NCDEQ/ IECA E&SC Planning and Design Workshop
Raleigh, NC – December 4, 2018

Post Construction Stormwater Research

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Research Project Locations

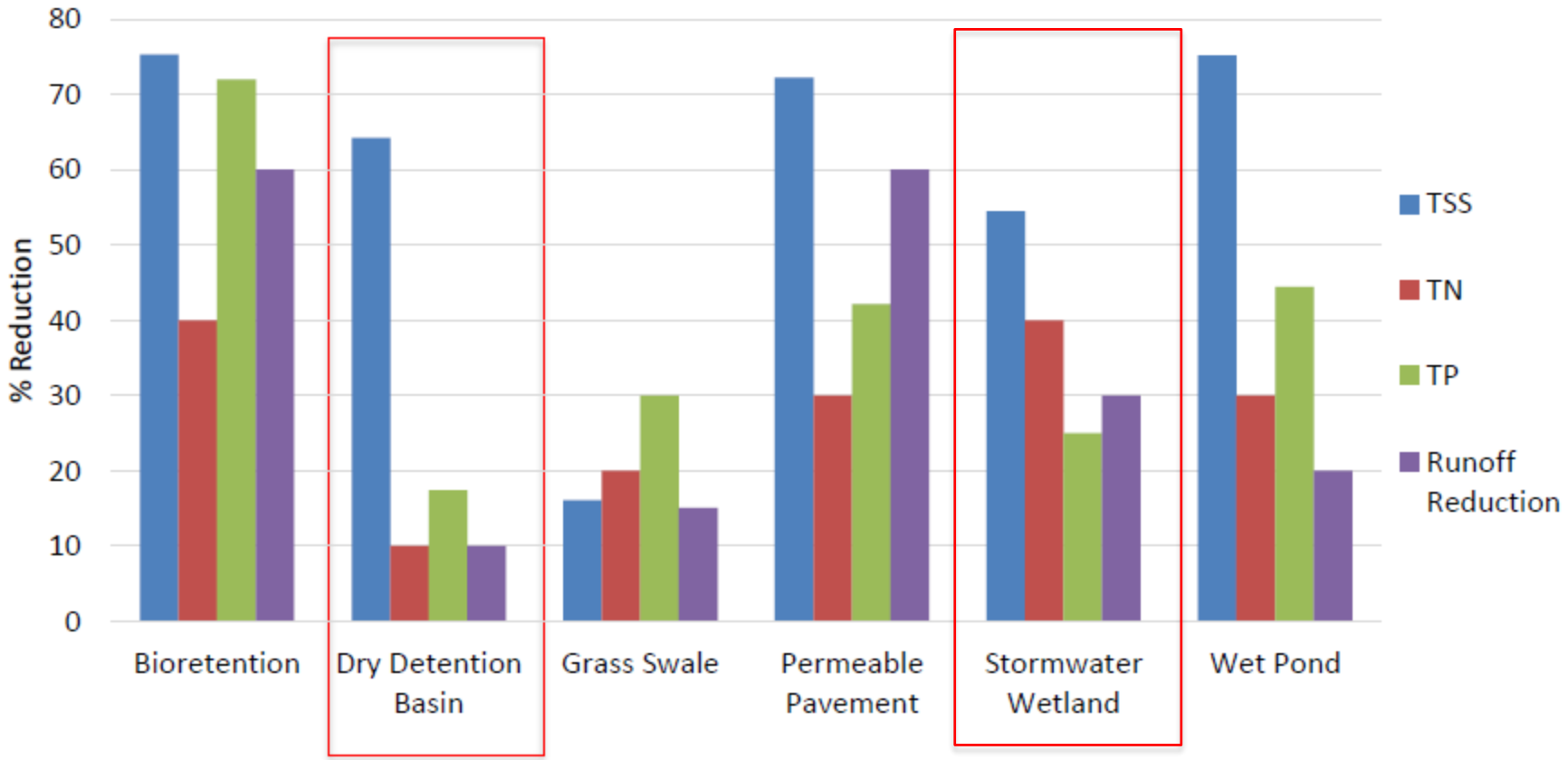
Overall Research Objectives

How can we **retrofit** existing SCM to improve WQ performance?

Are we taking appropriate **nutrient credit** for SCM practices?

Should **design and maintenance** recommendations be modified?

