Bioretention Studies Searching for Possible Engineered Soil Mixes to Improve 1004 Technical Standard

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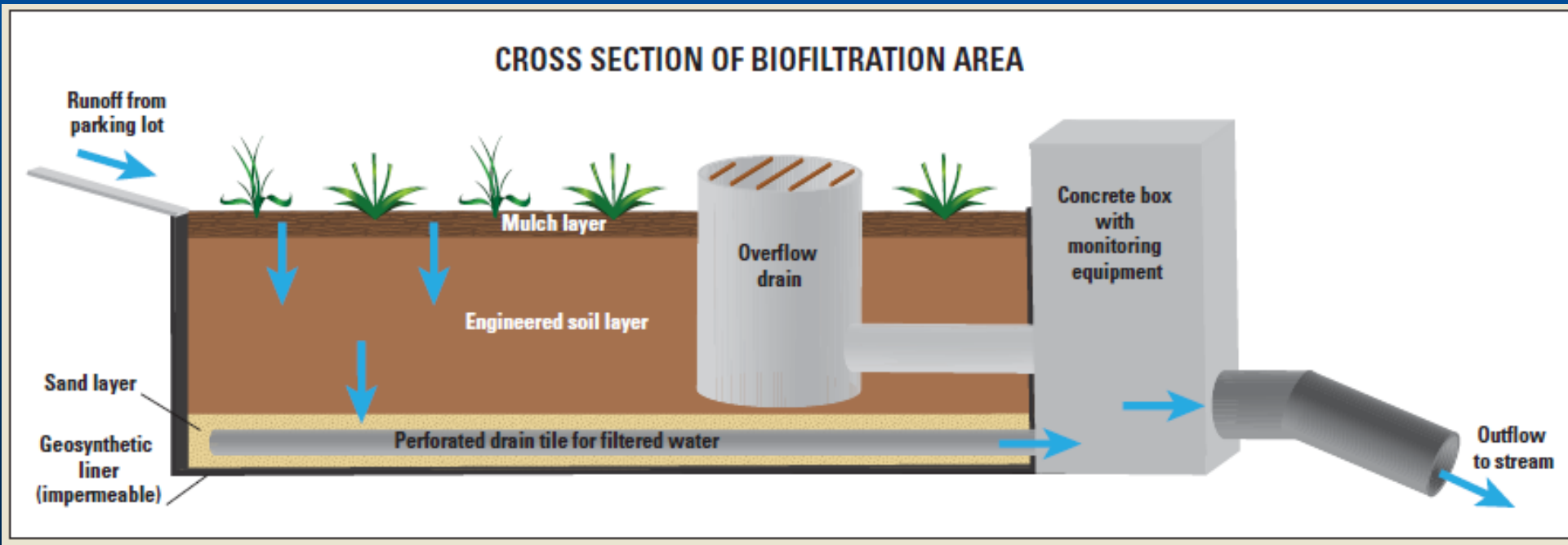
We Are Going Evaluate a Number of Engineered Soil Mixes for Wisconsin's Bioretention Technical Standard 1004

1. ***Bioretention Studies***
2. ***TSS Reduction***
3. ***Phosphorus Reduction***
4. ***WinSLAMM Modeling***



Neenah Parking Lots

2009-2011
2011-2013

Three Cell
(1,2,3 ft depth)

Mix-1
50% Concrete Sand
50% Compost

Mix-2 (UWS&PL)
86% Sand
11% Peat Moss
3% SorbtiveMedia

Middleton Parking Lot

2012-2014
2014-2016

One Cell
(3 and 2 ft depth)

Mix-3 (NCSU)
87% Sand
8% Fines
5% Bark

Mix-4
100% Sand

Waukesha Highway Median

2014-2016

Two Swales
(2 ft depth)

