Overview of Bioretention System Performance Criteria and a Bioretention-Gravel Wetland Hybrid to Optimize Nutrient Removal

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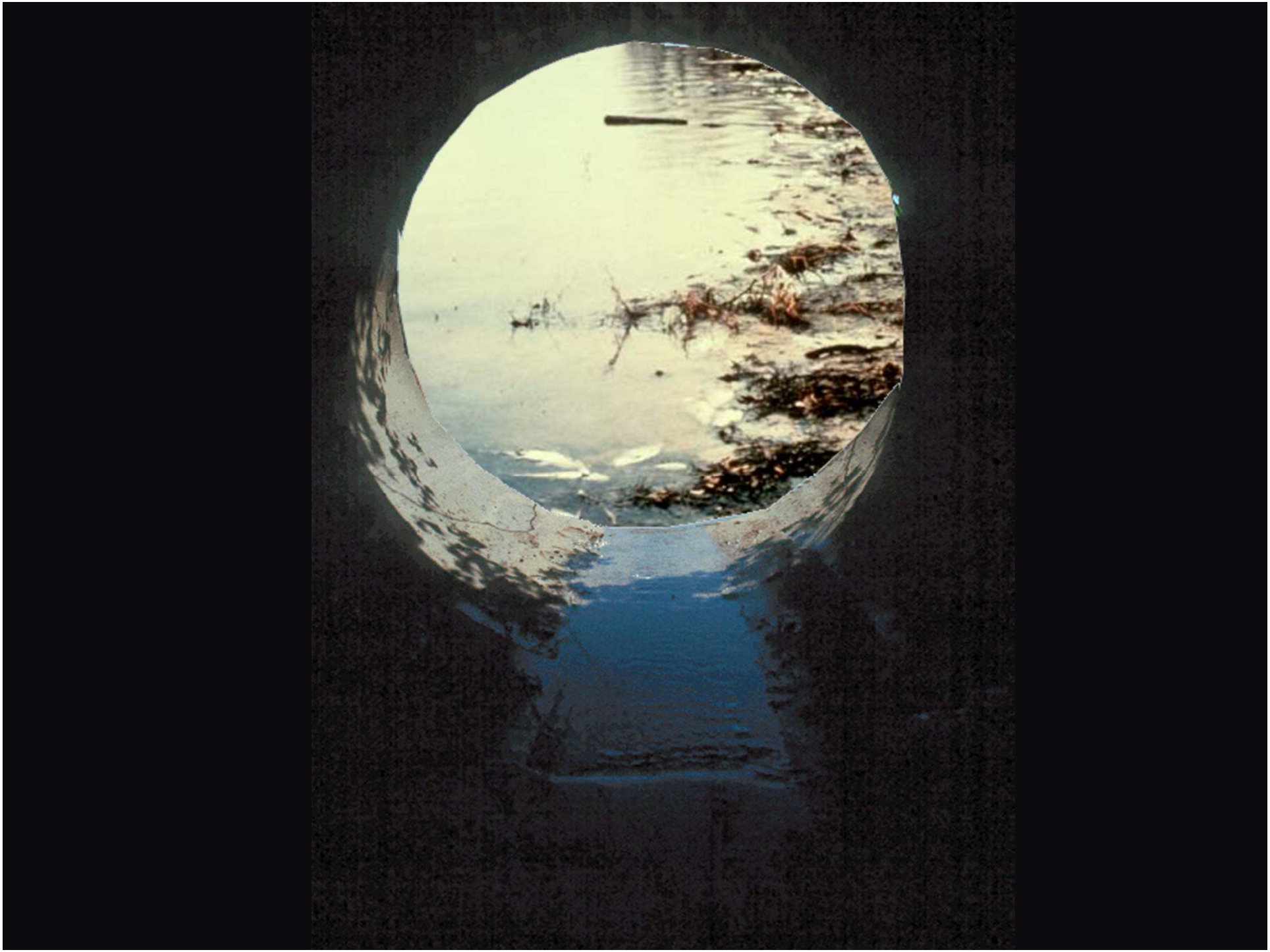
East Coast Excavating



In the News…..

Thursday, July 31, 2008

New regs may drown taxpayers

EPA told cost key issue in storm-water plan

By Thomas Caywood TELEGRAM & GAZETTE STAFF
Add a comment

WORCESTER — City officials talked tough and took a few sharp jabs at the U.S. Environmental Protection Agency yesterday morning at a public hearing on proposed steps to curb pollution flowing into area bodies of water from city storm drains.

The city maintains the EPA's proposed regulations, developed in conjunction with the Massachusetts Department of Environmental Protection, would cost a fortune to implement and force steep water and sewer rate hikes for residents and businesses.

March 13, 2012, 1:46 PM

A Greener Strategy for New York's Runaway Sewage

By MREYA NAVARRO

Department of Environmental Protection

A green roof in Long Island City, Queens helps keep storm water out of the sewage system.

Politics & Policy

New York State and city officials announced Tuesday that they had wrapped up an agreement under which the city would commit more than $2 billion in public and private investment to new environmental techniques to help prevent the flow of untreated sewage and storm water into city waterways when it rains.

What is difference between these outcomes?

Negotiated plans using Green Infrastructure to reduce reliance on Gray Infrastructure

Line in sand drawn over wastewater

By Charles McMahon

PORTSMOUTH — City officials on Friday criticized state and federal environmental regulators over a perceived "lack of sincere effort" in working with local communities on wastewater treatment testing.

Criticism of both the state Department of Environmental Services and U.S. Environmental Protection Agency can be found in a memorandum that City Manager John Bohenko released to the City Council in advance of their meeting Monday night.

In the memorandum, Bohenko asks the City Council to authorize him to continue working with local communities belonging to the Great Bay Coalition to ensure regulators follow state law when it comes to setting permit limits for nitrogen.

Clean Waters

Program Summary

Amended by the Philadelphia Water Department
June 1, 2011

Green Infrastructure and Low Impact Development

Modeling designs after natural systems

Design and Performance

- There is a tremendous amount of variety within design specifications and resulting performance that is not well understood
- Bioretention systems vary widely with respect to design features
- We surveyed over 175 systems in the literature, from a range of databases

Design Features and Specifications

- Drainage Area
- Surface Area to Drainage Area Ratio(1:##)
- % Impervious
- Land Use
- Watershed Cover Type
- Avg Depth of Precip
- Avg Annual Precip.
- Avg Annual Daytime Temp
- % Sand
- % Compost
- % Amendment
- Amendment Type
- % Fines (<22 micron)
- P-index (Mehlich 3)
- Soil pH
- % Organic Matter
- CEC
- Underdrain
- Internal Storage Reservoir
- Design Media Thickness
- Design Infiltration Rates
- Slope
- Ponding Depth
- Drawdown Time (hours)
- Sizing (flow control or WQ)
- Methodology (static, dynamic)
- Pretreatment
- Online/Offline System
- Season
- Age of System
- Actual Infiltration Rates
- Hydraulic Residence Time
- Compost Quality
- Vegetation Cover (grass, flowers, species type)
- Maintenance
- Volume Treated (cu ft/in of rain)
- Flow Range

WHY DO WE CARE?

