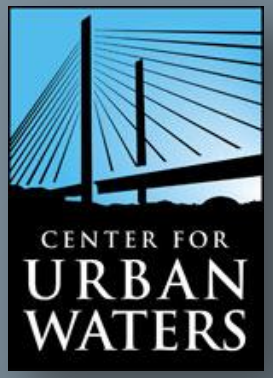
CAPTURING PHOSPHORUS USING WASTE PRODUCTS IN BIO-RETENTION SYSTEMS



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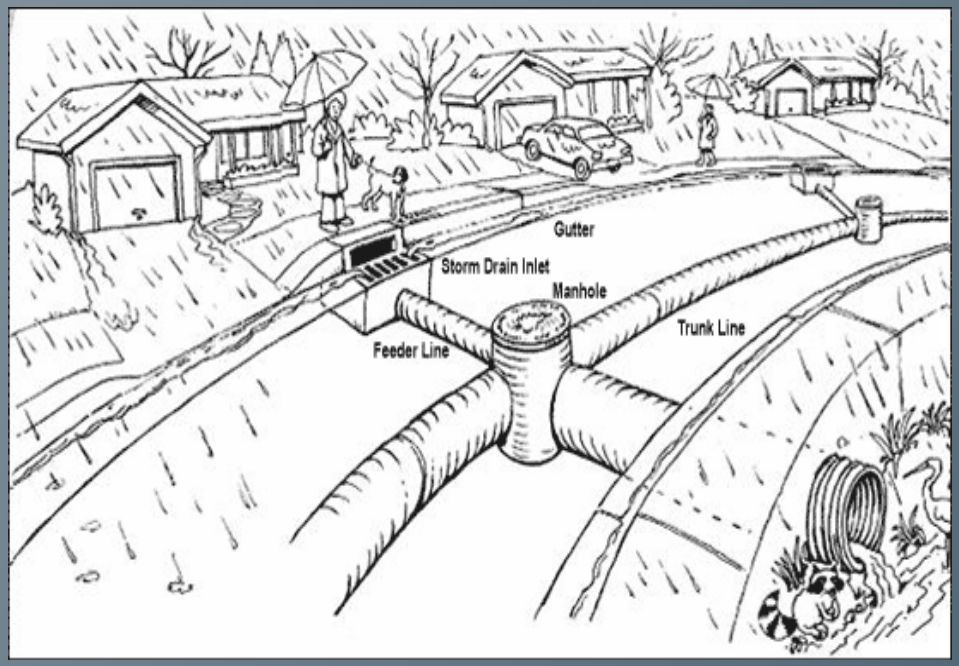
The staff working in the labs at the City of Tacoma

- **Phase 1**
  - **Rain Garden Soil Mixes**
    - **Characterization**
    - **Phosphorus overview**
- Phase 2
  - Year Long Study
    - Capturing phosphorus
- Phase 3
  - This Summer's Research
    - Combine phase 1 & 2
    - New rain garden design

Storm Water is the Problem

- Water collects contaminants as it flows
- Impermeable surfaces force urban runoff into storm drains

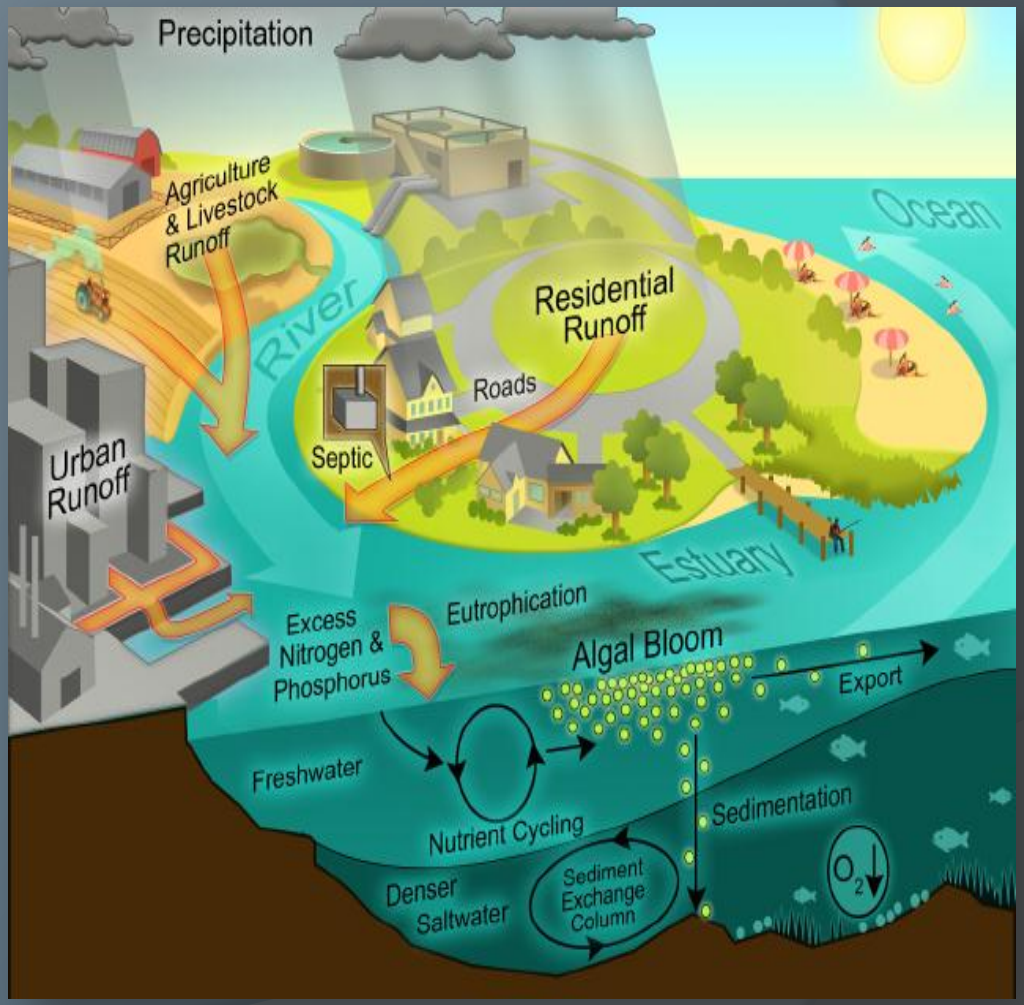


(stancounty.com)

(pugetsoundstartshere.org)

Sources of Pollutants

- Urban Development
- Automobiles
- Fecal Matter
- Detergents
- Lawn Care



Storm Water Impacts

- 75-89% of female Coho Salmon die before spawning upon entering Longfellow Creek

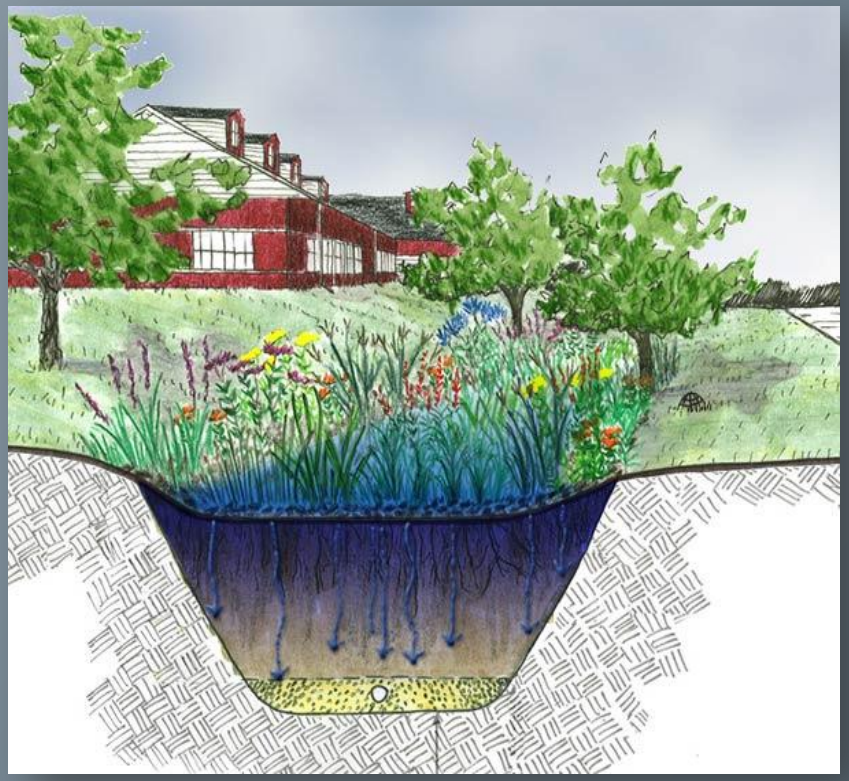
- Eutrophication
  - > 0.05 mg / L of P

- Storm water
  - ≈ 0.30 mg / L of P

(NOAA.gov)

(lakescientist.com)

Are Rain Gardens the Solution?