Mix-5
75% Sand
25% Compost

Mix-6
Six Inch Growth Over
18 I*nches* Sand

Neenah Parking Lots

Cell Ratio
Cell-1 30:1
Cell-2 62:1
Cell-3 53:1

#Rainfall Events
Mix-1 123
Mix-2 116

No Infiltration

Volumes & Overflows

Water-Quality
TSS, PSD, TP, DP, Others

Middleton Parking Lot

Cell Ratio
Cell-4 30:1

#Rainfall Events
Mix-3 125
Mix-4 120

No Infiltration

Volumes & Overflows

Water-Quality
TSS, PSD, TP, DP, Others

Waukesha Highway Median

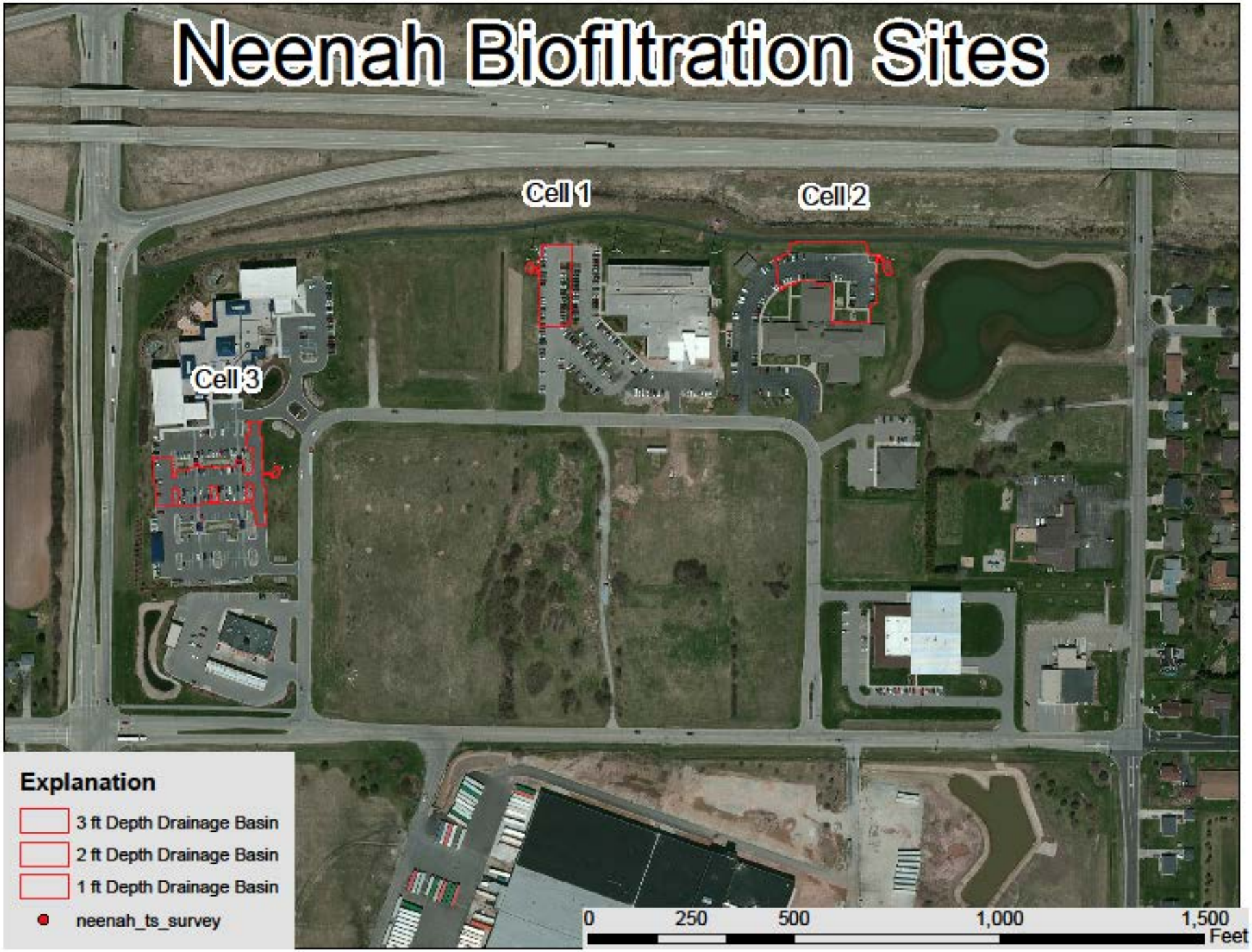
Cell Ratio
Cell-5 5:1
Cell-6 4:1

#Rainfall Events
Mix-5 113
Mix-6 113

Infiltration

Volumes & No Overflows

Water-Quality
None


Neenah Biofiltration Sites
Cell 1
Cell 2
Cell 3
Explanation
3 ft Depth Drainage Basin
2 ft Depth Drainage Basin
1 ft Depth Drainage Basin
neenah_ts_survey
0
250
500
1,000
1,500
Feet

Mix-1 Neenah Sites

Mix-2 Neenah Sites

Middleton Parking Lot

Middleton Parking Lot

Waukesha Highway Median Bioswales

Biofiltration Watershed and Measured Volume

Cell Depth	Watershed Size (Acres)	Impervious Surface (%)	Ratio Watershed:Cell*
1 ft	0.34	90	30:1
2 ft	0.76	75	62:1
3 ft	0.63	93	53:1

*Watershed area to cell's effective infiltration area

Cell Depth	Inlet Volume Compared to the Outlet (%)	Number of Overflow Events	Average Peak Flow Reduction (%)
1 ft	84	9 (2)	84
2 ft	95	7 (2)	64
3 ft	94	20 (10)	62

( ) Number of events that overwhelmed the system, were not included in calculations

Preliminary Information-Subject to Revision. Not for Citation or Distribution

Bioretention

Credit and Technical Standard

Credit Allowance of 80% TSS Based on Measured Bioretention Cells

Site	Neenah		Middleton		Waukesha	
	Mix-1	Mix-2	Mix-3	Mix-4	Mix-5	Mix-6
Cell-1	87	87	77	83	~95*	~95*
Cell-2	81	74	-	-	-	-
Cell-3	65	82	-	-	-	-

