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# Transport de sel de déneigement à travers un bassin de biorétention

## *De-icing Salt Transport from the Street to a Roadside Bioretention Basin*

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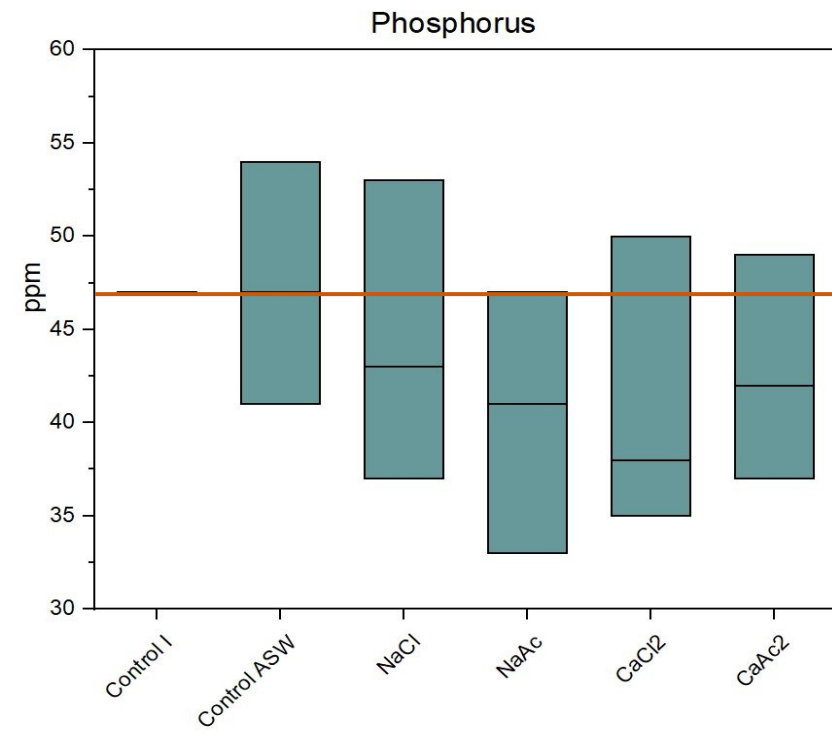
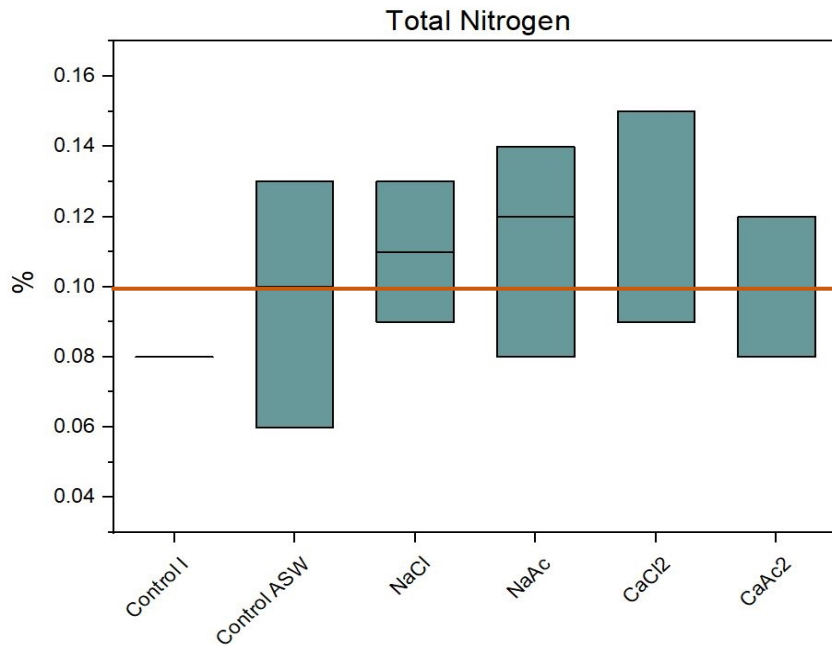
**PennState**  
Harrisburg

Applied salt runs off surface to  
curbside green infrastructure.



What impact does salt have on soils?

# Laboratory Testing of Impacts on Soil Chemistry from Sodium Chloride and Alternatives

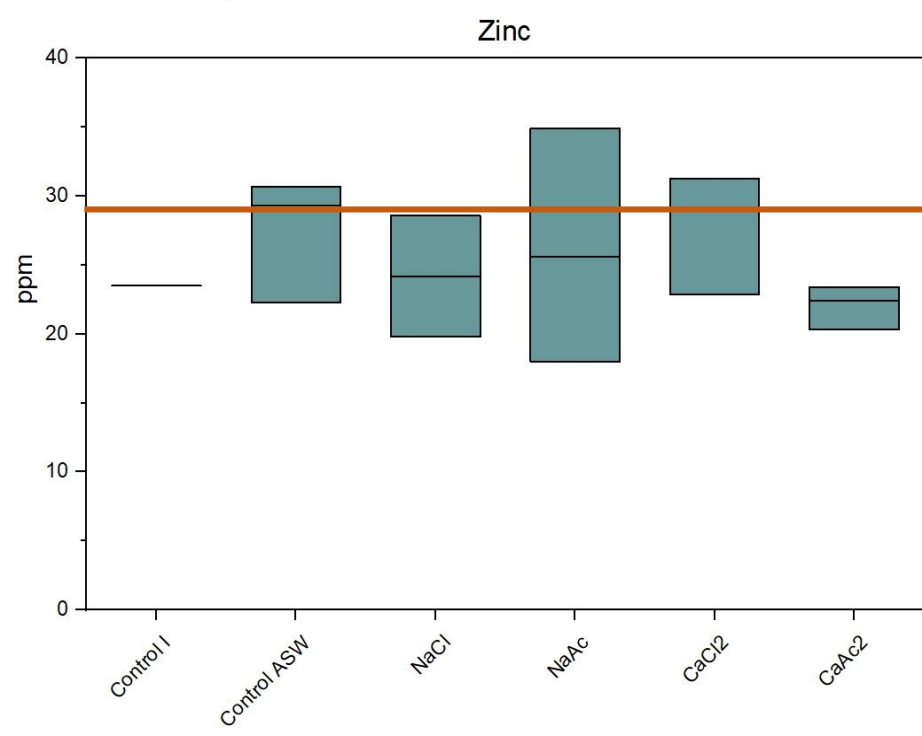
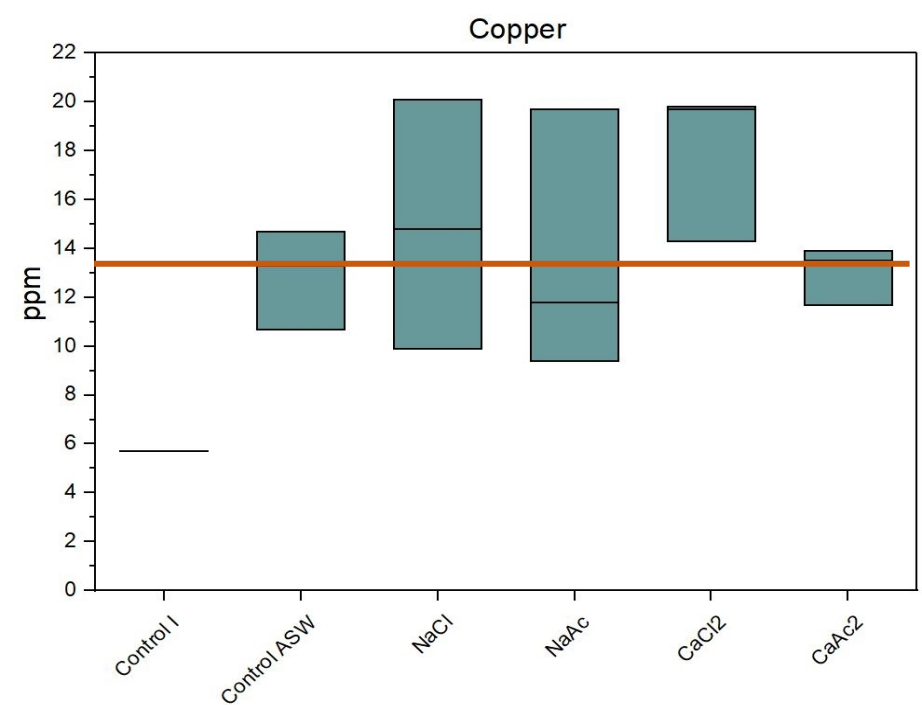


