Impacts of salt loading on nutrient and metal processing in stormwater bioretention

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Research Question(s) and Hypothesis(es)

How do different levels of salt present in a BMP due to road application impact the BMP's nitrogen removal efficiency and export rates out of the BMP of pollutants such as heavy metals?

Hypotheses:

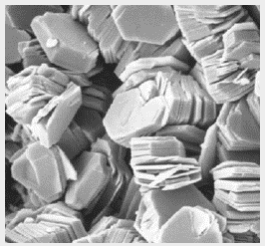
- Increased salt loading into stormwater BMPs is correlated to overall increased export or decreased removal efficiency of N and metals (Cu and Zn).
- Increased soil moisture, greater hydraulic residence times and more salt-tolerant vegetation in stormwater BMPs can moderate impacts of salt loading on N removal.

Our thinking behind these hypotheses:
impacts of de-icers

Physical

Clay dispersion

Colloid transport



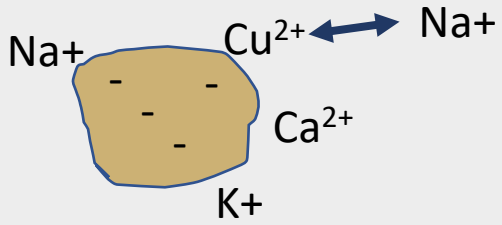
Clogging

Biological

Cl and Na kill bacteria and plants, reduce denitrification, assimilation

Chemical

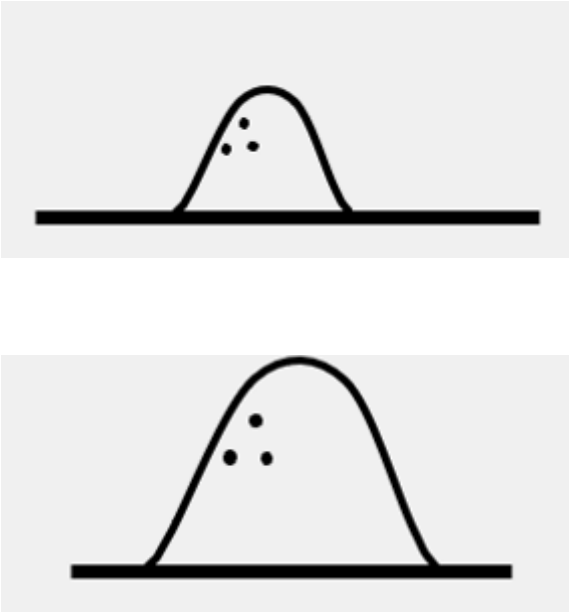
Sodium competes with other cations, and can exchange with metals previously sorbed to soils



Chloride complexes with heavy metals

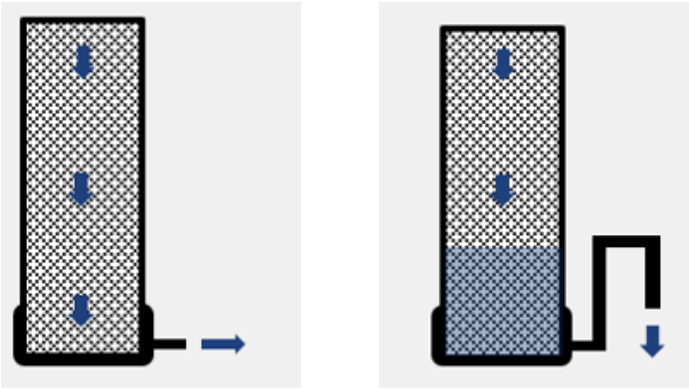
Our thinking behind these hypotheses:

