

# Aicam Laacouri

## Minnesota Department of Agriculture

**Afternoon Speaker**

*Monitoring for Chloride in  
Agricultural Areas in Minnesota*





# Monitoring for Chloride in Agricultural Areas of Minnesota



Aicam Laacouri | Research Scientist

Pesticide Fertilizer Management Division

Salt Symposium 2022

# Outline

- Chloride and Crop Nutrition
- Sources of Chloride in Cropping Systems
- Minnesota Department of Agriculture Chloride Monitoring
  - Groundwater Monitoring
  - Surface Water Monitoring
  - Edge of Field-Discovery Farm Monitoring

# Chloride is an Essential Micronutrient

## Chloride (Cl) is a plant **micro-nutrient**

- Macro-nutrients: N, P, Potassium (K)
- Micro-nutrients: **(Cl)**, B, Cu, Fe, Mn, Mo and Zn
- Crop requirement: **3.5 to 7 lb/ac** for an average crop

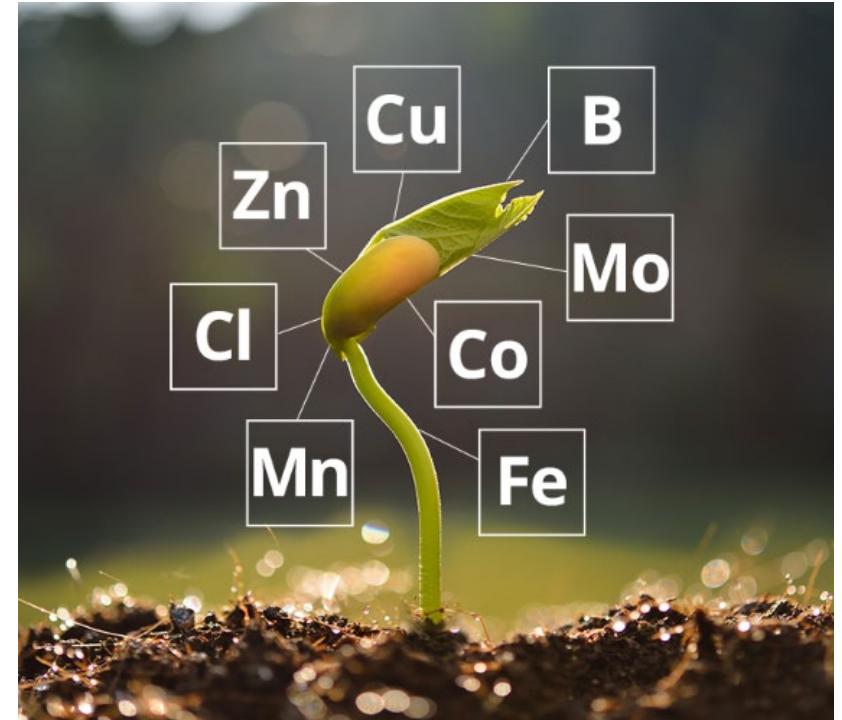


Photo Credit: [www.taurus.ag/](http://www.taurus.ag/)

# Chloride is Mostly Found in the Crop Residue

- **Uptake form:** Plant uptake in chloride form ( $\text{Cl}^-$ )
- **Distribution in plant:** Chloride is found mostly in the **crop residue**, not in the crop grain
- A typical corn yield (150-200 bu/ac) will have about **4 lbs in corn grain** and **68 lbs in corn stover/residue**

Table 1. Chloride removal by selected crops.

Crop	Plant part	Cl content	Reference
Alfalfa	Shoot	7.6 lb/ton (dry wt)	NRC, 1981
Barley	Grain	0.024 lb/bu <sup>1</sup>	Fixen, 1993
Potatoes	Tubers	0.06 lb/cwt	Saffigna et al., 1977
Sweet clover	Shoot	7.4 lb/ton (dry wt)	NRC, 1981
Wheat	Grain	0.026 lb/bu	Fixen, 1993
Wheat	Grain + straw Low soil Cl High soil Cl	0.17 lb/bu 0.44 lb/bu	Schumacher, 1988

Fixen, 1993

# Chloride in Subject to Leaching the Soil

- Chloride **moves** from soil solution to plant root mainly via **mass flow**
- Chloride is **negatively charged**: Potential to **leach** below the root zone
- Chloride is **not altered** by soil **microbes**: Often used for soil **water flow tracing**
- Chloride **movement** in the soil profile **controlled** by **ET** and **precipitation** with the **potential to buildup in soils** where **ET>Precipitation** (not from carry over)

# Potash is a Major Fertilizer Source of Chloride

- Commercial Fertilizer: Mainly as **Potassium Chloride KCl** (Muriate of Potash MOP):
  - **Cost effective for K** (but provides both K, and Cl)
  - Logistics: **available** at local fertilizer dealers/coops
  - Potash is about **48% Chloride** and 52% K (60% K<sub>2</sub>O)
  - **Alternative K fertilizer** sources: Potassium sulfate (SOP), potassium Mg. Sulfate but **cost is higher** than KCl
- **Manure** also provides a source of chloride and other plant nutrients



Photo Credit: [www.nutrien.com](http://www.nutrien.com)

# Chloride in Manure

## Ongoing Research at the University of Minnesota

- Ongoing research at the University of Minnesota
- Initial results show Chloride content of manure ranges from 0.09% for liquid dairy to 0.56% for dry sheep manure
- Manure chloride content is animal species dependent

Chloride content (as rec'd)			
Liquid Manure	%	lb/1000 gal	# samples
Dairy	0.09	7.8	370
Swine	0.24	20.0	78
Solid Manure	%	lb/ton	# samples
Beef	0.22	4.5	41
Calf	0.10	2.1	2
Dairy	0.14	2.8	80
Poultry	0.41	8.1	74
Sheep	0.56	11.3	1
Swine	0.41	8.2	6