Rate of Nutrient Change on Soil (mg Nutrient/kg Soil per dosing event)	
<b>Nitrogen</b>	
After ASW	0.0014
After NaCl application	0.0019
<b>Phosphorus</b>	
After ASW	0.028
After NaCl application	-0.43

ASW =  
Artificial  
Stormwater  
Without  
Added Salt

- Nitrogen continued to be retained at approximately the same rate or higher. Only calcium acetate may have stopped nitrogen uptake.
- Phosphorus released from the soil with all potential deicing salts.

# Laboratory Testing of Impacts on Soil Chemistry from Sodium Chloride and Alternatives



Rate of Metal Accumulation on Soil (mg Metal/kg Soil per dosing event)	
<b>Copper</b>	
After ASW	0.6
After NaCl application	0.29
<b>Zinc</b>	
After ASW	0.32
After NaCl application	-0.46

ASW =  
Artificial  
Stormwater  
Without  
Added Salt

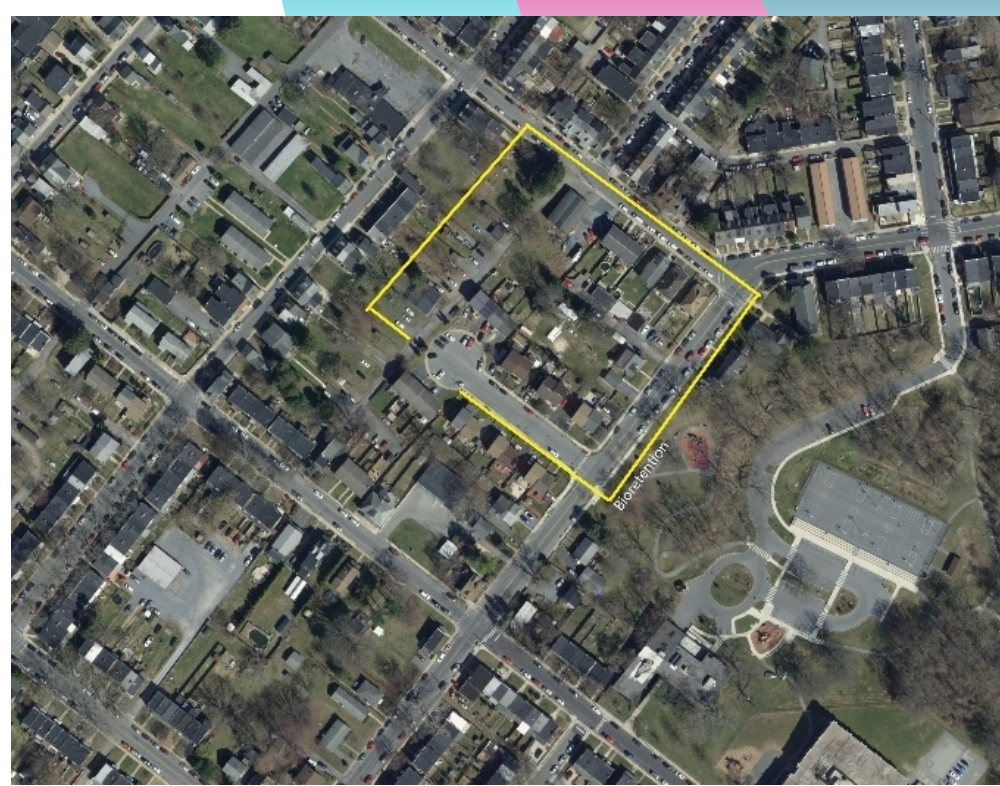
- Reduced rate of metal uptake/retention on soil after repeated dosing with artificial snowmelt water.
- Copper continued to be retained but at lesser amounts.
- Zinc was released from soil.

# Field Testing at Brandon Park Bioretention

## Design Criteria

- Soil top layer consisted of sand to loamy sand amended with organic matter
- Design soil infiltration rate: 15 cm (6 in) per hour after installation
- Installed >1,000 plant plugs

(The City of Lancaster Department of Public Works, 2019-2021)



