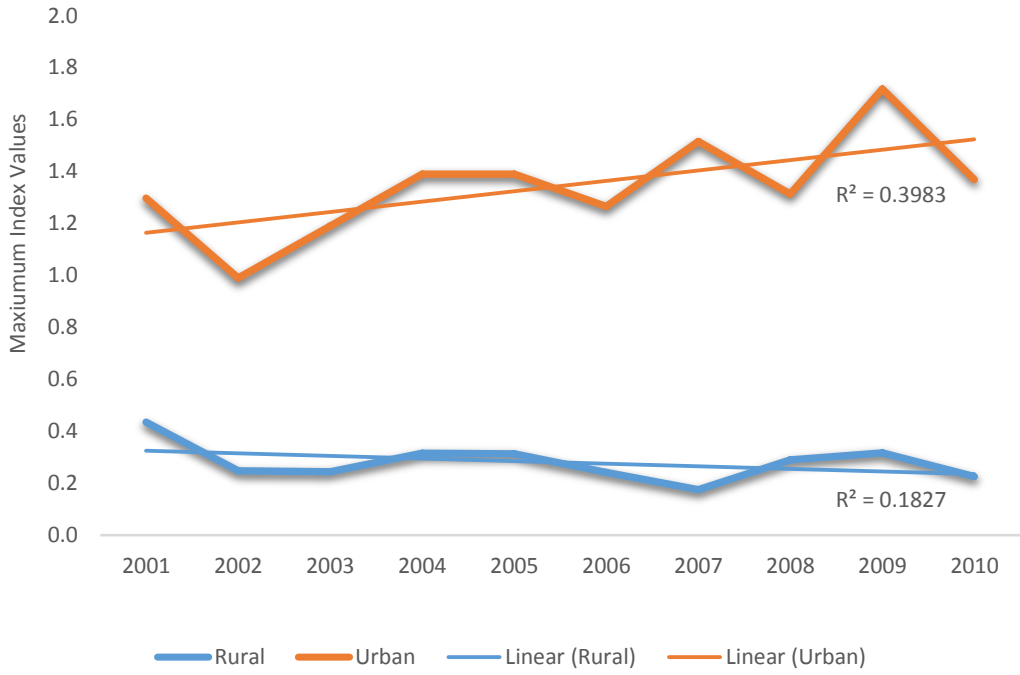
Chloride – Sulfate Mass Ratio (CSMR)
Potential to Promote Galvanic Corrosion (PPGC)

2001-2010 Data: Chloride-Sulfate Mass Ratio

Median CSMR Values: Increasing



Maximum CSMR Values: No Trend



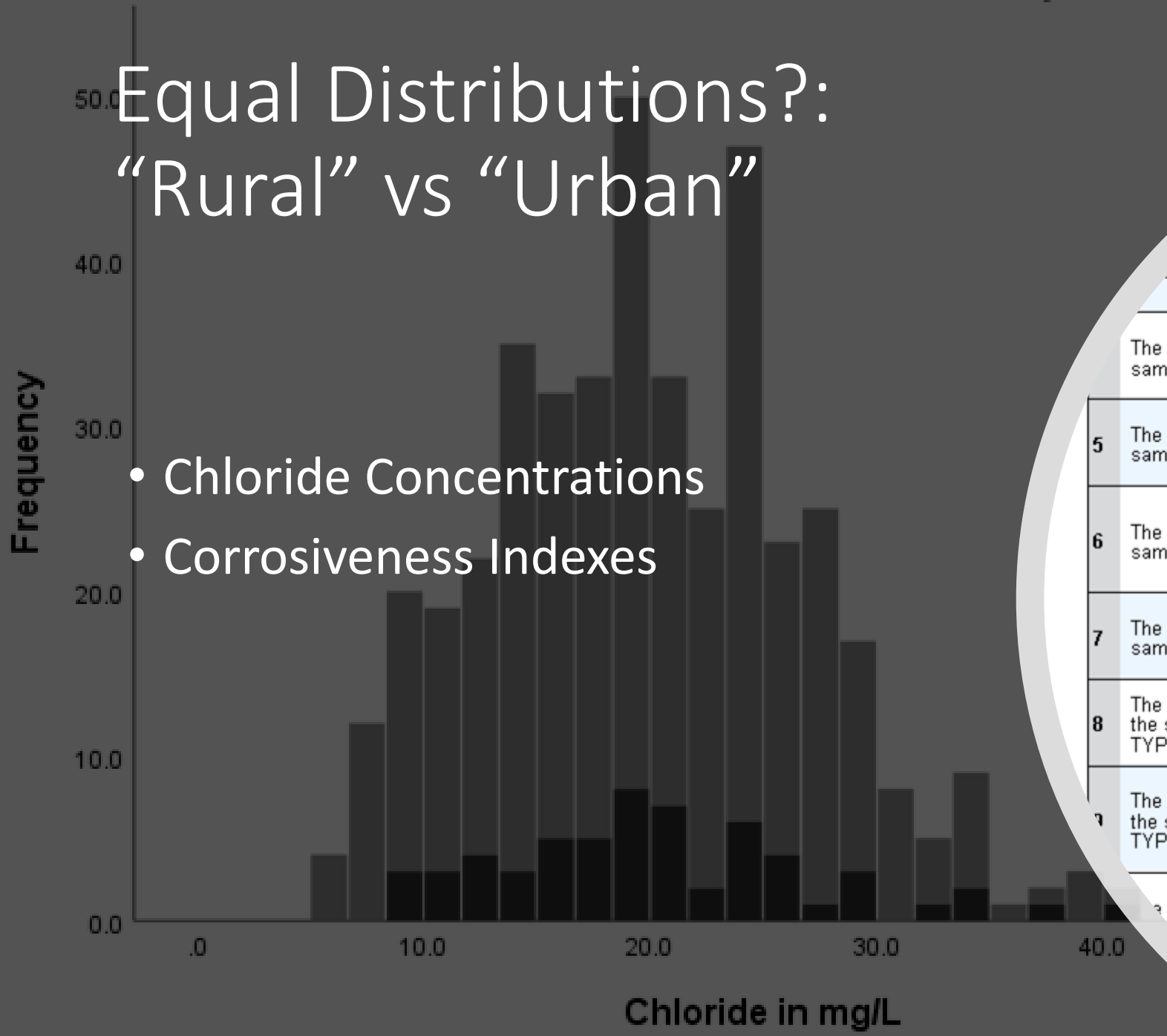
According to Statewide Trends…

Parameter	Sites	Mann-Kendall Trend Detection (sig p<0.05)	
		Median	Maximum
Chloride in mg/L	Rural	-	-
	Urban	Decreasing	Decreasing
Chloride-Sulfate Mas Ratio	Rural	**Increasing**	-
	Urban	**Increasing**	-
Larson-Sköld Corros. Ratio	Rural	-	-
	Urban	Decreasing	Decreasing
Langelier Saturation Index	Rural	-	-
	Urban	-	-

- Chloride is actually decreasing over time.
- Corrosiveness may be increasing due to changes in sulfate, not chloride.
- Carbonate geology can buffer (*initial)* effects.