*Minimum water-quality samples values estimated from WinSLAMM

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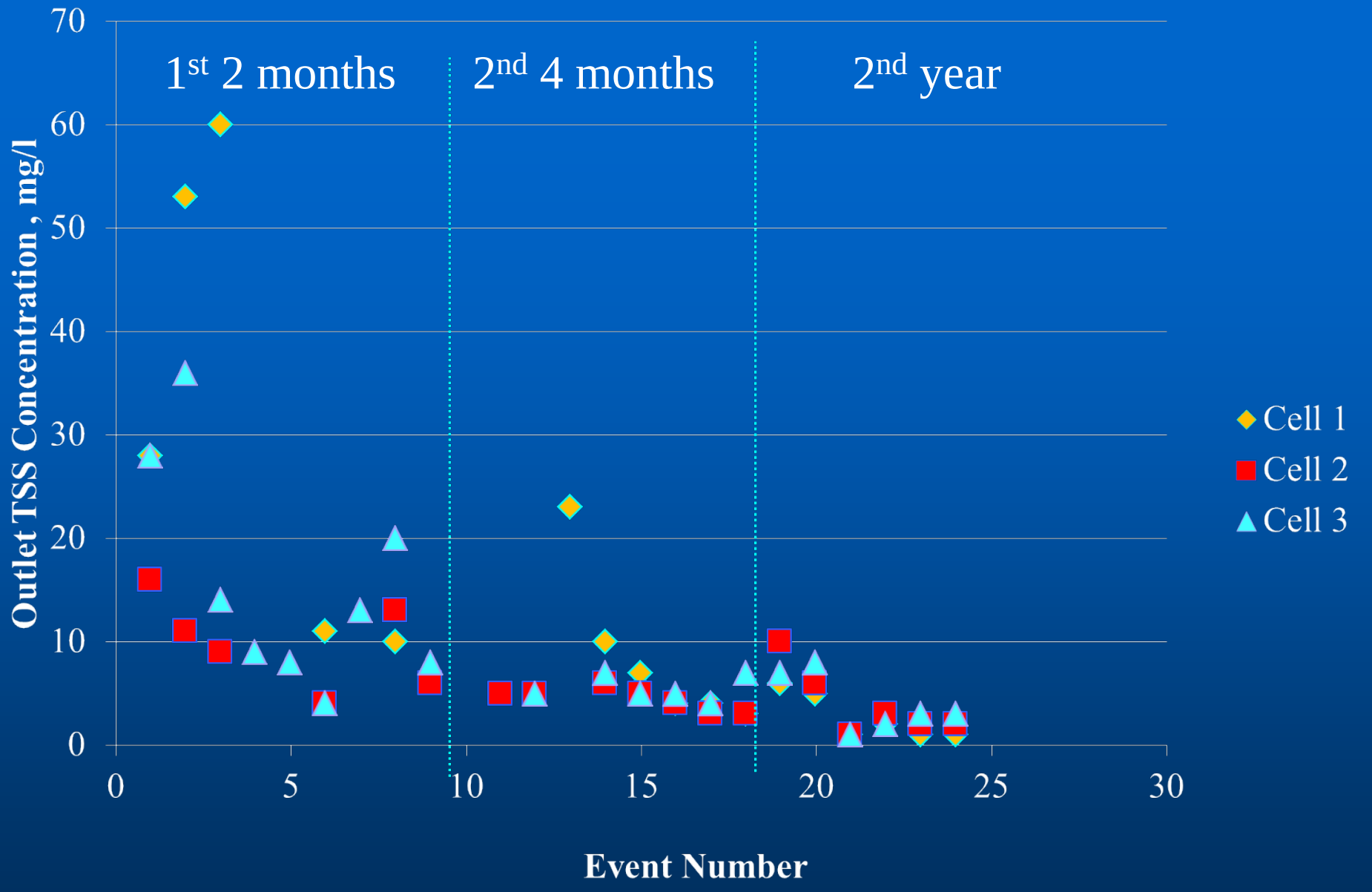
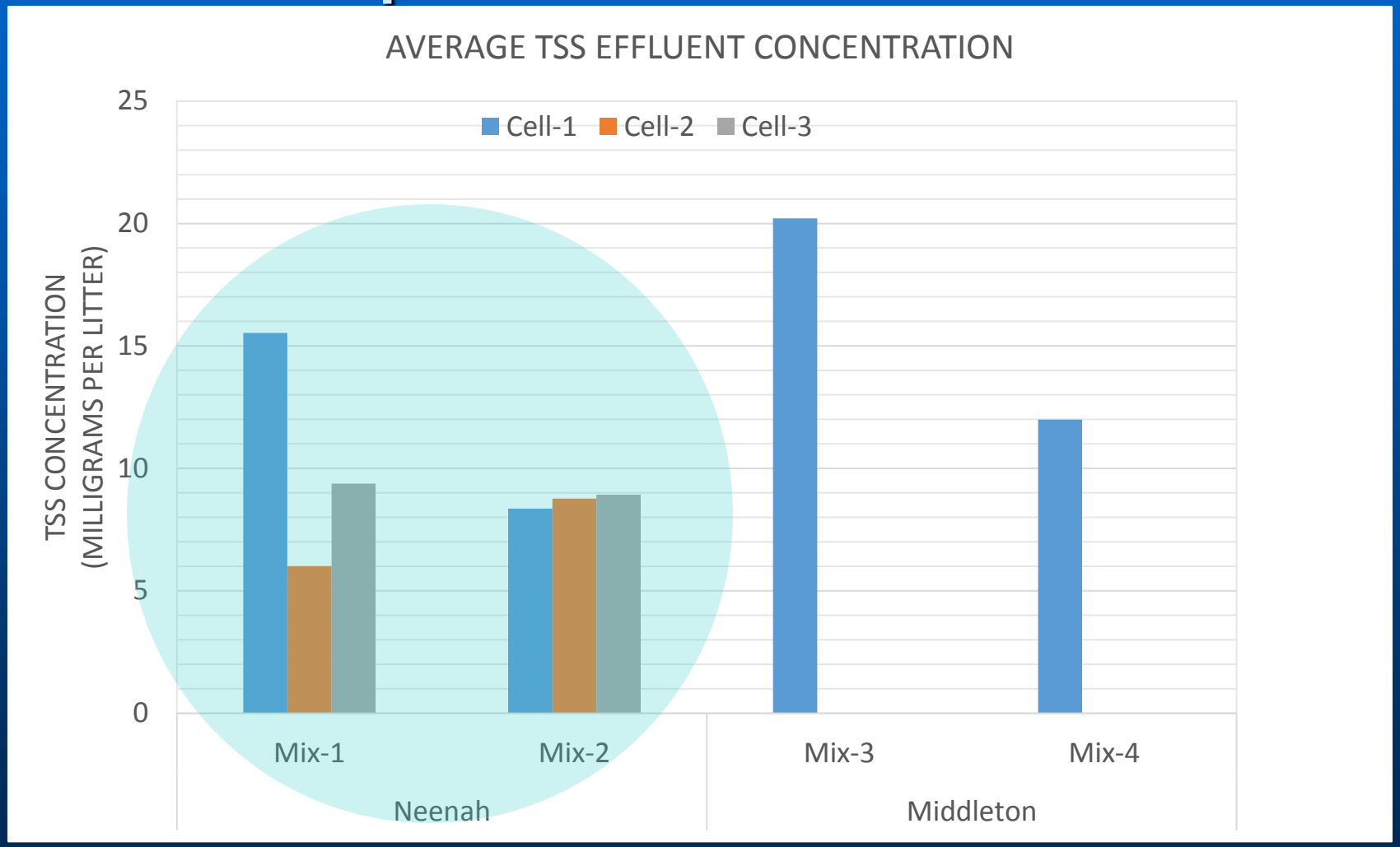