Source: Dr. Melissa Wilson, University of Minnesota

# Minnesota Department of Agriculture is Monitoring for Chloride

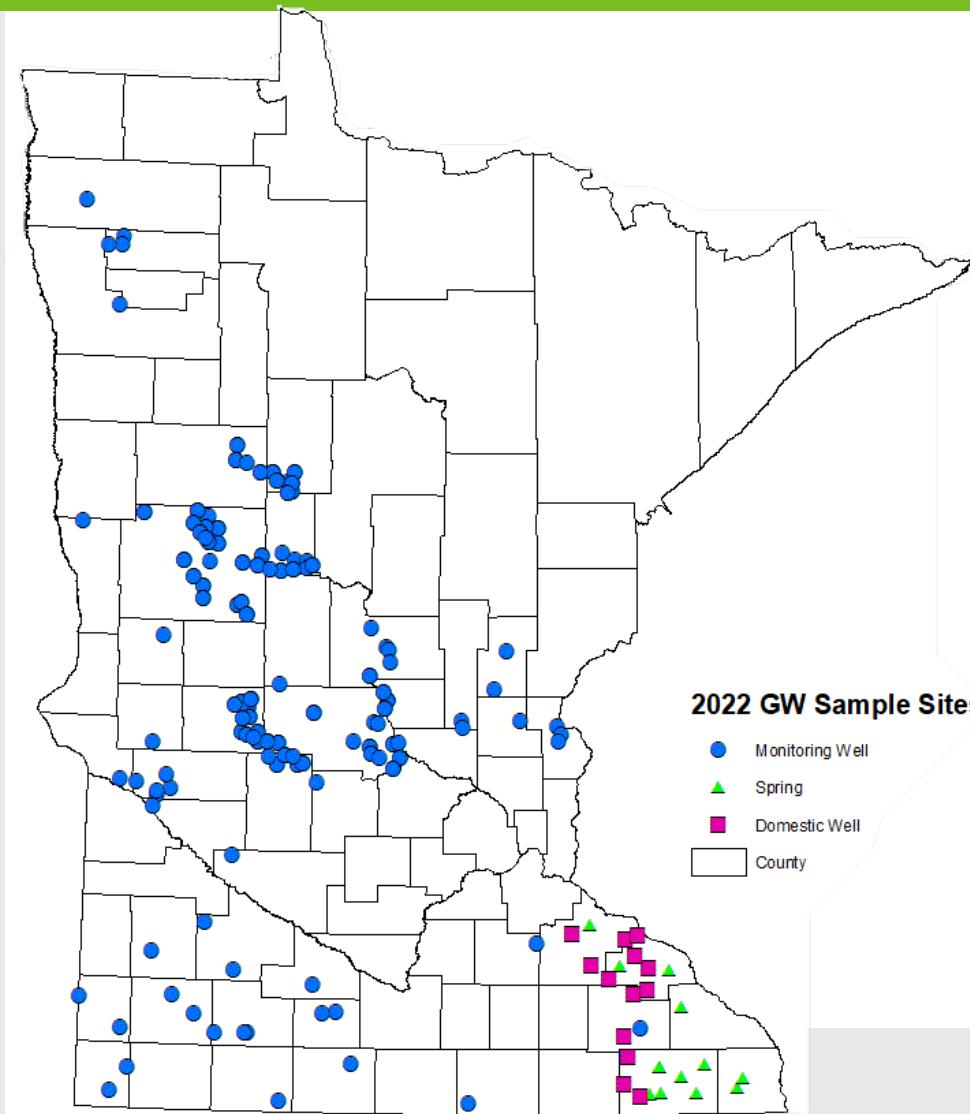
- **Groundwater**
- **Surface Water**
- **Edge of Field –Discovery Farm**



# 2022 Preliminary Results

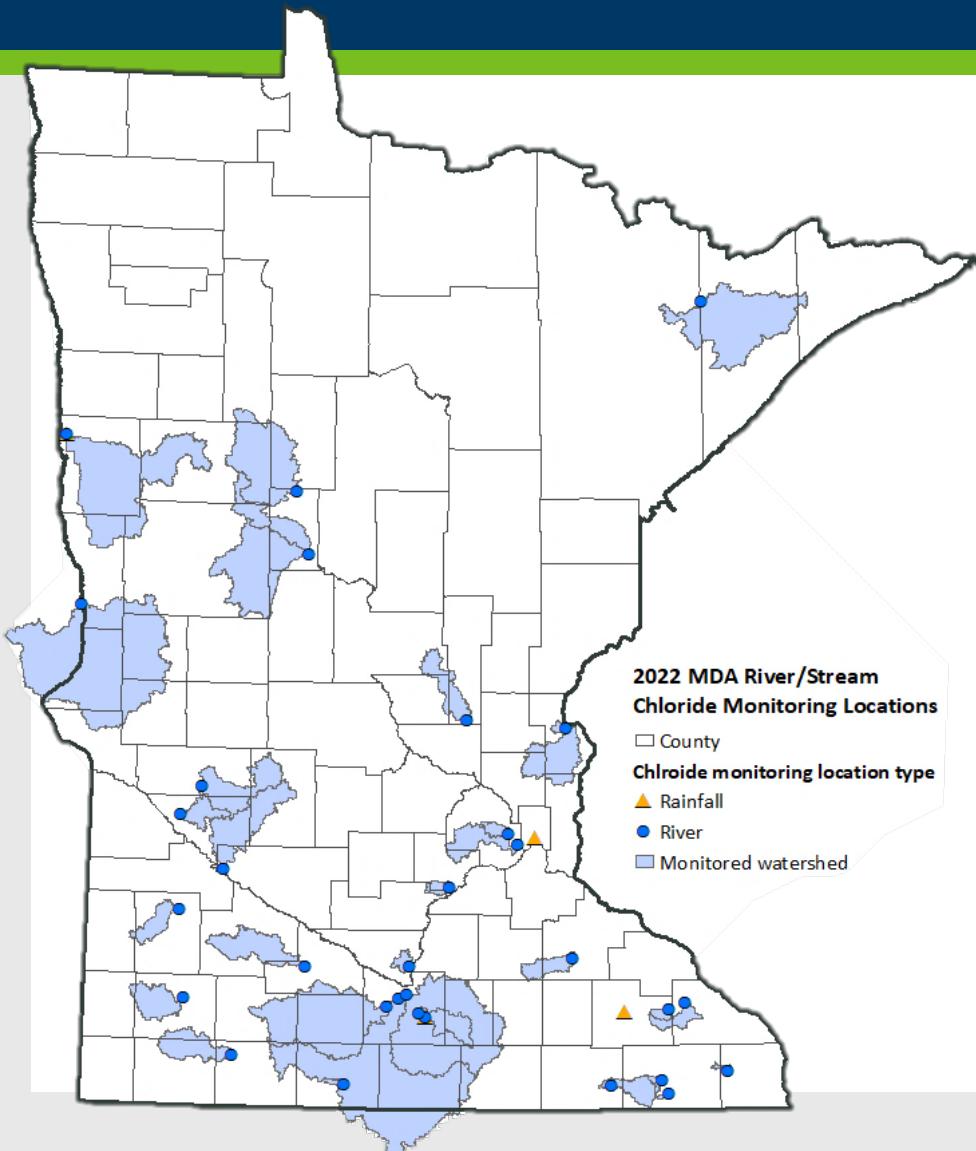
- More samples are being collected and analyzed
- Initial results are subject to change

# 2022 MDA Chloride Monitoring - Groundwater



- 208 samples will have chloride analyzed
- **Shallow water table wells in agricultural areas with vulnerable groundwater**  
(Springs and domestic wells in southeast Minnesota)
- About 40% of 2022 data returned  
**(preliminary)**
  - Median 12.2 mg/L
  - 1 sample > 250 mg/L (Chisago county)