Dry Detention to Constructed Wetland



Data from Wright Water Engineers, Inc. & Geosyntec Consultants, (2016) International Stormwater BMP Database; Battiata et al., (2010)

Dry Pond

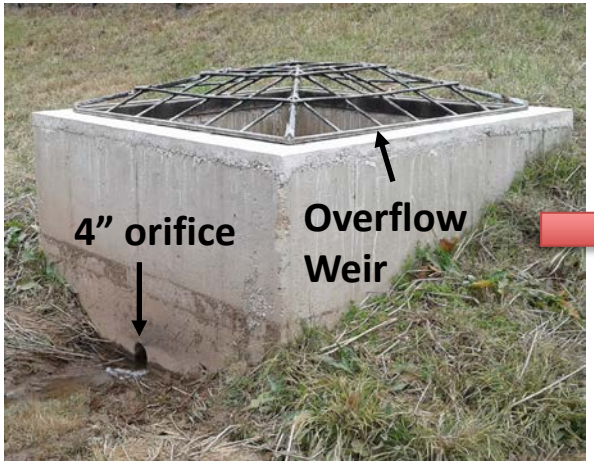
- Sedimentation
- Short Detention Time

Constructed Wetland

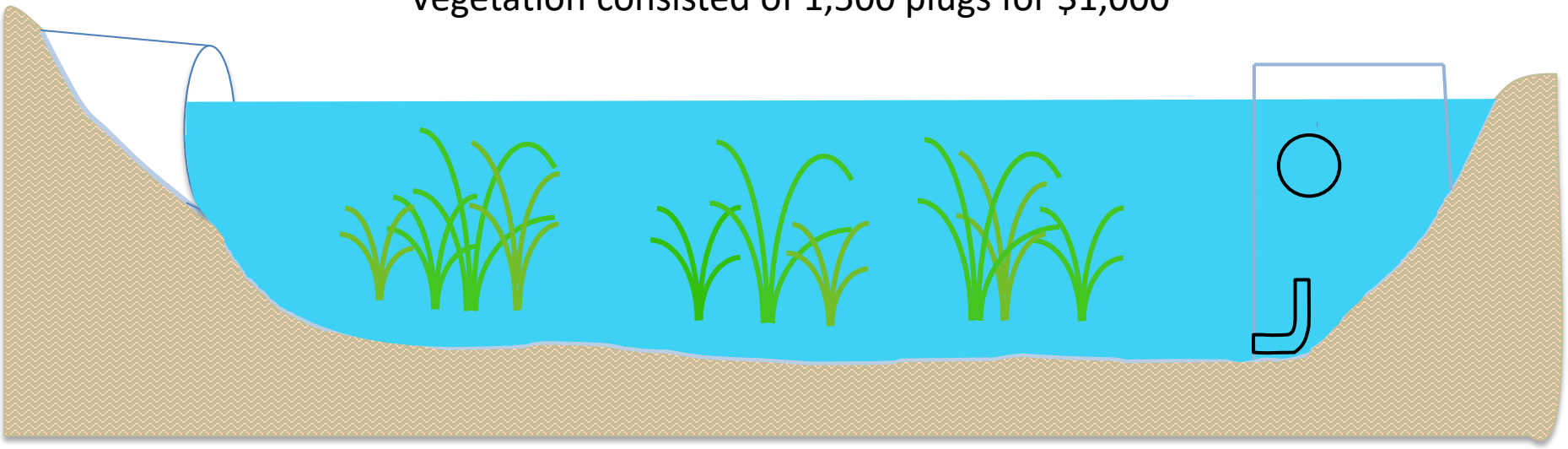
- Filtration
- Biological Processes
- Sorption
- Longer Detention Time

Acknowledgement to Katy Mazer

Retrofit #1, Total Cost <$2000



Vegetation consisted of 1,500 plugs for $1,000



Retrofit #2, Total Cost <$420

Infiltrated within 48 hours

Retrofit Load Reduction

Pollutant	LSM Reduction
TSS	**89%***
TP	**60%***
OP	**57%***
TN	**71%***
TKN	**75%***
$NO_{2,3}$-N	39%
ON	**75%***
TAN	**69%***