ways to mitigate impacts



Salt loading

Plant selection

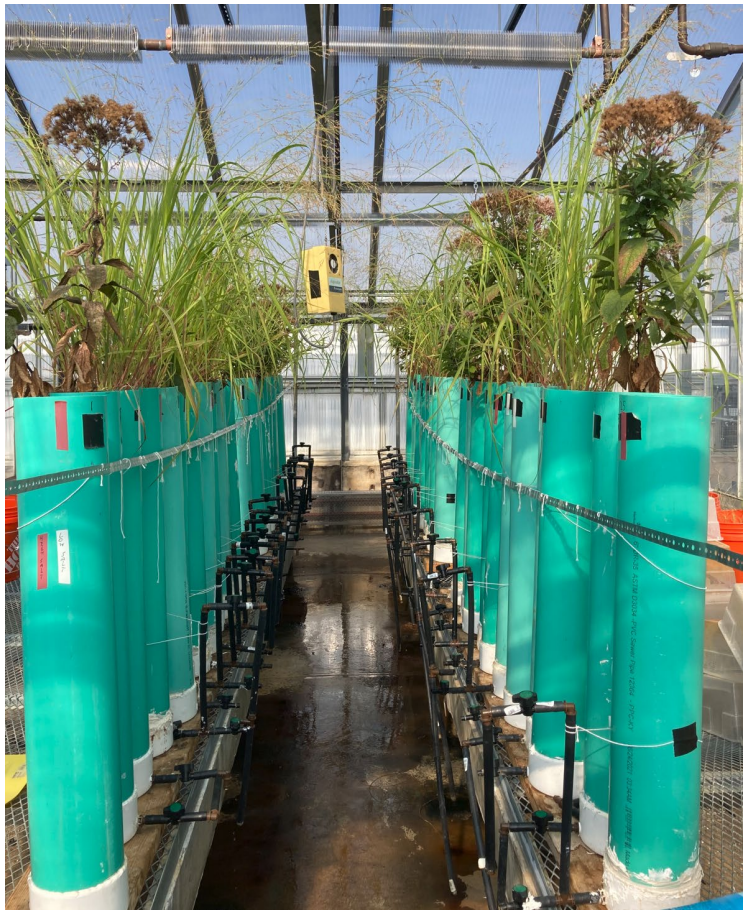


Hydraulics/ moisture regime

Approach

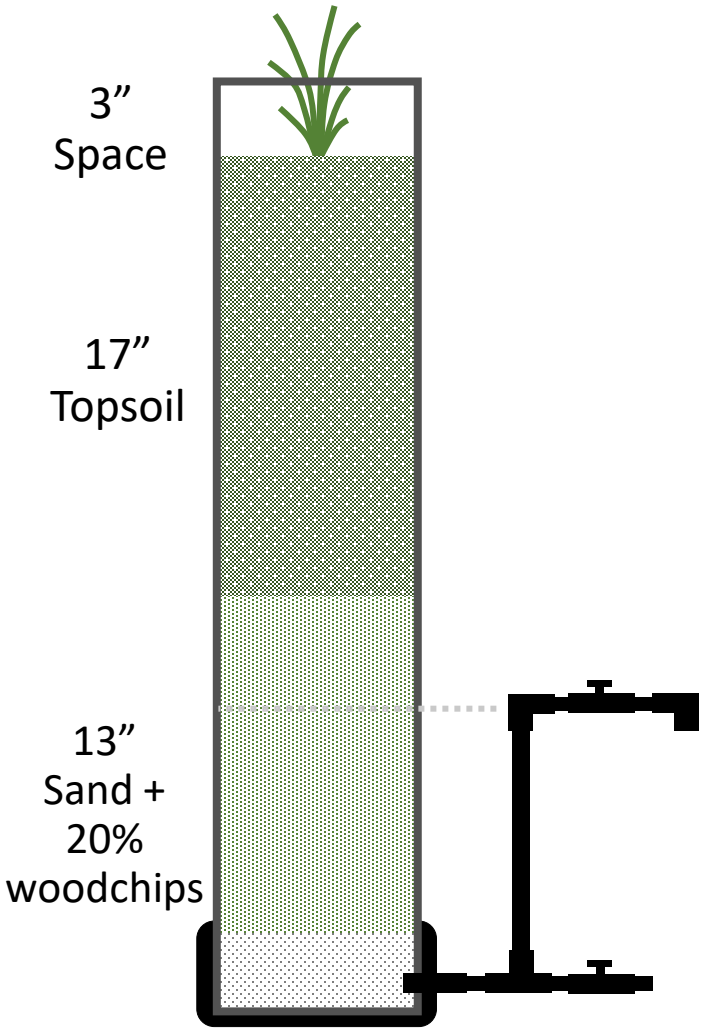
Field study w/ two basins w/ different salt loading in Lancaster, PA

