Effects of Regenerative Stormwater Conveyance Systems (RCSs) on Water Quality

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Pollutants

Nitrogen
Phosphorus
Metals
Sediment

Urban Stream Syndrome

- Flashy flows
- Incised channels
- Disconnected floodplain
- Impaired biogeochemistry

Regenerative Stormwater Conveyance:

Weirs → step pools → decreased peak flow → stormwater retention

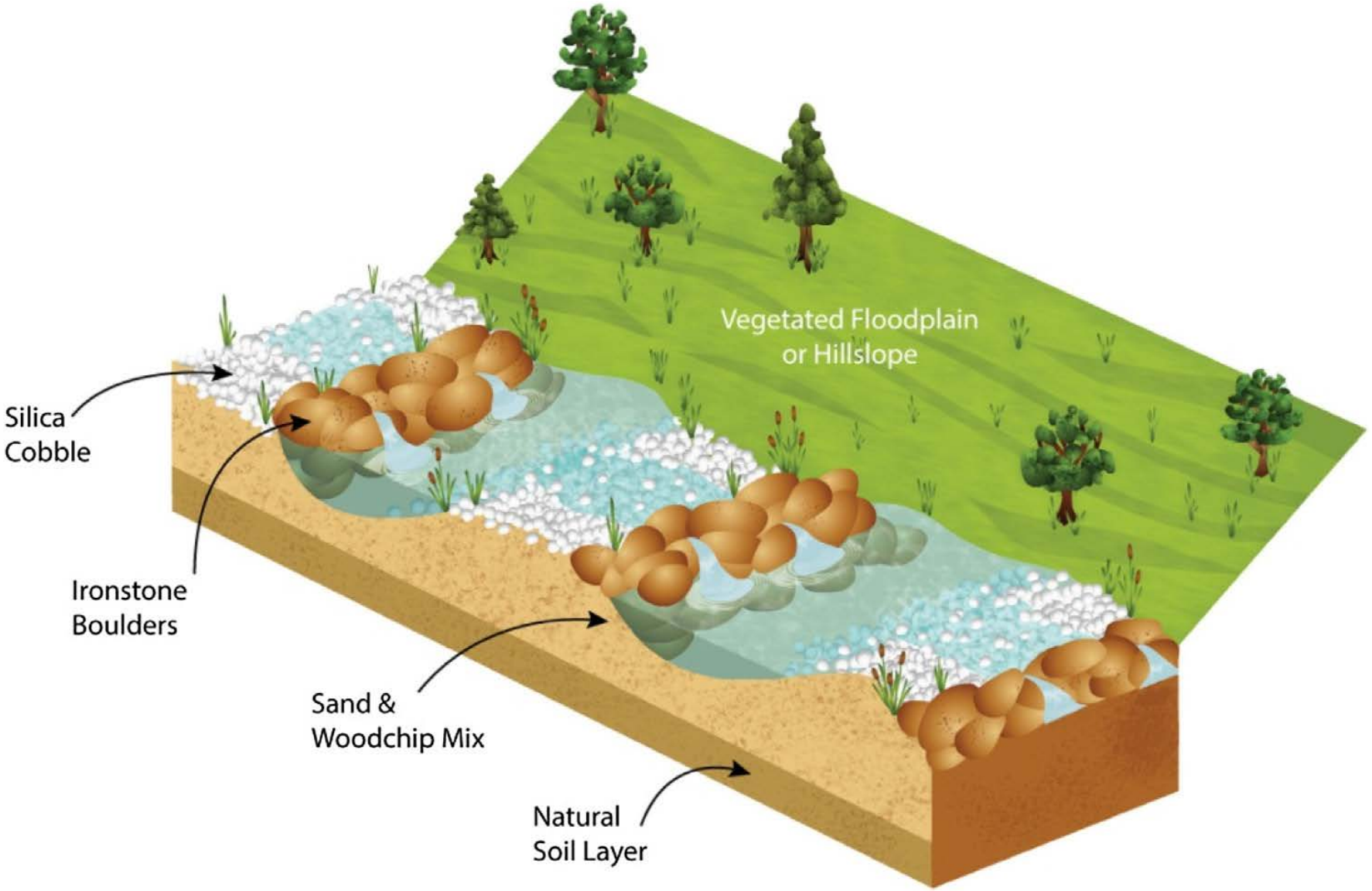


Figure from: Williams, Wessel, Filoso 2016 Ecological Eng Fe and Fe-oxidizing bacteria in RSCs