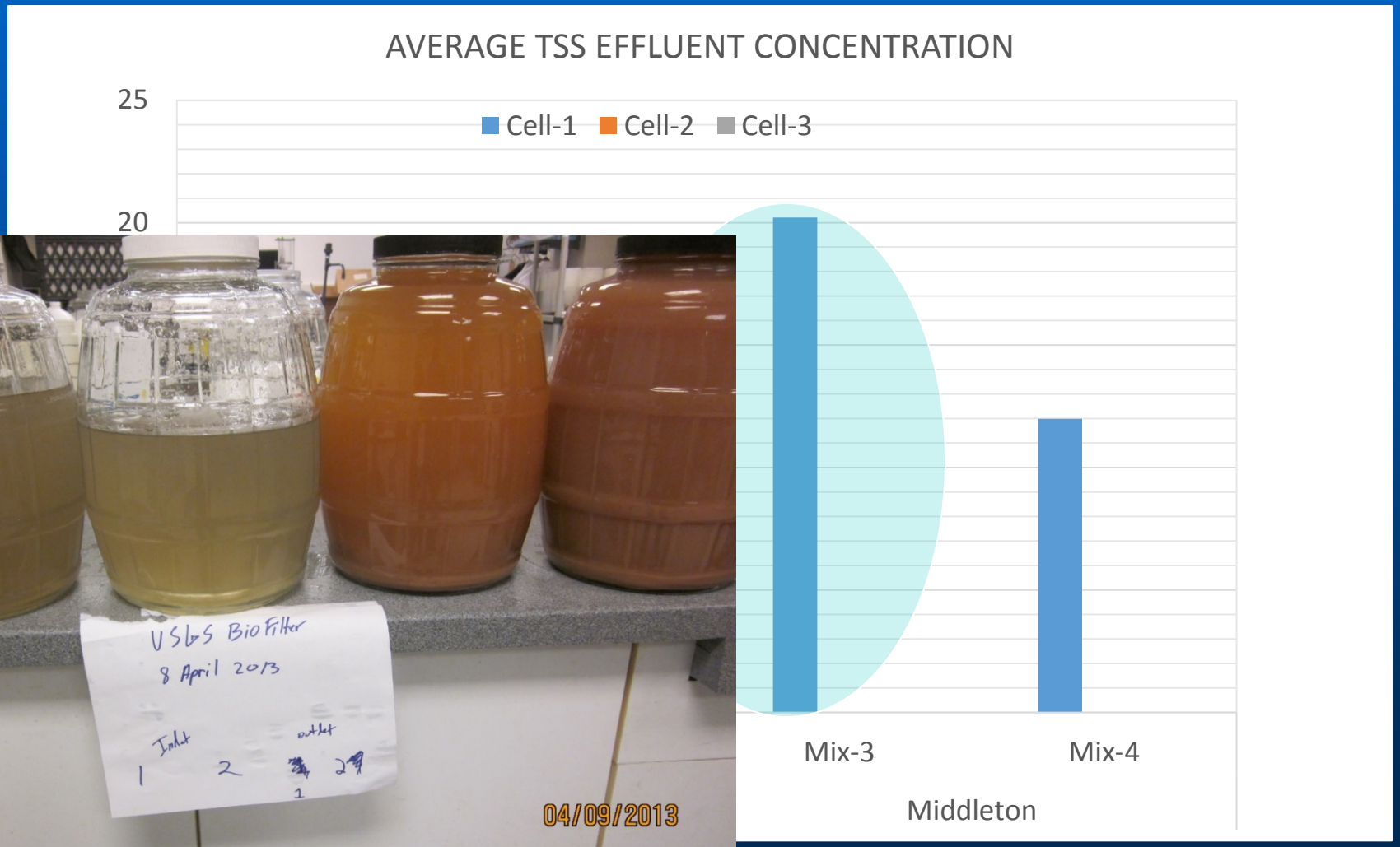
The TSS outlet concentrations as a function of time

Change in Technical Standard Depth from 3ft to 2ft

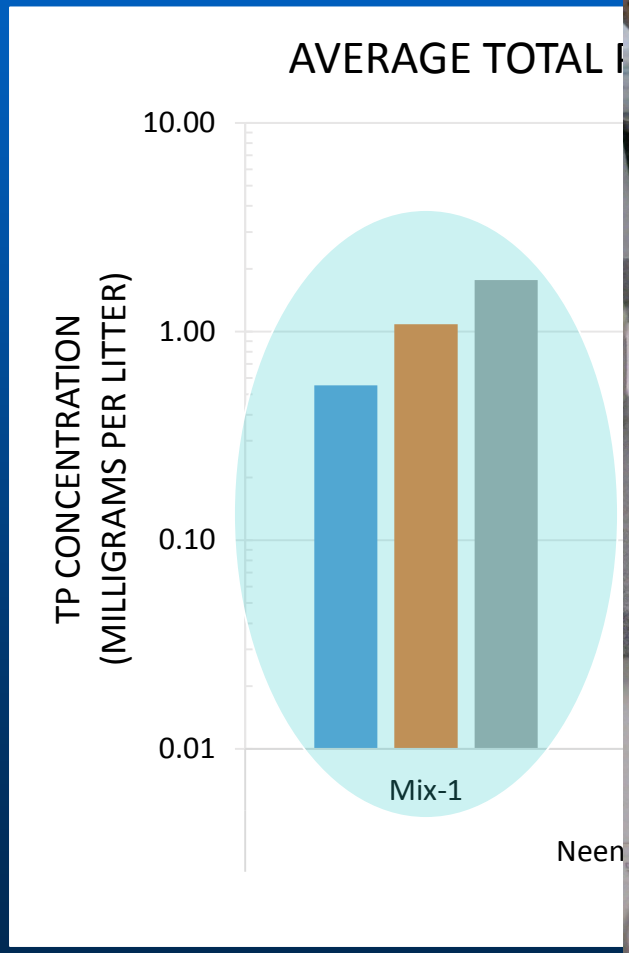


Kruskal-Wallis samples come from same distribution

Change in Technical Standard Reduction in Percent Fines



Change in Technical Standard Compost from 50% to 15 to 25%



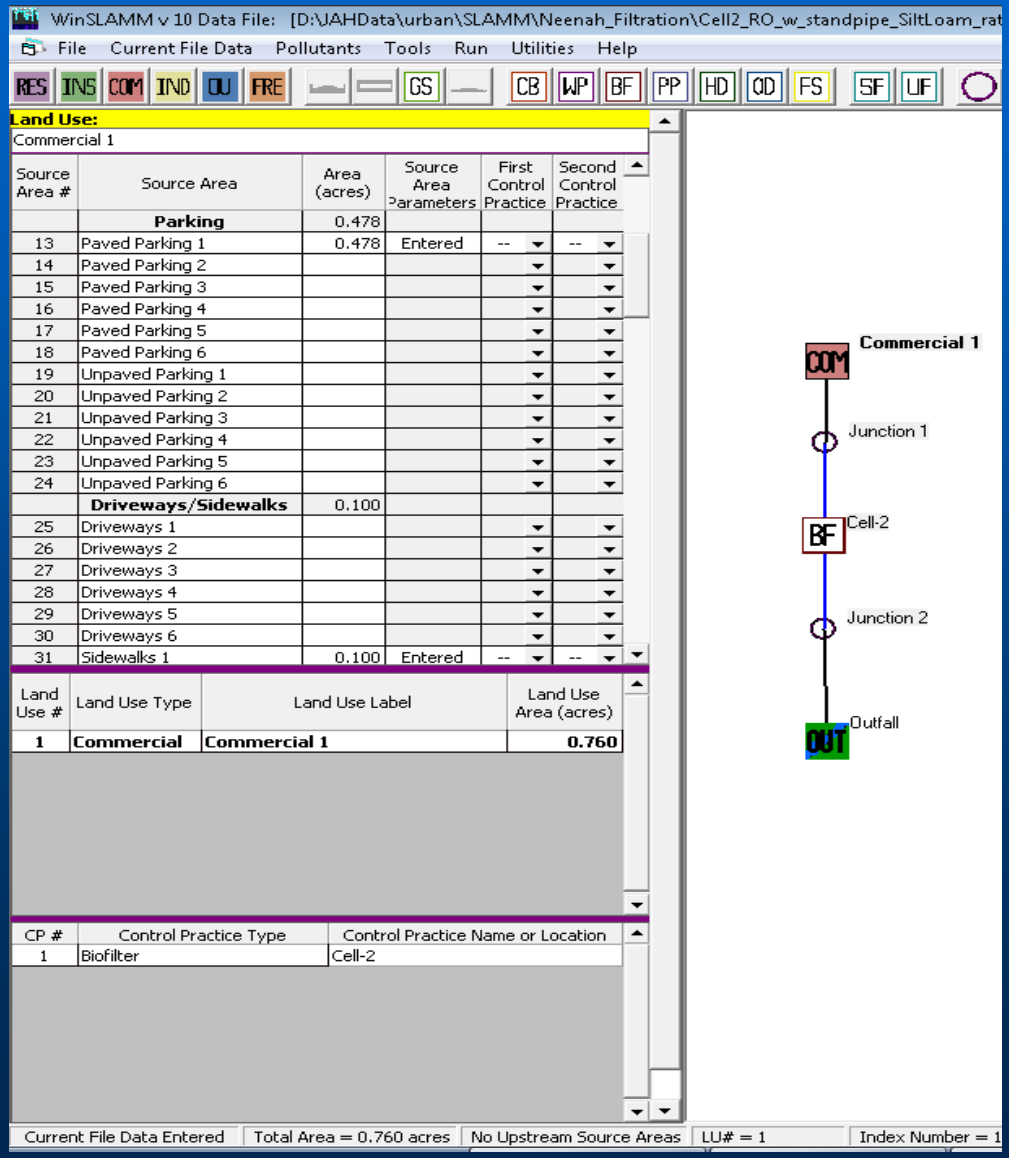
Summary of Results for Testing Engineered Soil Mixes