# 2022 MDA Chloride Monitoring – Surface Water



- **25 agricultural watersheds, 2 urban watersheds, 1 reference watershed**
  - 8 to 15 samples collected **May through August**
  - 4 rainfall locations
- About **25% of 2022** data returned (**preliminary**)
  - Ag: 4.3 mg/L to 28.2 mg/L
  - Urban: 136 mg/L to 284 mg/L
  - Reference: 1.17 mg/L to 5.22 mg/L
  - Rain: <0.5 mg/L

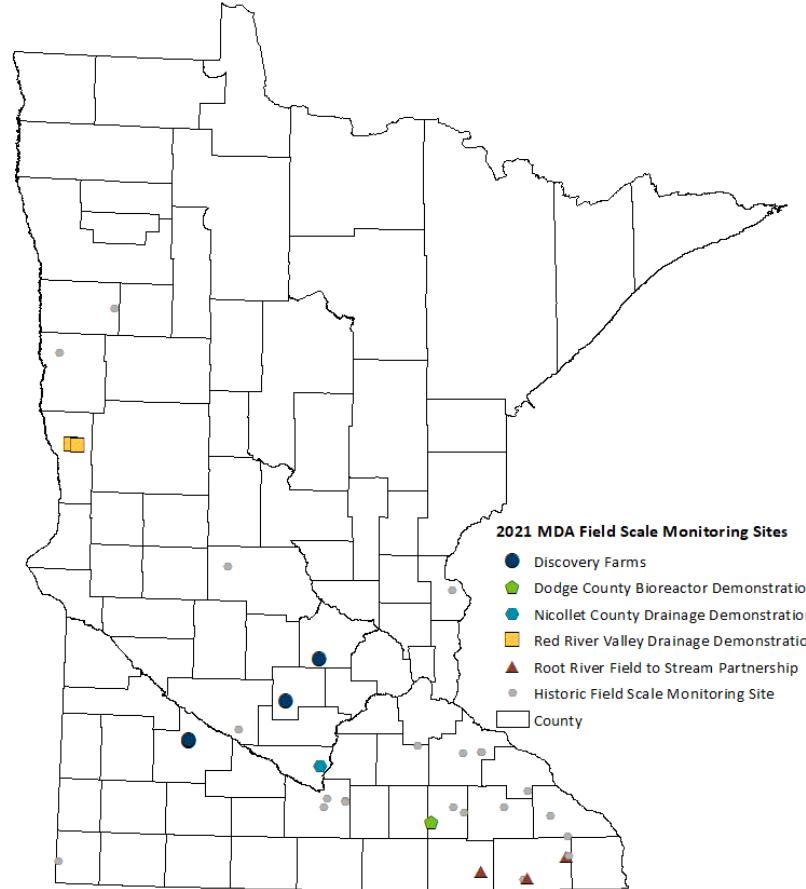
# Discovery Farm: Edge of Field- Field Scale Monitoring

- **Discovery Farm Minnesota:**

- Led by the **MAWRC** in partnership with the Minnesota Department of Agriculture
- **Long term monitoring** of agricultural water quality attributes under **different managements**
- Chloride monitoring in **tile drainage** and **surface runoff**