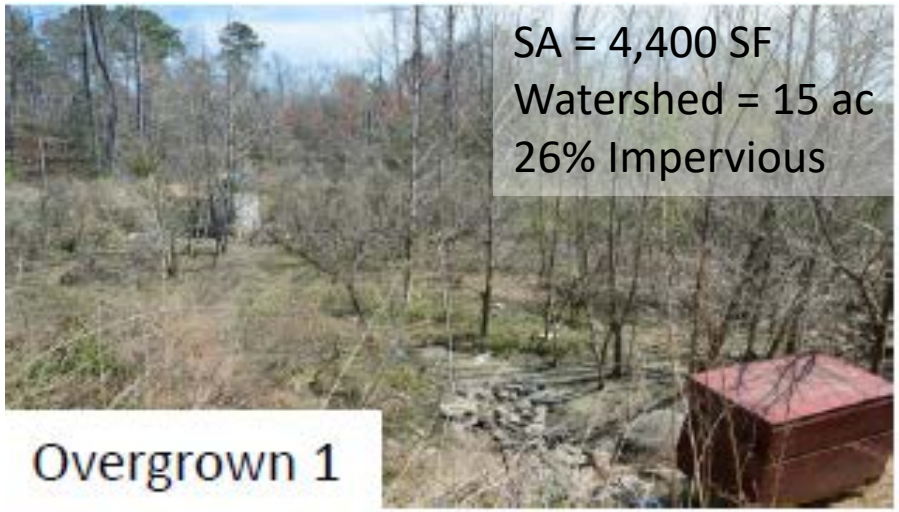
*Bold values are significant to $\alpha = 0.05$

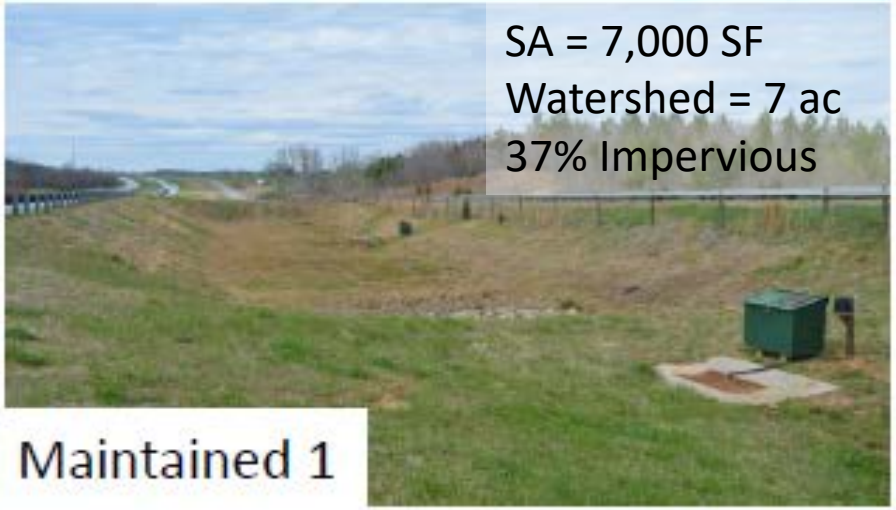
Retrofit Cost Savings

	TN	TP
Initial Load (kg/yr)	43.4	7.29
LSM Reduction	71%	60%
Reduction (kg/yr)	30.6	4.36
Falls Credit Costs	$21,000	$54,000
Jordan Credit Costs	$268,000	$99,100
Tar-Pam Credit Costs	$16,800	$34,000
Cost of Retrofits	$2,000	$2,000

Costs for nutrient offset credits were retrieved from NCDEQ's Department of Mitigation Services (2018)