(bhbuilders.com)

- Allows water to better infiltrate soil surface
- Filters metal particles and hydrocarbons
- Lessens amount of pollutants that enter rivers and streams

Bio-Retention Soil Mix (BSM)

- Storm Water Management Manual for Western WA
- Sand used for high infiltration rates
- Compost used to fertilize plants

60% Sand
40% Compost

Phase 1 Overview

- Characterization of Media
  - Bio-Retention Soil Mix (BSM)
- Proposed Amendments to BSM
  - City of Tacoma's TAGRO
    - Alternative to compost
  - Water Treatment Residual (WTR)
    - Used to capture phosphorus

TAGRO Garden Mix

- Composed of Class A bio-solids pasteurized to eliminate pathogens

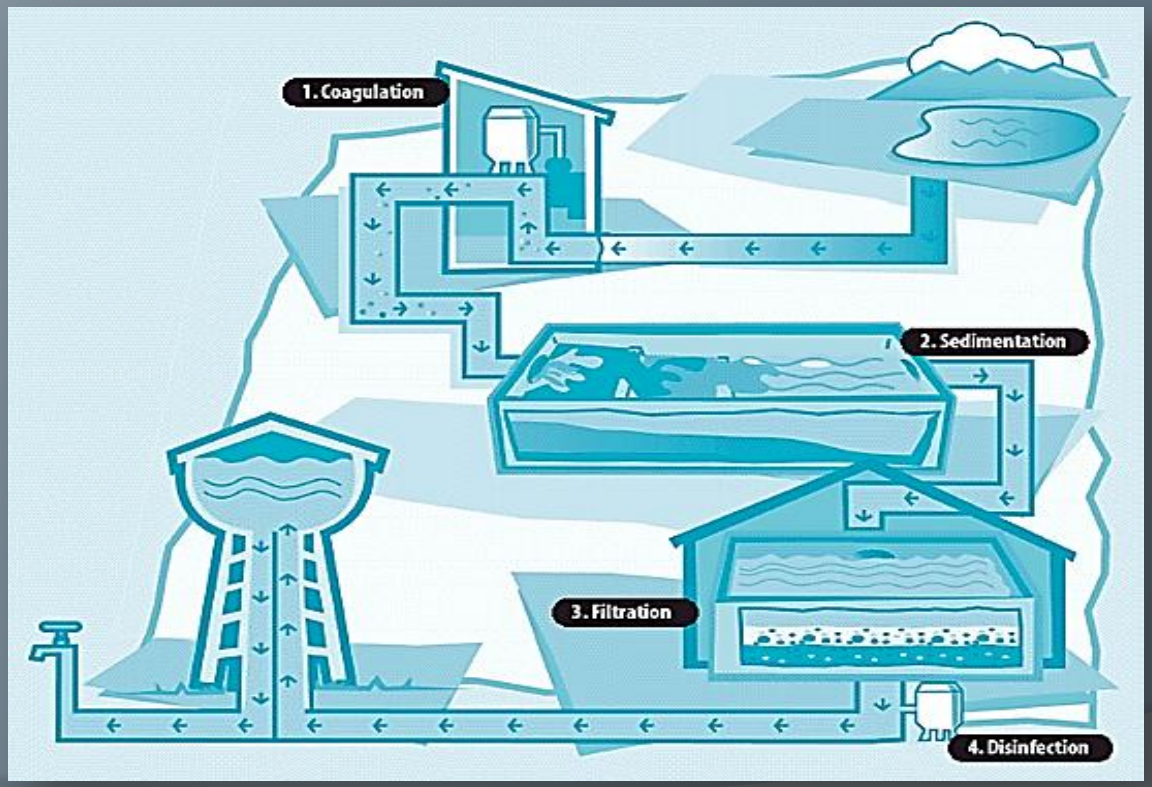
50% Bio-Solids
25% Sand
25% Sawdust

(weeklyvolcano.com)

Water Treatment Residuals (WTR)

- 25 – 50 % Aluminum and Ferric Sulfates (additive)
- 15 – 25 % Organic Matter (source water)
- 35 – 50 % Clay / Silt (source water)

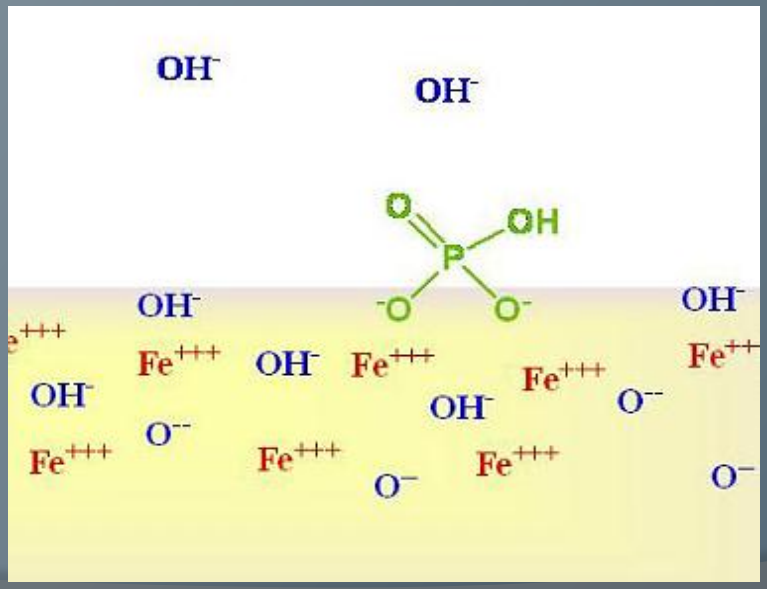
(ecy.wa.gov)



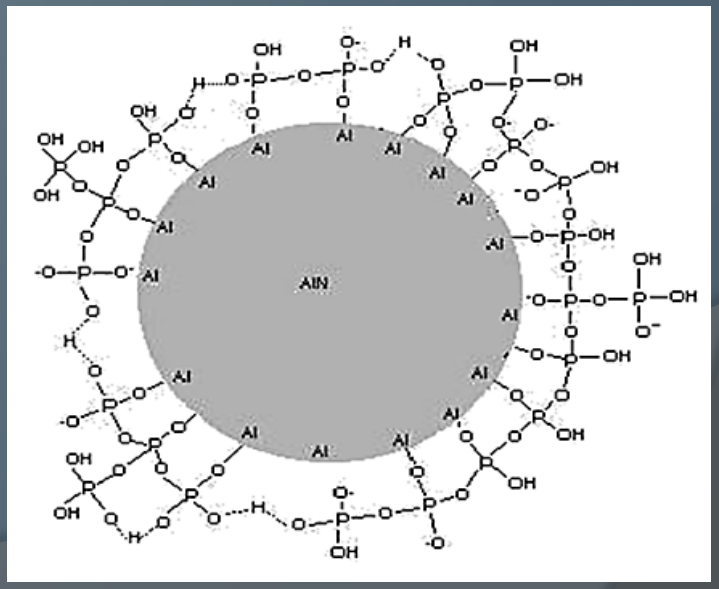
(waterandhealth.org)

Adsorption and Absorption

- WTR captures ortho – P through dual process
  - Adsorption – Fast process
    - Easily reversible
  - Absorption – Slow process as particles dry-out
    - Uptake into matrix of particle



(reefkeeping.com)

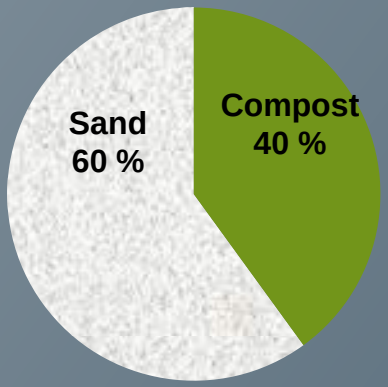


(intechopen.com)