RSC’s in practice

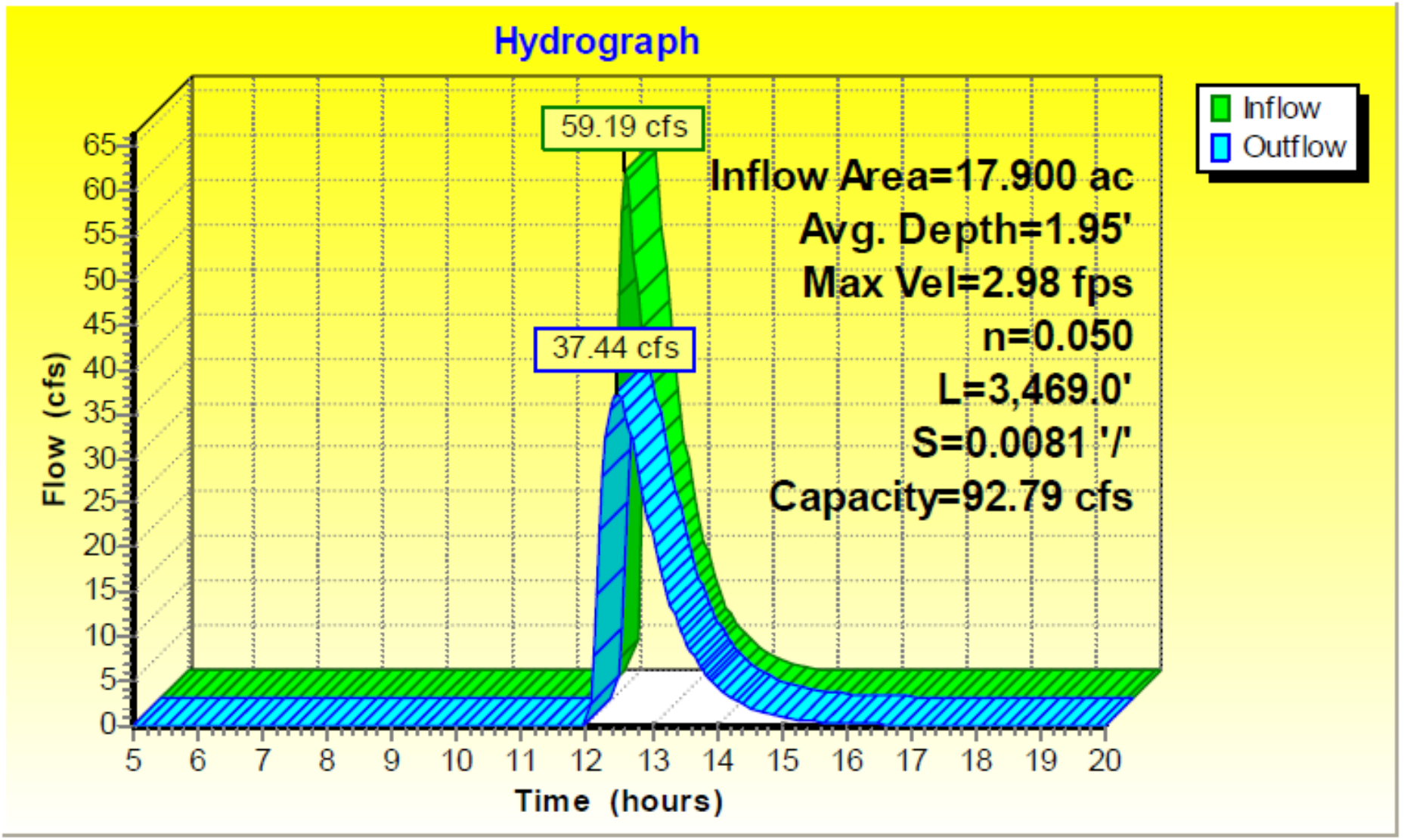


Figure 7: Hydrograph of the outflow from the RSC Conveyance in developed condition

From: Brown, Berg, Underwood 2010

Objectives

- Examine effect of carbon on retention of nitrogen & phosphorous in RSCs

- Examine effect of substrate type on mobilization of metals (iron and manganese)

Denitrification

$$NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2$$

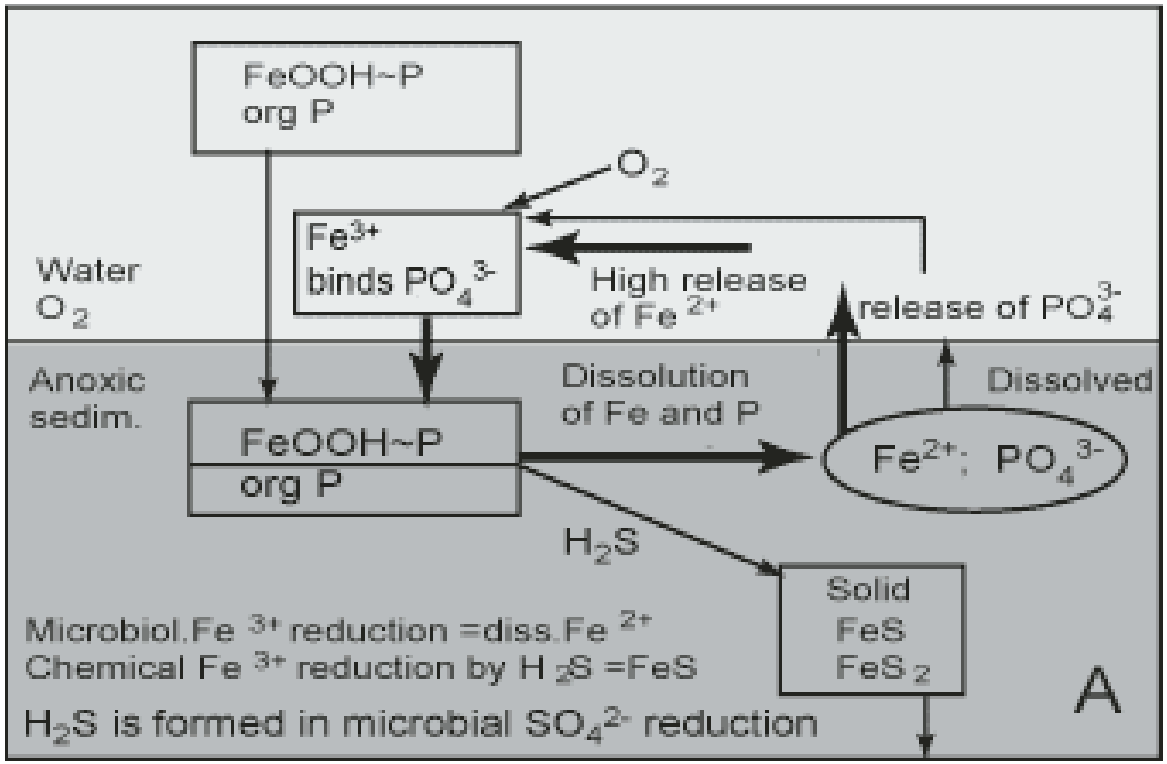
>Anaerobic

>Heterotrophic (requires organic C)