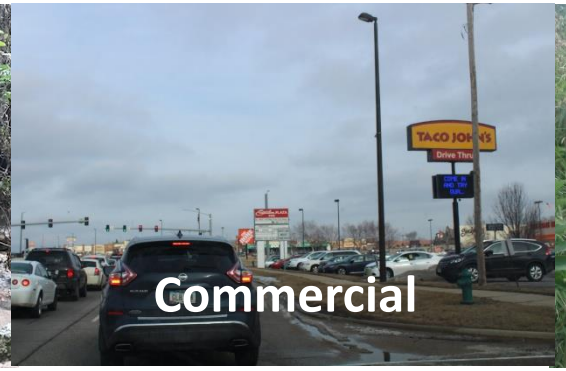
Equal Distributions?: “Rural” vs “Urban”

- Chloride Concentrations
- Corrosiveness Indexes

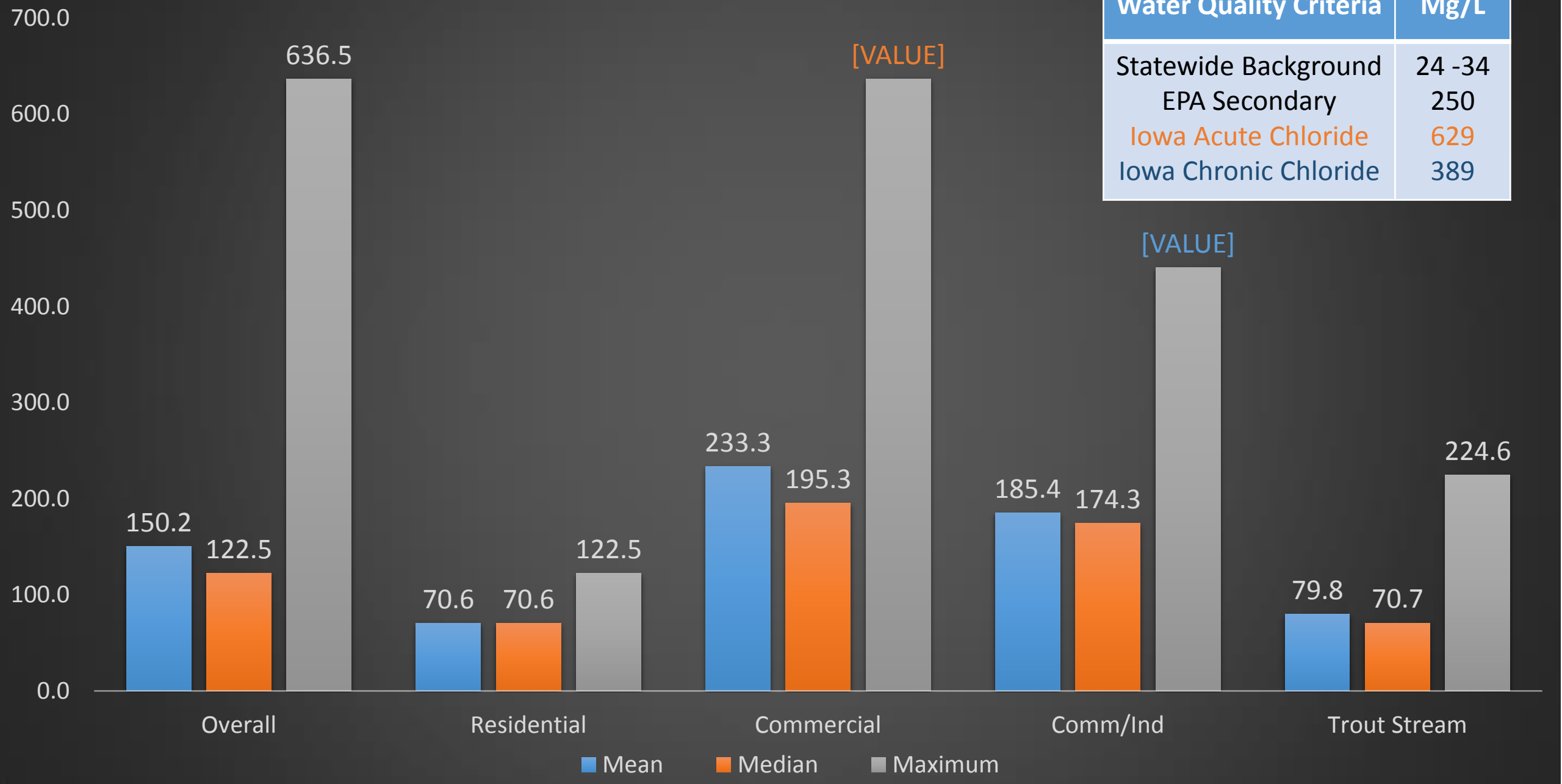


	...ORIDE is the ...gories of TYPE.	Independent-Samples Mann-Whitney U Test	.290	null hypothes...
	...tribution of CHLORIDE is the ...e across categories of TYPE.	Independent-Samples Kruskal-Wallis Test	.290	Retain the null hypothesis.
	The medians of CSMR are the same across categories of TYPE.	Independent-Samples Median Test	.000	Reject the null hypothesis.
5	The distribution of CSMR is the same across categories of TYPE.	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis.
6	The distribution of CSMR is the same across categories of TYPE.	Independent-Samples Kruskal-Wallis Test	.000	Reject the null hypothesis.
7	The medians of Larson_Sko are the same across categories of TYPE.	Independent-Samples Median Test	.000	Reject the null hypothesis.
8	The distribution of Larson_Sko is the same across categories of TYPE.	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypothesis.
9	The distribution of Larson_Sko is the same across categories of TYPE.	Independent-Samples Kruskal-Wallis Test	.000	Reject the null hypothesis.
	...e medians of LSI_VALUE are the ...e across categories of TYPE.	Independent-Samples Median Test	.000	Reject the null hypothesis.
	...tion of LSI_VALUE is ...s categories of	Independent-Samples Mann-Whitney U Test	.000	Reject the null hypoth...

How does this compare with *local* data?