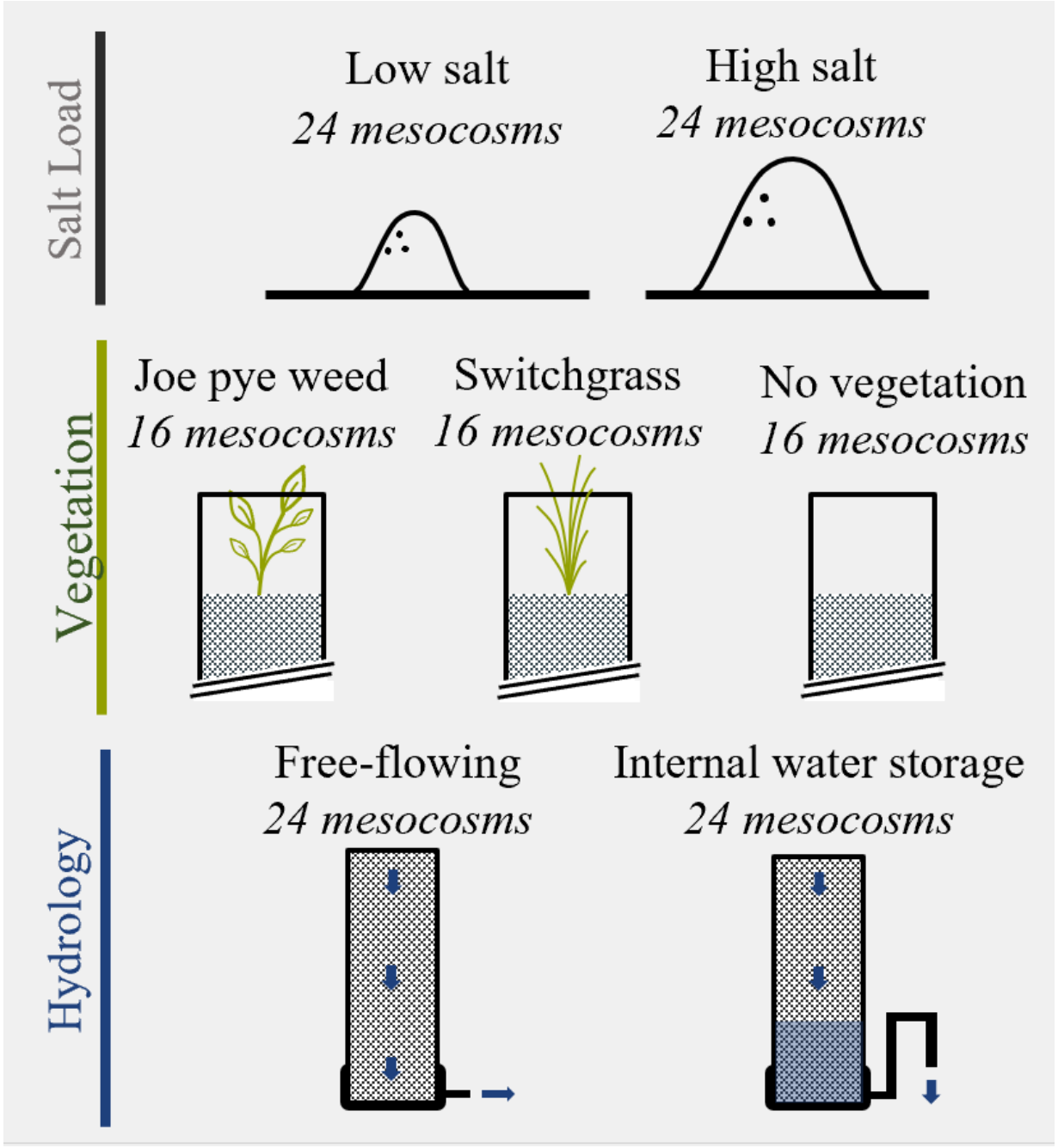
Greenhouse mesocosm study



Lead: MS student Alex Brown (who is about to be on the job market for stormwater-related positions in the DC area!)