>Microbes, C, and N must mix in the subsurface

Nitrogen cycle

Phosphorus and Iron cycles



Organic C enhances N removal via denitrification or immobilization

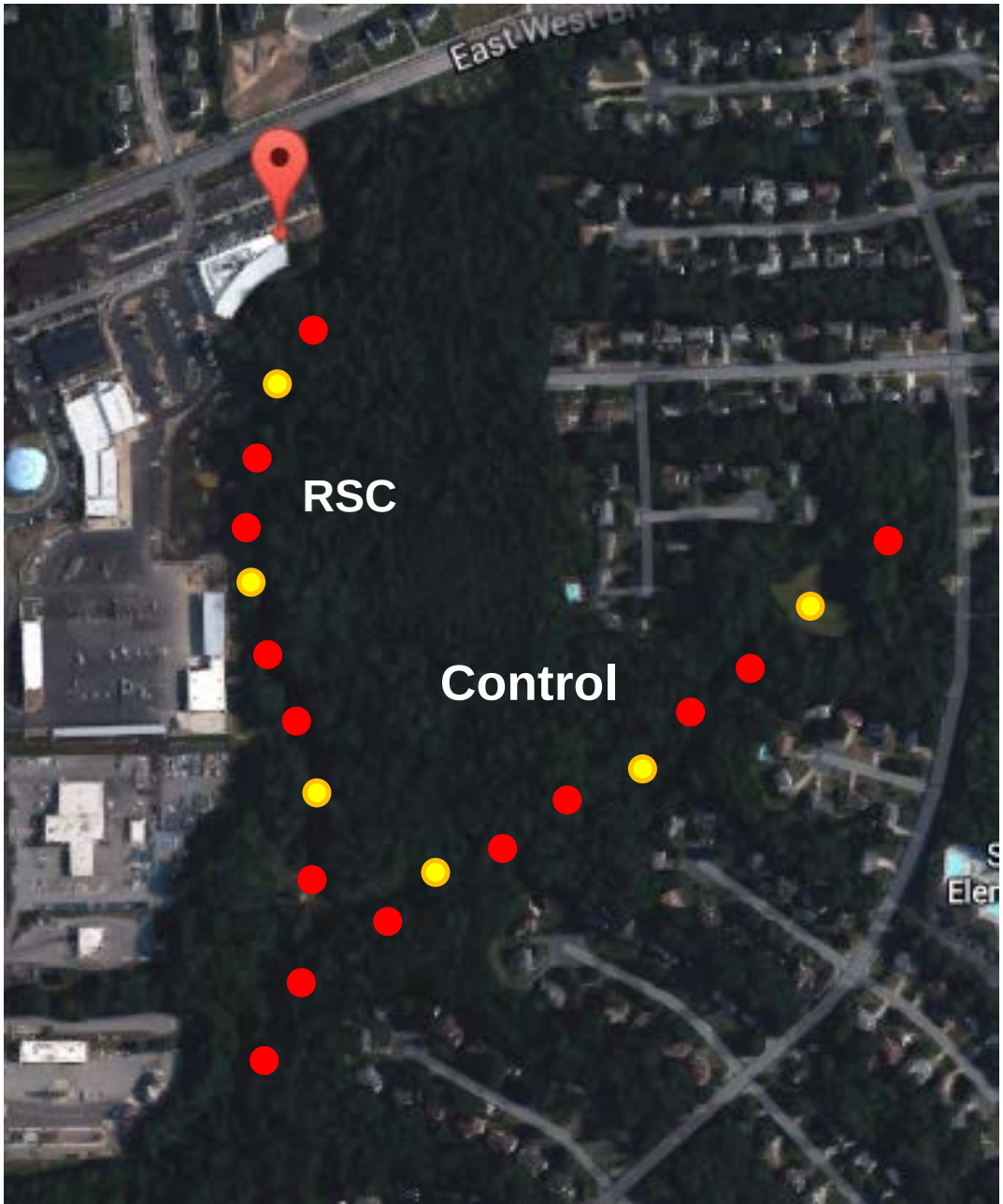
Anoxic, acidic conditions due to organic C may mobilize P, cations (Ca^{2+}) and trace elements (Fe and Mn)

Study Approach

1) field monitoring: two streams each with treated and untreated tributaries

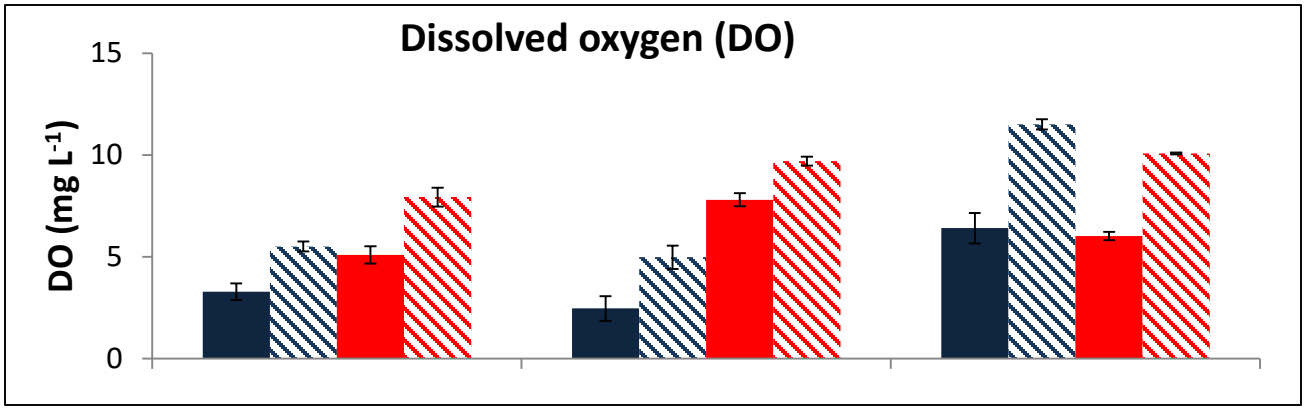
2) lab mesocosms: manipulated substrate, carbon type, temperature