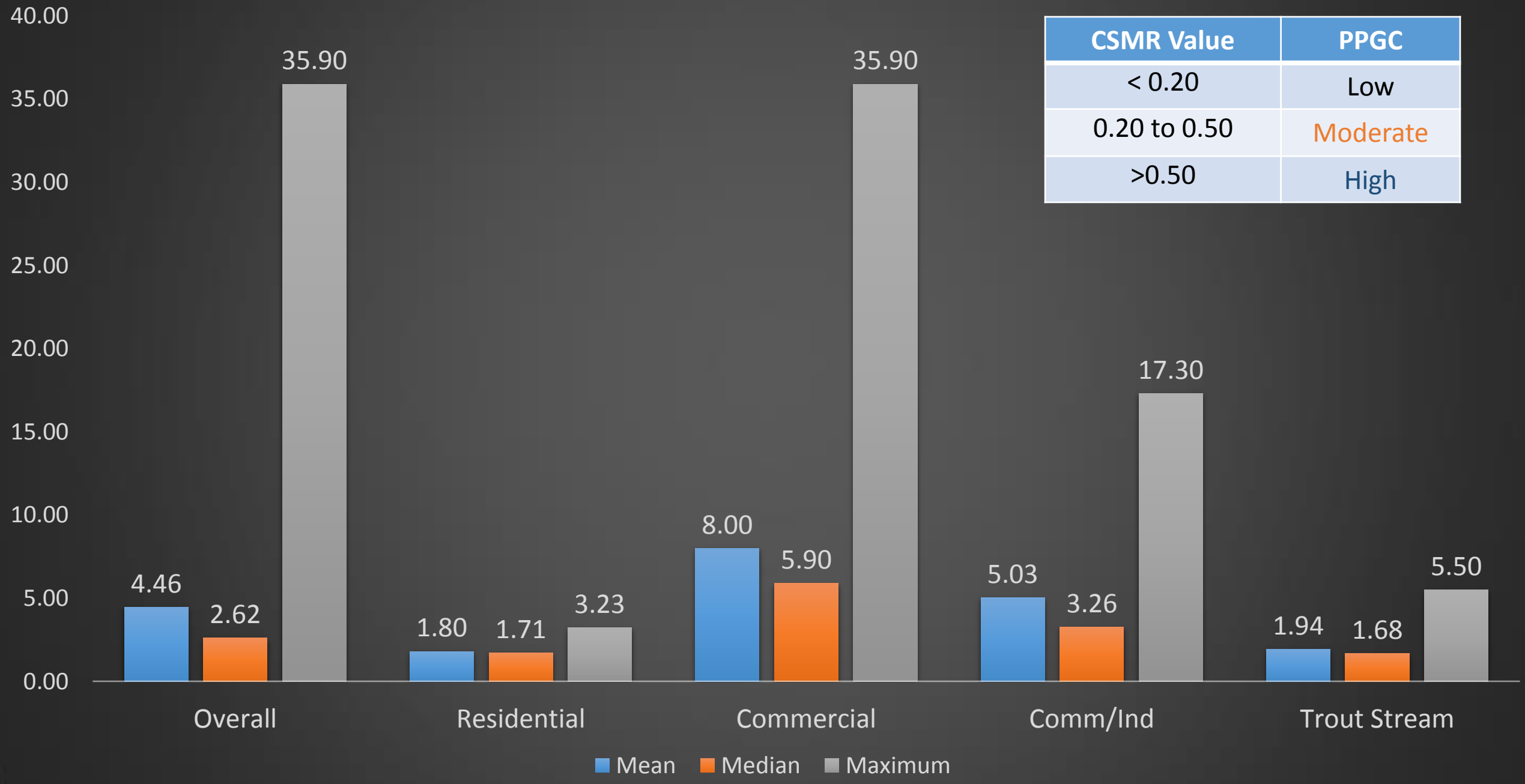


Bi-Weekly Chloride in mg/L



Water Quality Criteria	Mg/L
Statewide Background	24 -34
EPA Secondary	250
Iowa Acute Chloride	629
Iowa Chronic Chloride	389