Baseline Study of Dry Detention





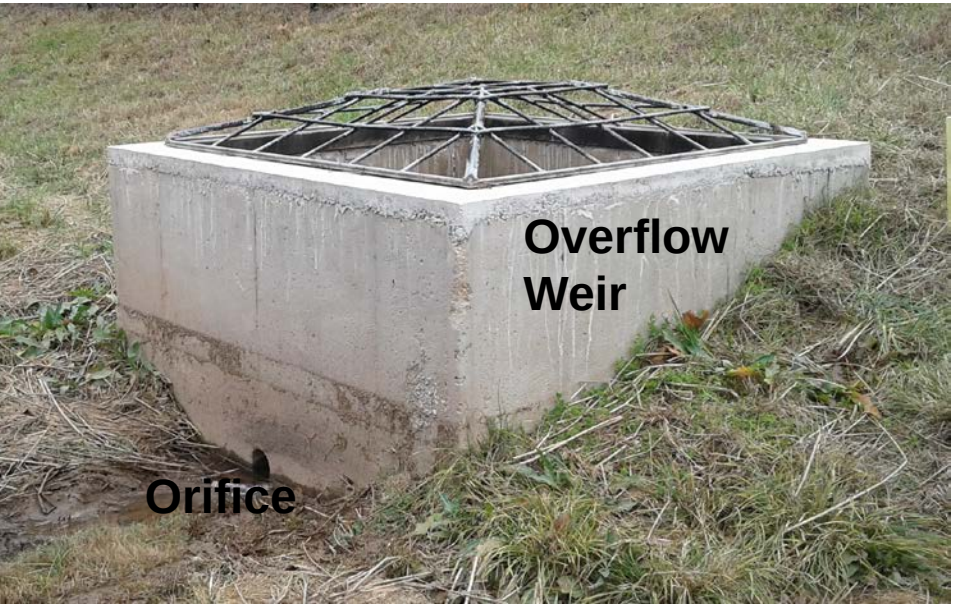
Acknowledgement to Austin Wissler

Preliminary Results

		TSS		TN		TP	
		Mean Influent EMC (mg/L)	Mean ER%	Mean Influent EMC (mg/L)	Mean ER%	Mean Influent EMC (mg/L)	Mean ER%
Overgrown1	(n=18)	13	39%	1.06	10%	0.11	6%
Overgrown2	(n=12)	33	-10%	0.82	-5%	0.09	-2%
Maintained1	(n=10)	191	31%	34.2	67%	2.5	65%
Maintained2	(n=4)	40	-25%	3.12	23%	0.27	14%