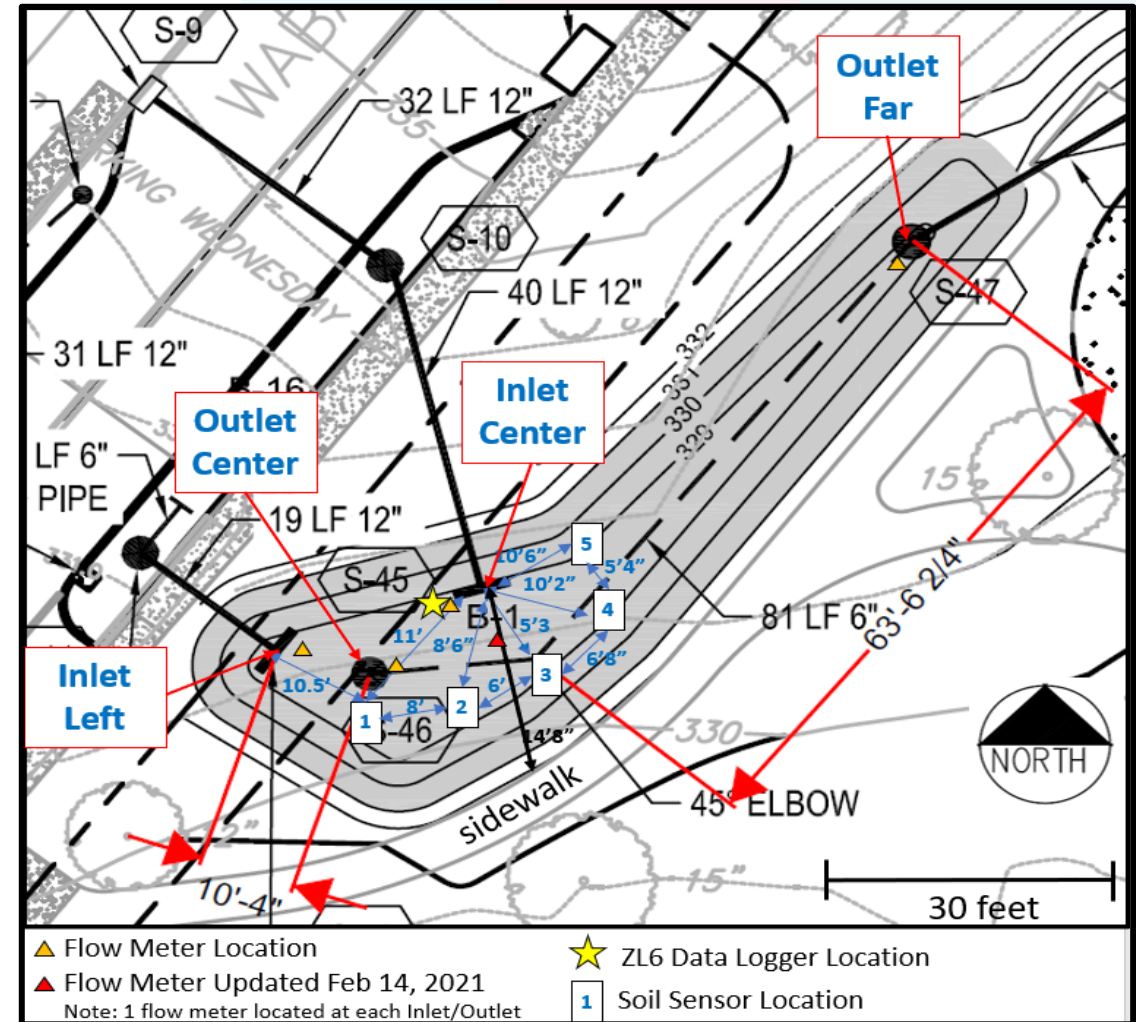
November 2020 Site Photograph



# Data Collection



- 5 - *TEROS 12* advanced soil moisture sensors: temperature ( $^{\circ}\text{C}$ ), bulk saturation extract (mS/cm), and moisture content ( $\text{m}^3/\text{m}^3$ )
- 4 - *Solinst Levellogger 5*: temperature ( $^{\circ}\text{C}$ ), conductivity (mS/cm), and level (m)