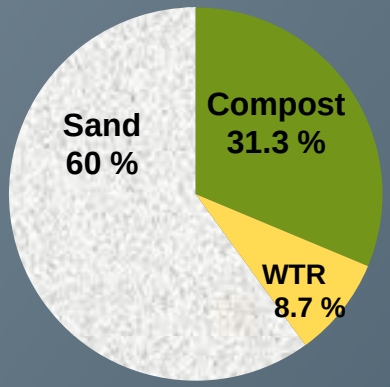
Soil Mixes

SAND

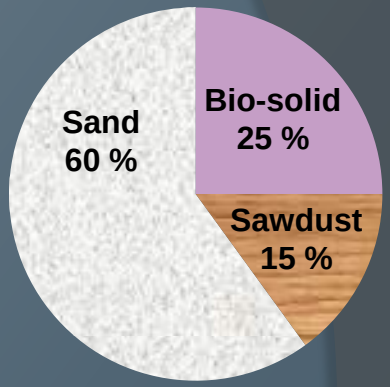
BSM

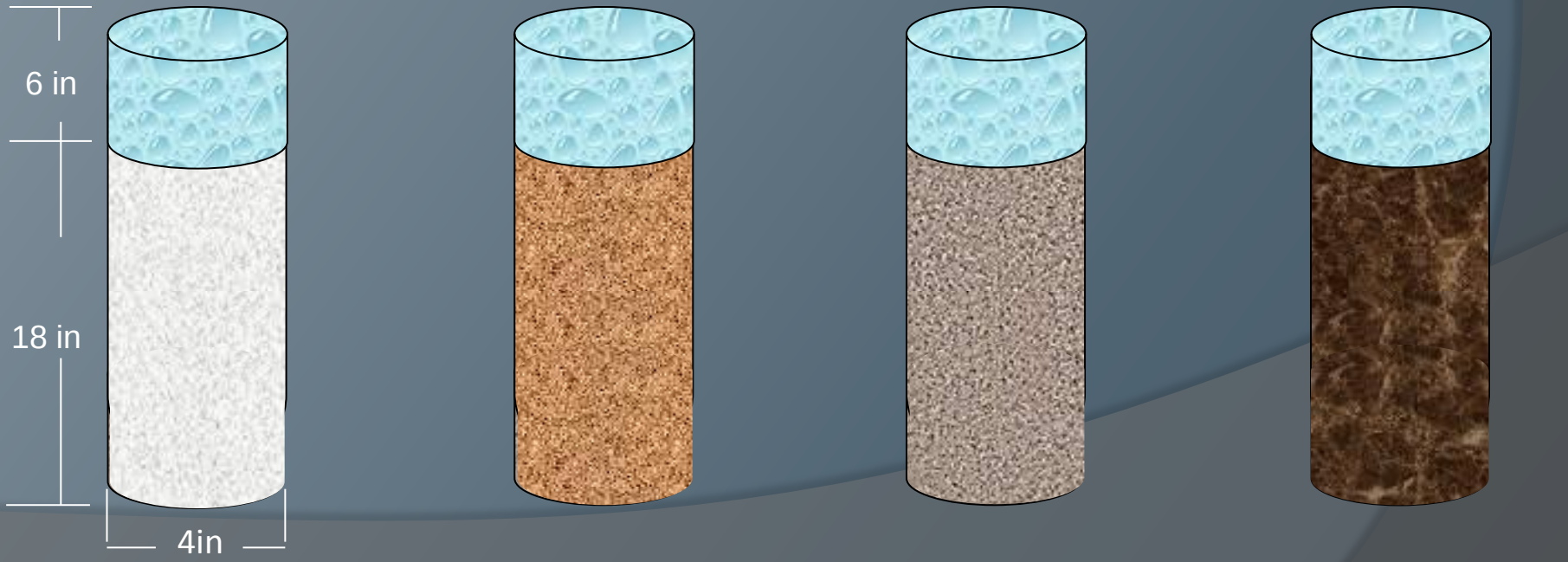


BSM / WTR



TAGRO MIX





Methods

- Columns dosed with ≈ 2 years storm water
  - 10:1 – Drainage : Retention
- Leaching Period - To condition media
  - 75 Liters ≈ 1 year storm water
  - 8 Liters twice per week
- Polluting Period – To show how it reacts to pollutants
  - 75 Liter ≈ 1 year storm water
  - 4 Liters twice per week
- Sampling – 1st Liter of rain event ≈ every 20 Liters

Leaching Period

- Cistern water is reject water from making Deionized water, and runoff from green roof

(Waterworld.com)

Polluting Period

- Sludge to make storm water acquired from City of Tacoma
- Wet Sieved < 150µm
- ≈ 50-300 mg/L TSS

(americleanpumping.com)

What We Are Looking For

Nutrients and Physical Traits

Major Anions

Alkalinity and pH

Infiltration Rates

Total Phosphorous

Ortho Phosphorus

Total Suspended Solid

Total Kjeldahl Nitrogen

Total Organic Carbon

Dissolved Organic Carbon

Metals (Total and Dissolved)