- System performance determines the degree and intensity of usage of a technology, and influence the cost of implementation
- Municipalities will be developing implementation plans for managing nutrients
- Improvements in performance could result in reduced cost of implementation

WHAT WAS DONE?

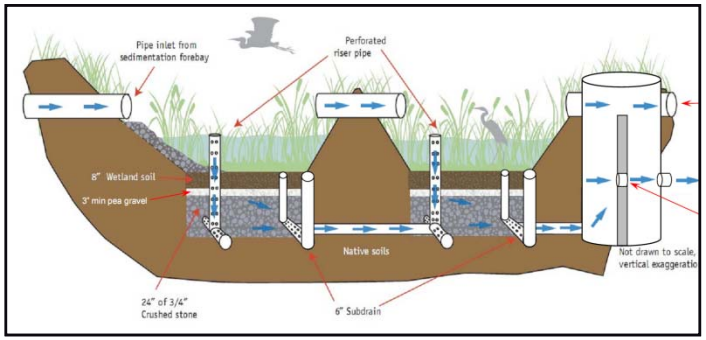
- Filter media composition can be optimized for phosphorus removal.
- Structural configuration optimized for nitrogen removal.

PROJECT OBJECTIVES

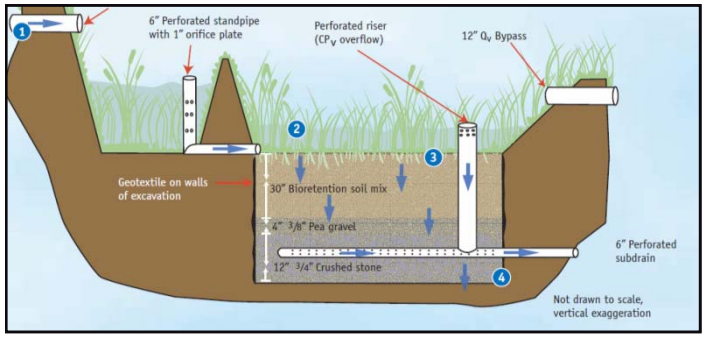
- Determine optimal BSM composition within lab
- Implement BSM composition based on laboratory results for P-removal
- Determine whether the lab model accurately predict field performance
- Examine structural configuration for N removal.
- Compare 2 variations of internal storage reservoir.
- Assess ISR for development of anaerobic conditions and hydraulic residence time

Hybrid System Background

Gravel Wetlands

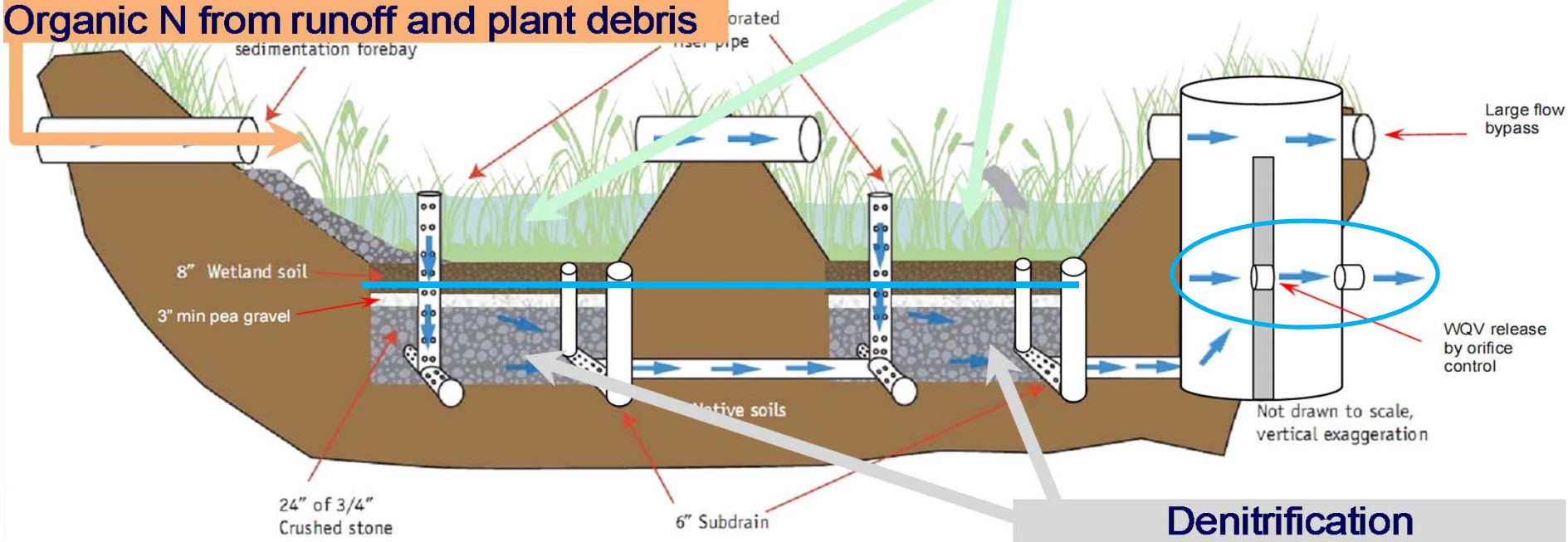


Bioretention



Nitrification
$NH_4 \rightarrow N0_2 \rightarrow NO_3$
Aerobic Zone
Forebay and surface of wetland