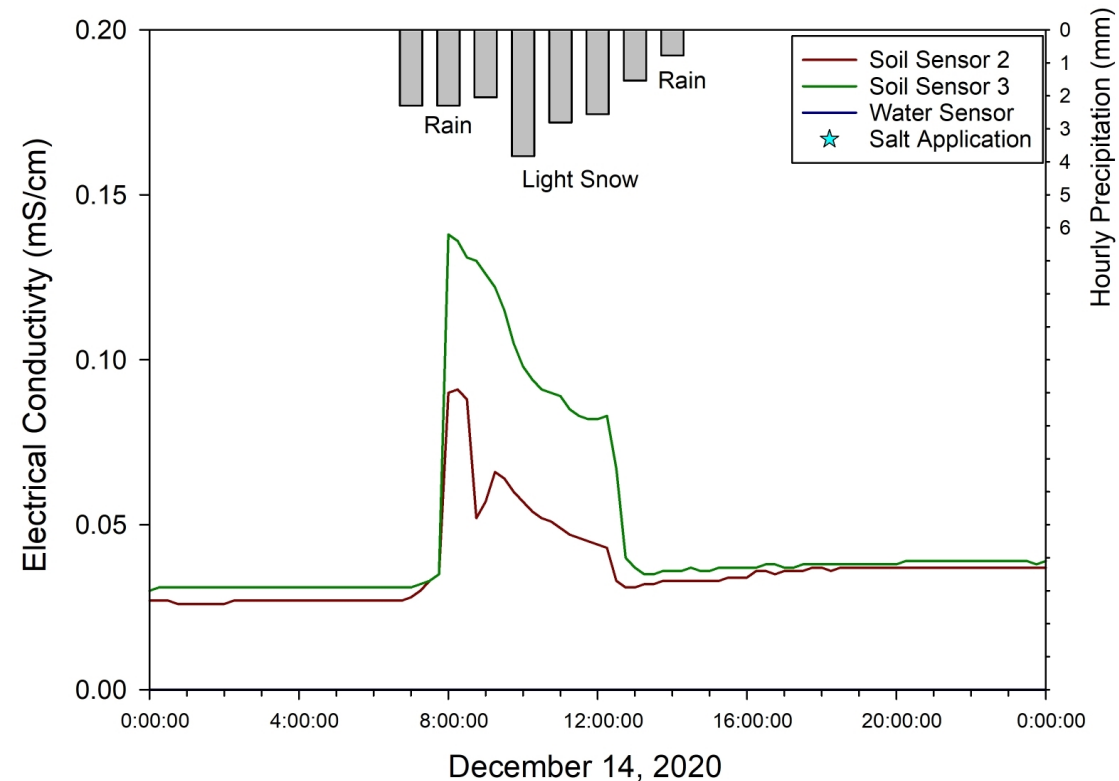


Data Collection Locations Overlain on the 2011 City of Lancaster Drainage Plan

# First of Season Snow Events

## Left: Before Salt Application (Small Event)

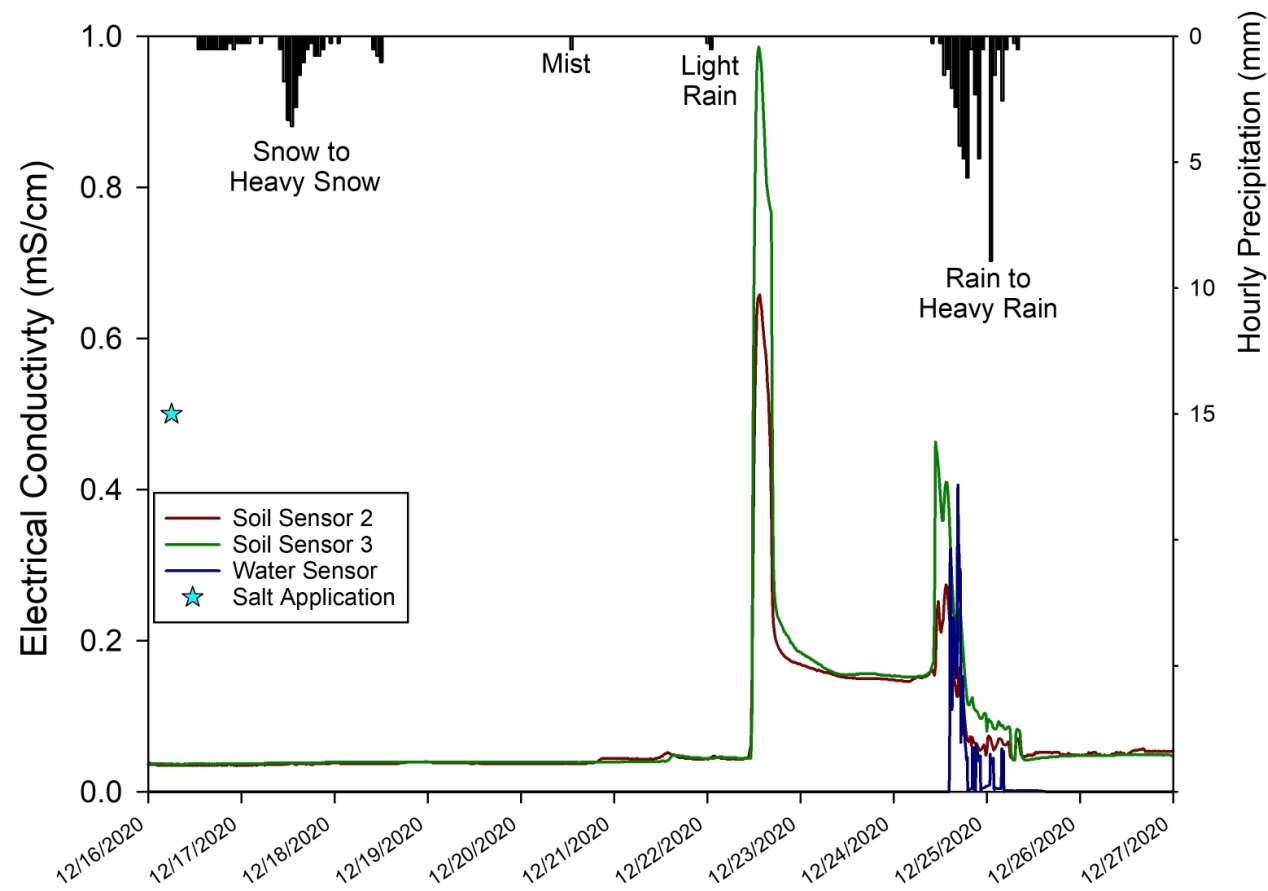
## Bottom: After Salt Application (Large Event)



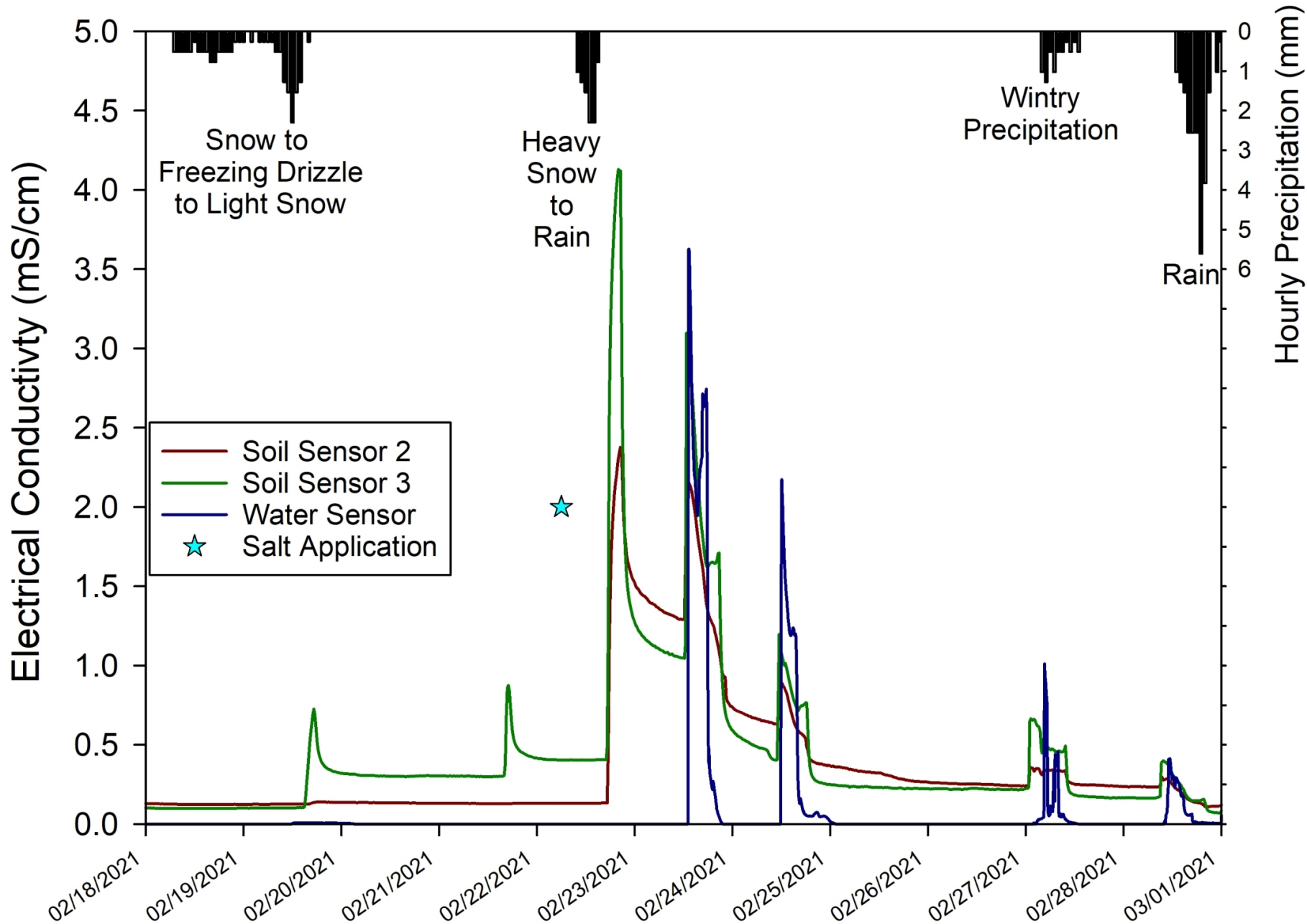
Light Rain/Snow Event with no salt: Slight increases in soil conductivity likely due to pavement

Heavier Snow Event: Significant delay in system response due to no liquid water movement; soil sensors register salt after a light rain; with no new salt, soil salinity decreases even with the spike of new water moving salt off streets