Aluminum

Arsenic

Cadmium

Copper

Lead

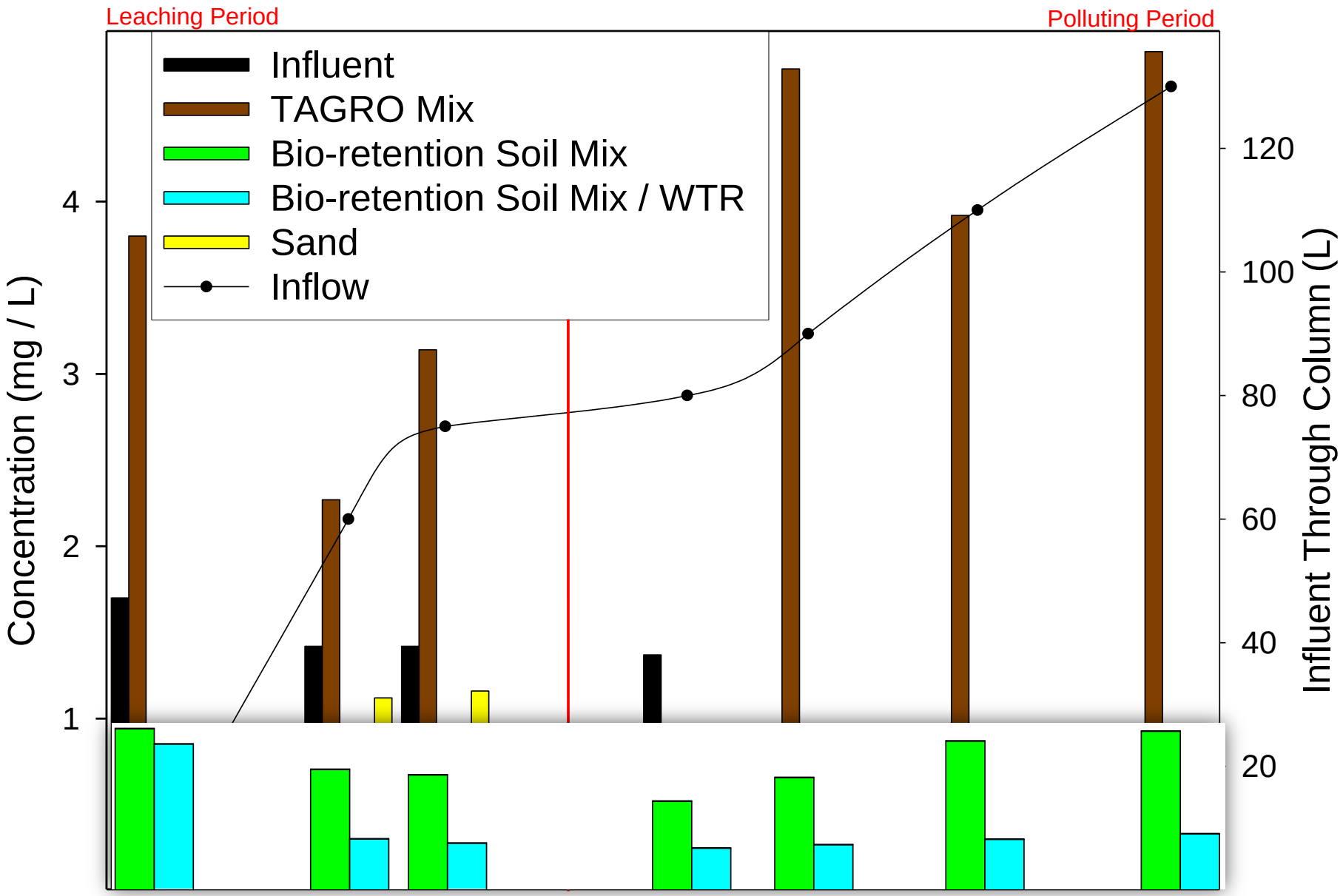
Nickel

Zinc

Ortho - Phosphorus

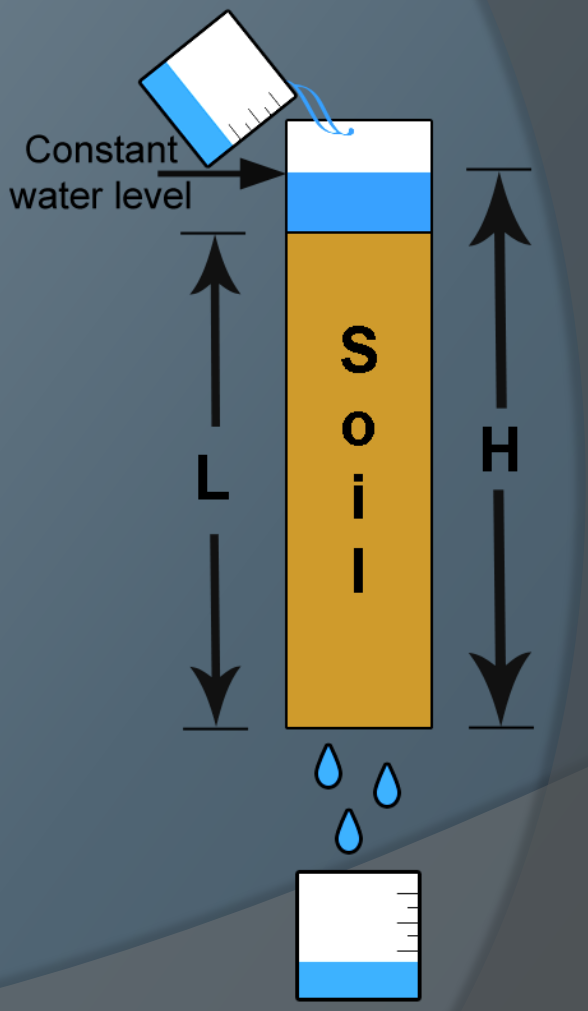
- Causes eutrophication in fresh water
- Sources of ortho - phosphorus:
  - Decomposing organic phosphorus in compost and bio-solids
  - Storm water runoff

Ortho - Phosphorus

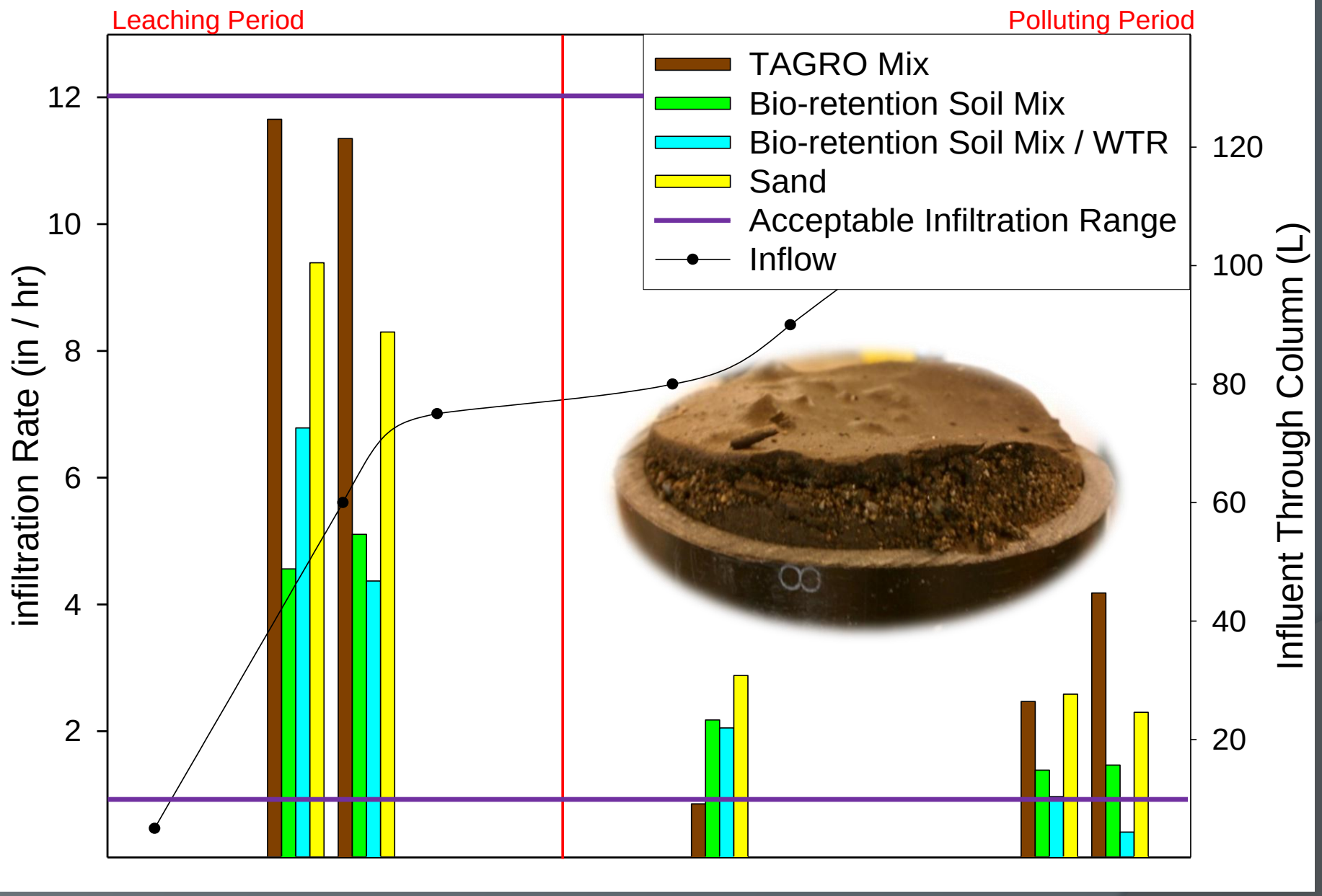


Infiltration Rates

- Can control the life span of rain-garden
- Rain-garden infiltration rates range between 12 to 1 in / hr
- Constant Head Method
  - Darcy's Law formula



Hydrologic Conductivity



Phase 1 Conclusions

Soil Amendments	Ortho - Phosphorous Removal	infiltration Rate Percent Drop (%)
Sand Only	-	76
BSM	-	67
BSM / WTR	+	94
TAGRO Mix	-	64

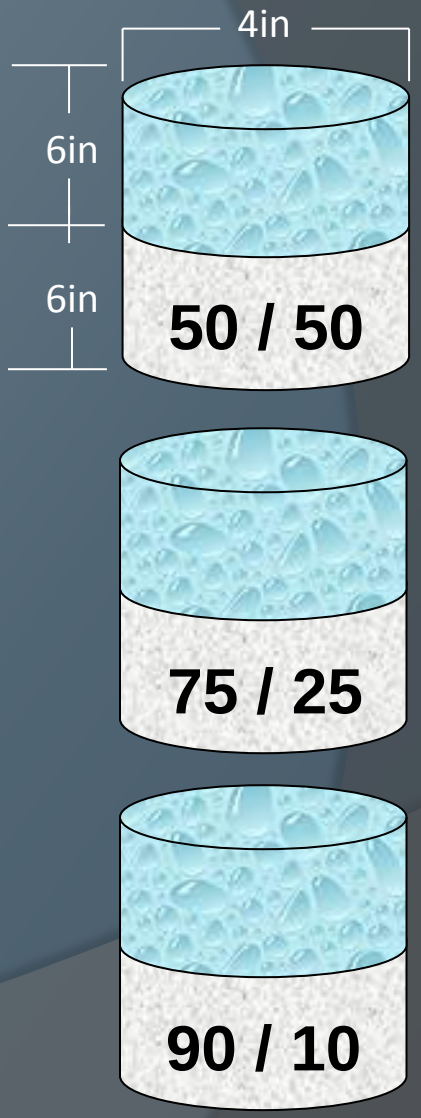
- WTR retains ≈ 50-60% of Phosphorus
- Infiltration rates slow down regardless of amendments
  - Could be controlled by fine grain particle loading