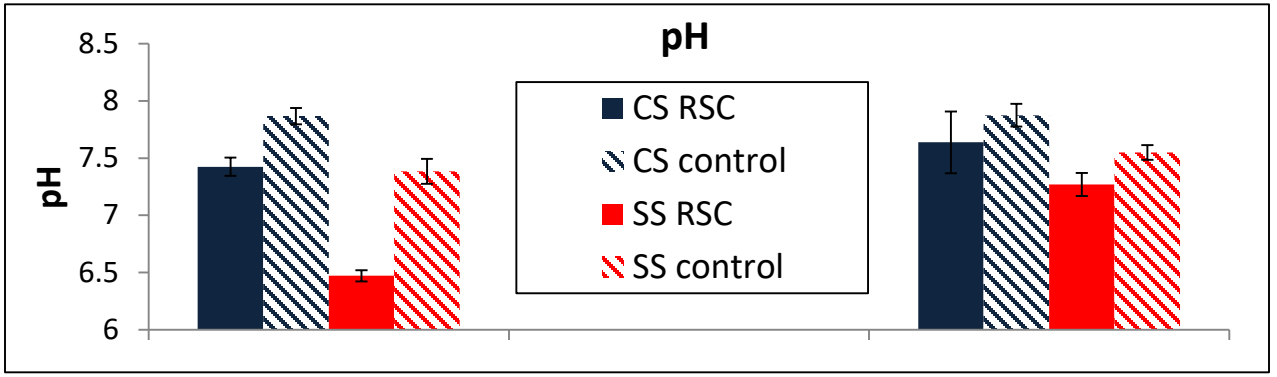
Part I: Field Studies



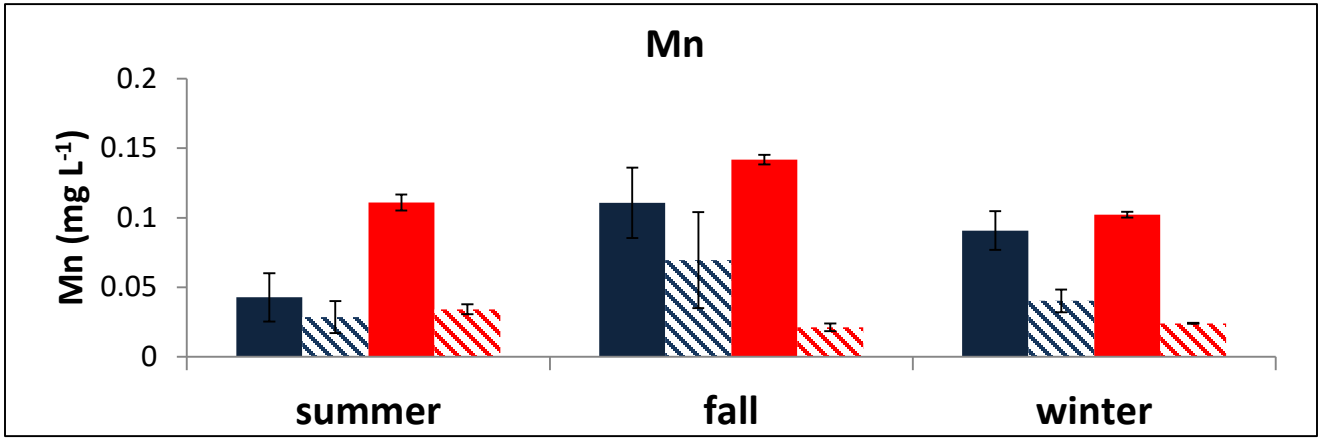
DO, pH, Mn

DO and pH lower in RSCs



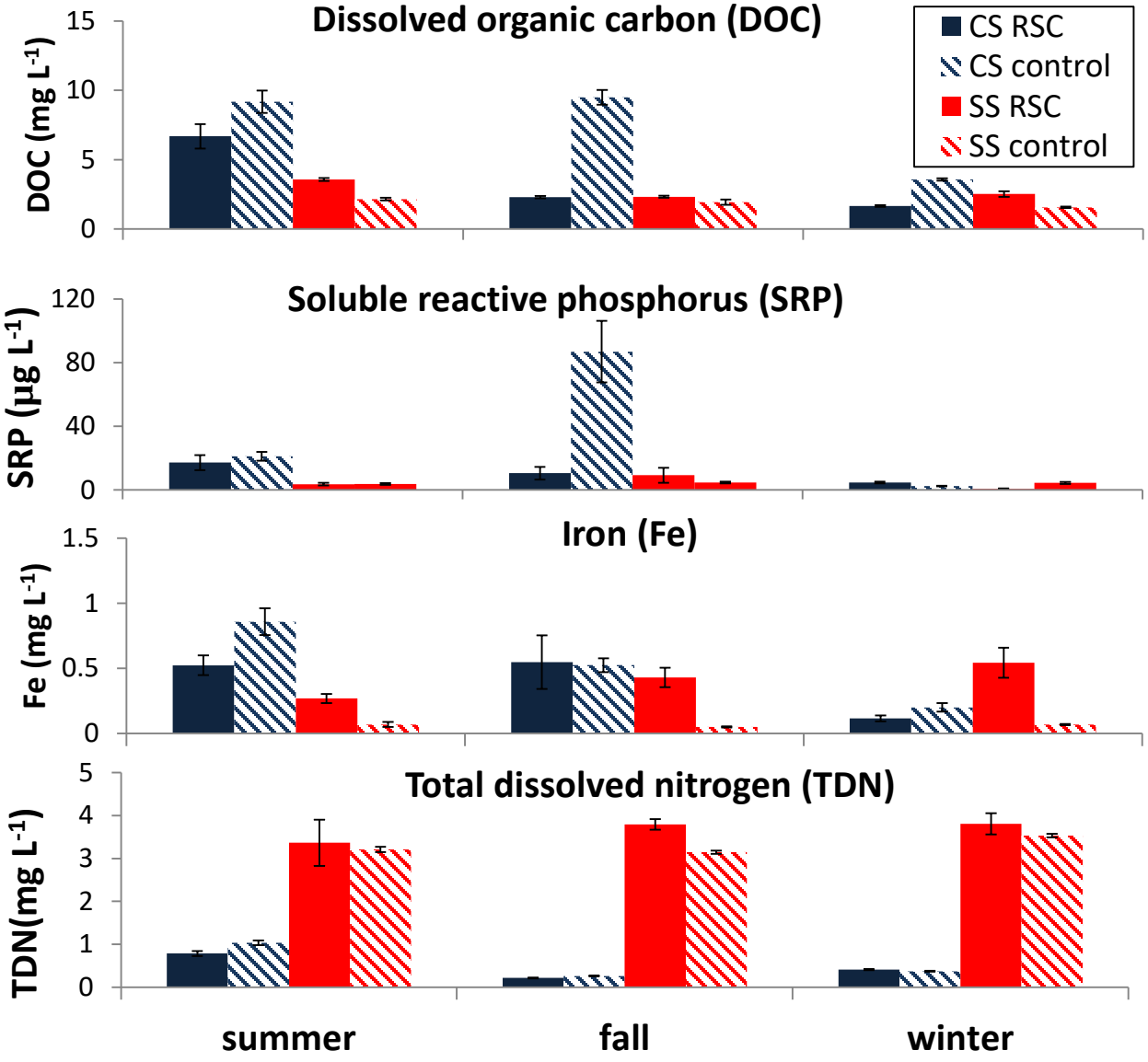


Mn usually higher in RSCs



DOC, SRP, Fe, TDN

No consistent differences between RSCs and control tribs