December 2020 Snowstorm



# February 18 - March 1, 2021 Snowstorm



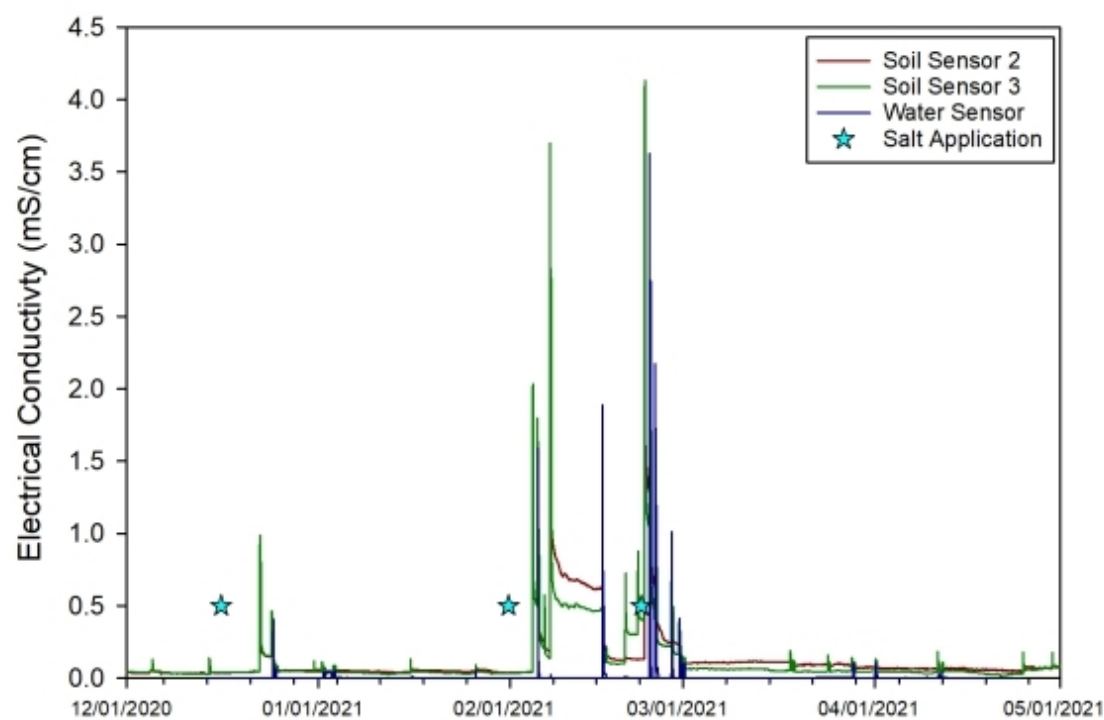
In sandier soil, rapid response to salt input.

Decrease in peak conductivity as runoff water becomes less “salty” and more of residual salt is washed off the street and the sidewalks.

Diurnal cycling of salinity due to temperatures rising above freezing, allowing for snowmelt to move into system.