Phase 2 Phosphorus Amendment

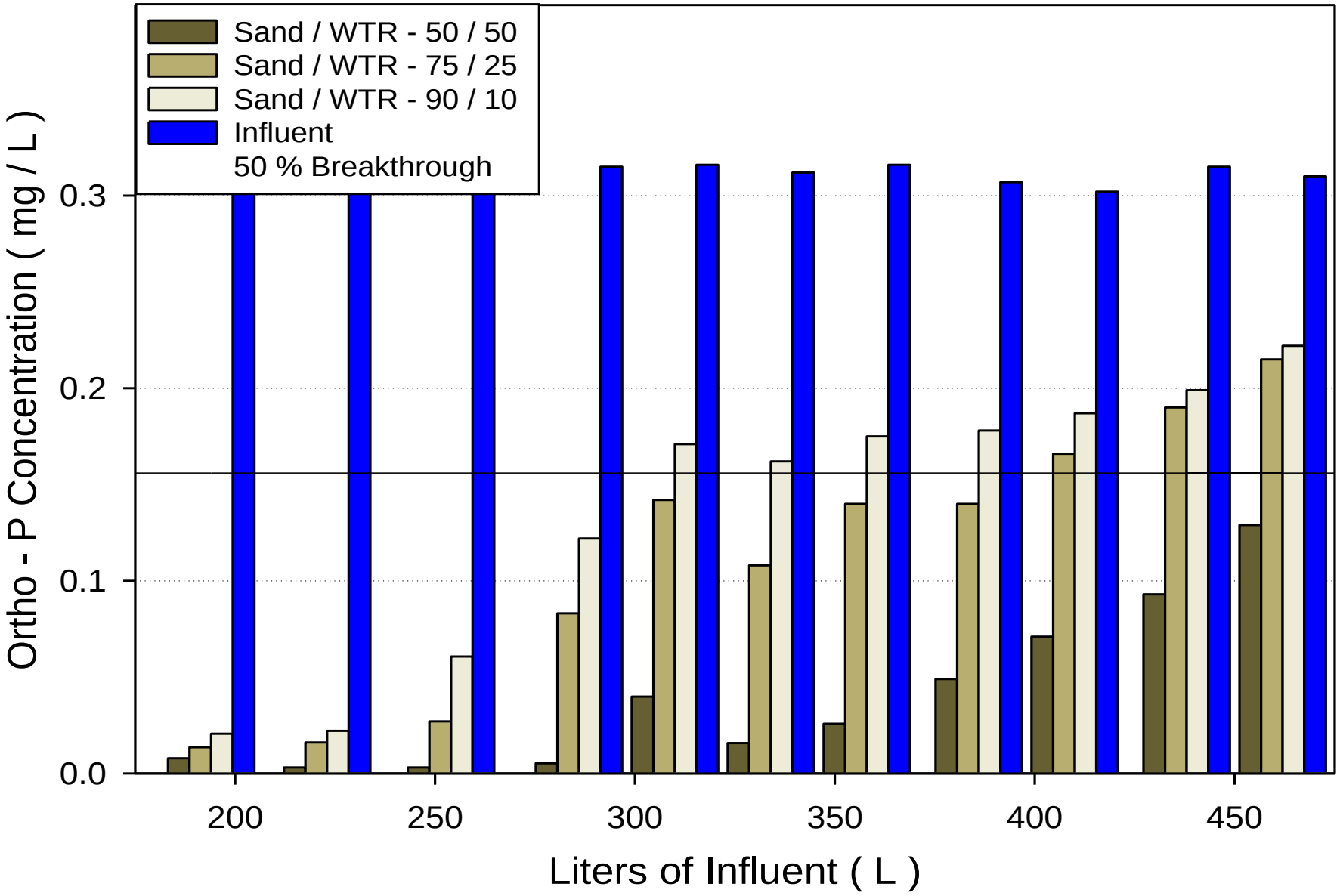
- Stratified Layers Sand / WTR
  - Will adding WTR at high volumes improve or harm rain garden function
- Sampling:
  - Ortho-Phosphorus
  - Infiltration rates

Project Design

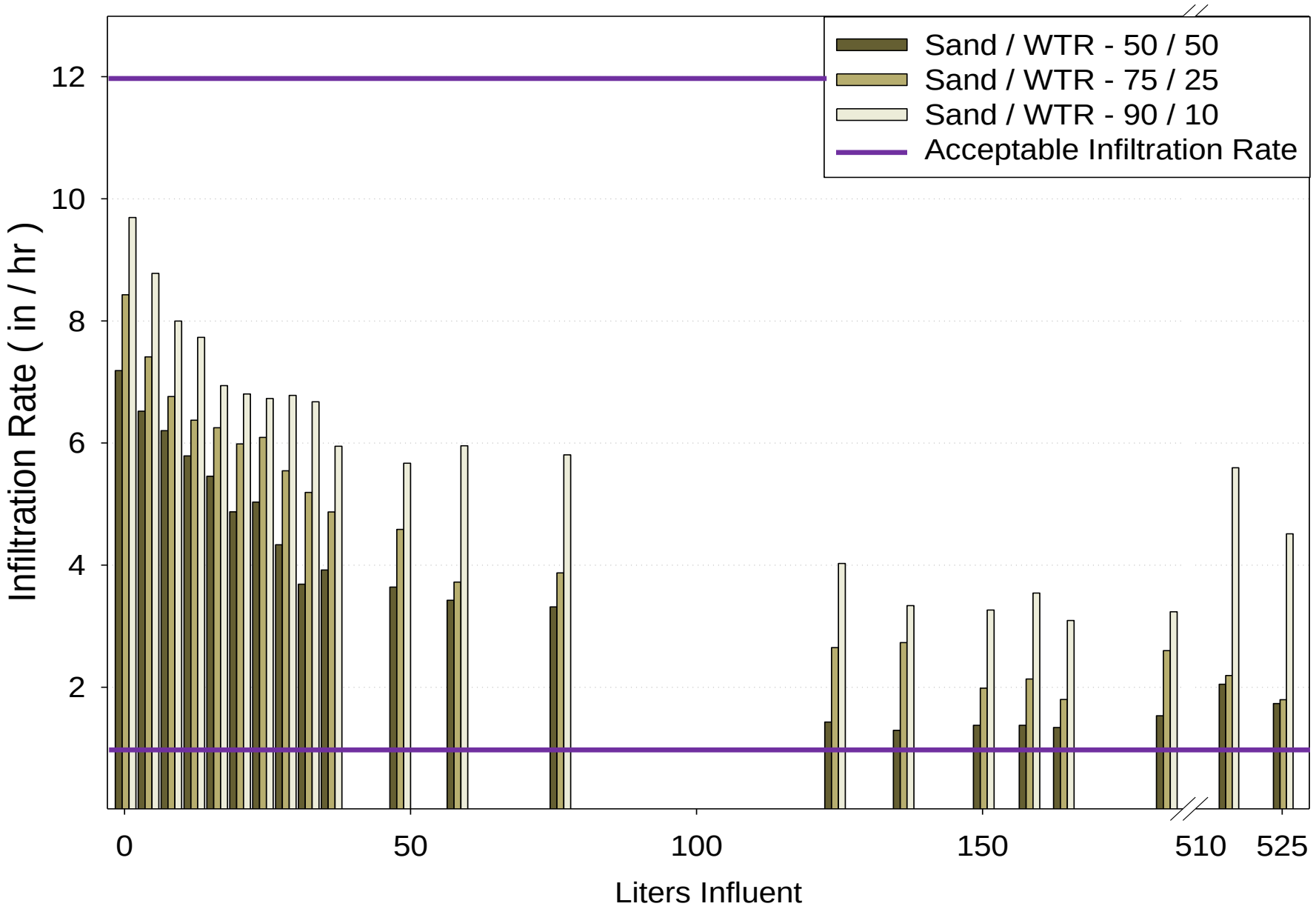
- Sand / WTR
- Influent: Synthetic storm water
  - 1 mg/L Nitrogen
  - 0.3 mg/L Phosphorus
- Loading Rate:
  - 4 Liters twice a week
- Sampling:
  - 1st Liter about every 30 Liters