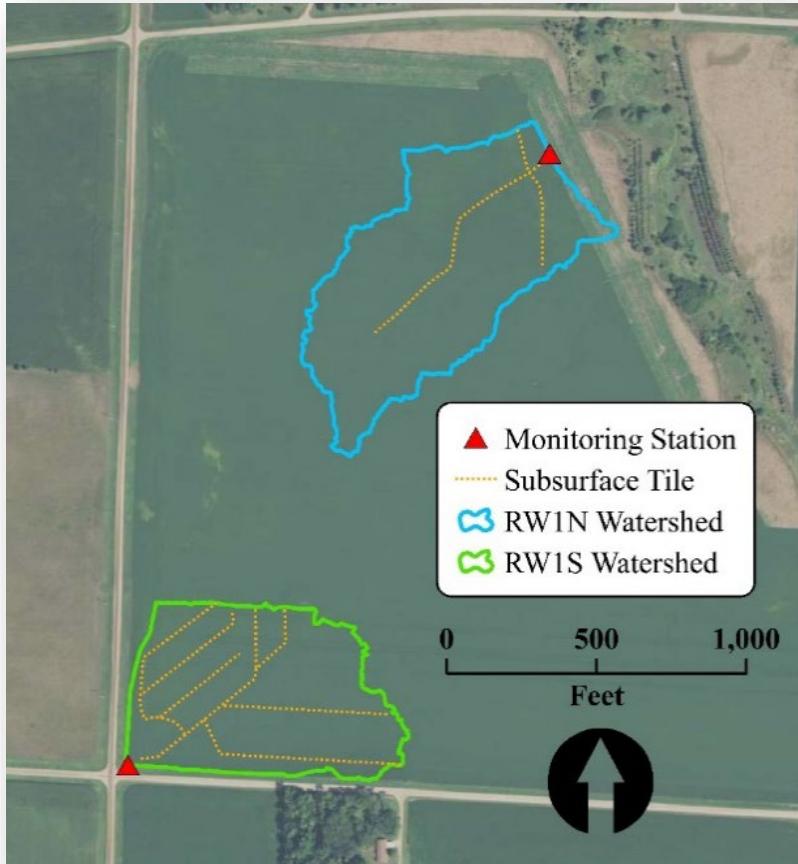


# 2022 MDA Chloride Monitoring – Field Scale Monitoring

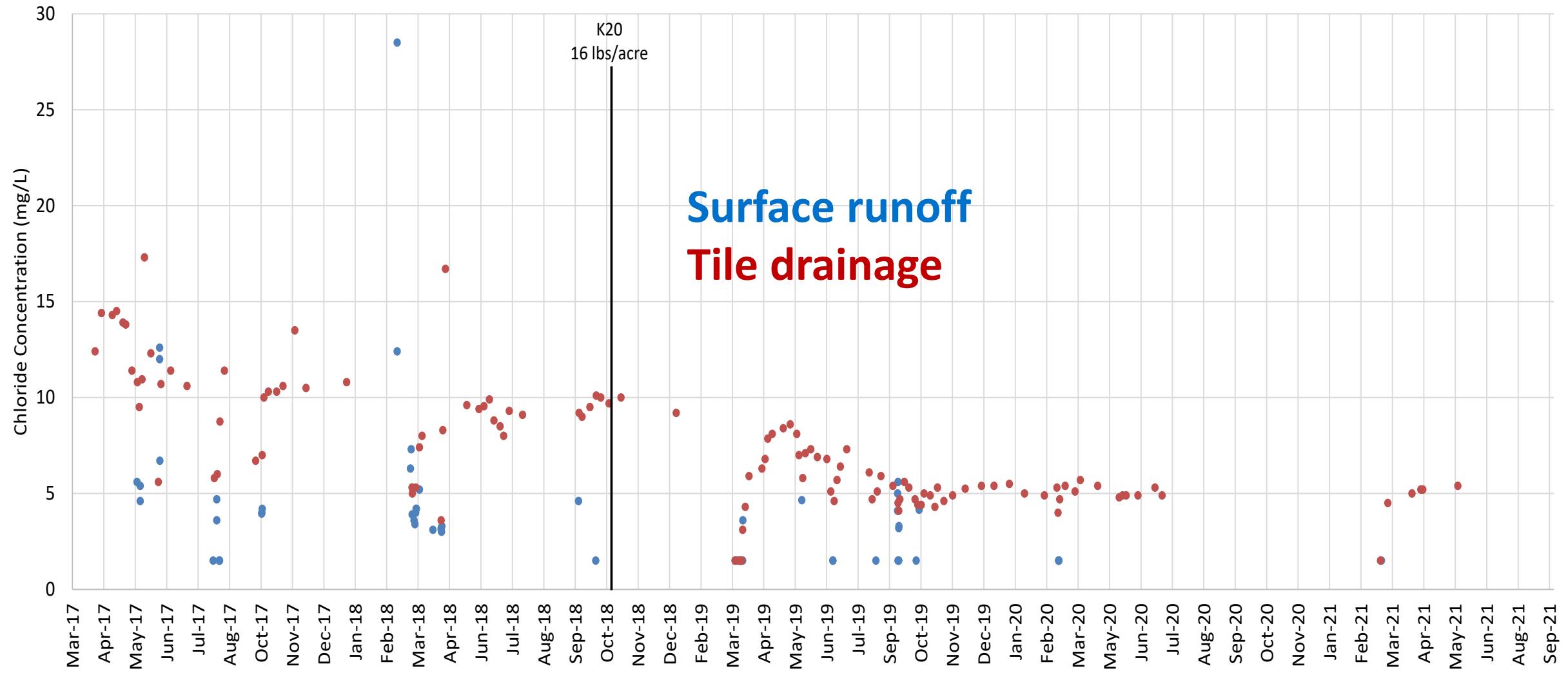


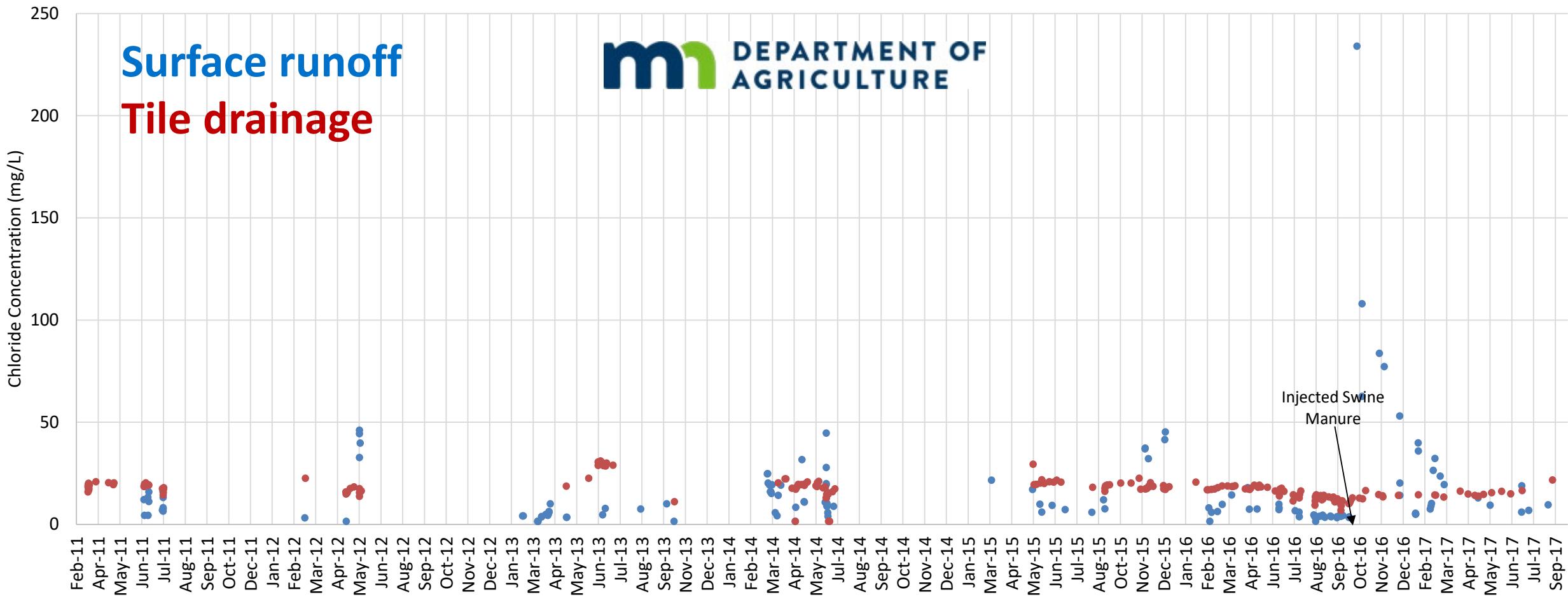
- 12 subsurface locations
- 6 surface runoff locations
- Preliminary 2022 range
  - Tile: 6.1 mg/L – 76.3 mg/L
  - Surface: < 0.5 mg/L – 148 mg/L