Greenhouse experiment treatments





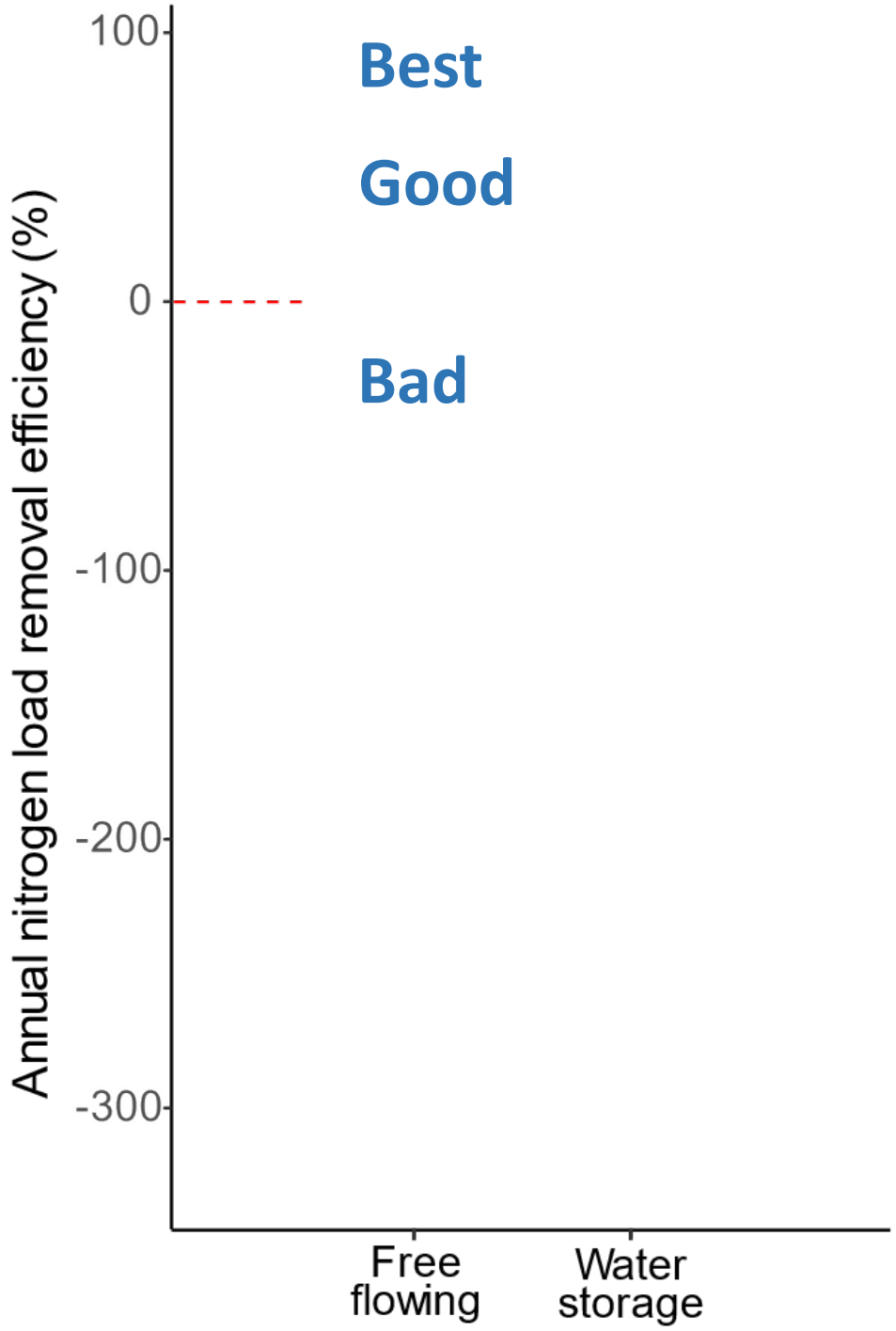
Sampling

Mesocosms are dosed twice weekly with semi-synthetic stormwater

Water sampling occurs monthly, except during early spring

In spring 2022 and 2023, ‘salty stormwater’ is added, w/ bi-weekly sampling

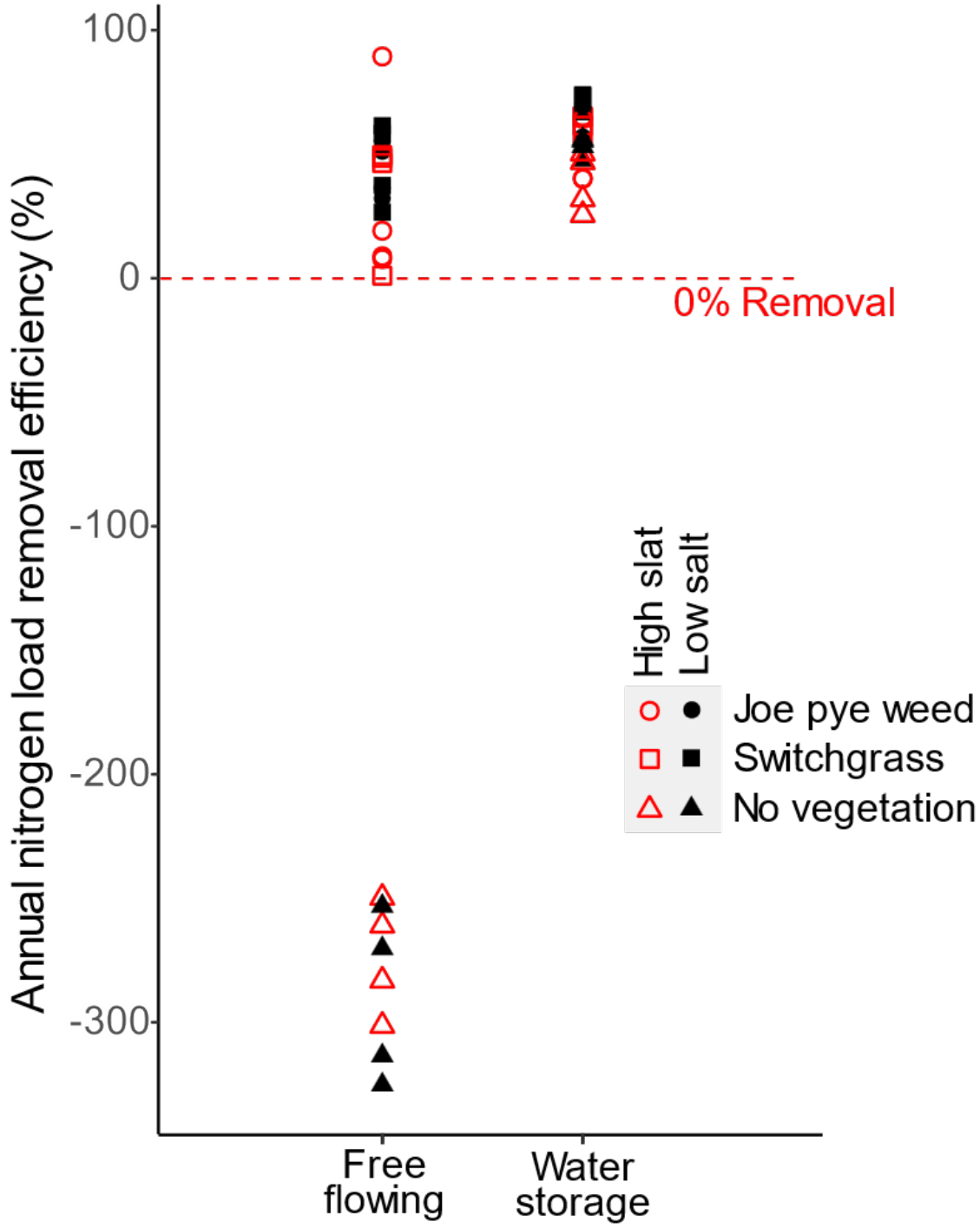
Interpreting results