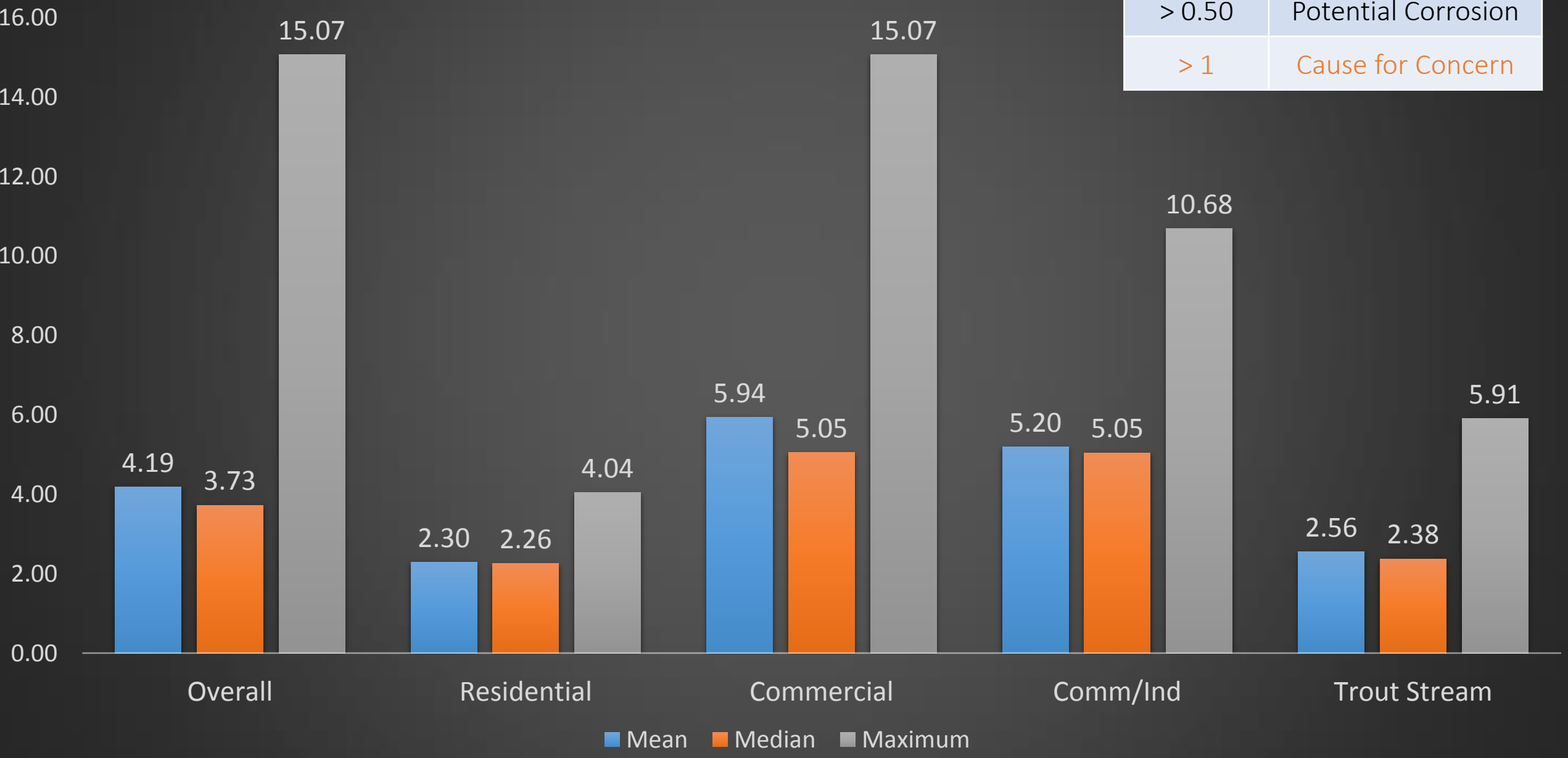
Bi-Weekly CSMR by Site



CSMR Value	PPGC
< 0.20	Low
0.20 to 0.50	Moderate
>0.50	High

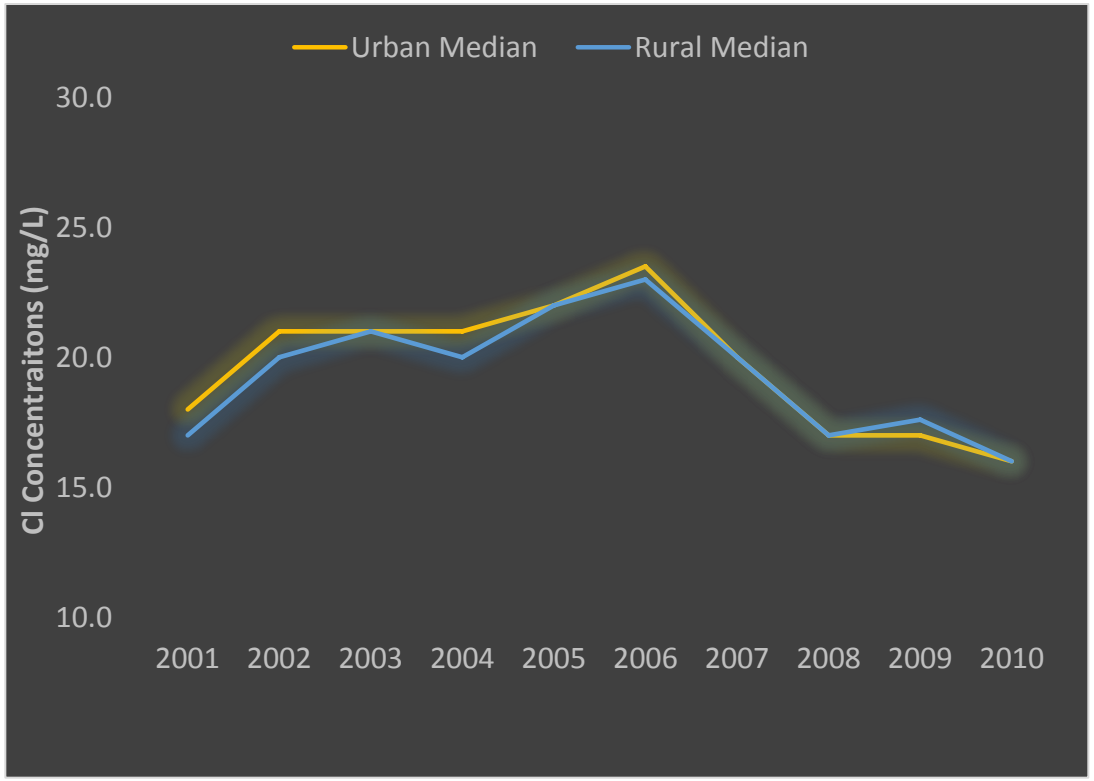
Bi-Weekly LSCR
Estimated Alk: 166 mg/L

LSCR Value	Steel Corrosion?
> 0.50	Potential Corrosion
> 1	Cause for Concern

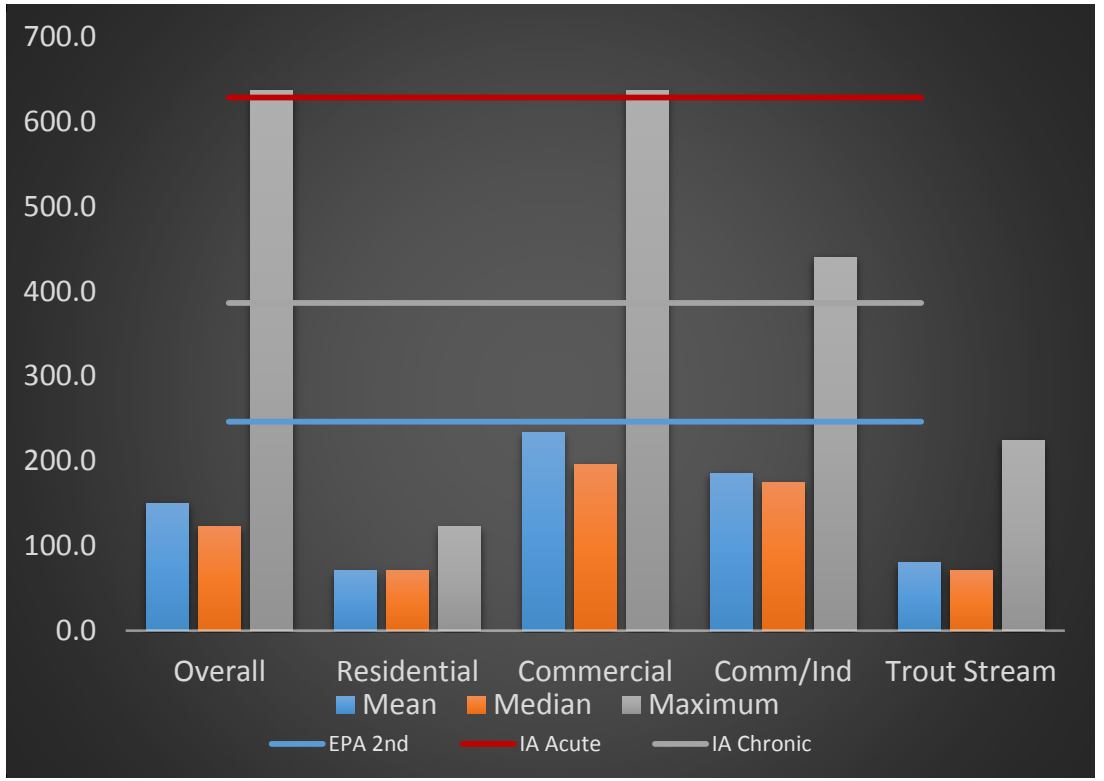


Apples & Oranges?