Type of Media	Mix	Annual TP Load Increase	Support Plant Growth	Cost, $/yard	Concerns
50/50	1	Yes	Yes	36	P Source
UWS&PL (Sorbtive Media)	2	No	Yes	161	Cost
NCSU (Pine Bark)	3	Yes	Yes	33	SAR
100% Sand	4	No	?	25	Plant Growth
Growth Layer	5	?	Yes	30	?
75/25	6	?	Yes	36	?

Dissolved Phosphorus not controlled

WinSLAMM Modeling

- Calibrated Using Measured WI Data
- Evaluate Bioretention Routine

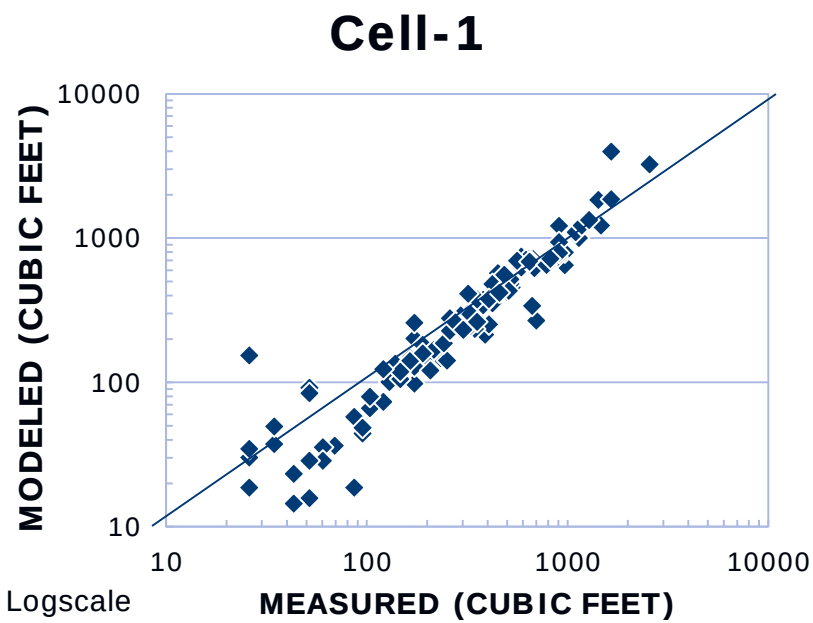


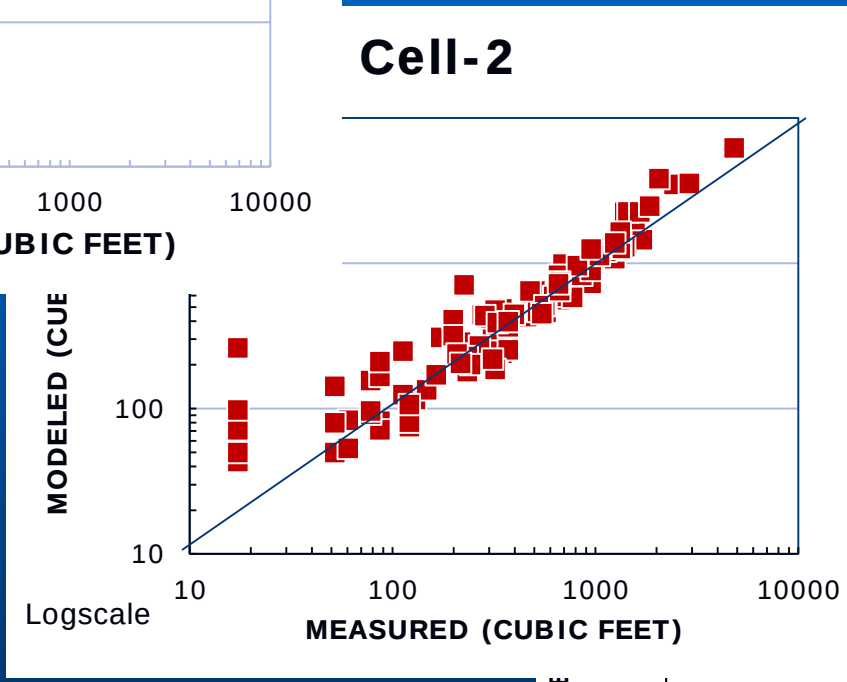
Assess WinSLAMMs Bioretention

- Zero Infiltration Mix-1
- Infiltration Mix-5&6
- Model Steps

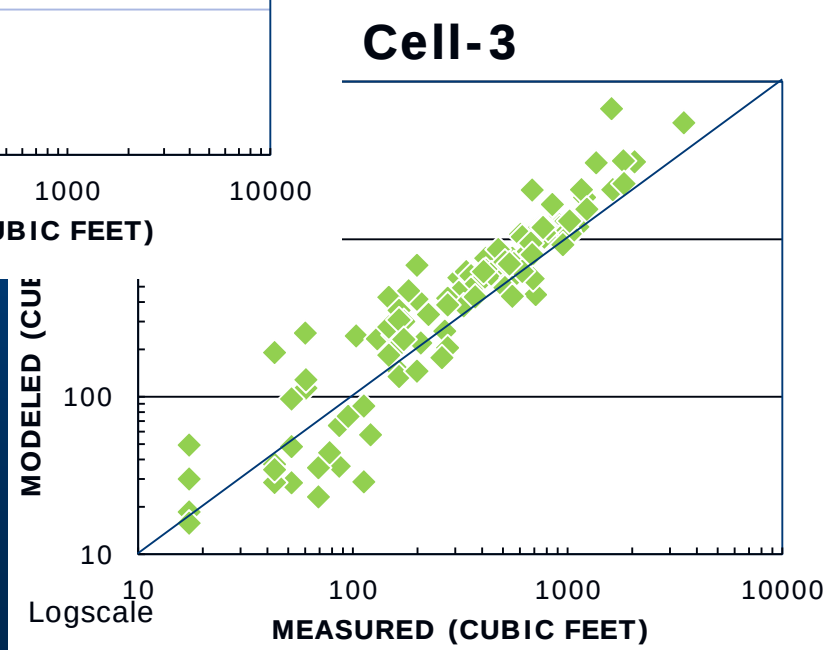
1. Create Rainfall Files From Measured Values
2. Assess Runoff Inlet Volumes
   - Measured vs Modeled
3. Assess Biofilter Volumes
   - Measured vs Modeled