ER = Efficiency Ratio

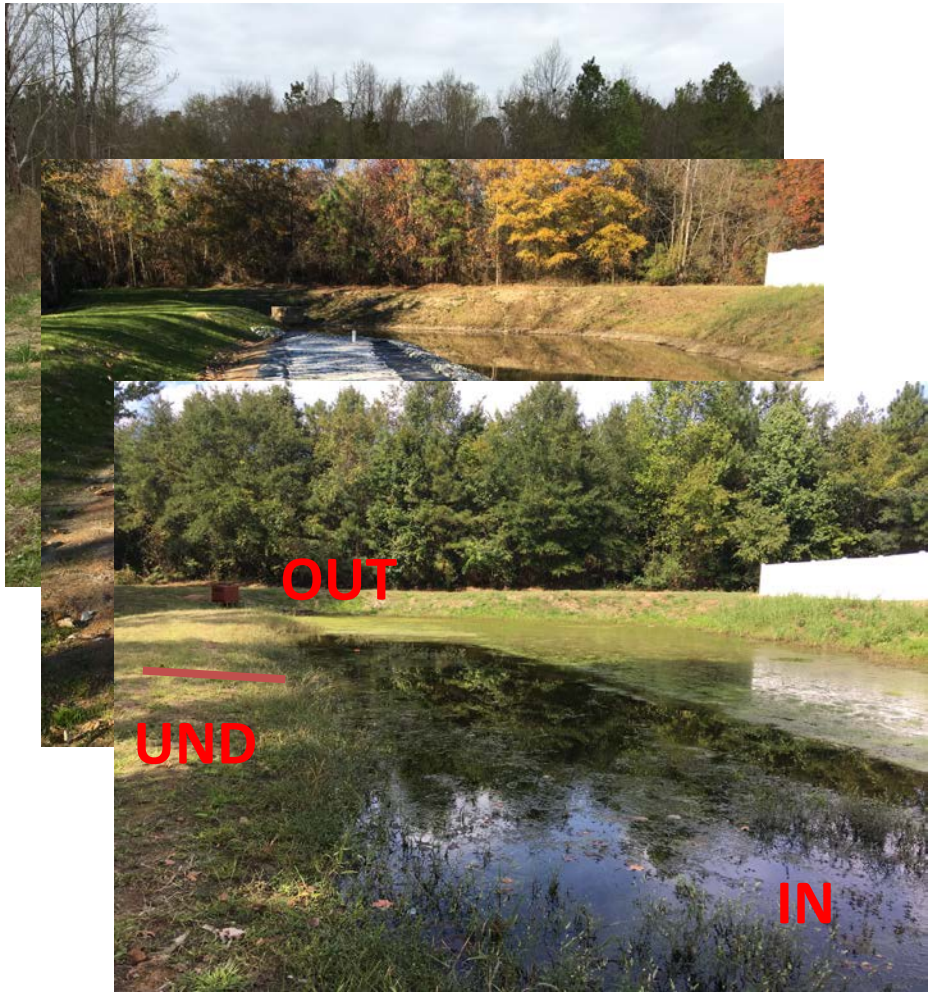
Future Dry Detention Retrofit

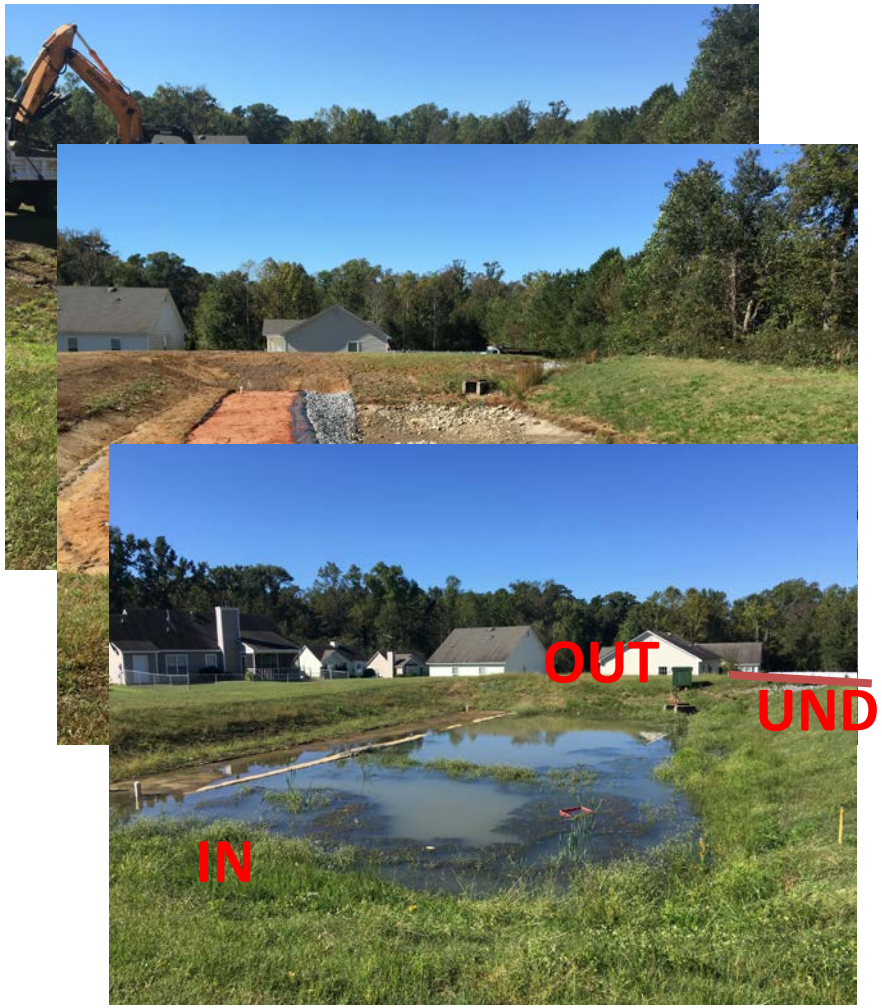


Top and Bottom Drawdown

Porous Baffles

Retrofit Wet Ponds with Sand Shelf





Sand Filter study

Column study to quantify nutrient removal

Do load reductions hold up over time?

Year 1

Year 15

Bioretention

Acknowledgement to Jeffrey Johnson

Site Characteristics

Characteristic	Chapel Hill BRC
Year constructed	2001
Underlying soil	Clay, clay loam, and silty clay
Drainage area (m^2)	600
Imperviousness	100%
Surface area ratio	14.9%
Bowl storage (mm)	95
Media depth (m)	1.2
Original media P-index	4-12 (3.7 – 11.1 ppm)
Vegetative cover	Perennial grasses, trees, shrubs

Monitoring Year Comparison

n =10

	Initial Monitoring	Current Monitoring
Pollutant	Mass Percent Reduction	Mass Percent Reduction
TN	40	69
NO_3-N	13	84
TKN	45	68
NH_3-N	86	83
TP	65	77
Ortho-P	69	68

Aged Bioretention Nutrient Reduction Calculations

- Median effluent concentrations for TN and TP

Period	TN (mg/L)	TP (mg/L)
NC DEQ Credit*	1.20	0.12
2002 – 2003	1.23	0.17
2017 – 2018	1.12	0.09