Median Concentrations: Statewide

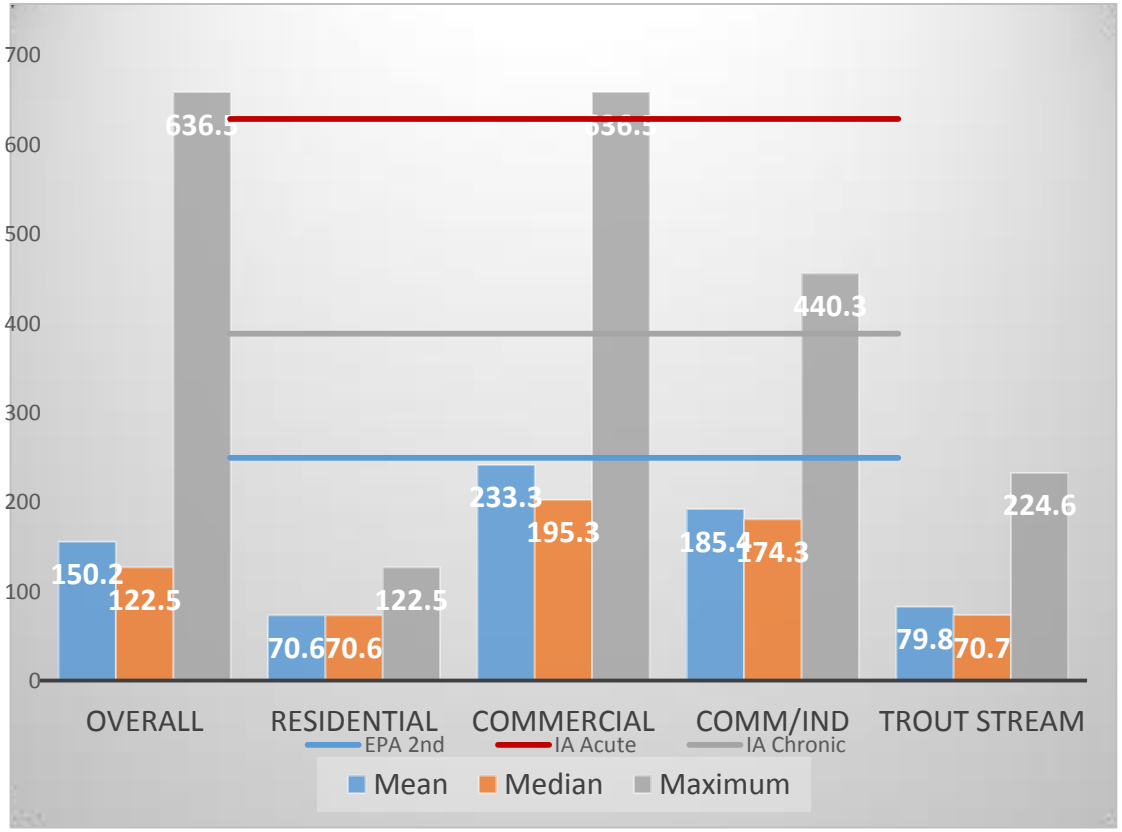


Median Concentrations: Local

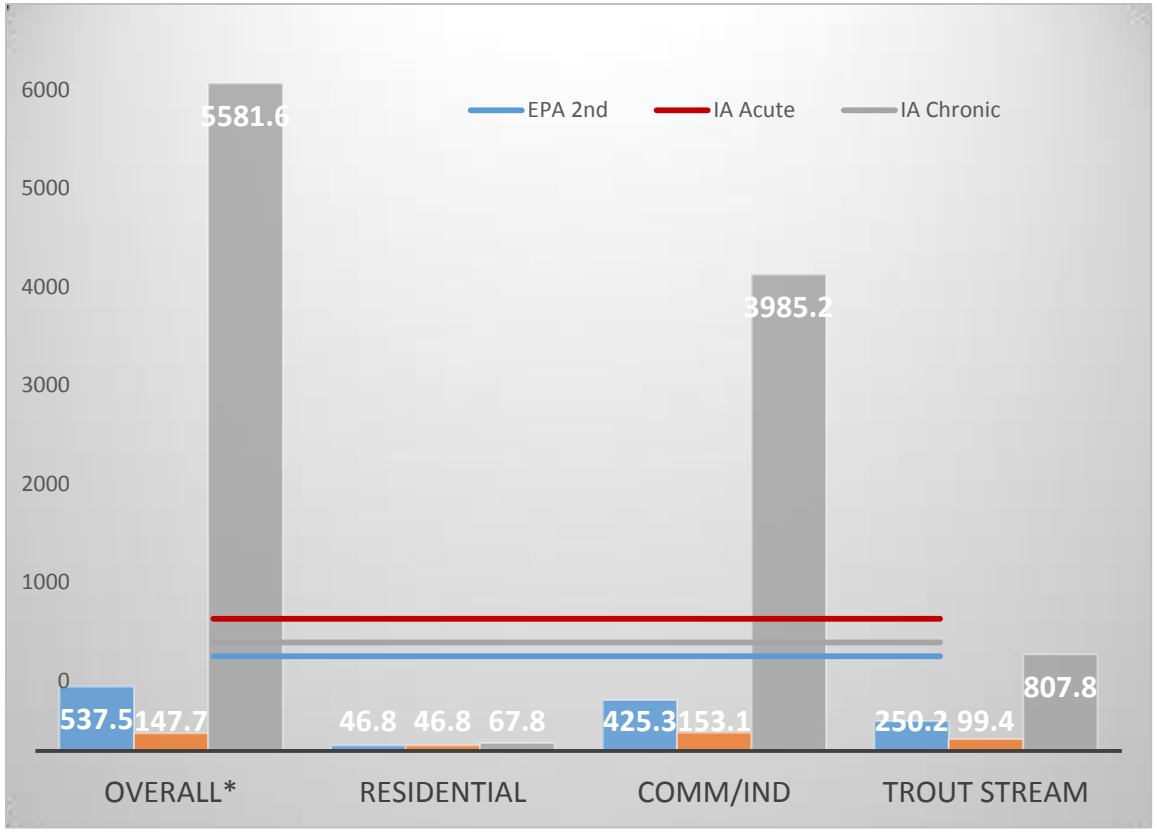


Event vs Scheduled Sampling

Bi-Weekly Sampling



Event Sampling



Iowa's Chloride Standard

Acute Chloride Criteria:

$287.8(CaCO_3)^{0.205797} * (SO^4)^{-0.07452} = Cl\ (mg/L)$

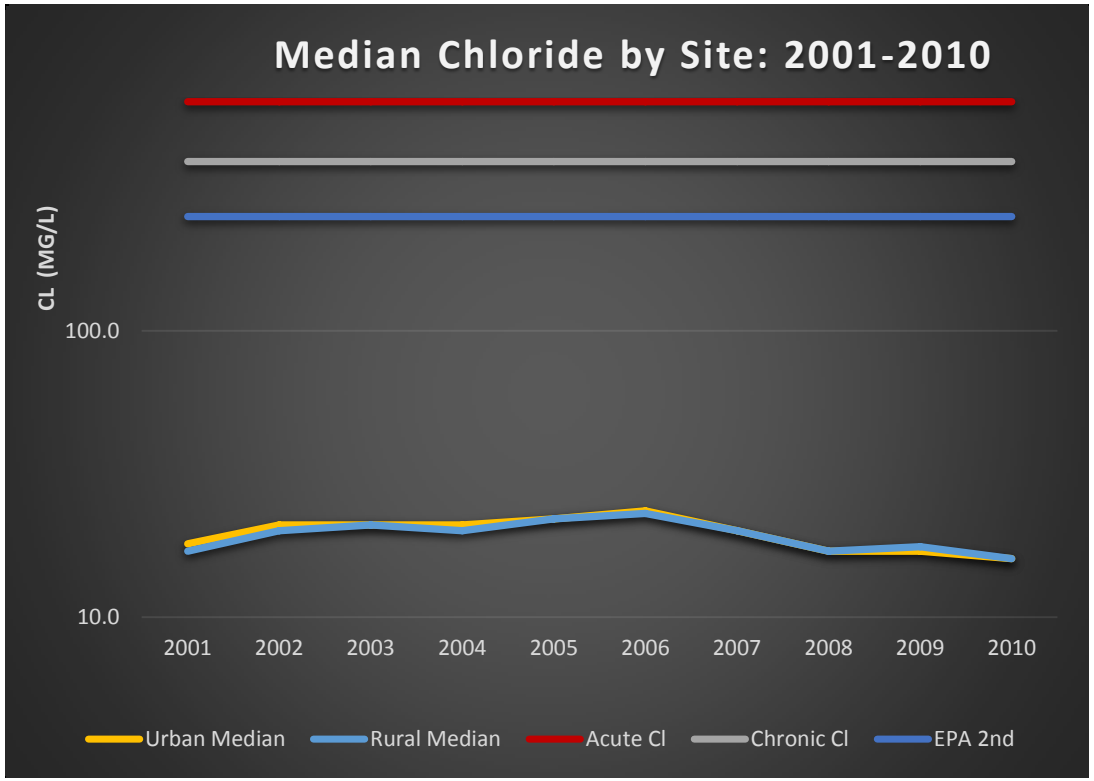
Chronic Chloride Criteria:

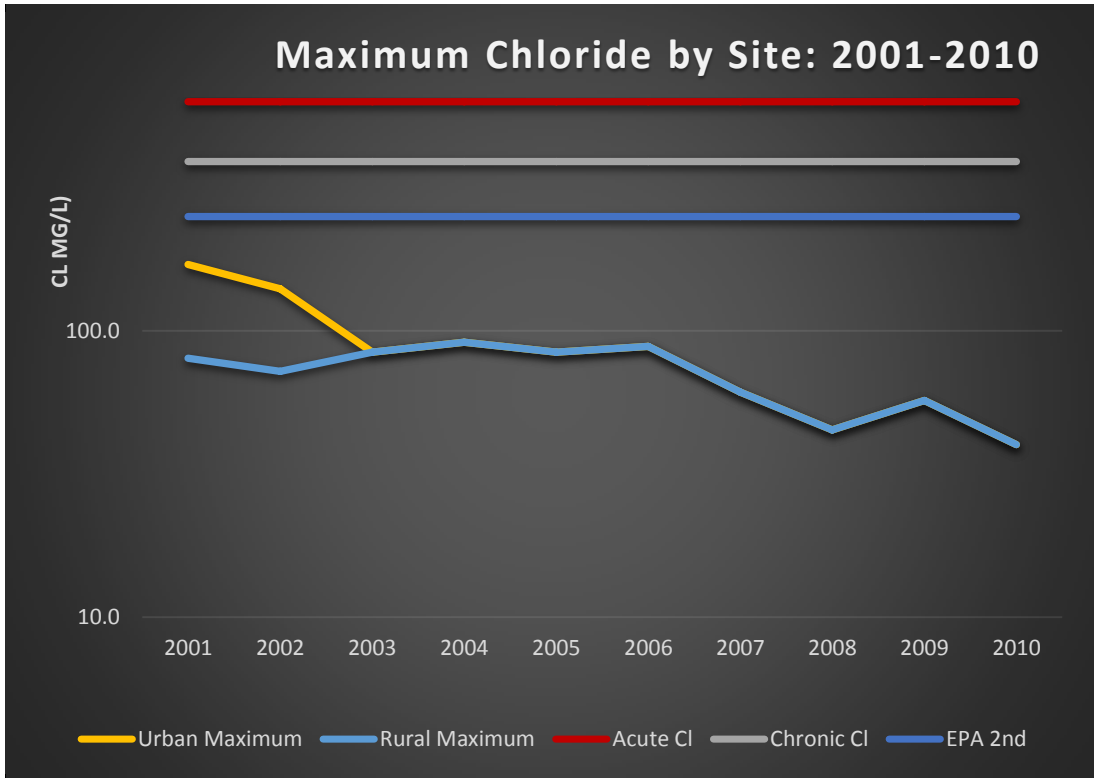
$177.87(CaCO_3)^{0.205797} * (SO^4)^{-0.07452} = Cl\ (mg/L)$

Acute: 629 mg/L

Chronic: 389 mg/L

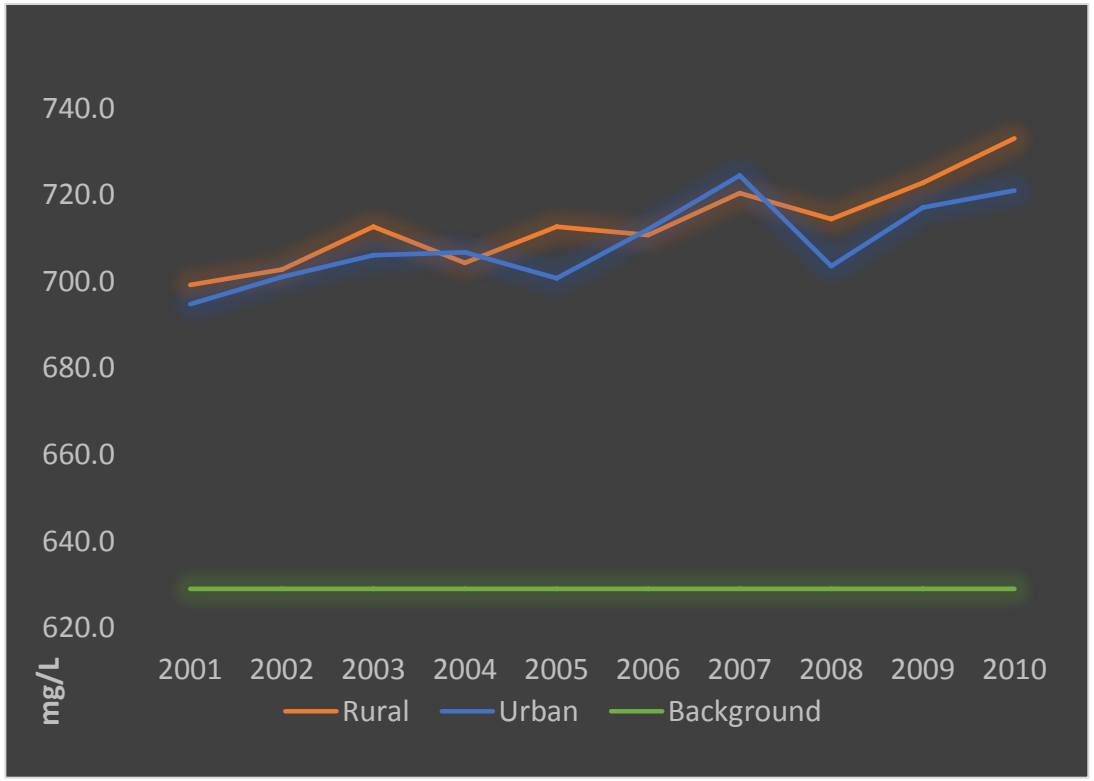
Still below, but approaching all criteria!