# Monitoring Site Examples



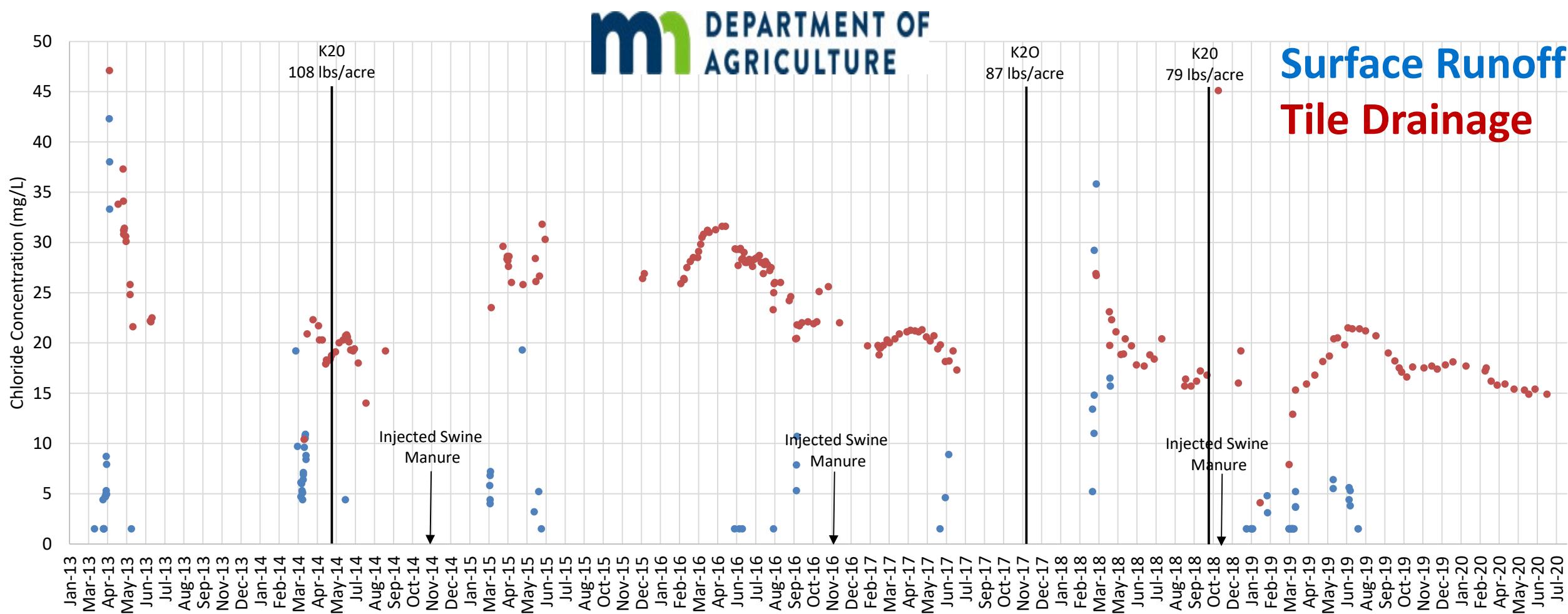
# McLeod County Corn/Soybean Rotation





**Short lived spike in runoff after manure application**

# Dodge County- Corn/Soybean Rotation with Swine Manure

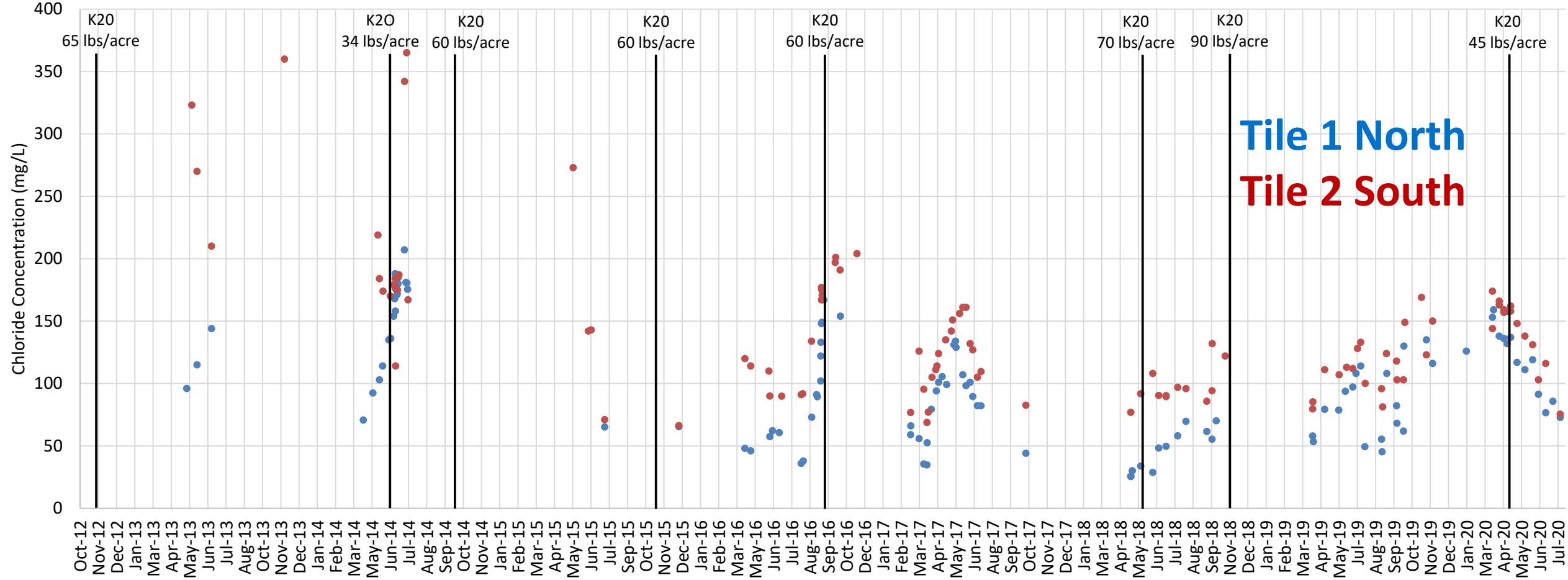


**Background level 5-30 mg/l**

**Lack of consistent spike after application of manure/fertilizer**

# Norman County- Corn/Soybean/Wheat/Sugar beet

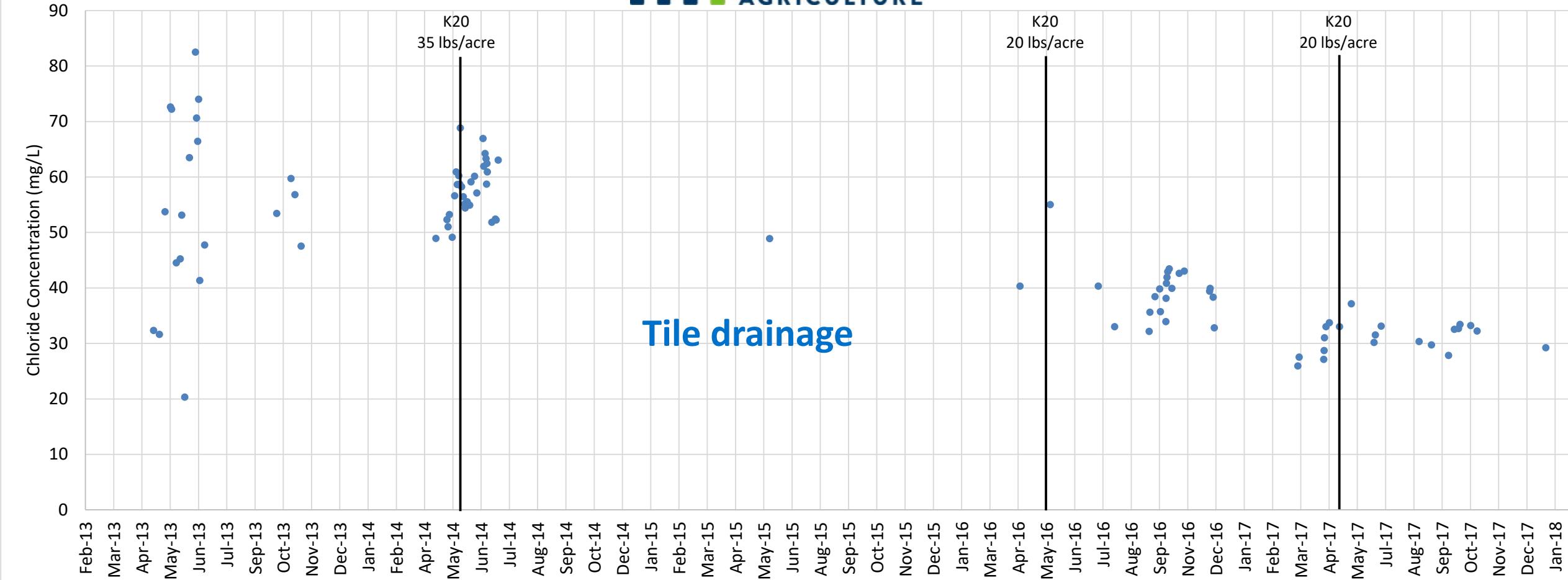
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**NW MN : Higher background level and lack of consistent spike in Chloride after fertilizer**