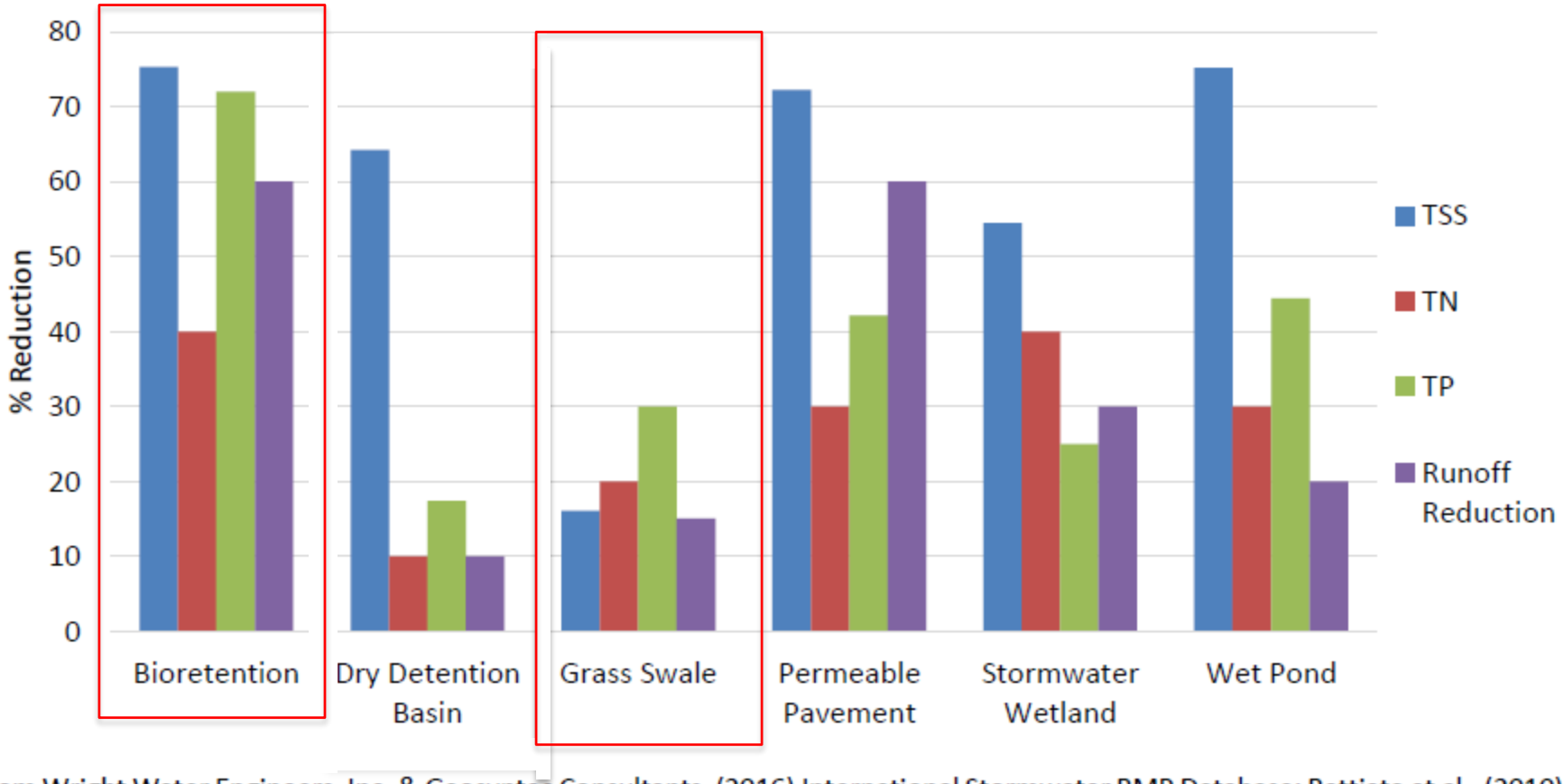
*Bioretention per MDC but without IWS (reference)

Bioretention Media Study

- Collect filter media samples from 30 BRCs of different ages in Jordan Lake watershed

- Analyze for trends in C, N, & P accumulation

Bioretention + Grass Swale = Bioswale



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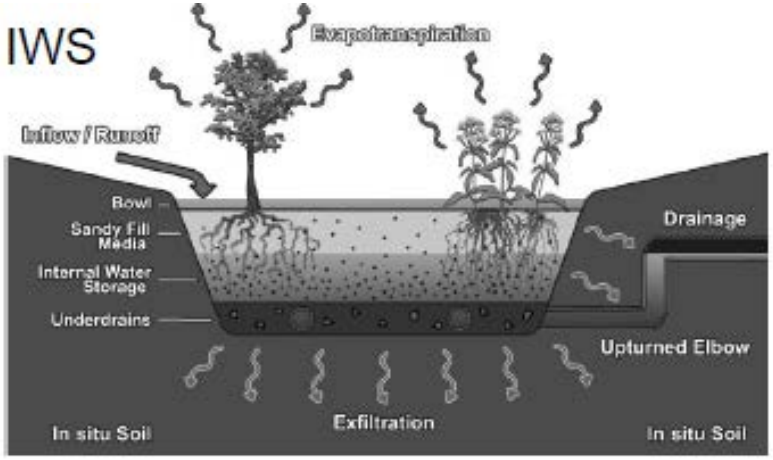
Bioswale Design Parameters