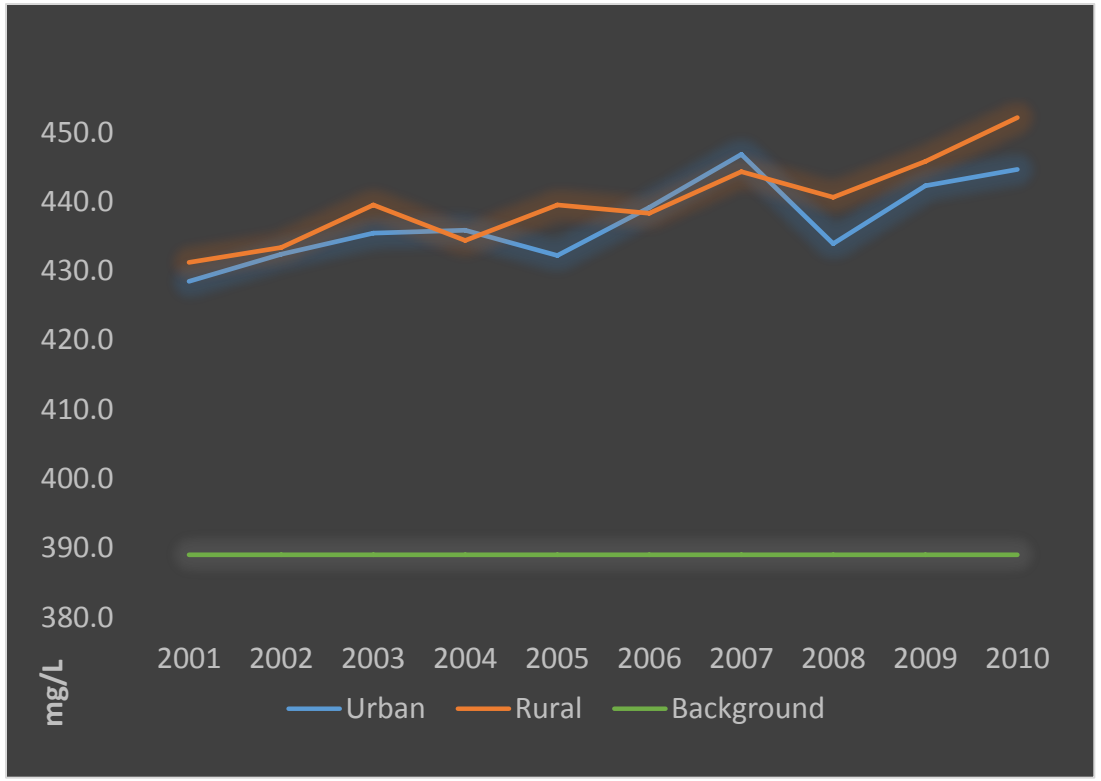


Iowa's Chloride Standard & Ten Year Data

Acute Cl Criteria for Median



Chronic Criteria for Median



What's up with SO4?