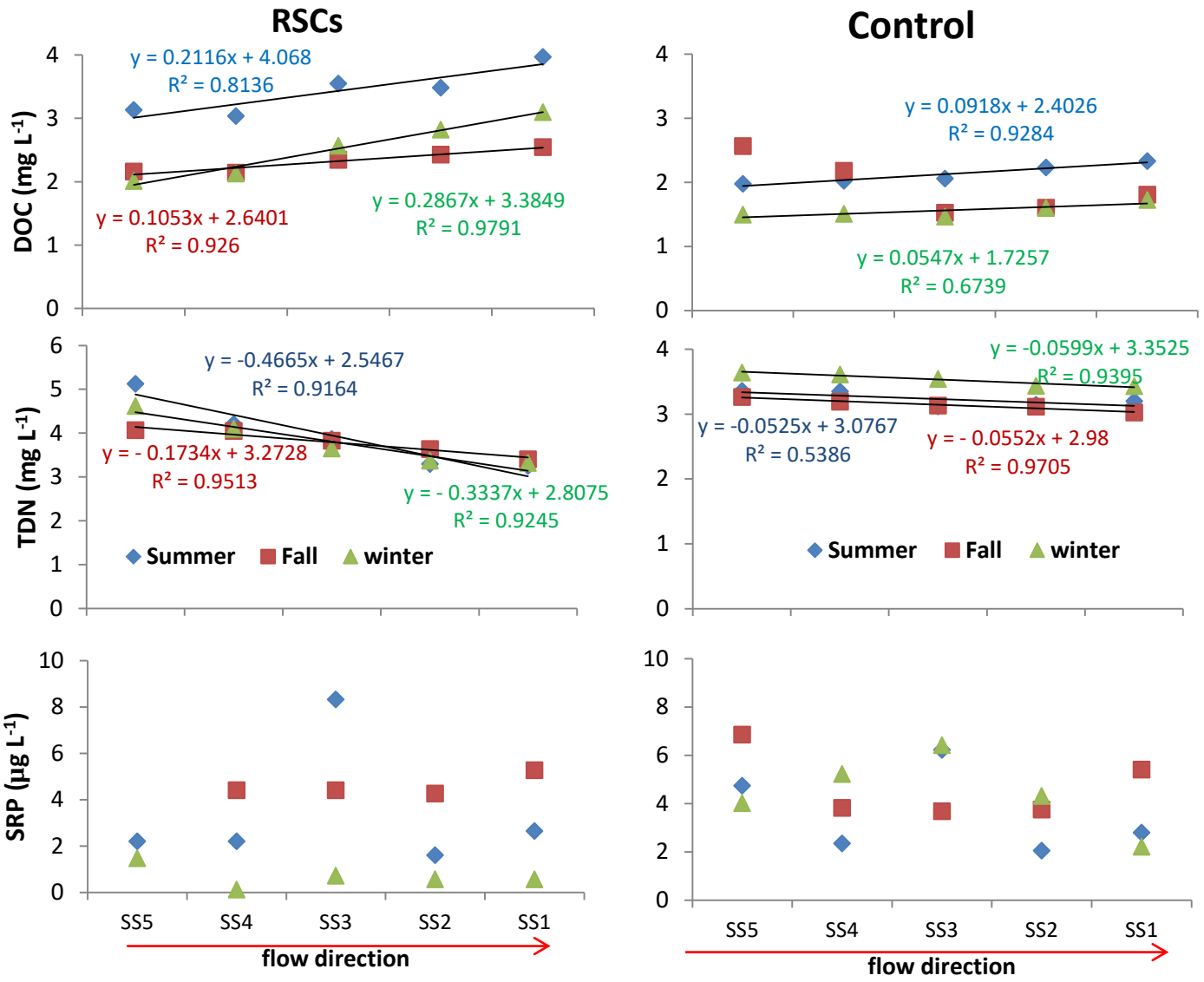


Downstream changes in DOC and nutrients at Central Sanitation

Downstream increases in DOC

Downstream decreases in TDN

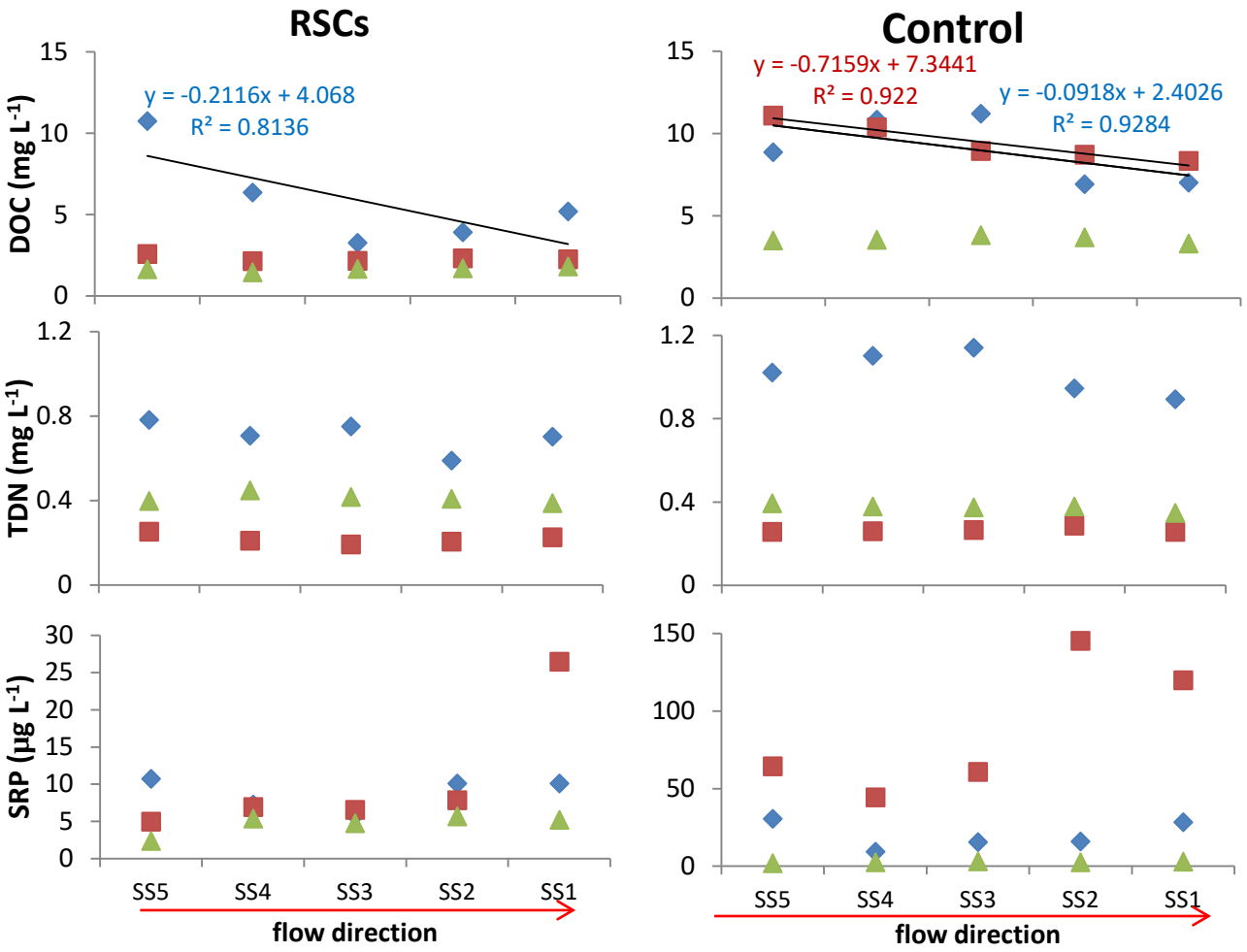
No trends in SRP



Downstream changes in DOC and nutrients at Crofton

downstream decreases in DOC?

No trends in TDN or SRP



Conclusions from field monitoring

- **DO and pH lower but Mn higher at RSCs relative to control streams**
- **DOC increased and TDN decreased along flowpath at one site**
  - **Conditions are highly variable**
  - **Engineering objectives are not always achieved**