Forebay

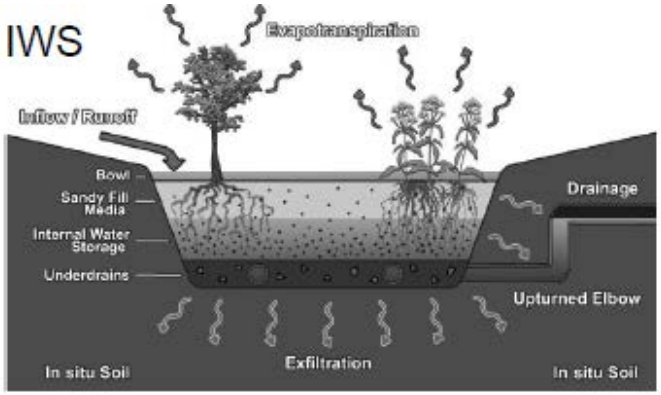
Check Dams



Acknowledgement to Rebecca Purvis

Forebay

Check Dams



IWS – site specific, Target NO2-3-N removal

Increased Hydraulic Retention Time

Practices that promote infiltration and exfiltration

BioswaleMod

Bioswale Design

Clear All Inputs

	Requires User Input
	Calculates based on user inputs

Assumptions
- Trapezoidal channel geometry
- Bioretention media depth = 2ft
- Underdrain runs full bioswale length
- Uniform flow
- Sandy underlying soil

Channel Design

Variable	Description	Value	
w_b	Bottom width		ft
H	Side slopes (H:V)		(H:1)
w_s	Side slope width		ft
L	Bioswale length		ft
S	Longitudinal slope		%
H	Bioswale depth		ft
w_t	Bioswale top width		ft

General Hydrology

Inlet Volume	0	cf
Inlet Peak Flow Rate	0.000	cfs
Overflow Volume	0	cf
Overflow Peak Flow Rate	0.000	cfs
Underdrain Volume	0	cf
Underdrain Peak Flow Rate	0.000	cfs

Total Outflow Behavior

% Overflow	0%

- Based on multiple linear regression equations
- Hydrology
  - Volume
  - Flow Rate
- Water Quality
  - Concentration
  - Load
  - Reductions

Over TSS Constants

Intercept	-146.9243
Slope	1.20956
Length	-0.26104
Base width	60.82563
Chedk Dams	-37.60304
IWS	-2.7007
Inlet P Fr	-6.38142
Inlet Vol	-0.00354
Over Vol	0.01464
Inlet TSS	0.06465

Vegetated Swale Study

Vegetated Swale

Rock-Lined Swale

NCSU Research Facility

Research Objectives:

1. Impact of channel length, shape, and slope on the hydrologic and water quality performance of a vegetated swale

2. Runoff reduction and water quality treatment benefits of a rock-lined swale and a rock-lined bioswale

Acknowledgement to Sujit Ekka

Suspended Pavement

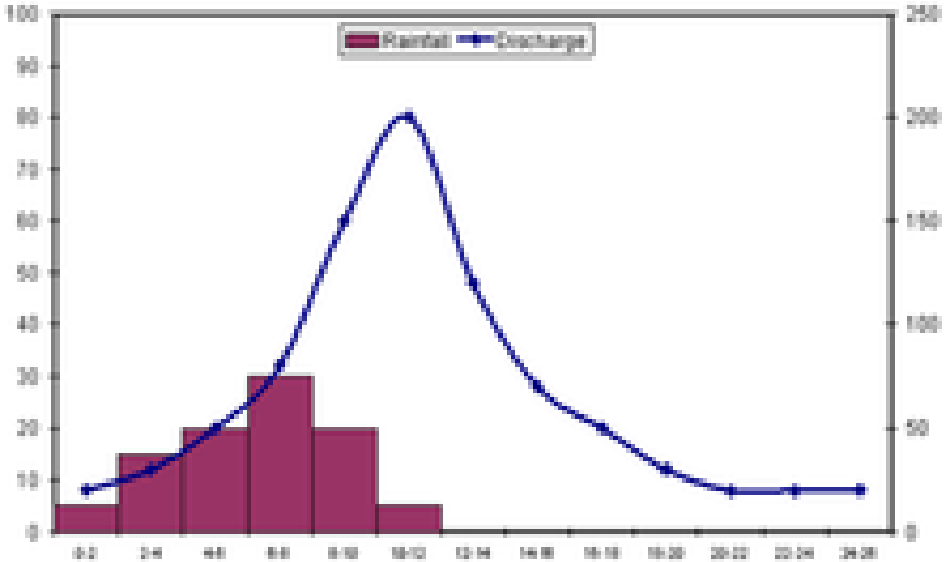
- What are the hydrologic impacts of an unlined system?
- How do loading ratios and underlying soils affect treatment?