Nitrogen leaches in non-vegetated, free-draining bioretention

Internal water storage universally improves N retention

Salt load does not appear to impact N retention overall



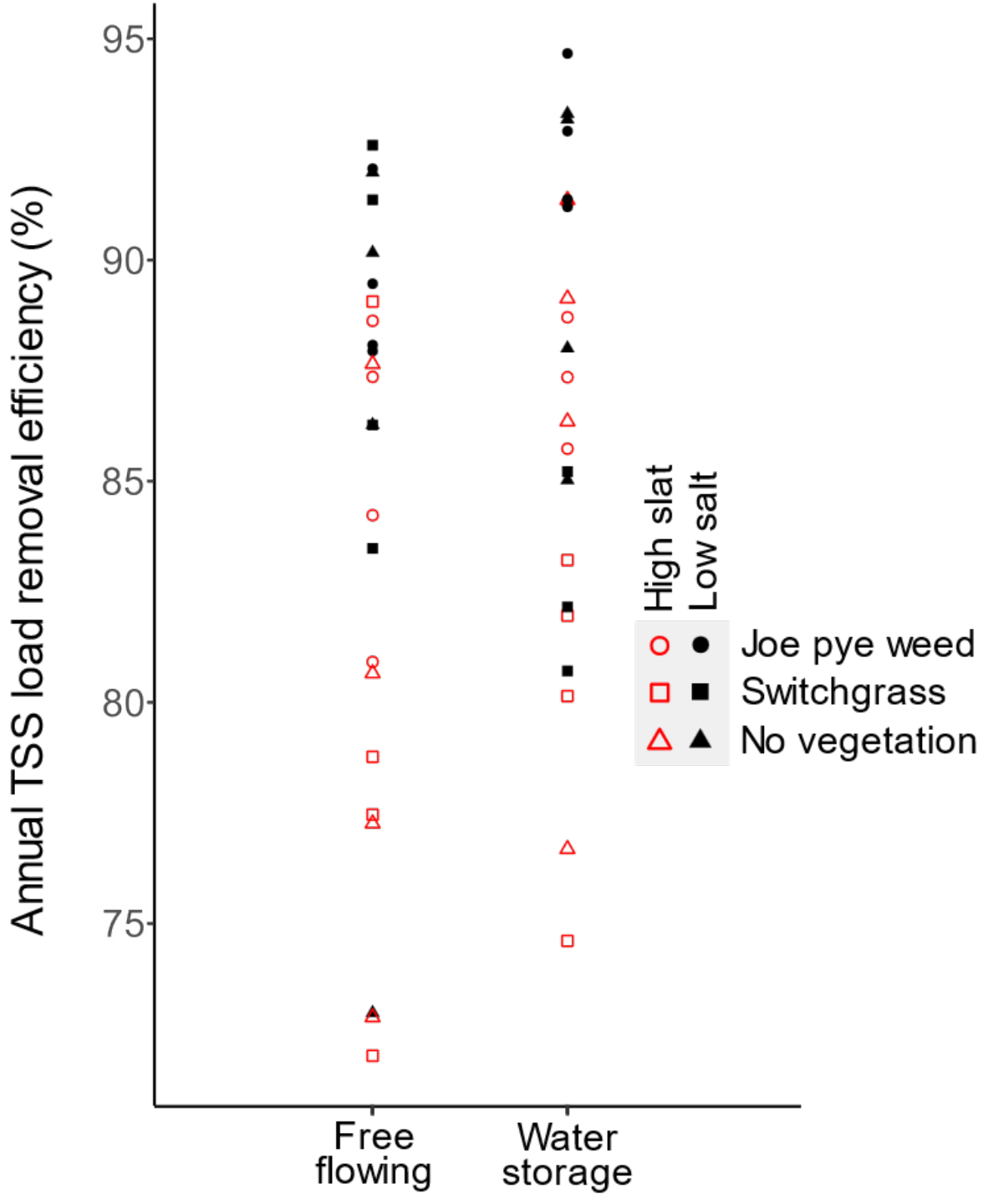
Phosphorus is generally well removed

Higher salt load led to reduced P removal

Internal water storage (IWS) improved P retention, and appeared to buffer salt impacts