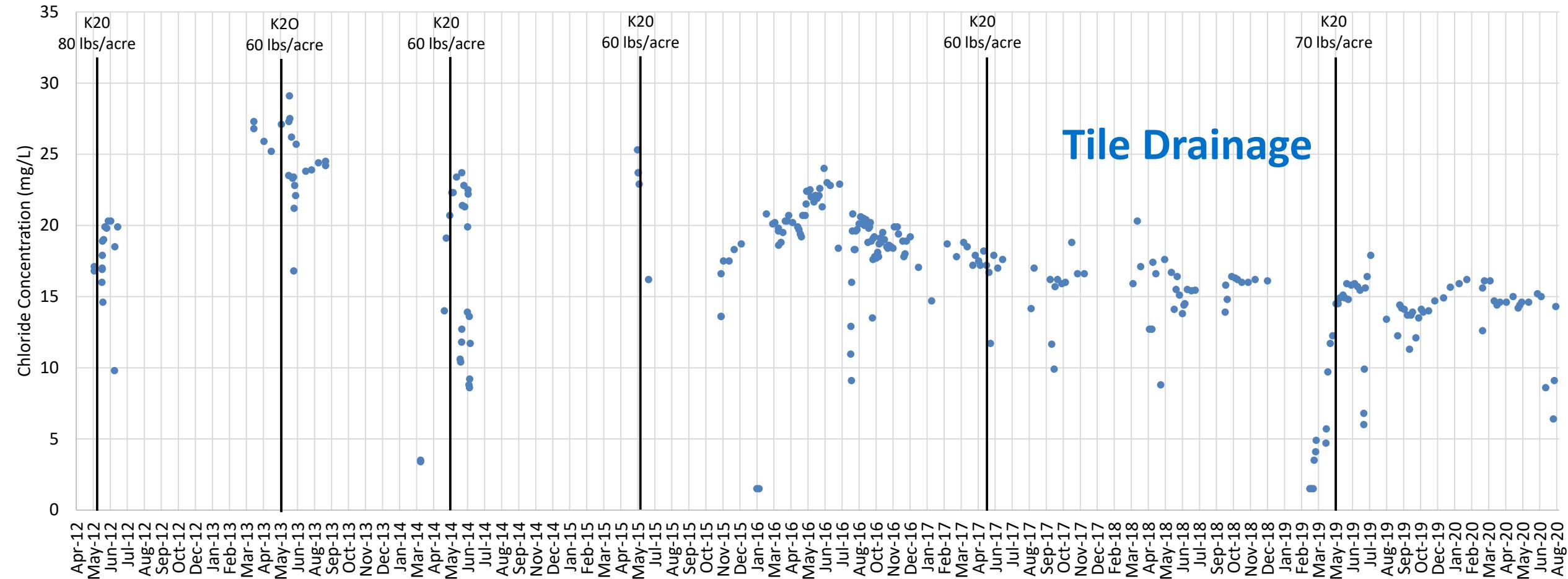
# Wilken County- Corn/Soybean Rotation

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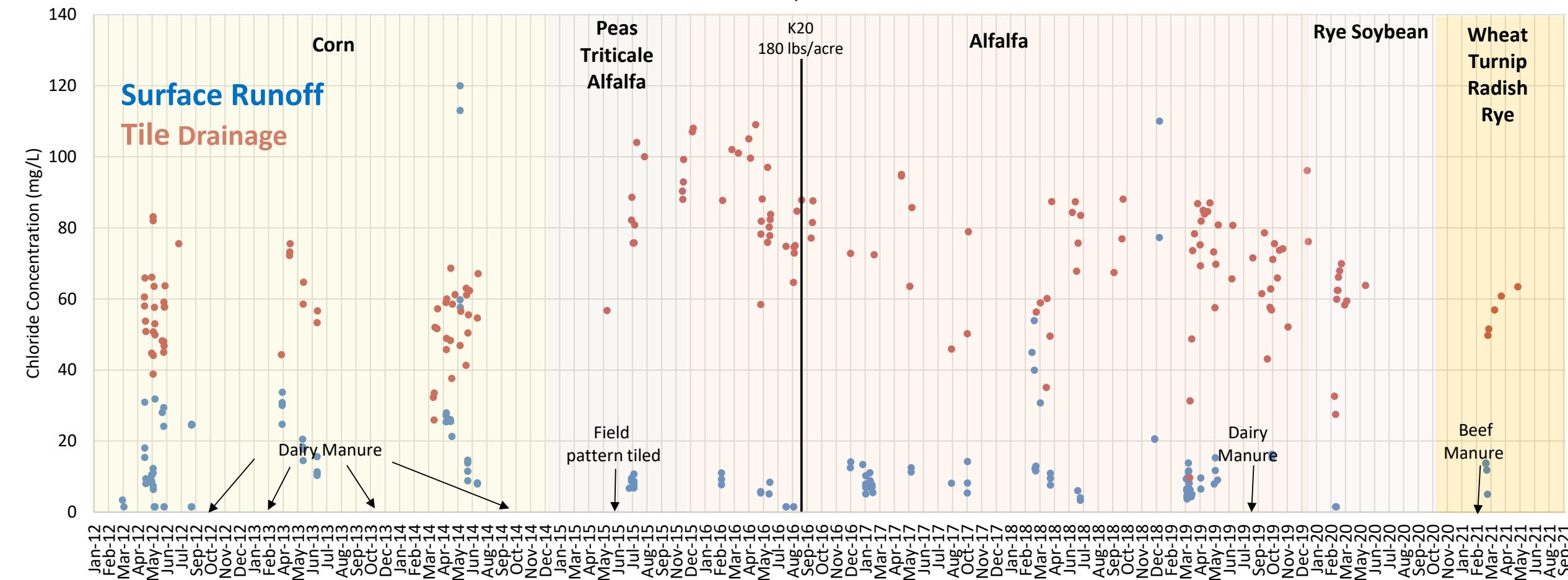