Influent
Organic N from runoff and plant debris



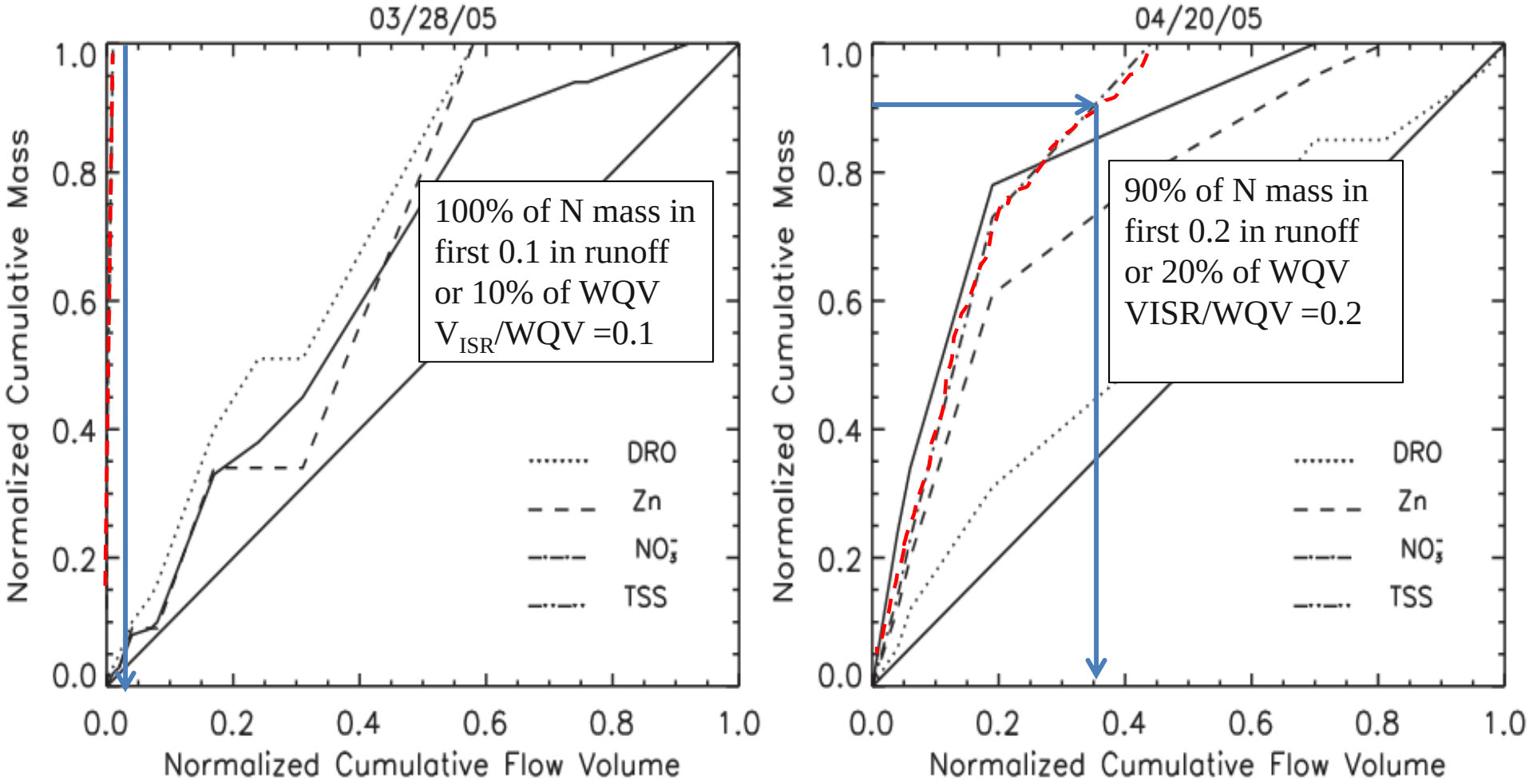
Denitrification
$\rightarrow N_2$ (gas)

Anaerobic Zone
Subsurface gravel

V_{ISR}=Volume of resident water in internal storage reservoir

WQV = water quality volume

V_{ISR}/WQV =0.26



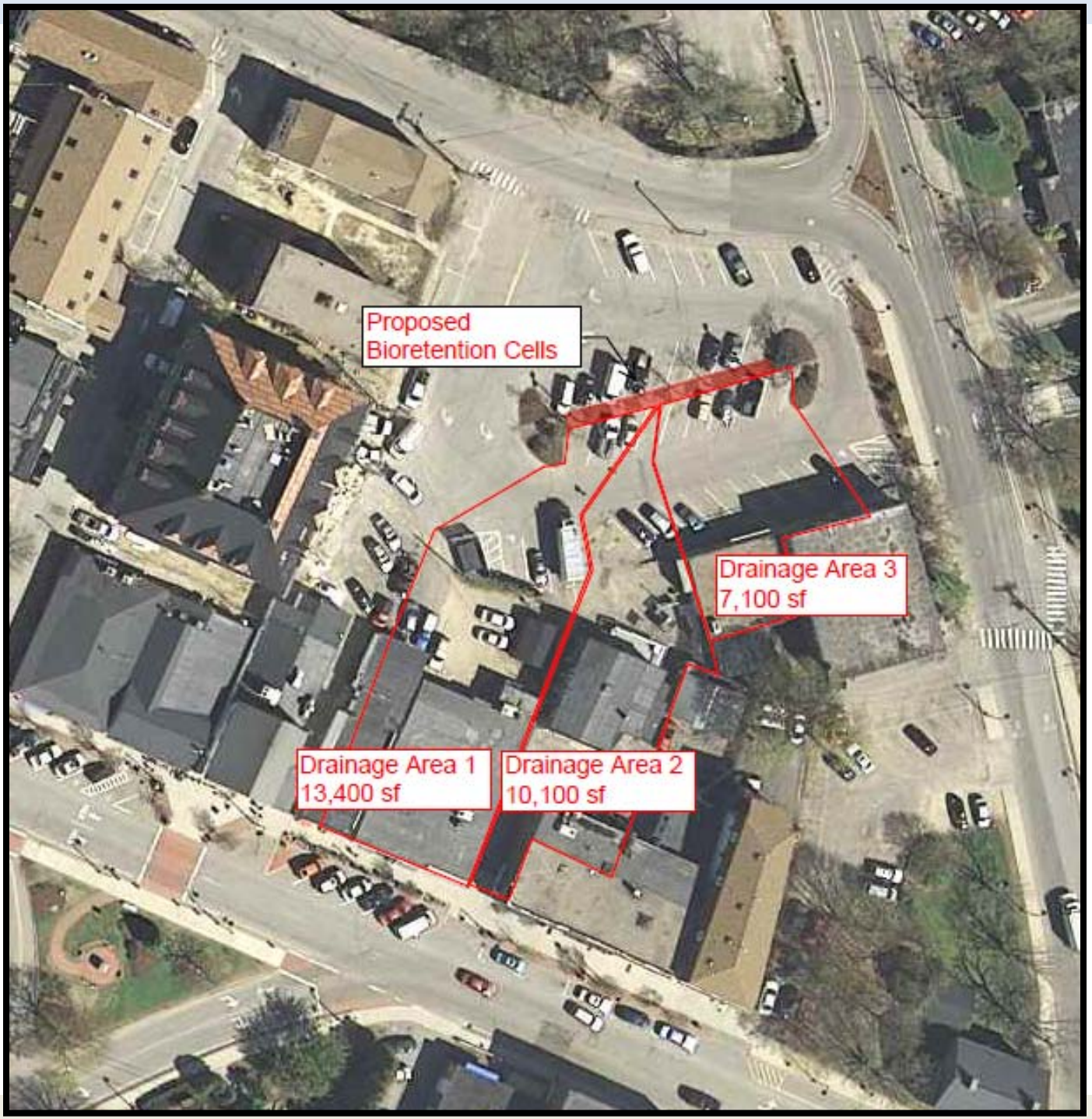
Mass loading for DRO, Zn, NO3, TSS as a function of normalized storm volume for two storms: (a) a large 2.3 in rainfall over 1685 minutes; (b) a smaller 0.6 in storm depth over 490 minute. DRO=diesel range organics, Zn= zinc, NO3= nitrate, TSS= total