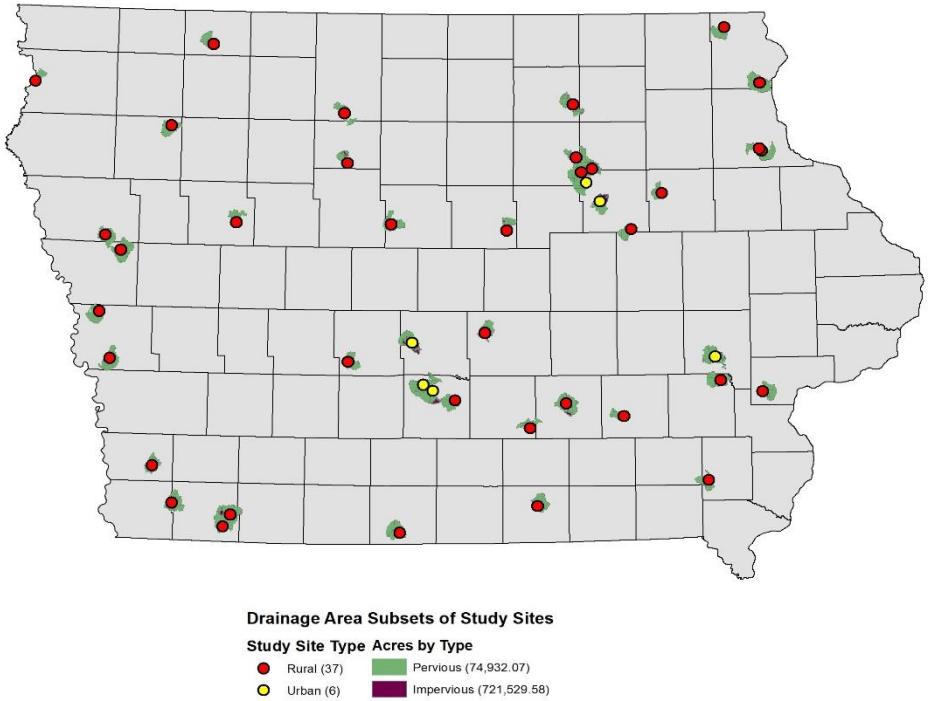
Median: 2001-2010

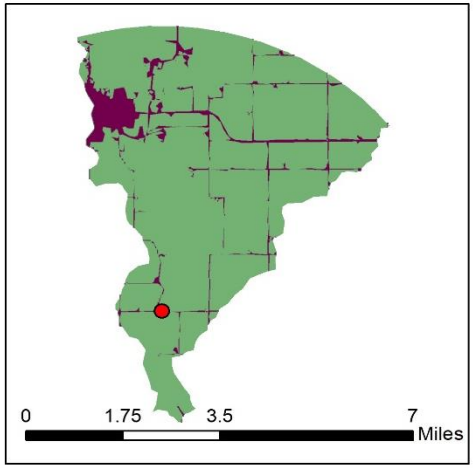
Maximum: 2001-2010

Statewide IS Comparison

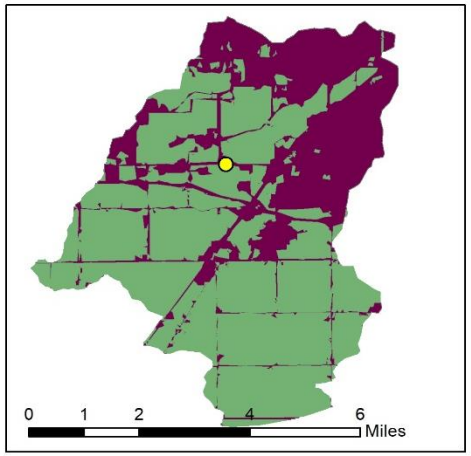
No statistical variation: urban/rural

2011 NLCD

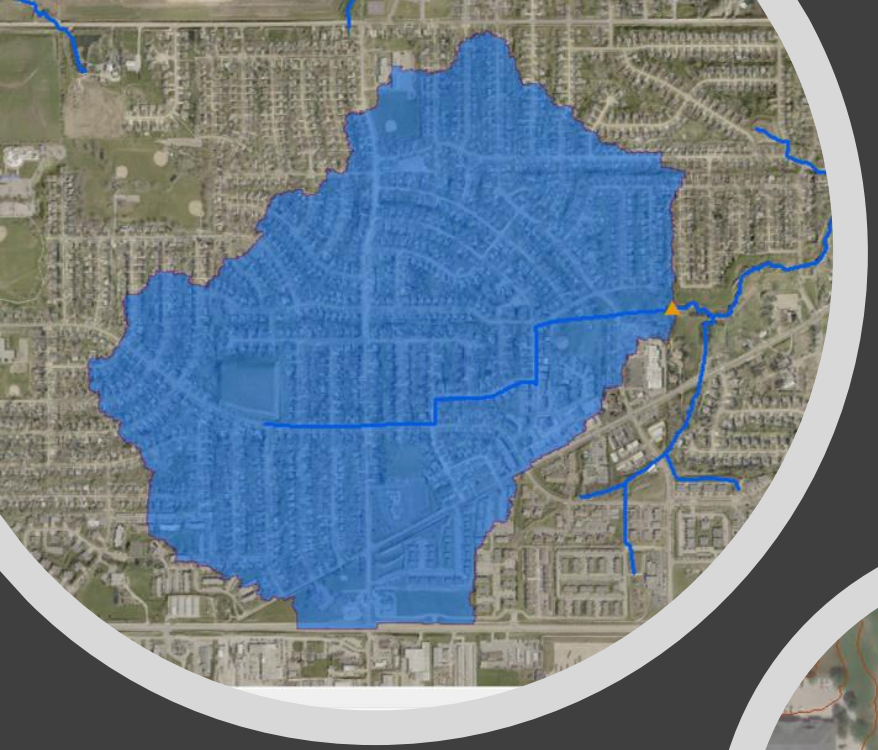


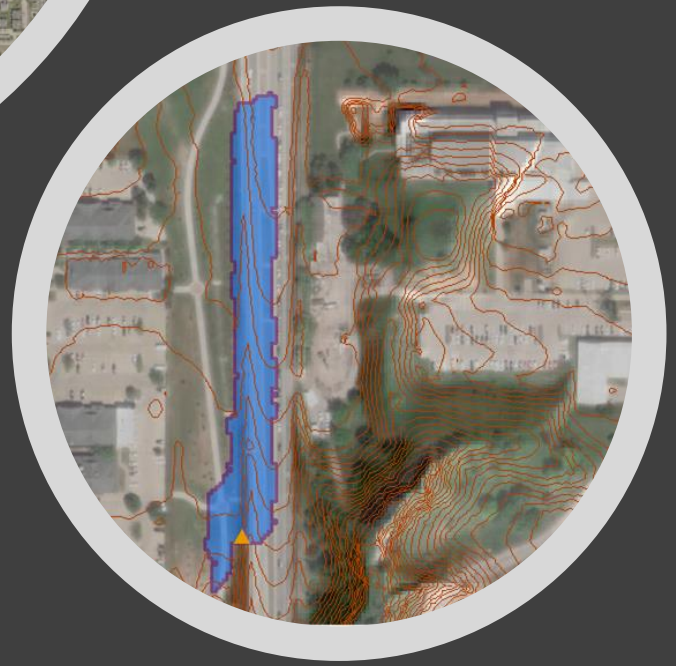


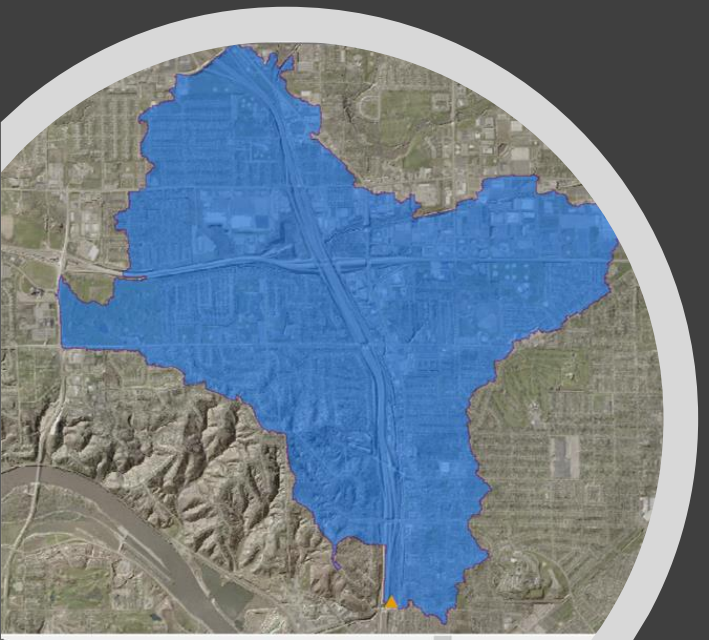
Rural Study Area



Urban Study Area







Local Sub-Watersheds

- Cl concentrations vary by site, sample type
- IS coverage varies by site
- WinSLAMM digital watershed model

Statewide data differ drastically from local data.

- Statewide scale doesn’t detect most variation.
- Statewide vs Local: Little evidence of increases in chloride over time.
- Possible/likely violations of acute/chronic criteria for chloride during local *pulses.*
- Potential for galvanic corrosion is possibly increasing statewide.
- Carbonate geology may be ***buying us time.***
- Local site data vary by Cl, IS coverage, etc.

“More research is needed…”

- What’s happening with SO4 in Iowa?
- What’s the status of ions, other functions of carbonate geology in urban areas? Over time?
- Is Cl >300 mg/L ok for aquatic life? *>600?*
- If corrosive urban waters occur, what’s the status of ***urban infrastructure***?
  - Culverts
  - Storm Sewers
  - Etc.

More of MY Research Underway

Ion Balance of Sample Data

Come check out my poster for more on this!

Compile Interview Data (n=17)

Analyze agency perceptions, attitudes on freshwater salinization

THANKS!

COE COLLEGE

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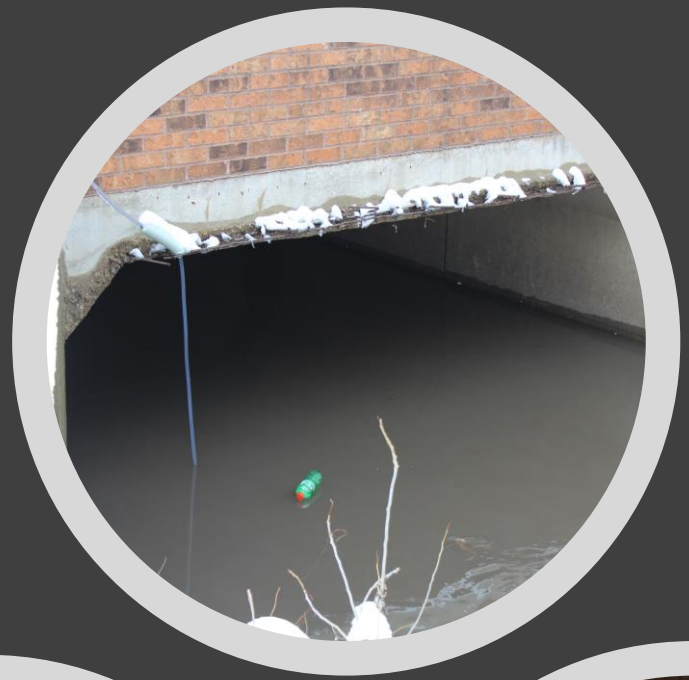
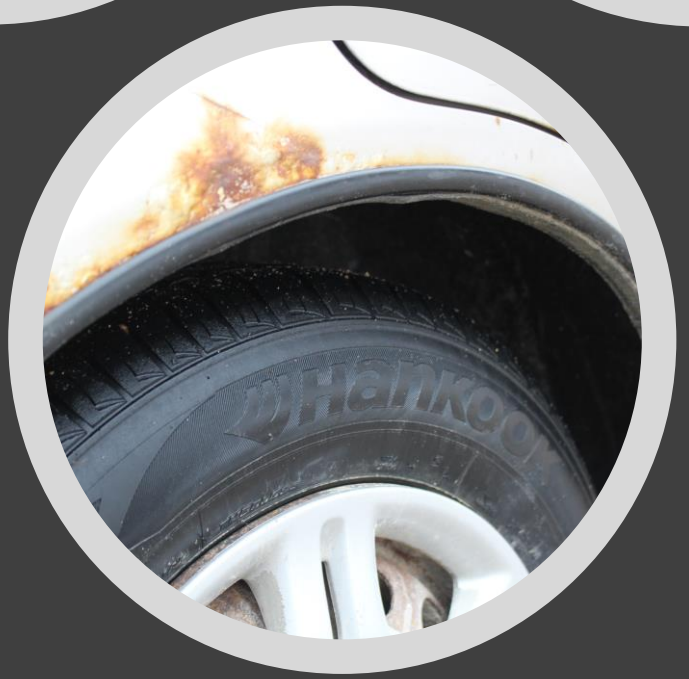

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