Ortho - Phosphate



Hydrologic Conductivity



Phase 2 Conclusions

Sand / WTR	Ortho - Phosphorus 50 % Breakthrough	Infiltration Rate Percent Drop (%)
90/10	≈ 300 L	42
75/25	≈ 400 L	74
50/50	> 460 L	71

- Sand / WTR removes ortho – phosphorus in synthetic storm water ≈ 3 – 5 years

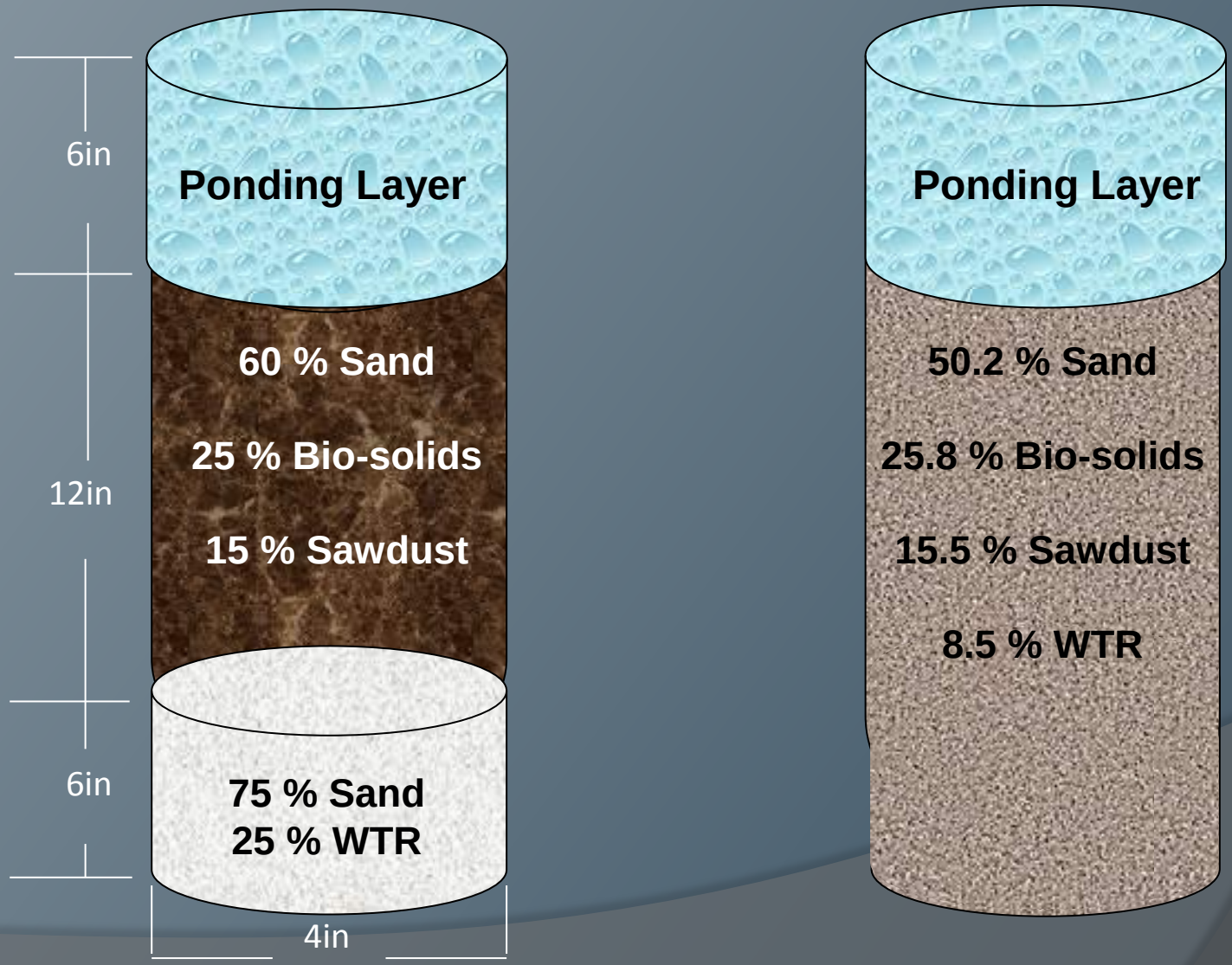
Phase 3 TAGRO / WTR mixes as Alternative to BSM

- Combine Phase 1 & 2 research
  - Balance phosphorus retention Vs. infiltration rates
- Building new rain garden design
  - Stratified WTR Layers vs. Mixed Throughout

Problems

- TAGRO and compost leach nutrients
  - Nitrogen and Phosphorus
- Storm Water Management Manual WWA DOES NOT allow Bio-Solids in BSM

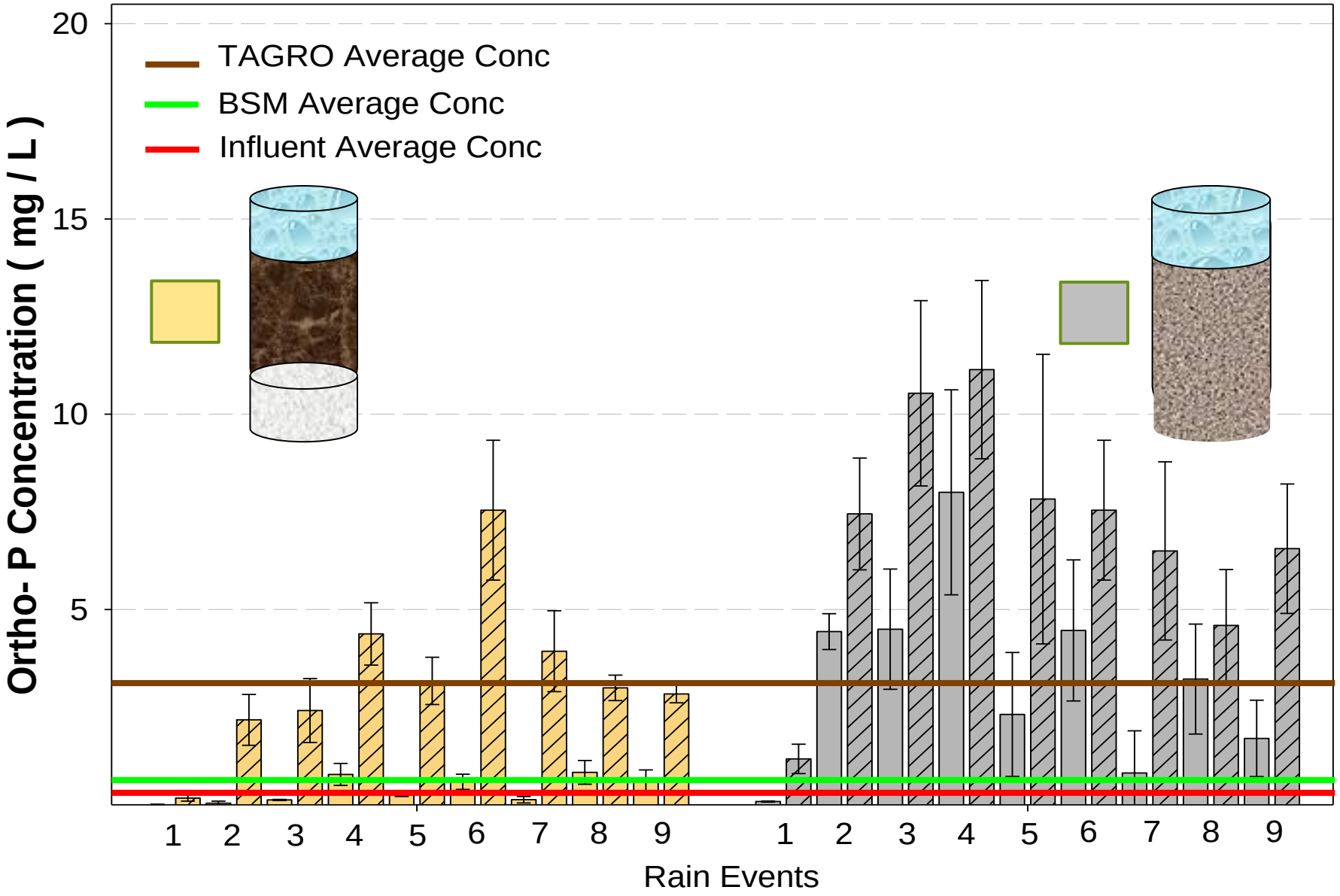
Stratified Layers Vs. WTR Mixed Throughout