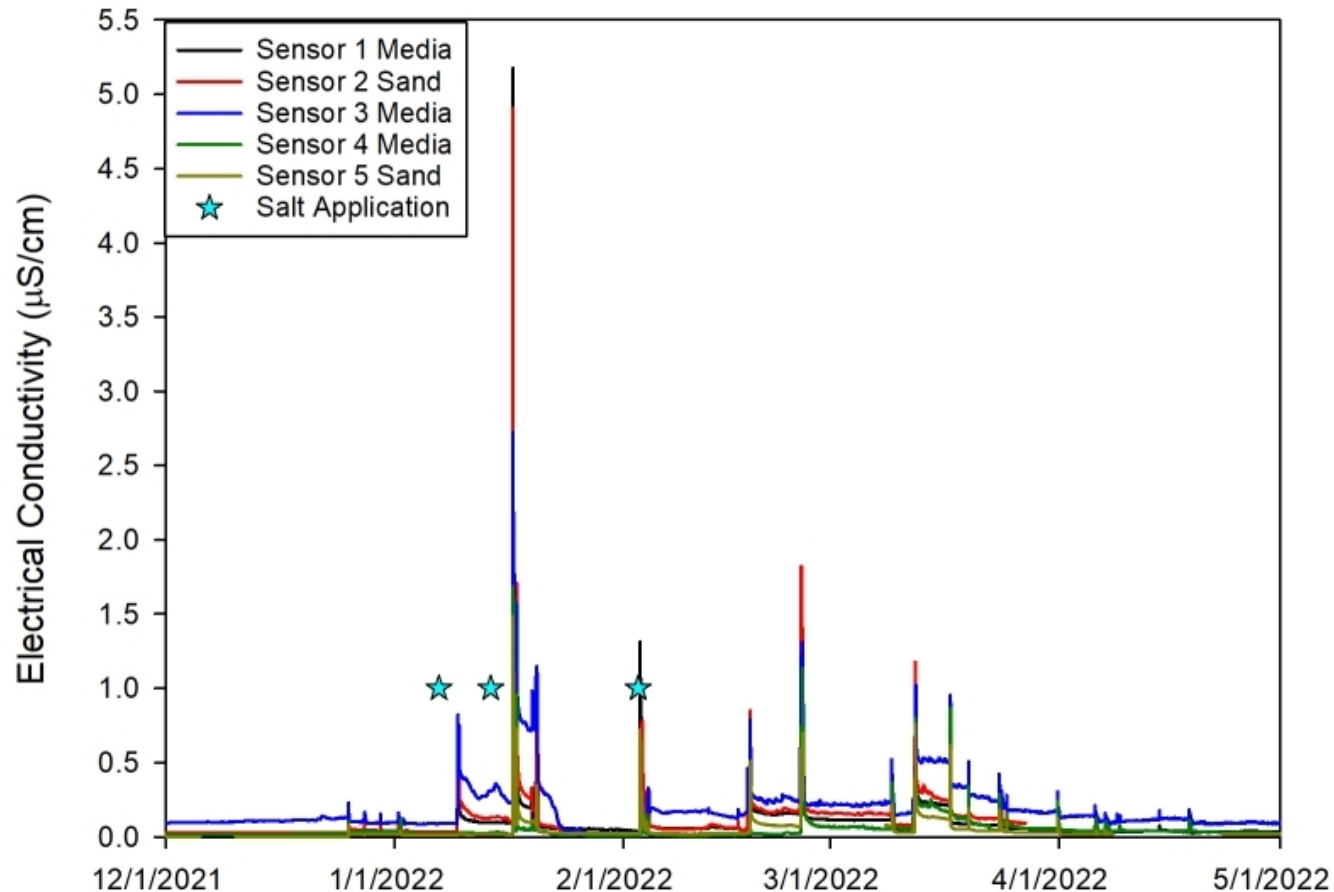


## ...Comparing 2021 Winter to 2022 Winter



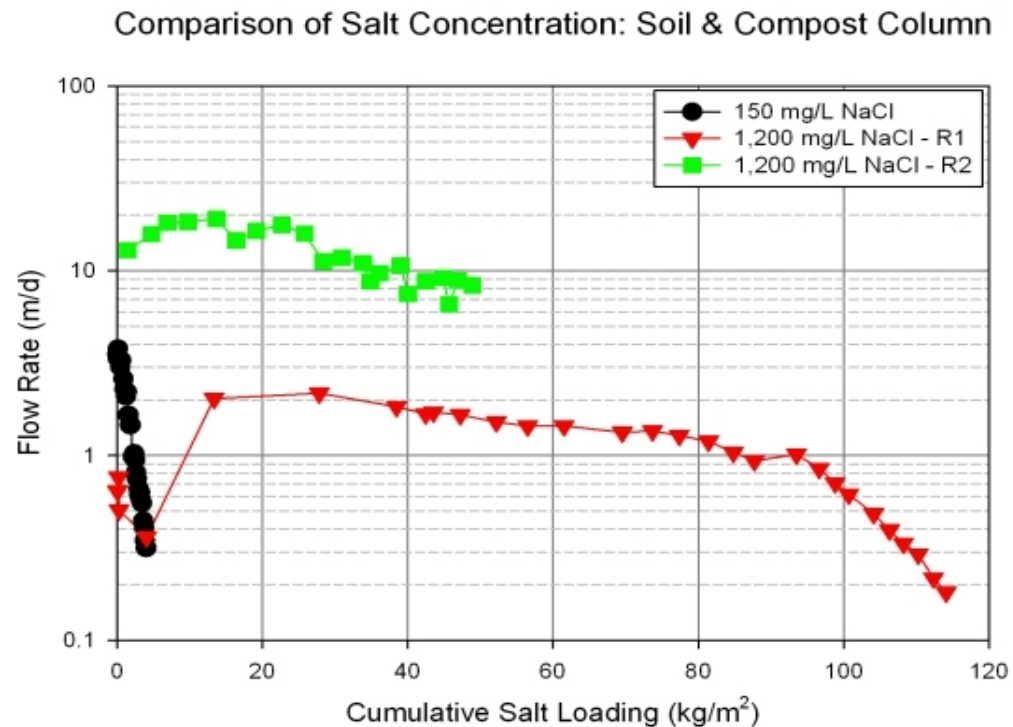
### Snowfall Depths (Total):

- Both seasons had 3 snow events with salt.
- Total snow depth:
  - 2020-21: 33.8 inches (85.9 cm)
  - 2021-22: 15.0 inches (38.1 cm)
- 2021 winter had longer cold periods, delaying salt movement.

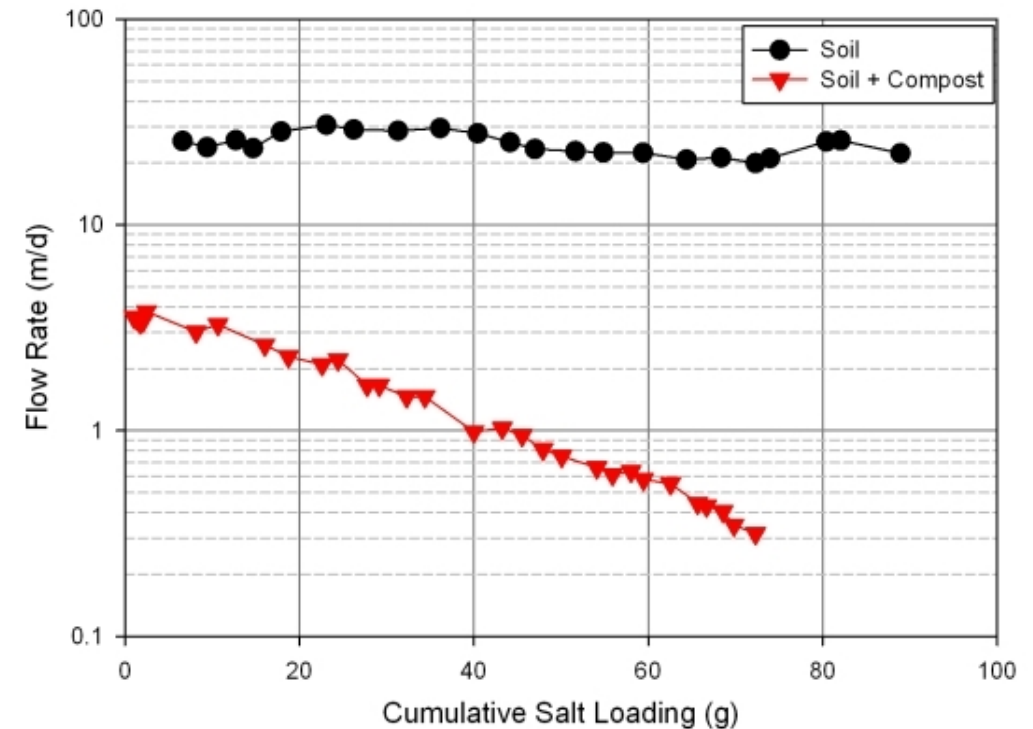


# Road Salt (especially halite and brine) Interact with Soils and Potential “Seal” Soils

## Salt Concentration



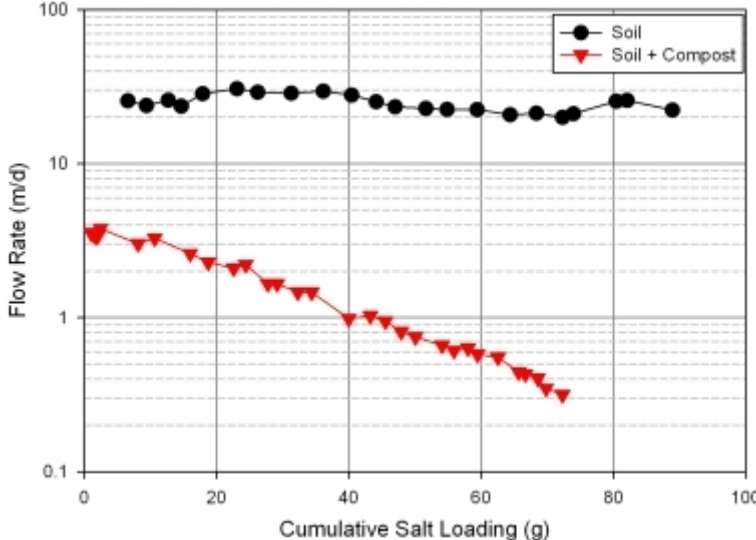
## Organic Matter



Organic matter encouraged in roadside SCMs, but it interacts with the salt and may accelerate soil sealing. Balancing act needed between plant needs, pollutant removal, and salt interactions.