Total suspended solids (TSS) reduction is overall very good

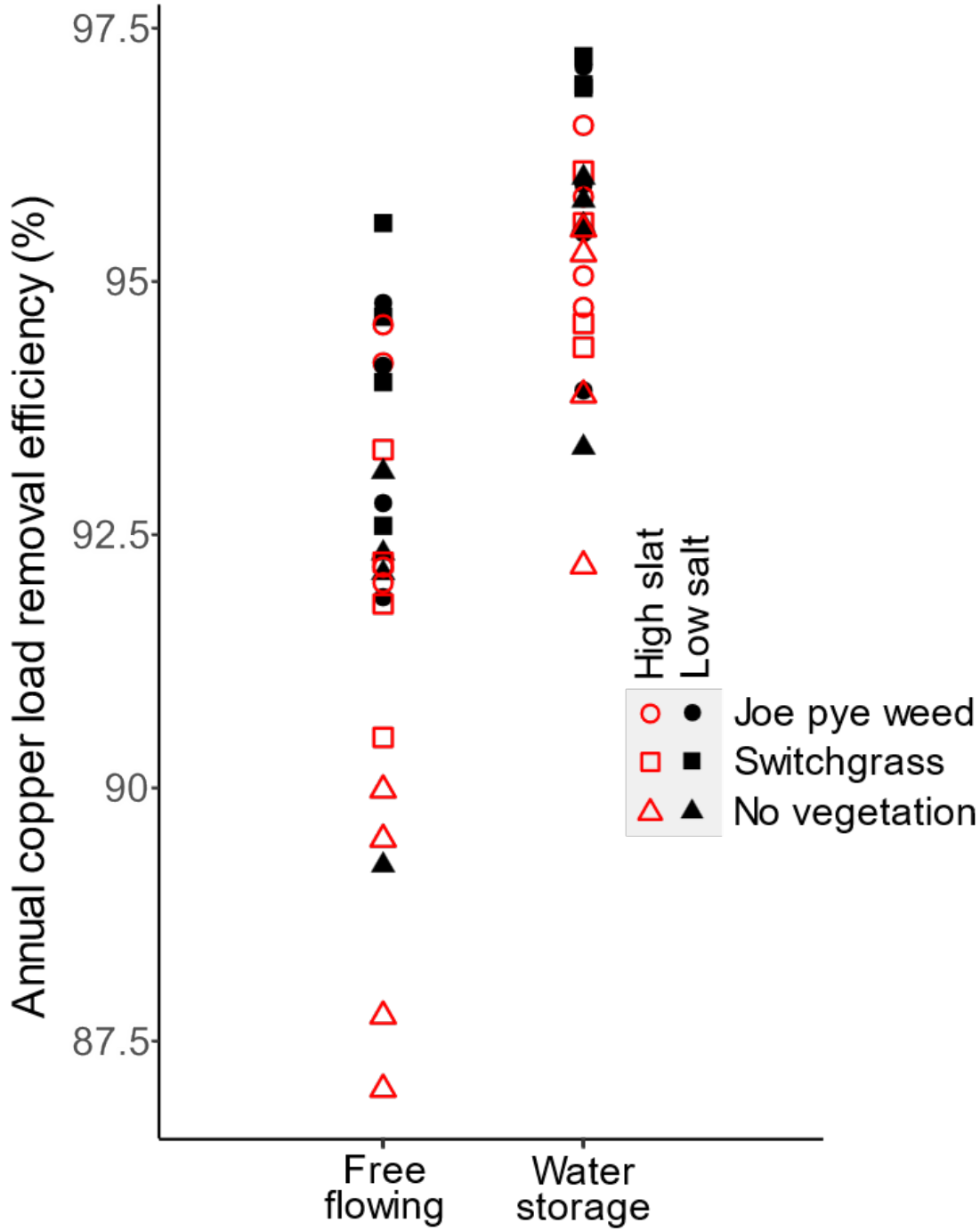
Higher salt load reduces TSS removal