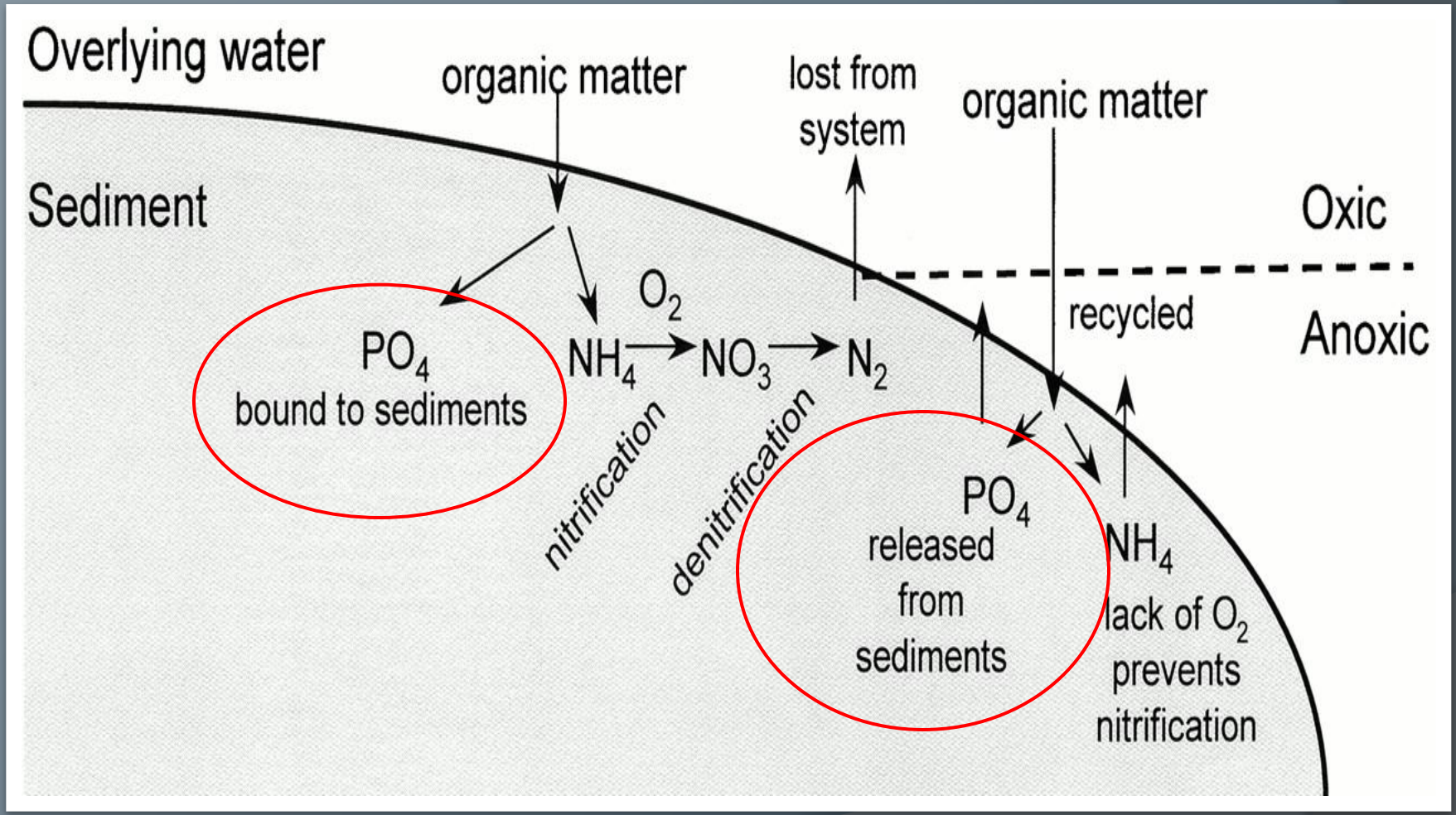
Methods

- Treatments run in triplicate
- Influent:
  - Synthetic storm water
    - 1 mg/L Nitrogen
    - 0.3 mg/L Phosphorus
- Loading Rate:
  - 8 Liters / rain event
  - 2 times / week
- Sampling:
  - 1st Liter & 2-8 Liter composite