**Slightly higher background level and lack of consistent spike in Chloride after fertilizer**

# Renville County- Corn/Soybean rotation- Potash

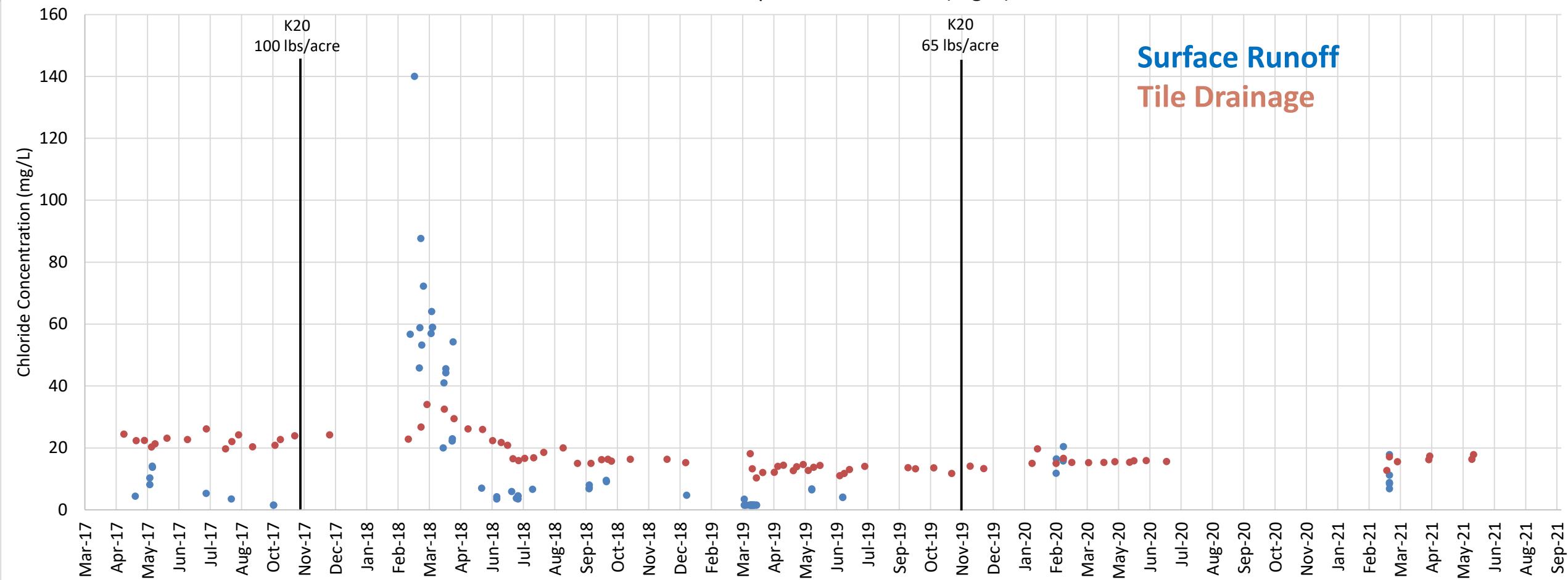


# Wright County-Conservation Rotation/Dairy manure

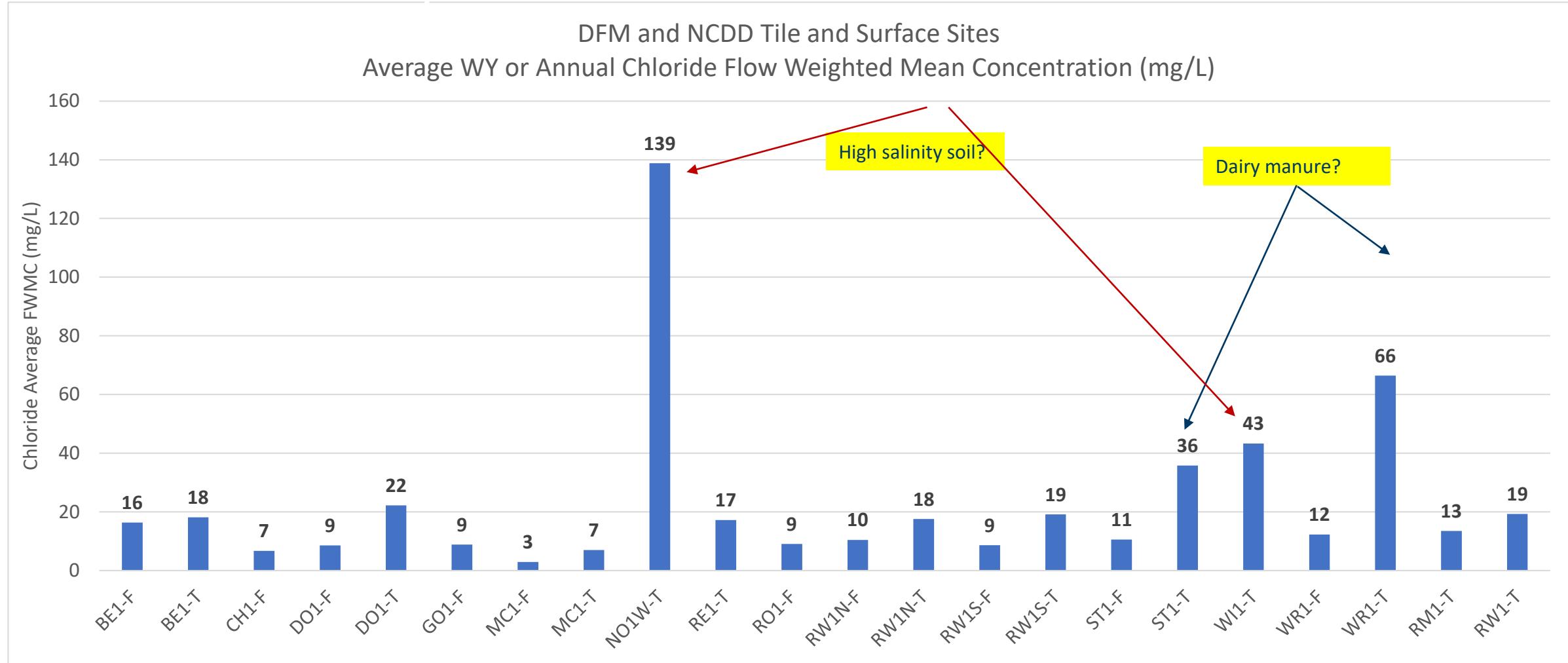


Slightly higher background level and lack of consistent spike in Chloride

# Redwood County- Corn/Soybean Rotation

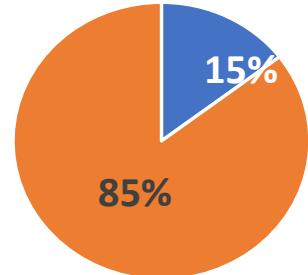


The sites with the highest chloride concentration were either newly tiled fields in the Red River Basin or fields with manure history