Parking Lot Runoff Volume Comparison





Number of Rainfalls 124
Total Rain Depth 57 in.



Measured Vs. Modeled

Preliminary Information-Subject to Revision. Not for Citation or Distribution

Comparison Measured to Modeled Mix-1

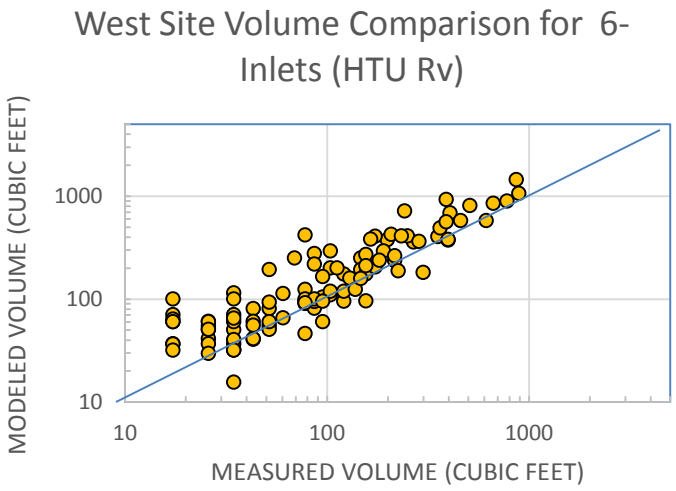
Cell Depth (ft)	Inlet Volume (%)*	Tile Outlet Volume (%)*	Overflow Volume as Percent of Inlet	Measured Overflow Count	Modeled Overflow
1	3	8	15	20	?
2	-14	-15	10	8	?
3	-44	-7	10	25	?

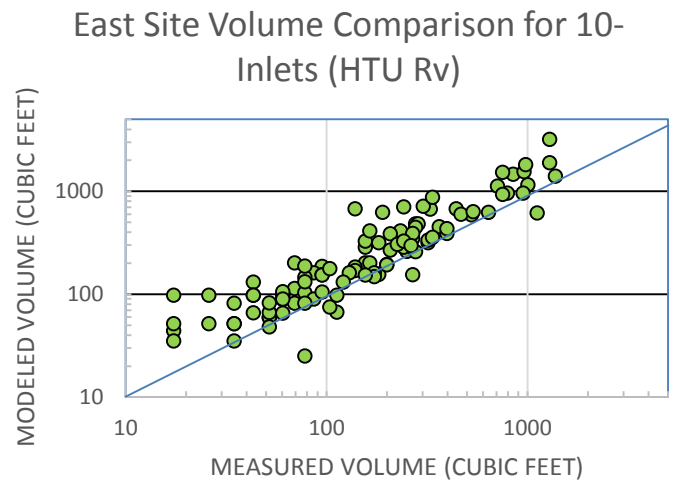
*Negative value indicates model over-prediction (1-model/measured)

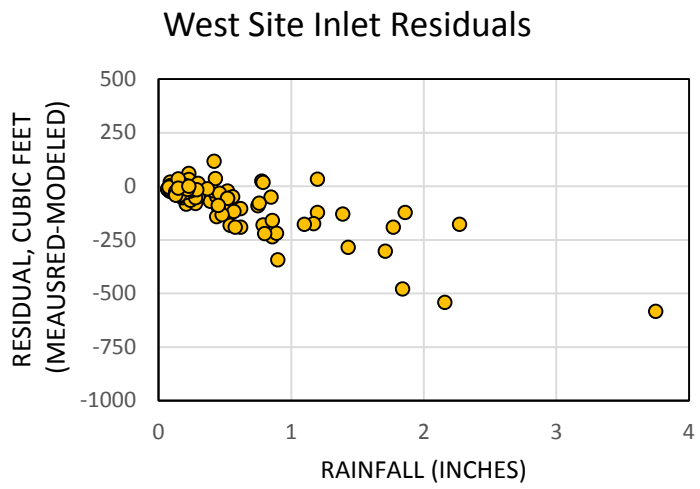
Preliminary Information-Subject to Revision. Not for Citation or Distribution

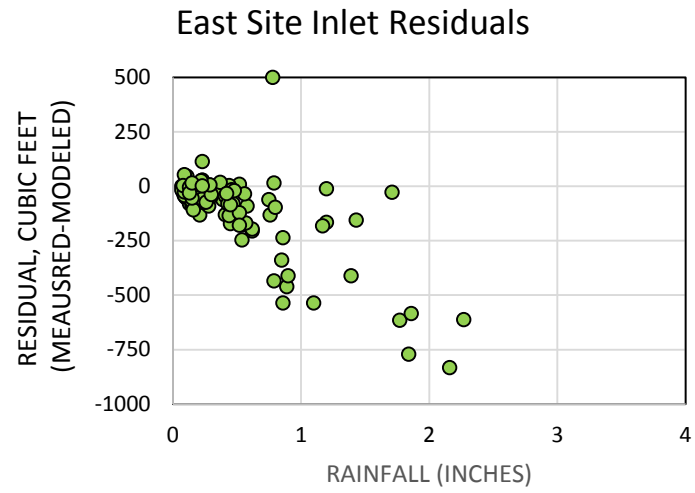
High-Traffic Urban Rv Inlet Volume Comparison Measured vs. Modeled