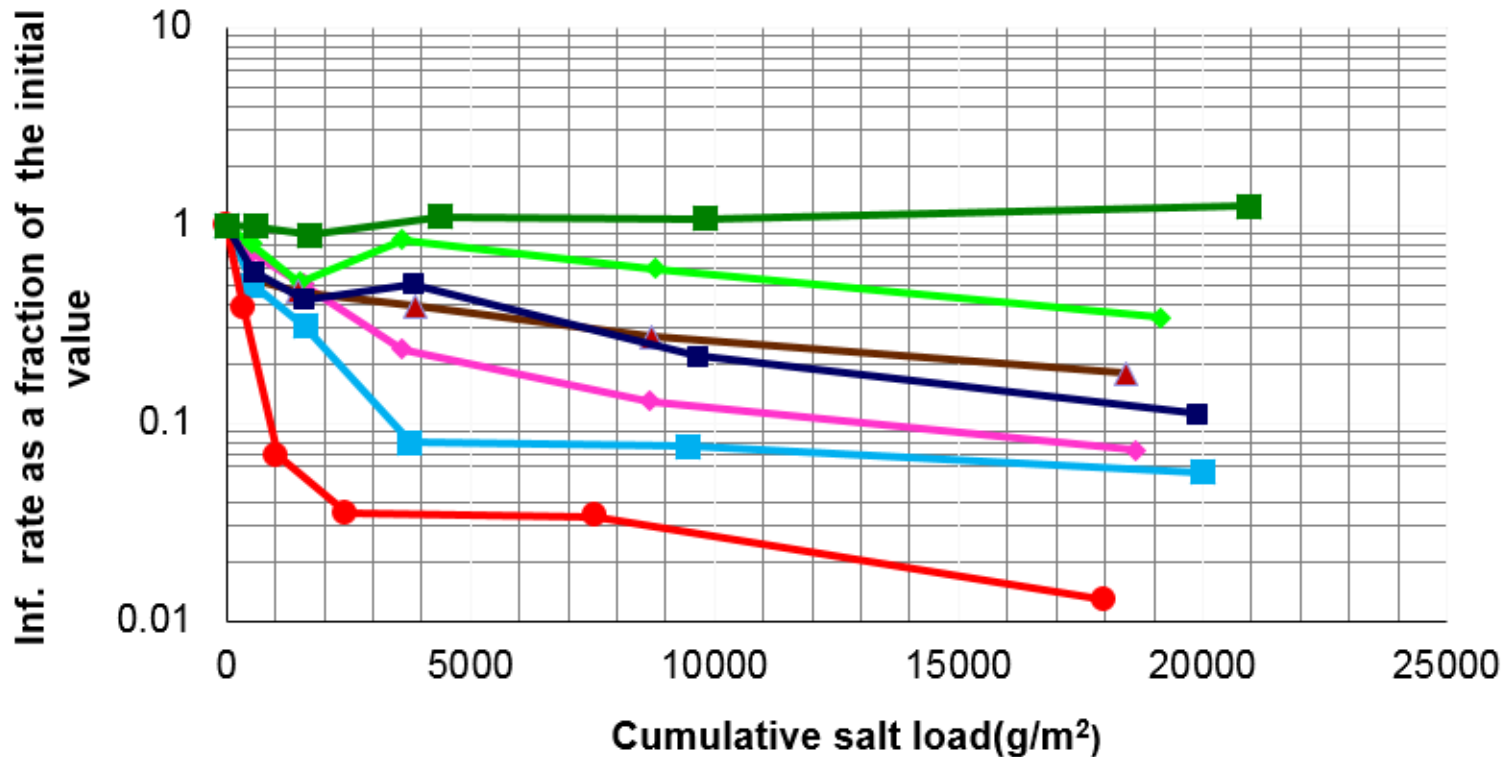
# Factors Affecting Infiltration Rate Decreases: Media Mixture Composition

Research from Univ. of Alabama  
 Drs. Pitt and Sileshi

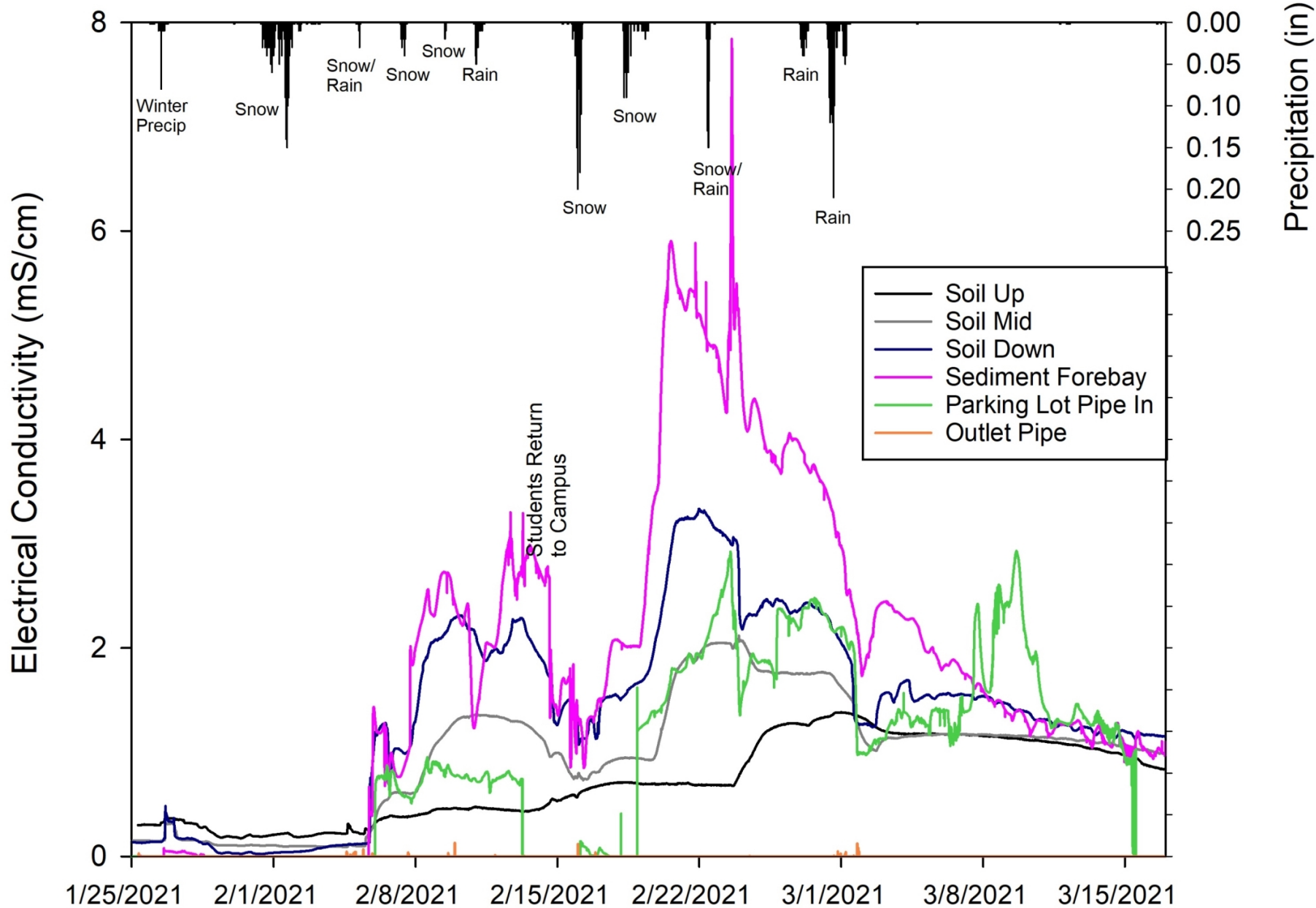


Organic  
 Matter and  
 Clay  
 Content??