Part II: Lab simulation experiments

Organic carbon

Wood chips – refractory C

Leaf litters –labile C

Sands

silicate sands (low Fe , Ca）

Carbonate sands (High Ca）

Fe-containing sands

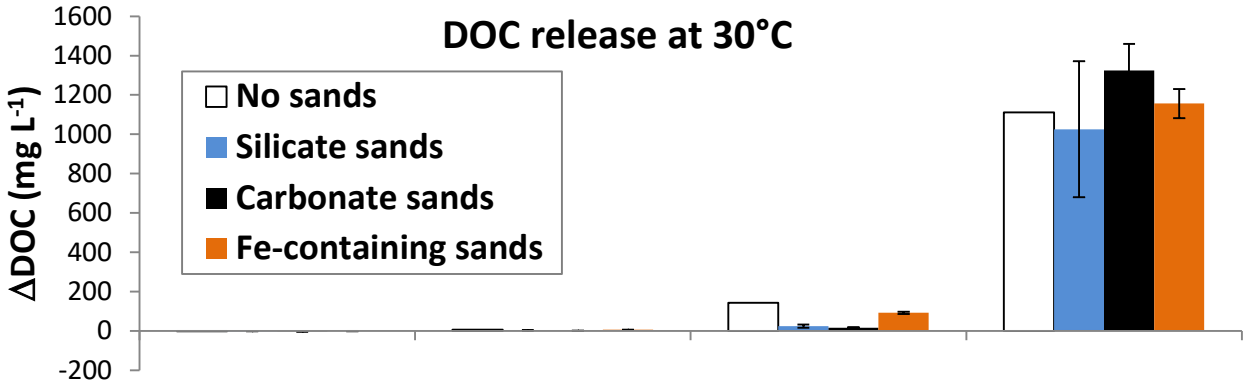
Lab Mesocosms

PVC tubes

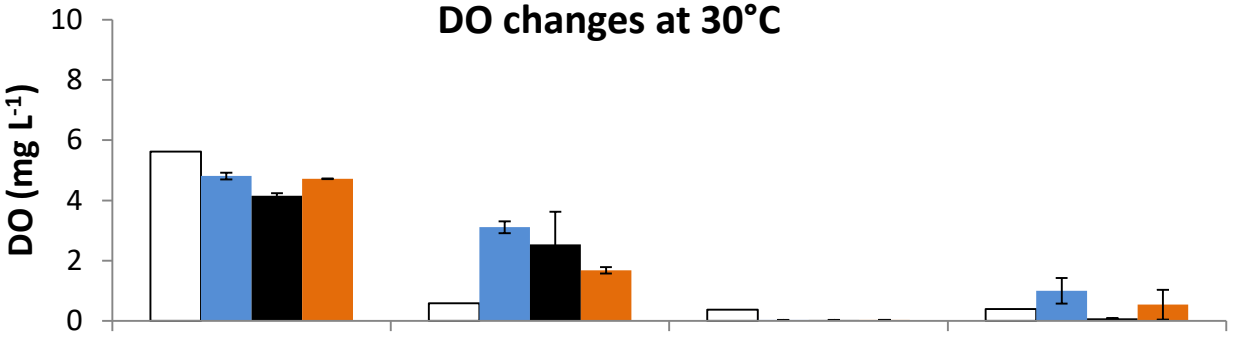
Carbon Treatments		Substrates		Incubation Temps
O%		no sand		30C
5% wood chips		silica		4C
20% wood chips		Fe		
20% leaf litter		carbonate		

DOC, DO, and pH

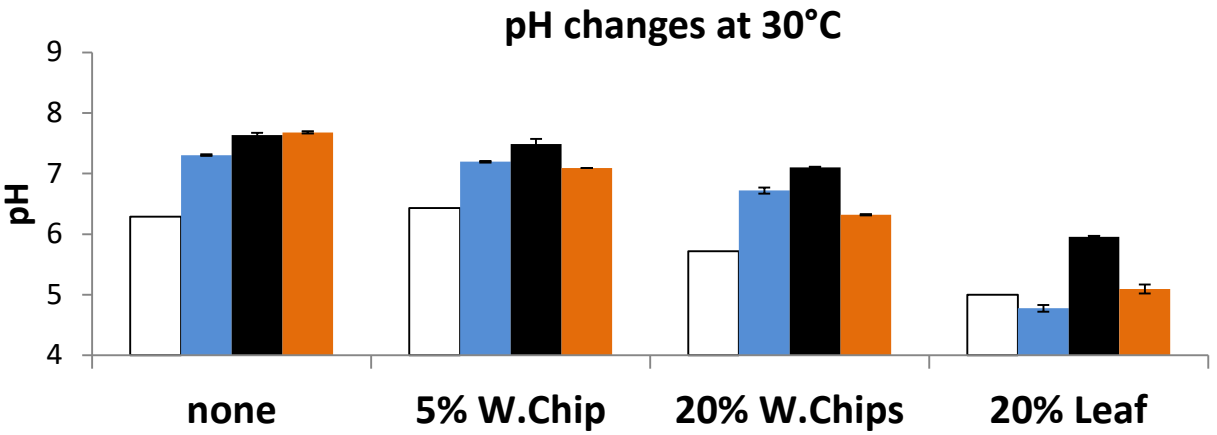
DOC release increased in leaf treatment



DO decreased due to DOC decomposition



pH decreased due to release of organic acids; Higher pH occurred in carbonate sands