WTR Stratified or Mixed

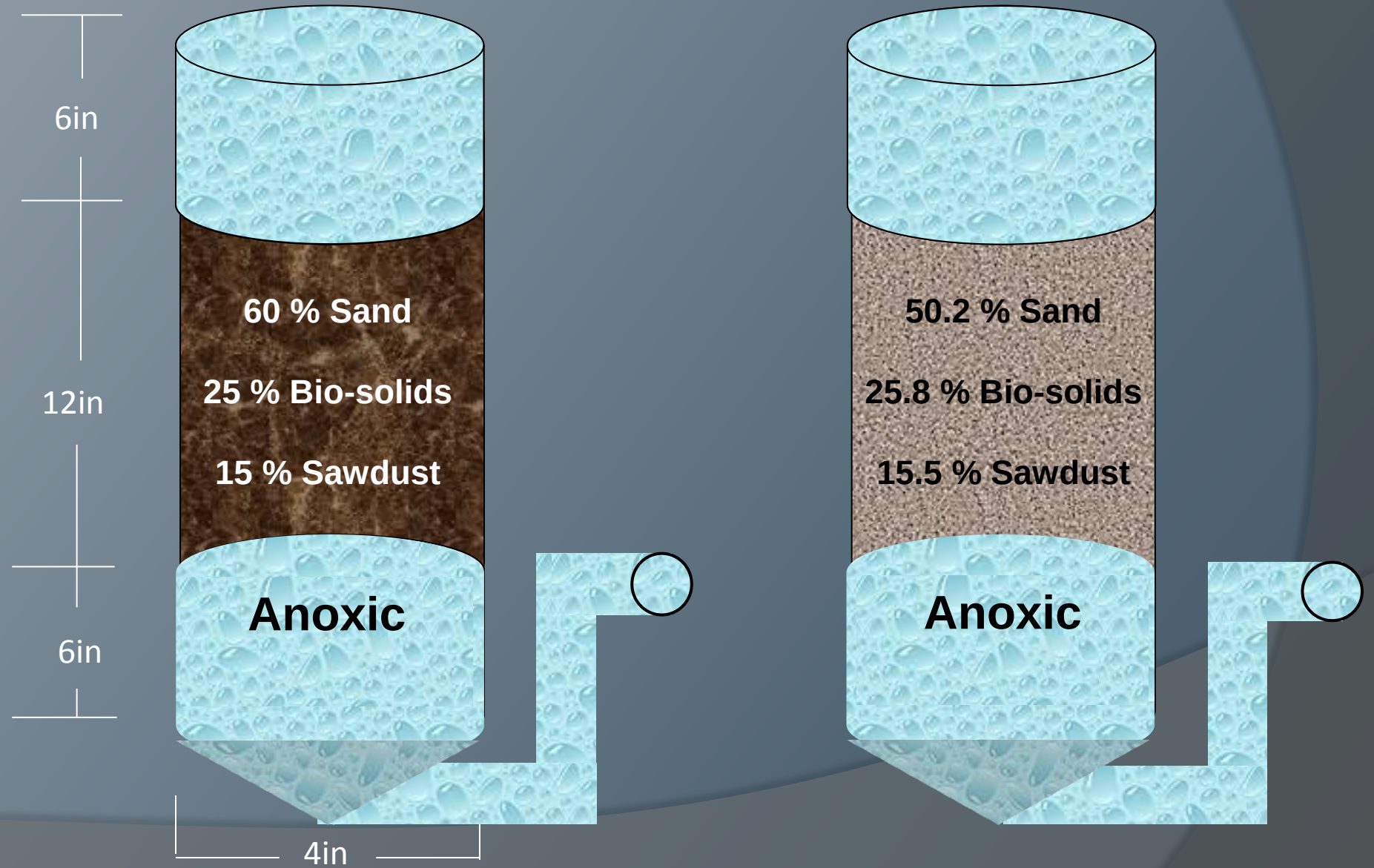


Phosphorus Release

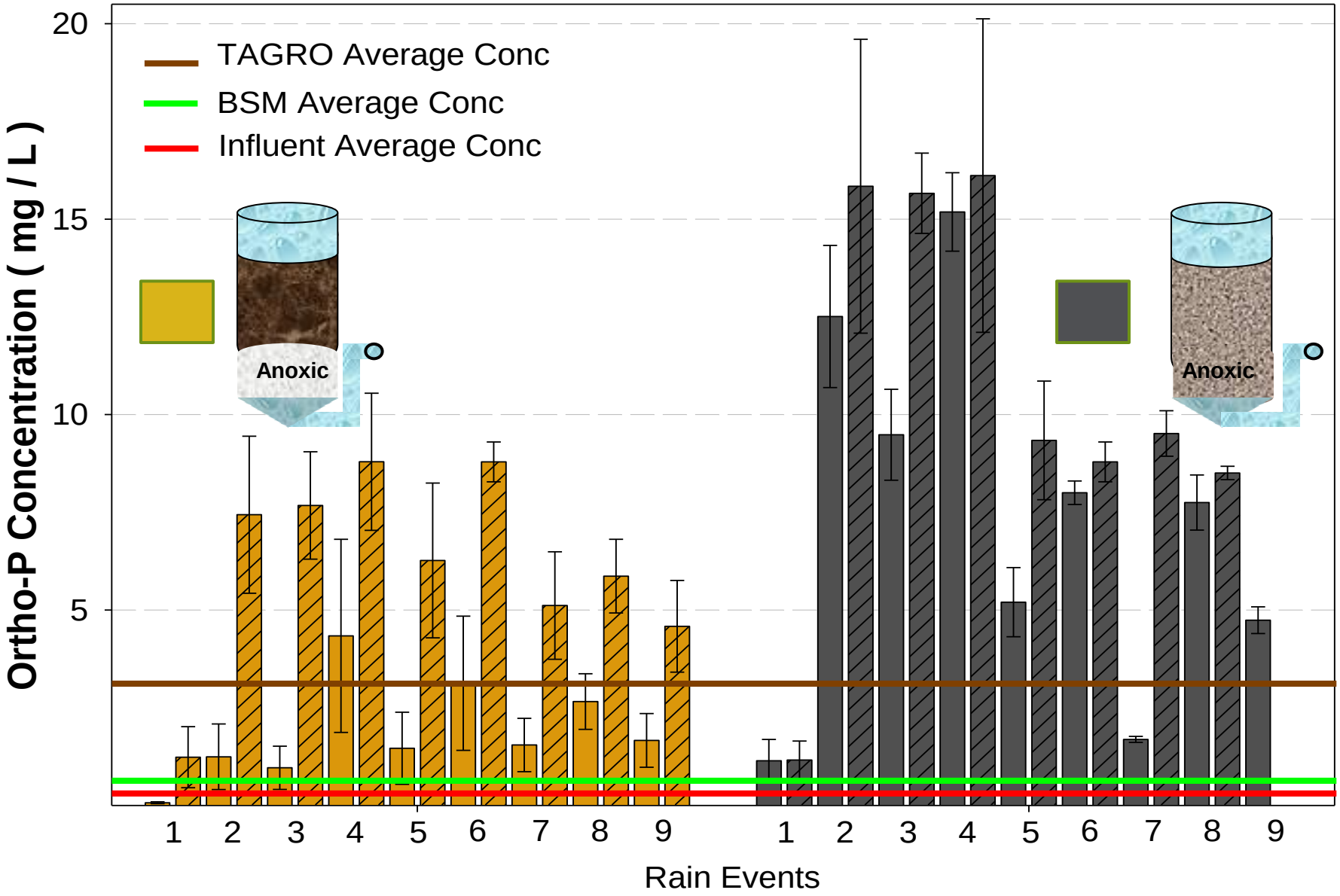


(soils.org)

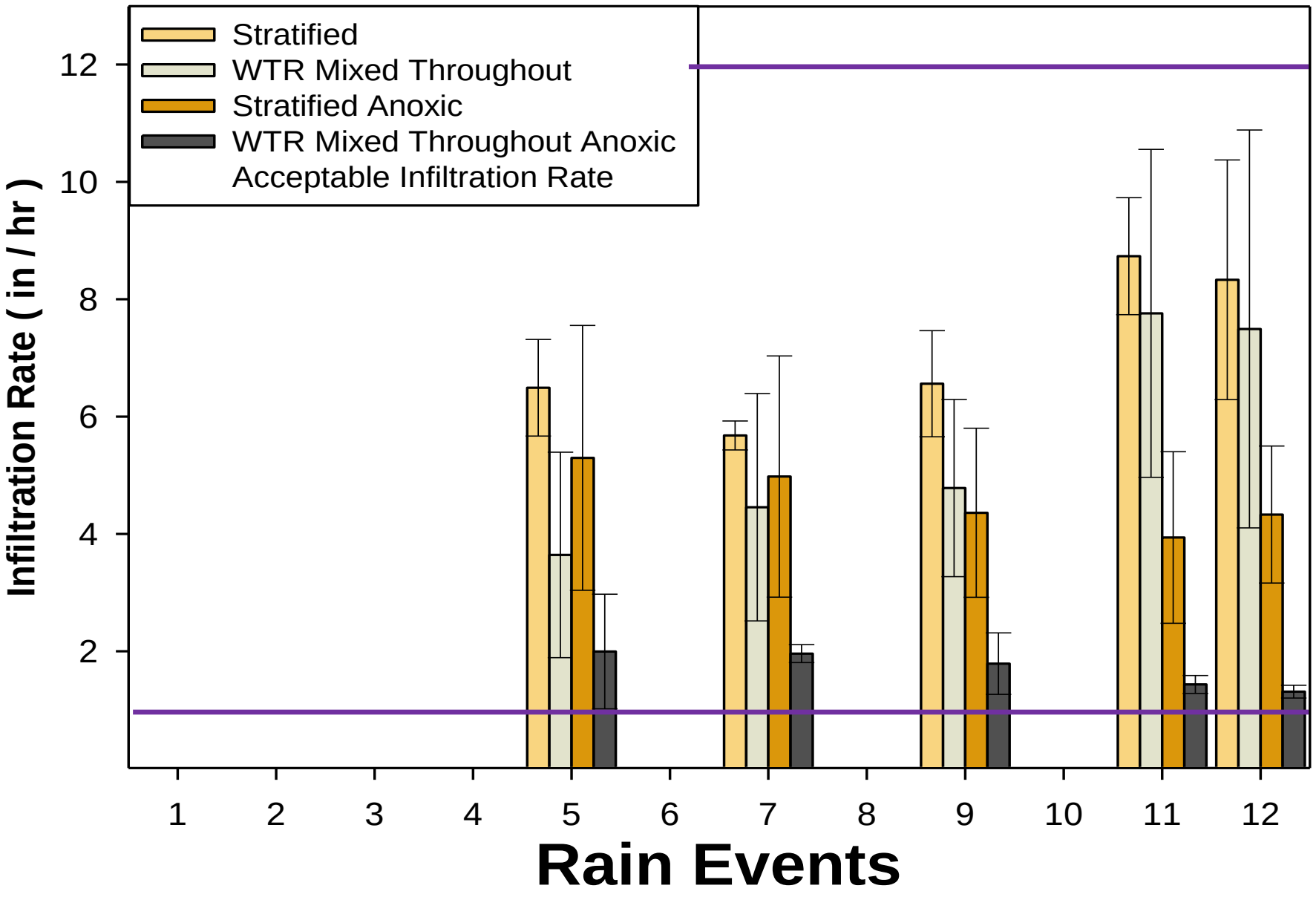
Phosphorus in Anoxic Conditions



Saturated Anoxic Layer



TAGRO Hydrologic Conductivity



Conclusion

- WTR may decrease phosphorus in run-off for 3-5 years of storm events
- WTR works better in layers than mixed throughout
- WTR should remain out of anoxic zone
- TAGRO mix may be viable alternative for BSM in tandem with WTR

(westseattleblog.com)

Future Studies