Both Sites WinSLAMM is Over-Estimating Event Volumes ~50 percent





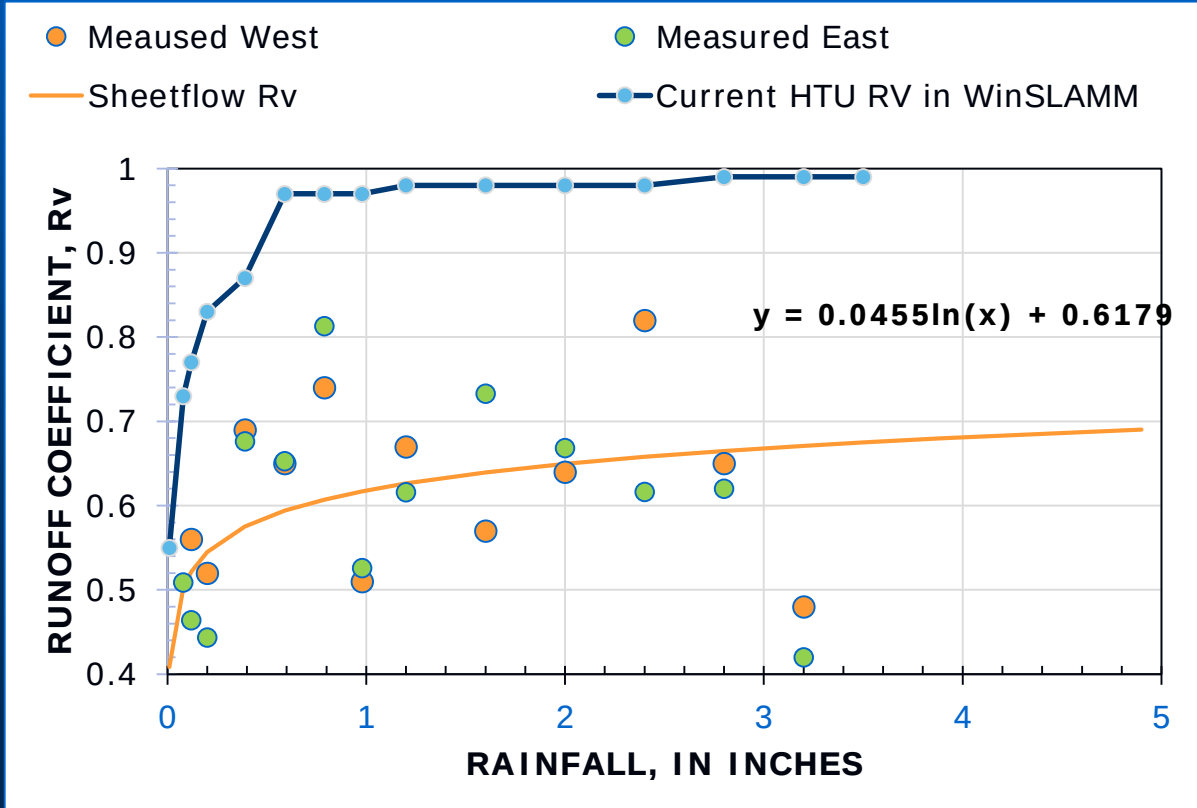




Develop A New Runoff Coefficient (R_v)

Split Dataset

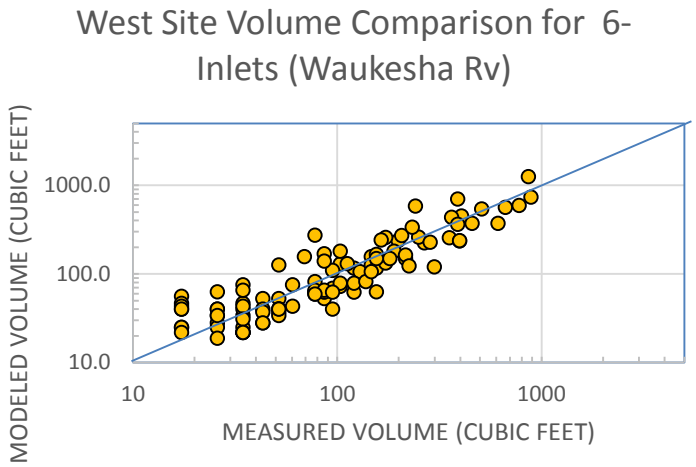
- West Site Calibration
- East Site Validation
- Calibration
  - Determine New Rv using Rainfall
  - Extend Rv to Larger Events not Measured

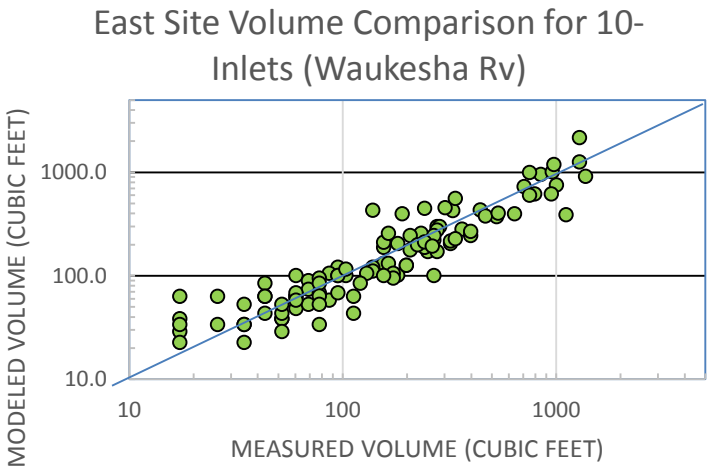


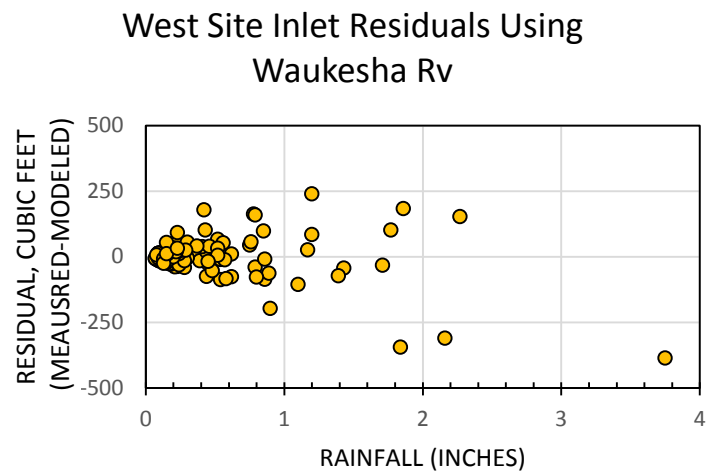
HWY-VV Rv Inlet Volume Comparisons Measured vs. Modeled