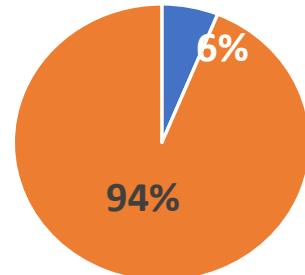


# The majority of chloride leaves agricultural fields in tile drainage

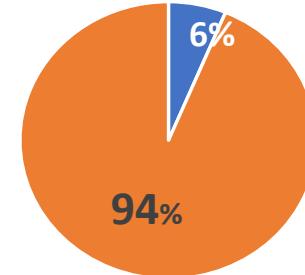
Total Chloride Yield (lbs/acre)  
DFM Site- BE1 (WY11-17)



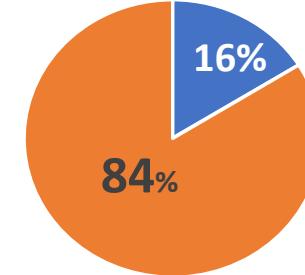
Total Chloride Yield (lbs/acre)  
DFM Site- DO1 (WY13-20)



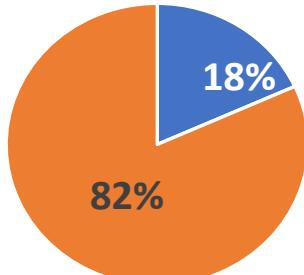
Total Chloride Yield (lbs/acre)  
DFM Site- MC1 (WY17-21)



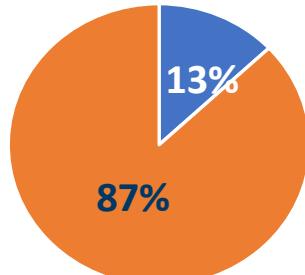
Total Chloride Yield (lbs/acre)  
DFM Site- WR1 (WY11-21)



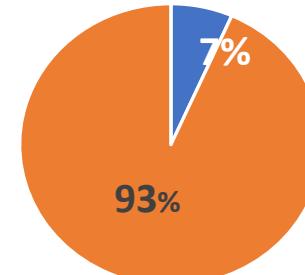
Total Chloride Yield (lbs/acre)  
DFM Site RW1N (WY17-21)



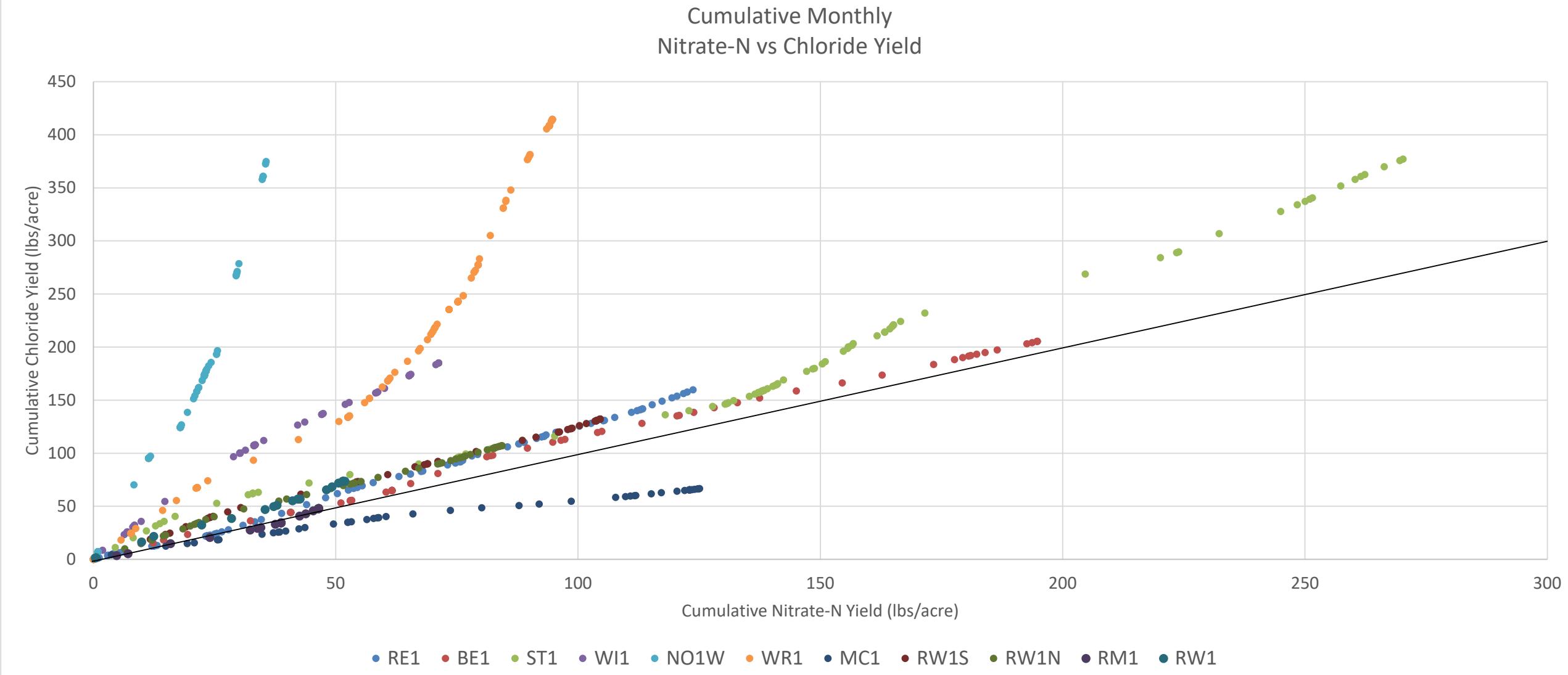
Total Chloride Yield (lbs/acre)  
DFM Site RW1S (WY17-21)



Total Chloride Yield (lbs/acre)  
DFM Site ST1 (WY11-20)



# Nitrate and Chloride Losses are Very Similar



# Conclusions

- Overall water samples collected from **agricultural areas** have **lower chloride concentration** than samples from **urban areas**
- Higher concentrations in **NW MN** and on a field with manure history
- **82% to 94%** of the chloride was delivered through tile drainage.
- Further studies are needed to understand factors that impact chloride loss in agricultural fields and to determine baseline concentrations in different regions of the state



# Thank you!

Aicam Laacouri

[Aicam.Laacouri@state.mn.us](mailto:Aicam.Laacouri@state.mn.us)

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