Copper removal is overall very good

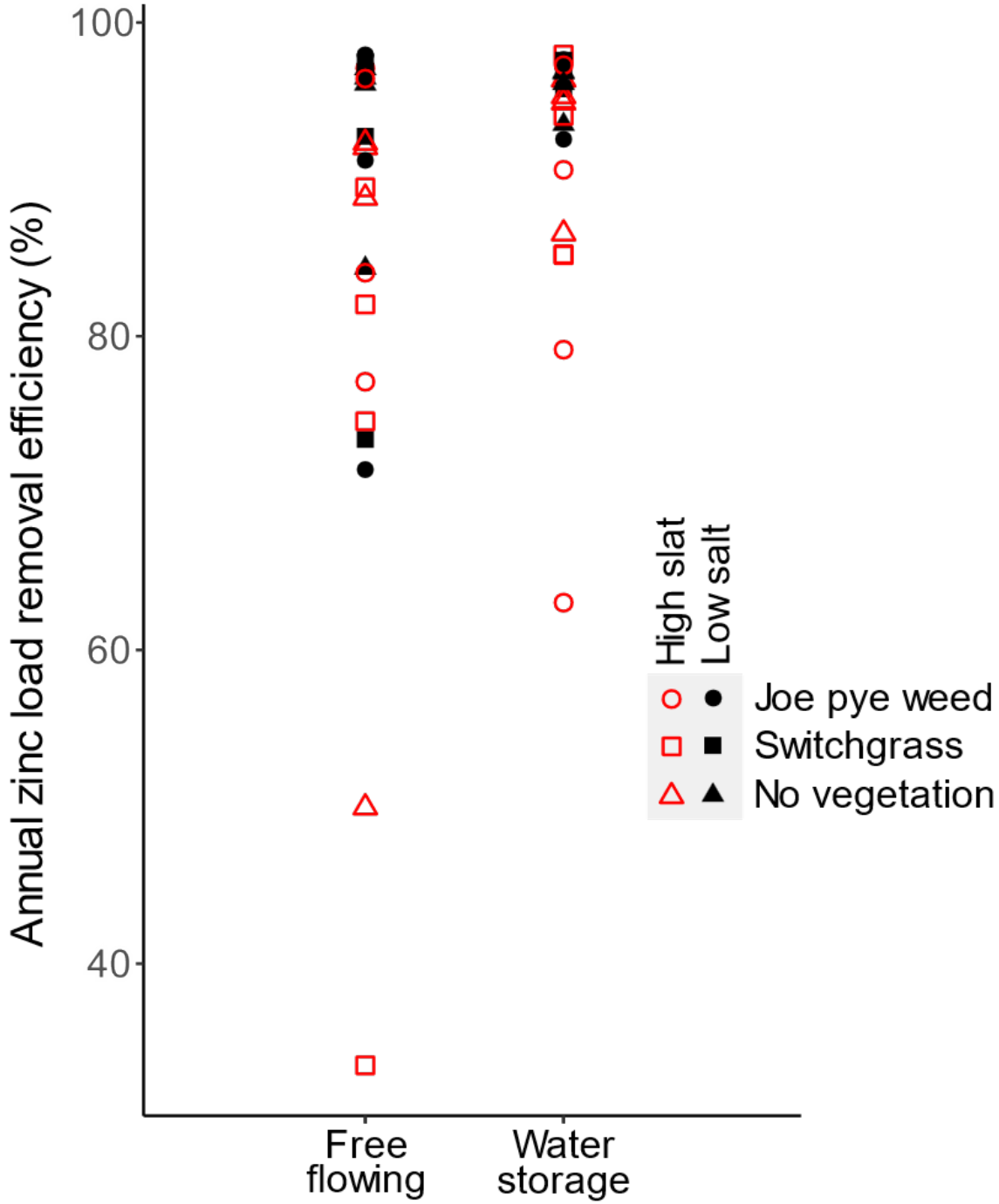
Higher salt load slightly reduces copper removal