- 50% of storms are less than 0.17 inches in depth,
- 75% are less than 0.45 inches in depth
- 92% are less than 1inch in depth

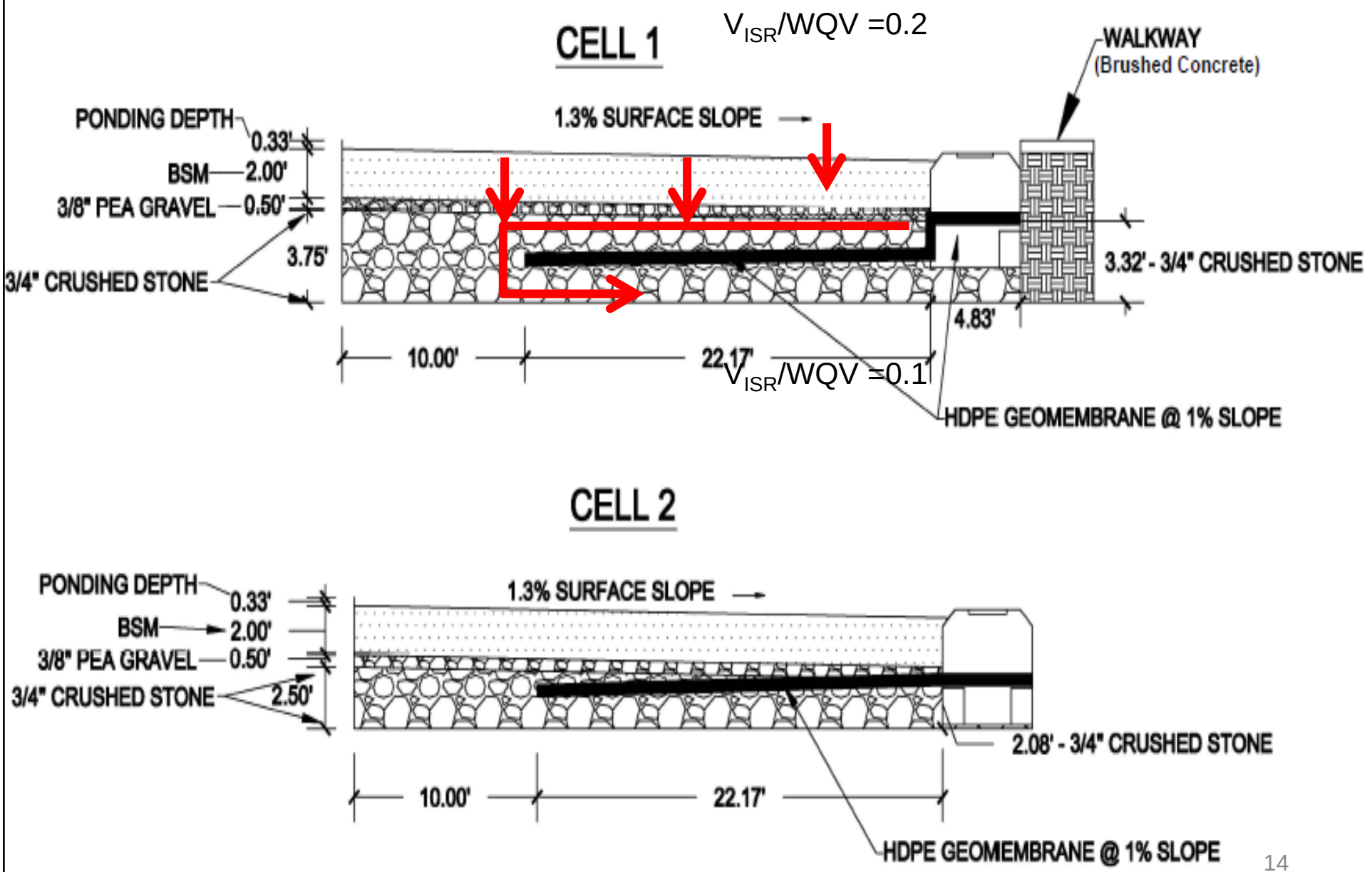
Drainage Areas

Distribution:

- Cell 1 13,400ft^2
- Cell 2 17,200ft^2

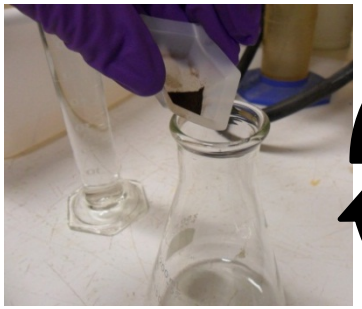


System Layout

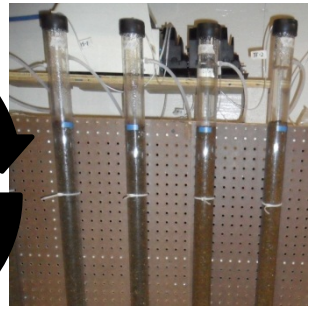


EXPERIMENTAL DESIGN

Component Characterization



Component Isotherms



BSM Column Study

Model Development

Field Installation

Model Validation

LAB METHODS: COLUMN STUDIES

- 8 columns – 4 mixes with duplicates

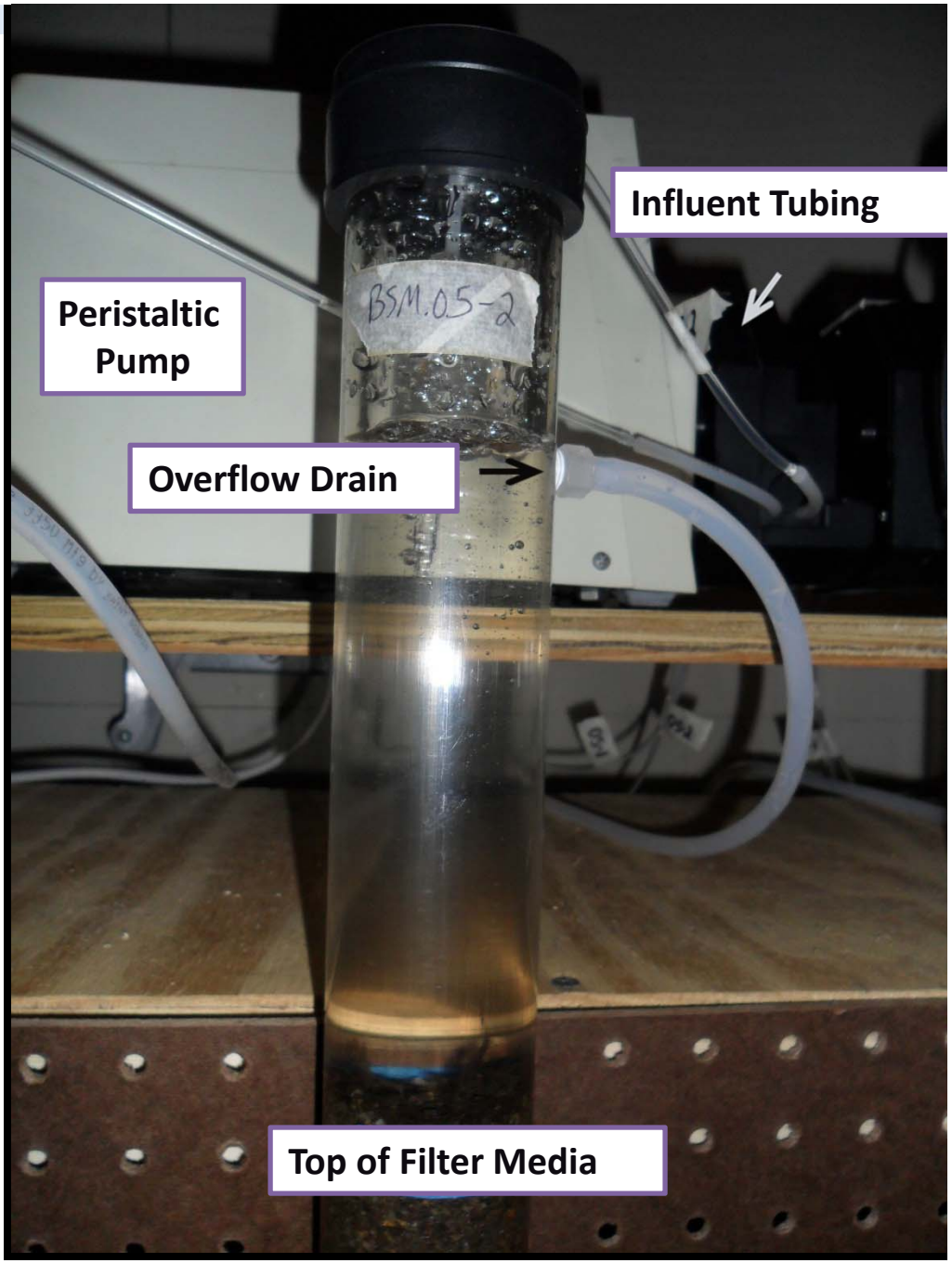


Fig 6: Mix Composition by Volume

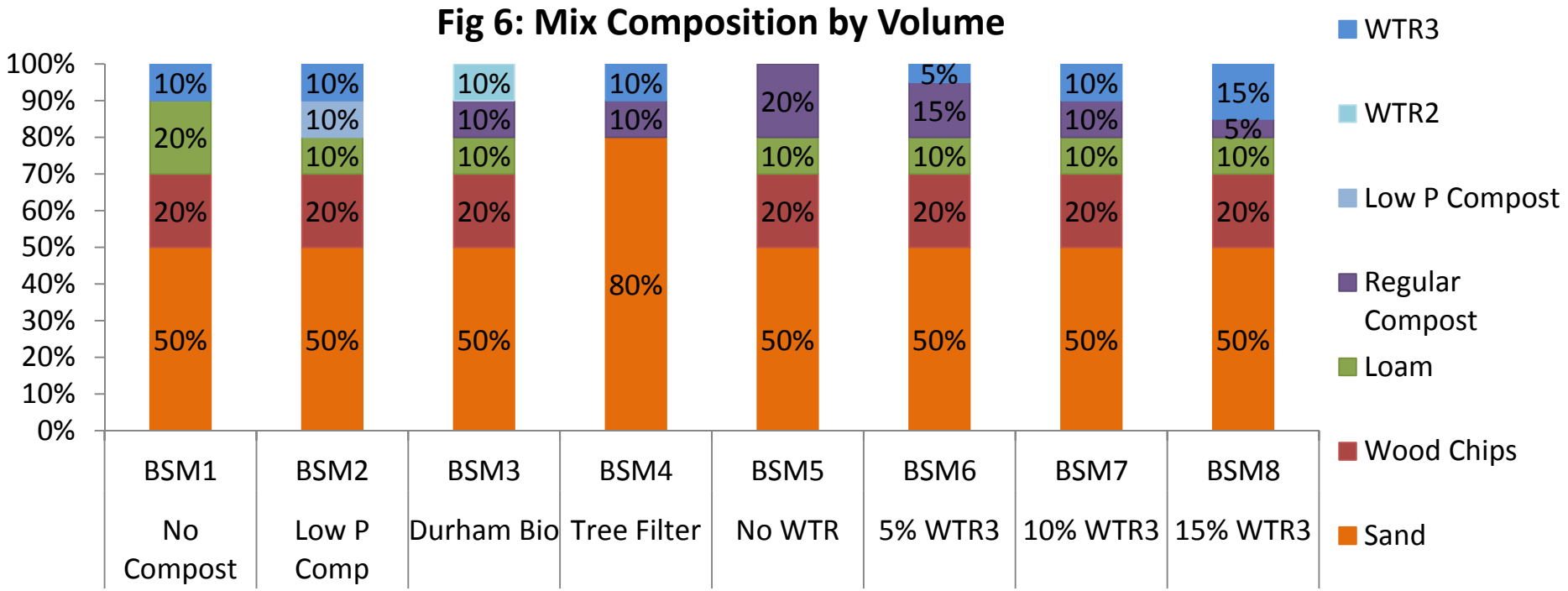
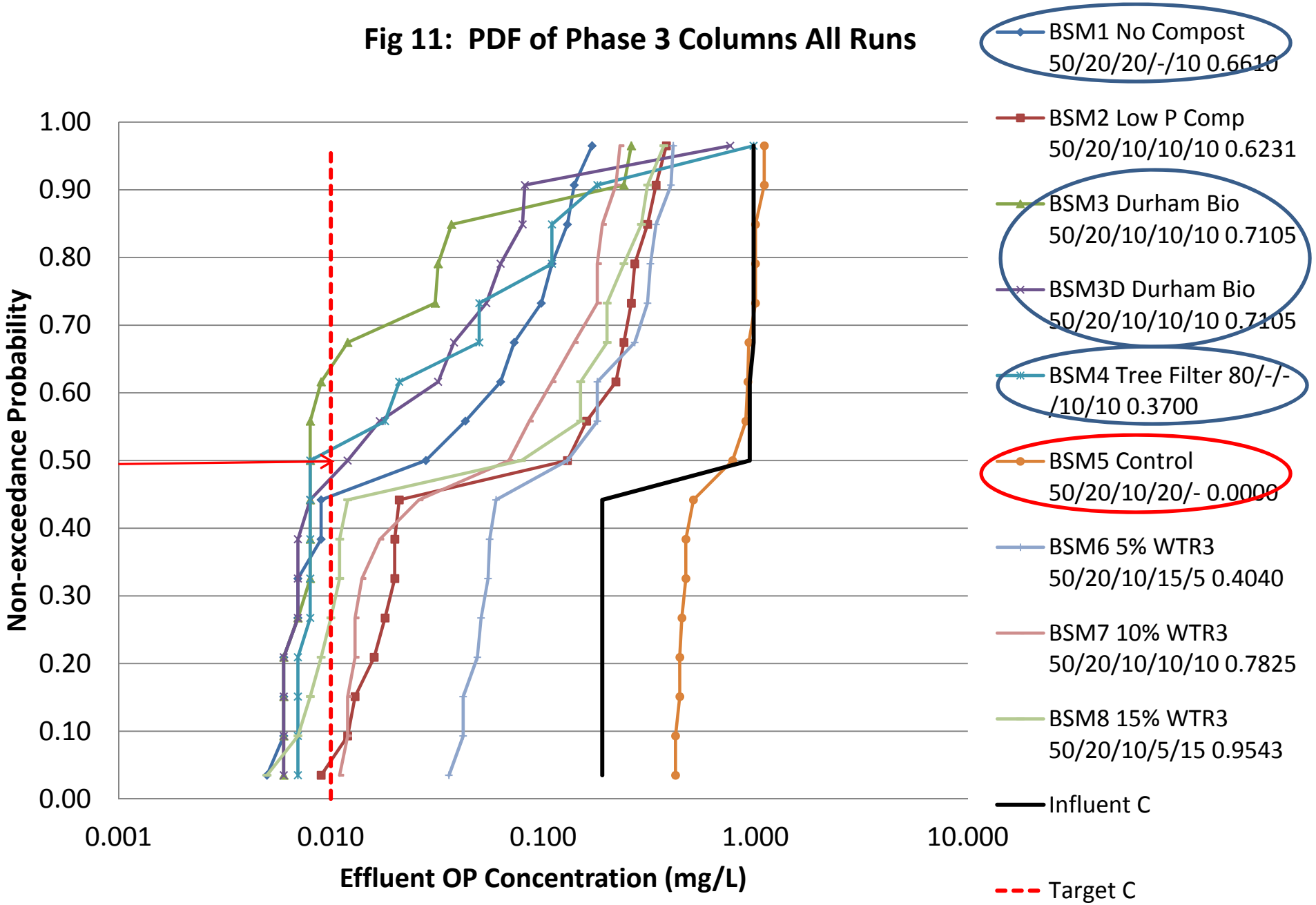