- ◆ 5 % clay & 0% peat
- ◆ 10% clay & 0% peat
- ◆ 20% clay and 0% peat
- ◆ 5% clay & 10% peat
- ◆ 10% clay & 10% peat
- ◆ 20% clay & 10% peat
- ◆ 0% clay & 10% peat

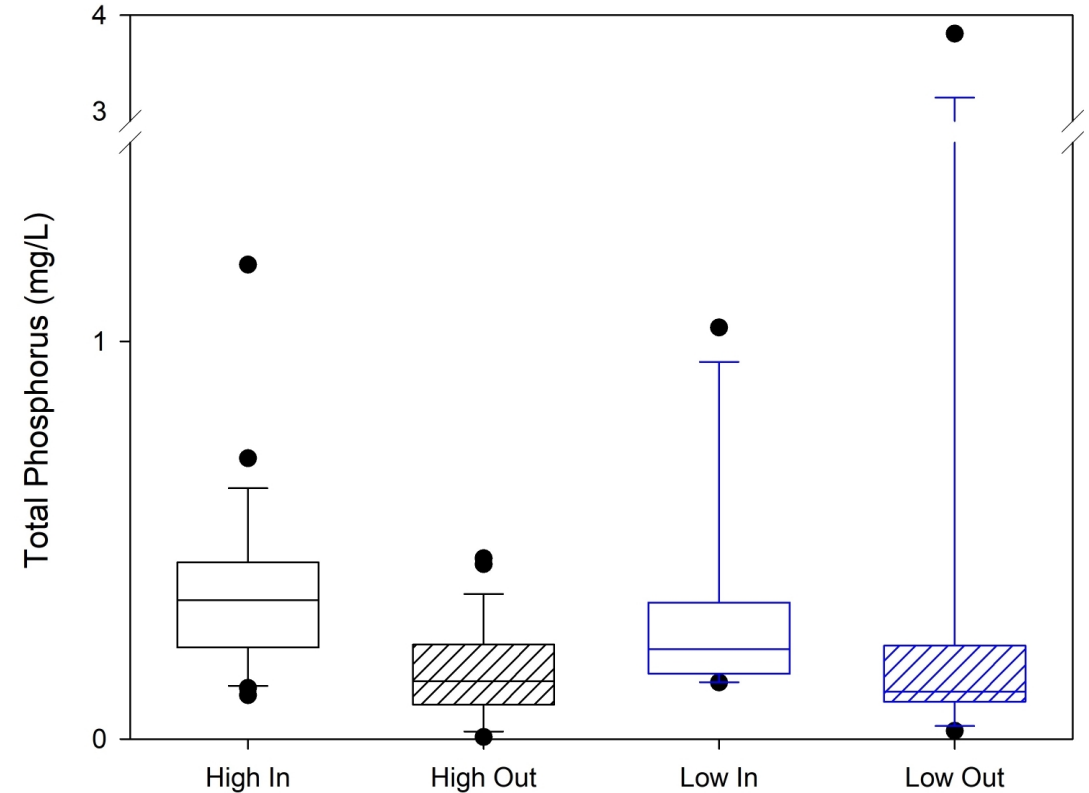
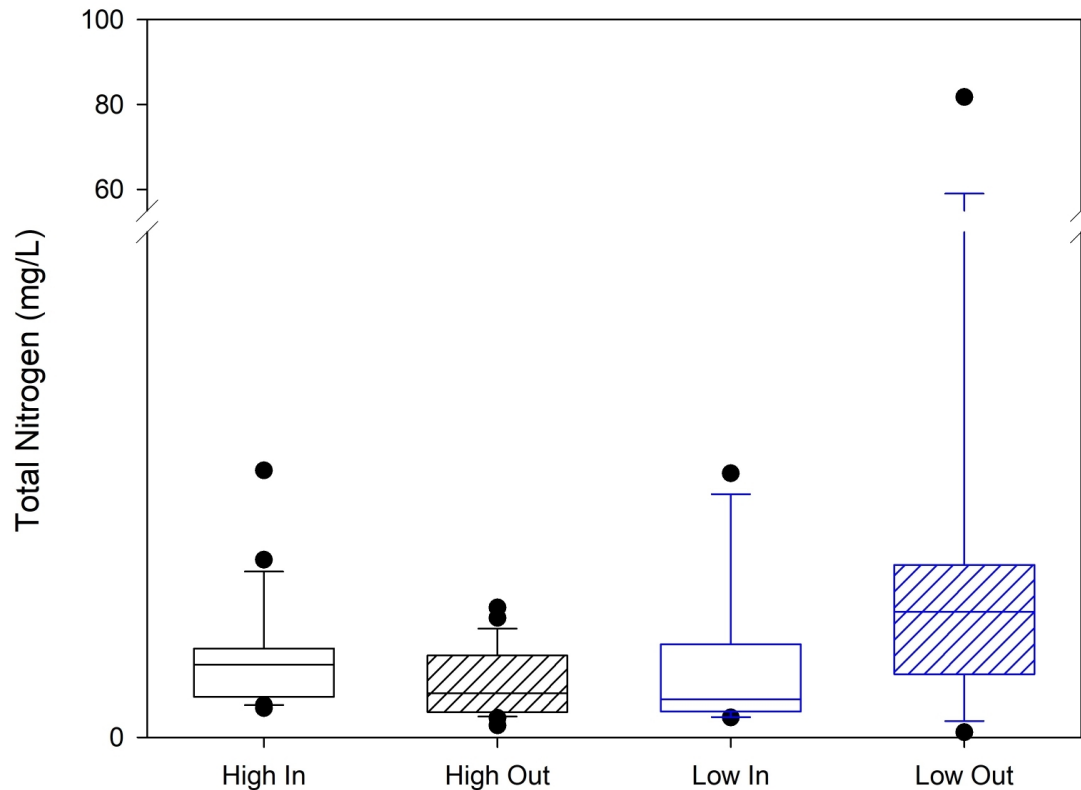


# Pond: January 25, 2021 - March 17, 2021



- Unlined infiltration pond draining parking lots (campus) and warehouse (>80% impervious).
- Amended native soil (significantly less sand in soil mixtures).
- Plantings are not planned except for turf grass.
- No sharp peaks of salinity (electrical conductivity).
  - Substantial salt residual in system – likely due to higher organic matter and higher clay content.
- Residual salt in soil entering plant season.

# Nutrient Removal at Brandon Park: Comparison of Basin Salt Loading



- Winter 2022 – 2023 was warm so limited to no salt application.
  - No explanation for negative nitrogen removals in winter 2023 in low-salt basin (but significant).
- TN removal in basin with higher salt load generally  $>0\%$ . At basin with lower salt load, TN removal  $<0\%$ .
- TP removal in both basins. Slightly greater removal in high salt loading basin.

# Conclusions

- Deicing Salts:
  - Sodium-based salts may “seal” soils and reduce infiltration rates – more common in soils with higher clay content and higher organic content.
    - Measured using Sodium Adsorption Ratio (SAR) or Exchangeable Sodium Percentage (ESP) – ratio of sodium concentration to calcium and magnesium concentrations → keep concentration of calcium and magnesium higher
  - Sodium salts may “clean” soils by displacing previously-captured pollutants such as metals. This accelerates downward movement of metals.
    - Clean industrial resins by applying high salt loads → soils acting similar to these resins
  - Alternative deicing salts also have challenges.
- Climate Change:
  - Salt application considered vital in areas where freeze-melt-refreeze cycles occur.
  - As snow line moves north, more areas are likely to be subject to freeze-melt-refreeze, pushing salt use in areas where salt is not currently commonly used.