Internal water storage slightly improves copper removal

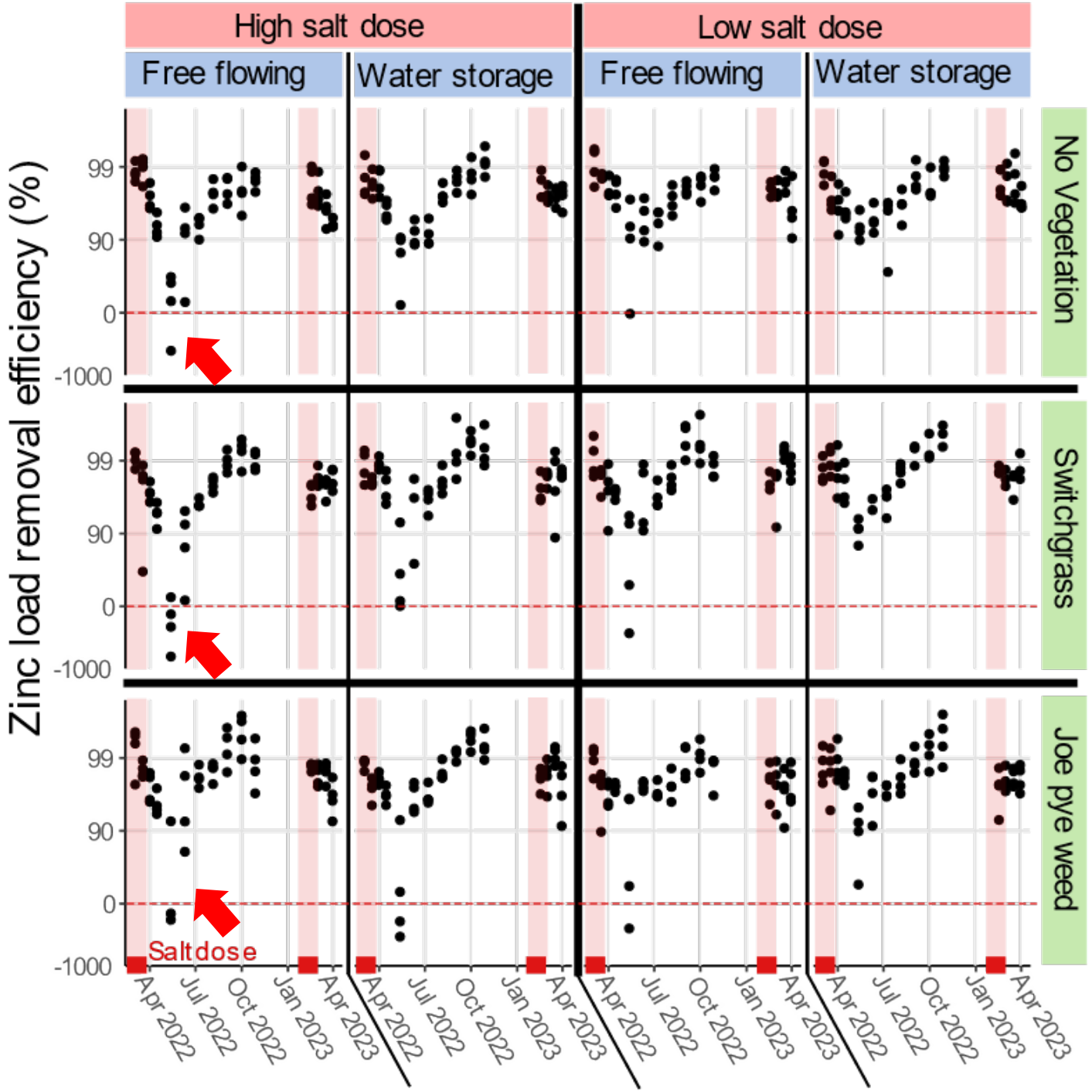


Zinc is removed well from inflowing stormwater

There were a few leaching events, mostly in free-flowing mesocosms



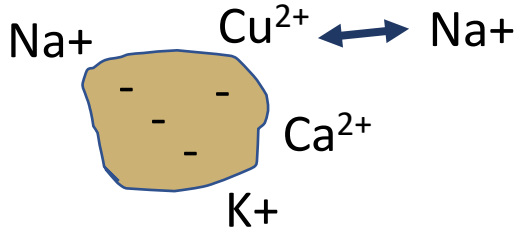
We attribute the zinc leaching to the salt events, as they occurred shortly after the last salty stormwater dosings



Summary points: *salt loading*

NaCl deicing salt negatively affects bioretention performance

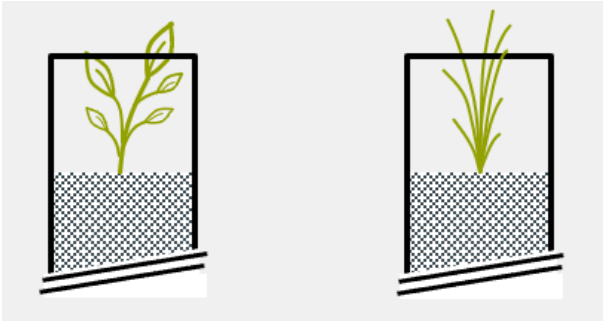
More salt loading led to….



- Reduced sediment and phosphorus retention
- Episodic zinc leaching
- Plant stress & death, particularly for Joe Pye Weed

Summary points: *design implications*

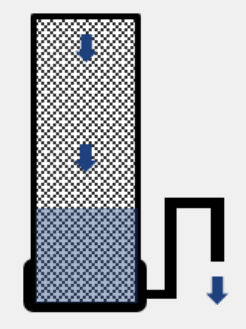
Presence of healthy plants was key for nitrogen retention



Internal water storage ….

Enhanced phosphorus and copper retention

Was essential for good nitrogen retention



Thank you!!

Chesapeake Bay Trust, Maryland Dept of Natural Resources, US EPA, Chesapeake Bay Program, National Fish and Wildlife Foundation, and Anne Arundel County

Assistance with mesocosm construction: Randall Bock
Donation of material: North Creek Nurseries, Metzler Forest Products
Lab assistance: Mitchell Corsi, David Brock

Lingering questions? Lauren’s email= stormwater @ psu.edu

Translation Slides

What are the take home points?
What does this mean for me?

Translation Slides by Sadie Drescher, Chesapeake Bay Trust

What does this mean for me?

- Salt reduction is key
- For bioretention systems:
  - Plant health is essential to the system's function (as designed)
  - Plant selection should consider natives that are also salt tolerant (e.g., coastal natives)
  - Plant success/maintenance should be monitored, e.g., replacement of dead plants
  - Internal water storage helped the system remove P, Cu, and N
  - There can be leaching from the system
- Good news is that removal occurs in the systems, so how do we optimize this is our charge

Adaptive management of BMPs is essential to maintain performance, especially where plants are relied upon for function

What does this mean for me?

What do I take from this if I am a practitioner:

- Consider the geographic location and future salt loading potential of the stormwater practice and adjust the plant palette to salt tolerant species, as needed
- Check plant success/health and replace dead/dying plants
- We could see clogging due to salt impacts to the soils/sediments

What do I take from this if I am a regulator:

- Continue to keep an eye on salt loading to help assess and share where there are "salt success stories" – Who is doing well and how can others do the same?

For us all – There is still a lot to learn about the microbes that work in these systems