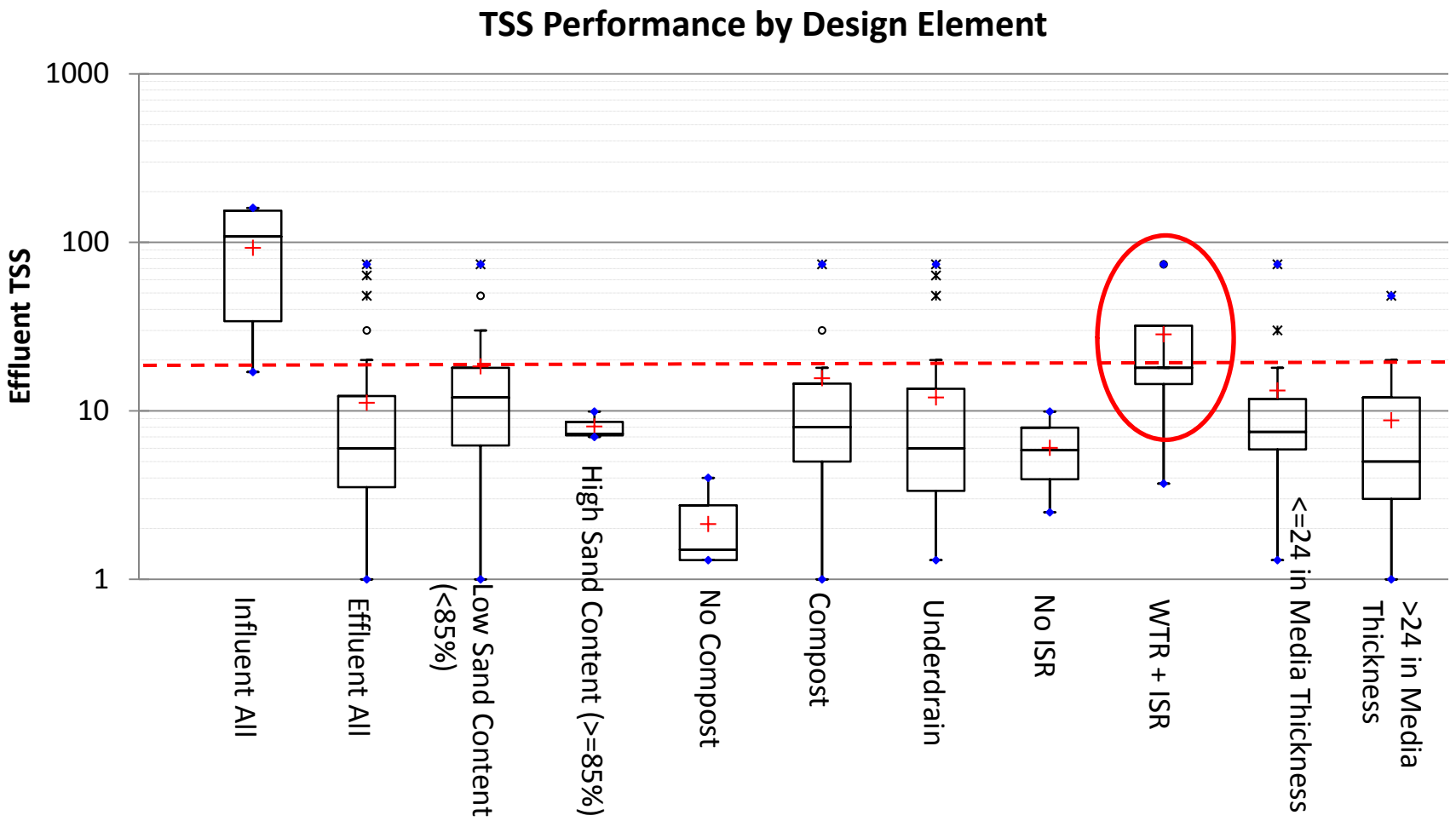
Fig 7: Mix Composition by Dry Mass

Fig 11: PDF of Phase 3 Columns All Runs

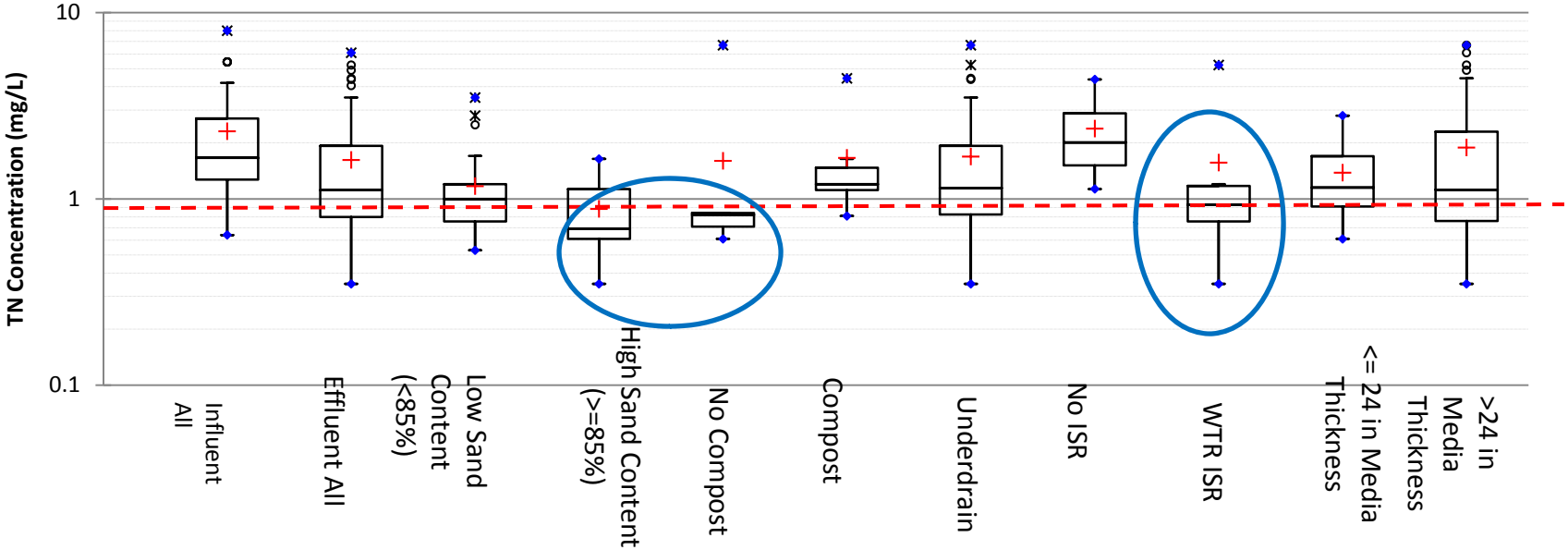


FIELD RESULTS AND NATIONAL STUDY COMPARISONS

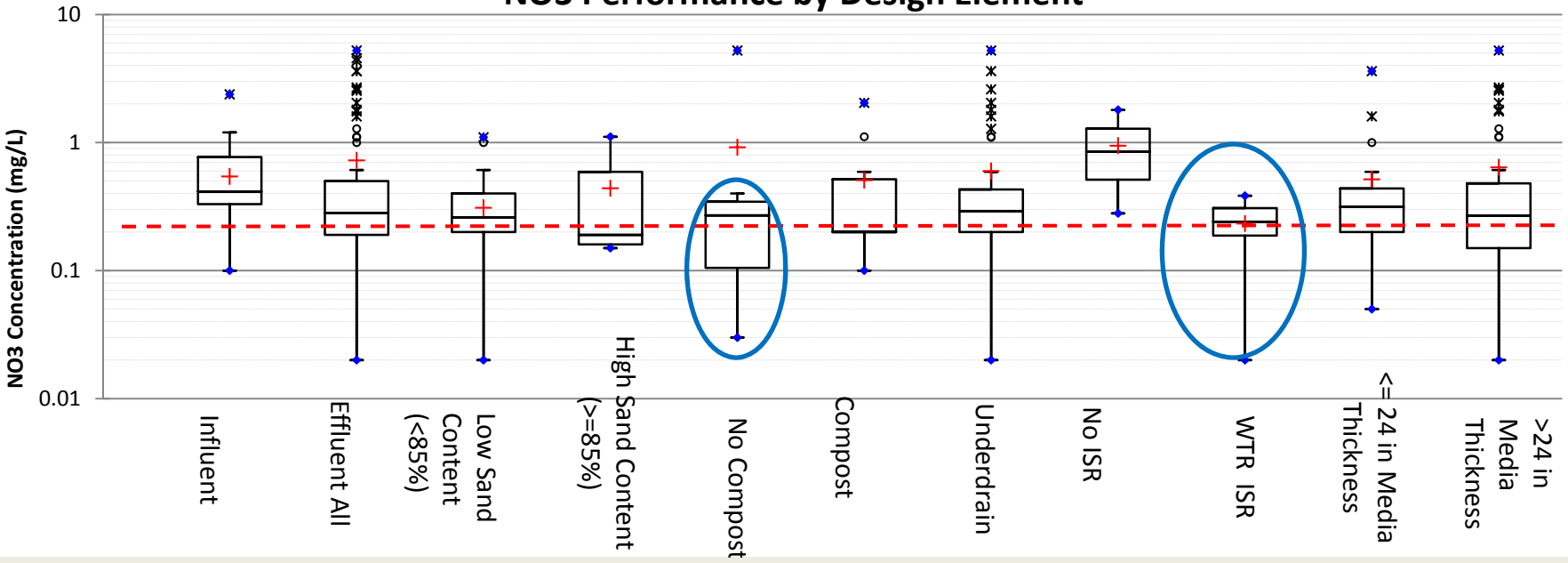
National Bioretention System Performance