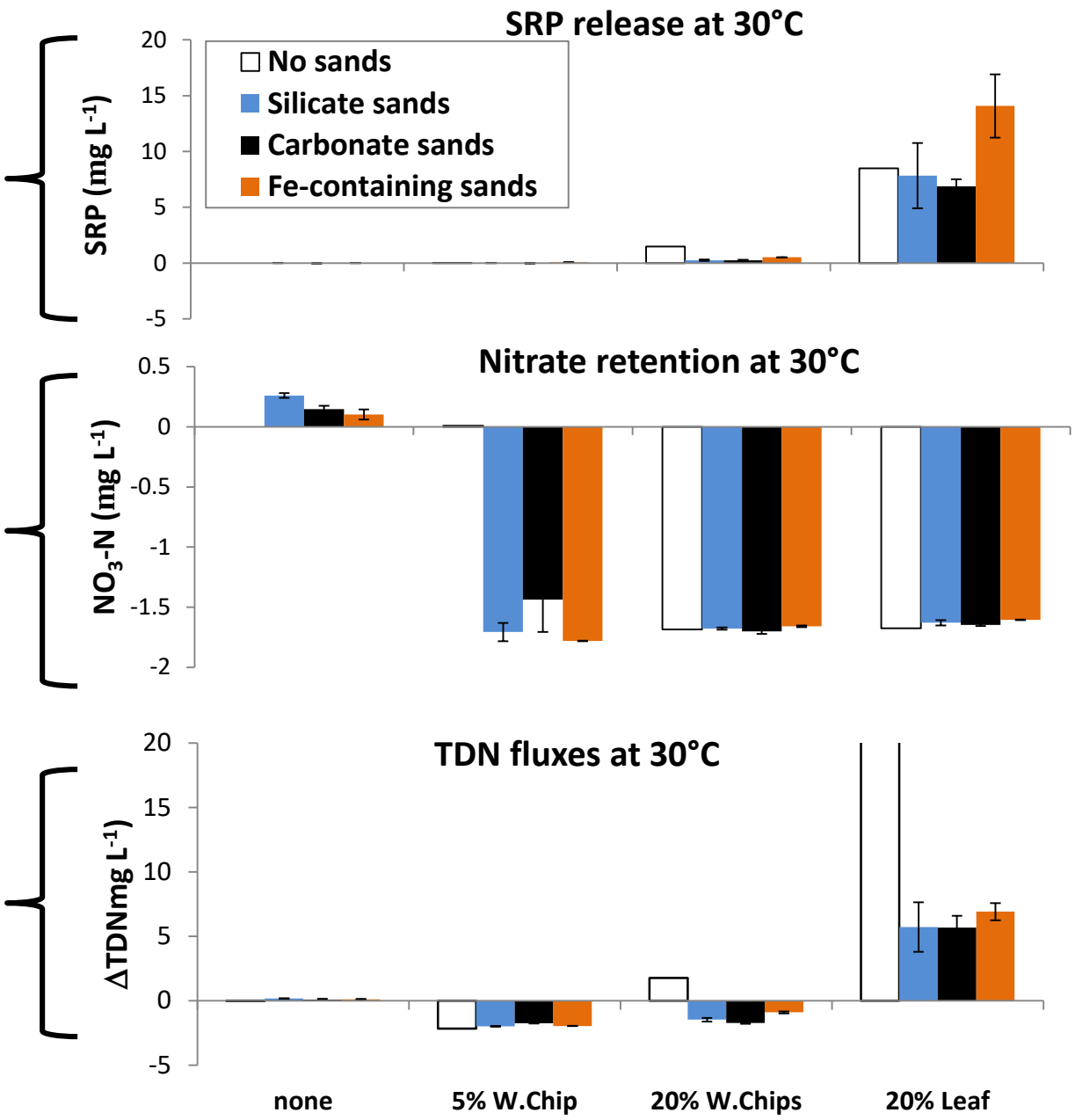


SRP, nitrate, TDN

Release of SRP release increased in leaf litter treatment especially with Fe- sands

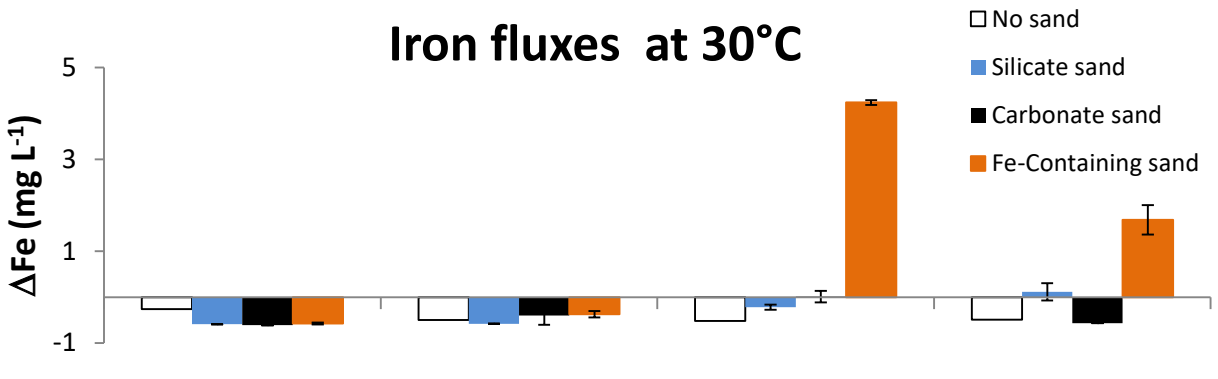
Nitrate retention did not differ with organic matter or sand types

TDN retained in wood chips but released in leaf litter treatment due to organic N inputs

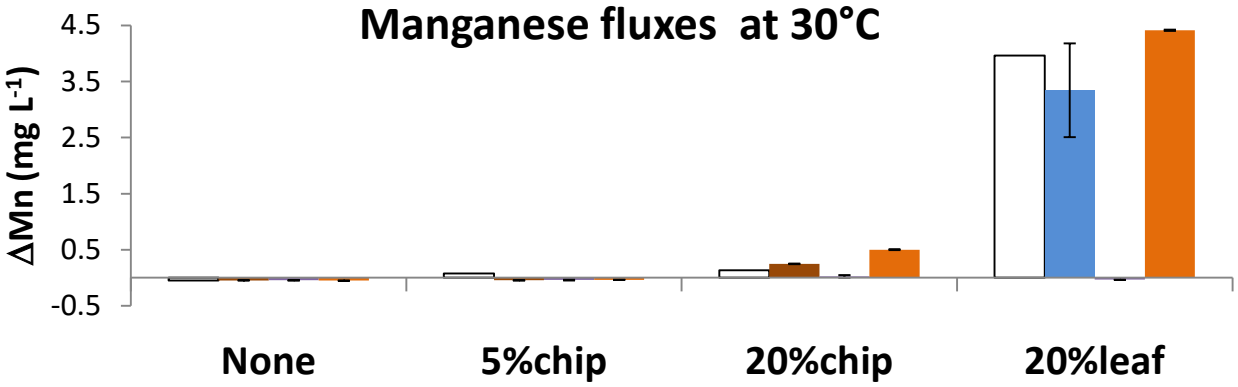


Release of Fe and Mn

Fe release occurred only in 20% organic matter



Mn release from Si and Fe-containing sands with 20% leaf litter



Conclusions from lab incubations

- **Iron released from iron containing sands, only when 20% organic matter added:**
  - **Avoid using iron-containing sand/gravel**
  - **reduce organic matter addition**

- **Nitrate is retained but phosphrous is released depending on DOC, DO, and pH:**
  - **RSC design may lead to trade-offs in N and P management**

Trade-offs and unintended consequences

Reduced water velocity & erosion

vs

Low DO and Fe flocculant

N retention

vs

P release & Riparian flooding

Overall Conclusions

- Nitrogen may be attenuated but phosphorus may be released in RSCs
- Modifications to the current RSC design may improve function:
  - Reduce amount of organic matter added to the bed
  - avoid using iron stone
- Dissolved oxygen is reduced at RSCs which may affect habitat for aquatic life
- Efficacy of RSCs in the field is highly variable and engineering objectives are not necessarily met