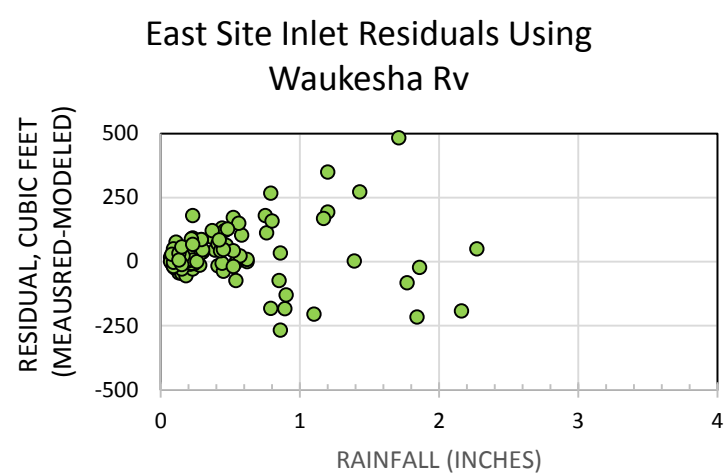
Percent Error: West 1

East 7

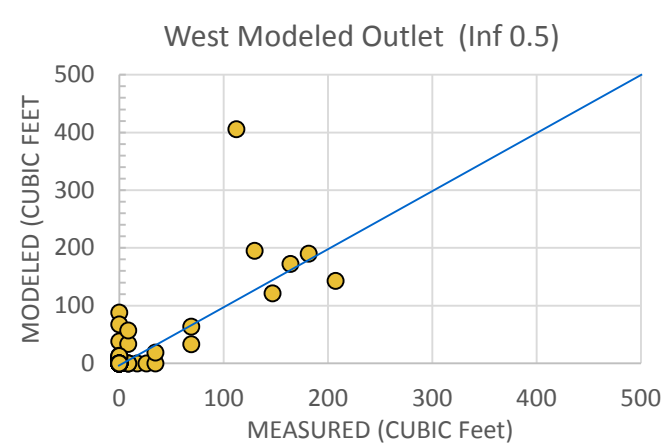


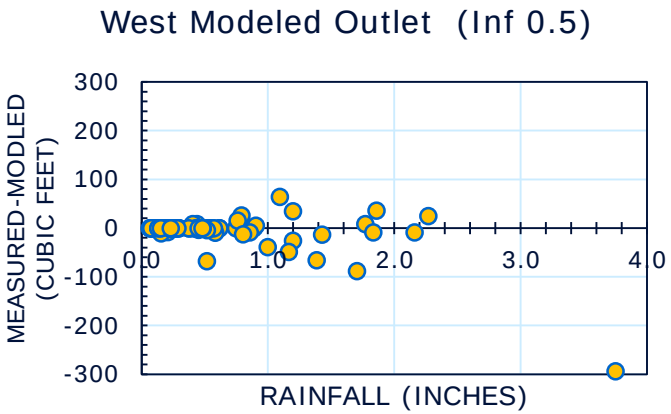




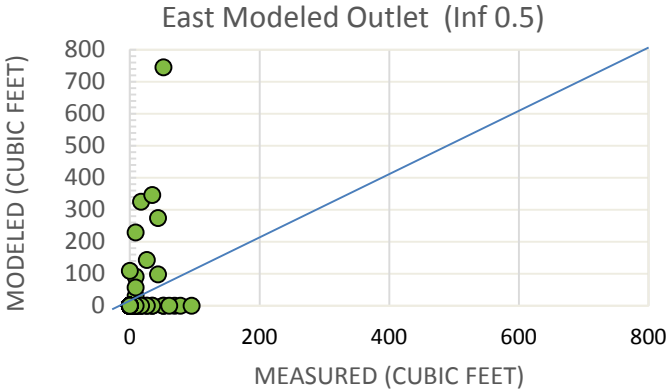


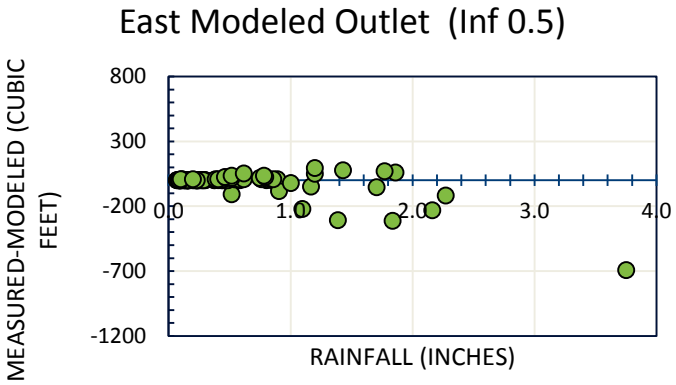
Bioretenion Outlet Volume Comparisons Measured vs. Modeled





West (Calibration)	Measured	Modeled
Percent Reduction	92	91
Number of Events With Volume	12	18





East (Validation)	Measured	Modeled
Percent Reduction	97	95
Number of Events With Volume	15	11

HWY VV BIOSWALE VOLUME COMPARISONS MEASURED VS MODELED

West	Measured (cf)	Modeled (cf)	Percent Difference	Infiltration Rate (in/hr)
Inlet	16,300	16,200	1	-
Outlet	1,240	1,700	37	0.5
Outlet	1,240	1,300	5	0.6

East	Measured (cf)	Modeled (cf)	Percent Difference	Infiltration Rate (in/hr)
Inlet	28,300	26,200	7	-
Outlet	950	2,500	158	0.5
Outlet	950	1,770	86	0.6

Future

Change Middleton Site

- Alternative Mix to Remove P
  - Iron filing
  - Peat Moss
  - Slag

WinSLAMM Calibrate and Validate

- Bioretention Concentration
  - TSS
  - Phosphorus
  - Particle Size
  - Others

QUESTIONS