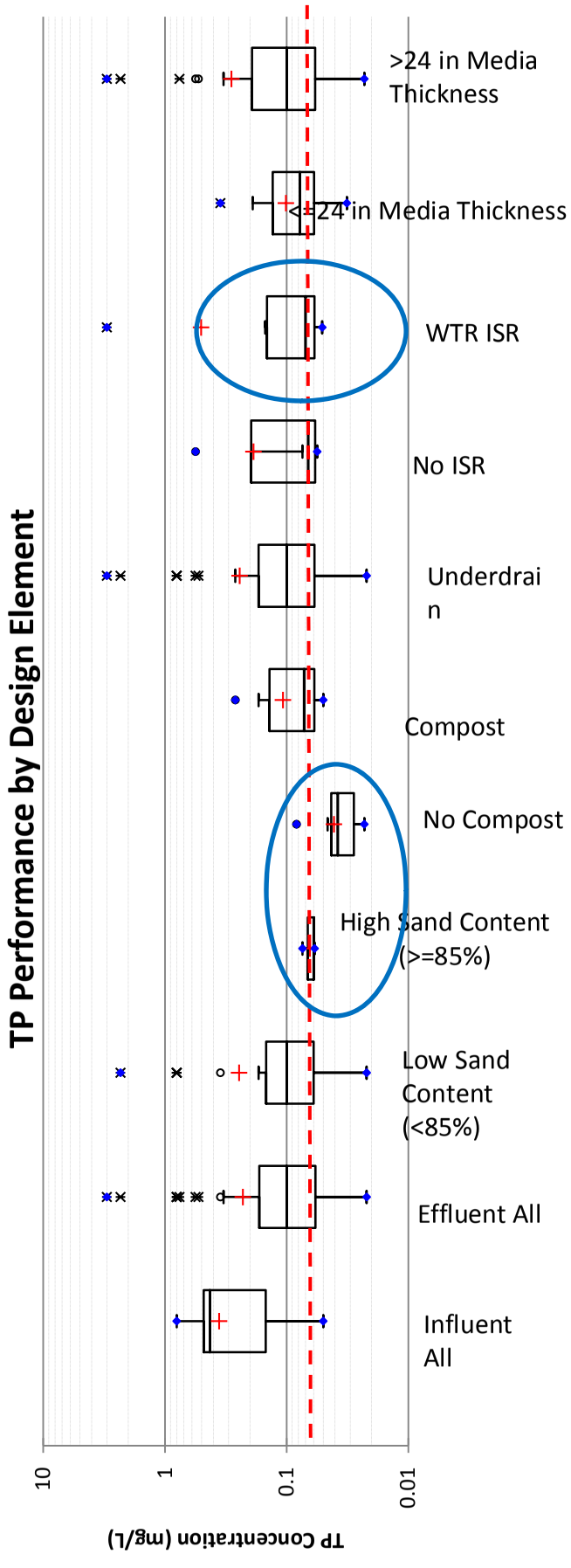


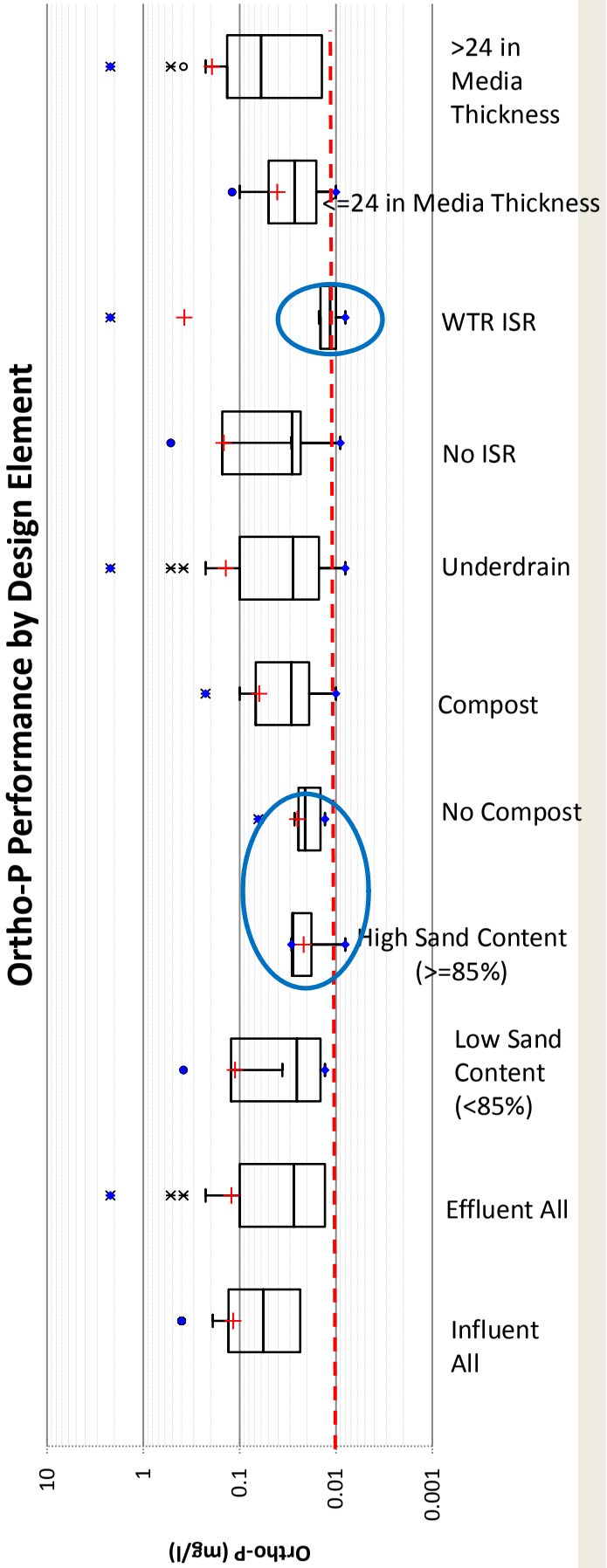
TN Performance by Design Element



NO3 Performance by Design Element




TP Performance by Design Element
>24 in Media Thickness
<=24 in Media Thickness
WTR ISR
No ISR
Underdrai n
Compost
No Compost
High Sand Content (>=85%)
Low Sand Content (<85%)
Effluent All
Influent All
10
1
0.1
0.01
TP Concentration (mg/L)


Ortho-P Performance by Design Element
>24 in Media Thickness
<=24 in Media Thickness
WTR ISR
No ISR
Underdrain
Compost
No Compost
High Sand Content (>=85%)
Low Sand Content (<85%)
Effluent All
Influent All
10
1
0.1
0.01
0.001
Ortho-P (mg/l)

Conclusions and Next Steps

- All bioretention systems are not equal
- Loam has tremendous P-sorption capacity
- Compost appears to be problematic
- Quality of WTR varies substantially
- More detailed monitoring of new system is needed, especially Cell 1
- Construction cost are modest increase, tripled the cost of crushed stone
- However, that was <5% of the total construction cost
  - Bioretention system with ISR = $24,800
  - Bioretention system without ISR = $23,800
- Quality controls should be considered for BSM production
- Careful specification of BSM design is important

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Questions?

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