Fayetteville, NC

Goldsboro, NC

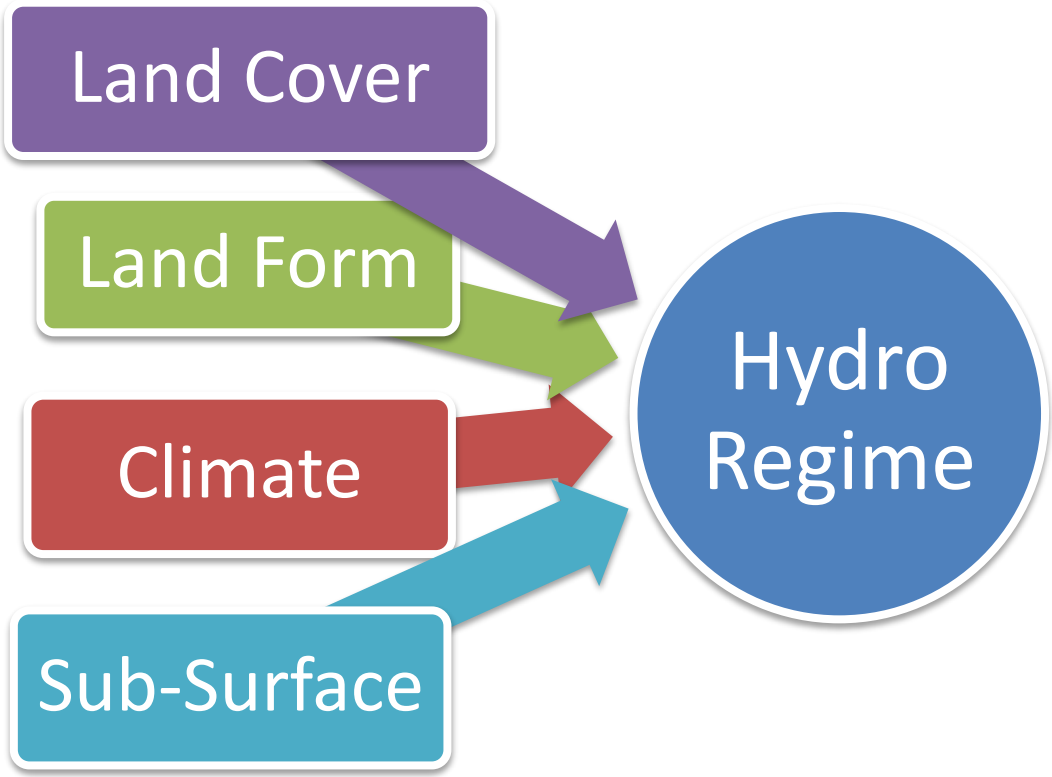
Acknowledgement to Katie Balaze

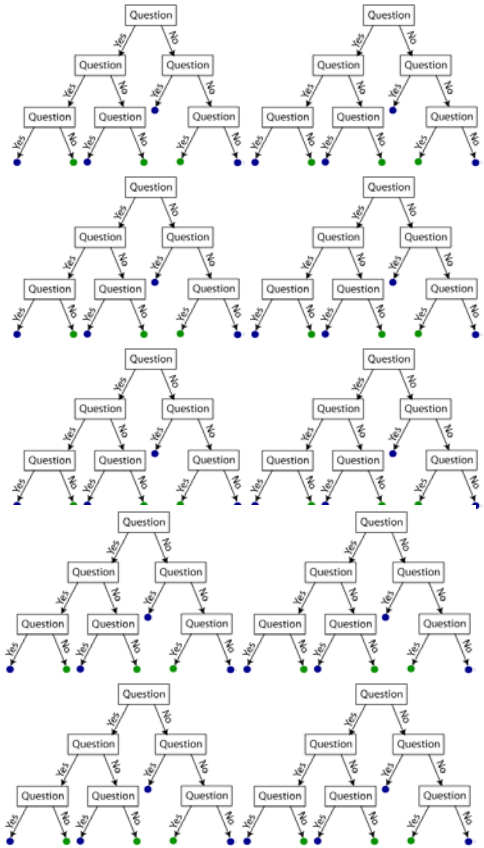
Design optimization of Stormwater Wetlands Using near-continuous sampling and active outlet system



Acknowledgement to Sheida Moin

Predict the value of a hydrologic metric based on the watershed attributes



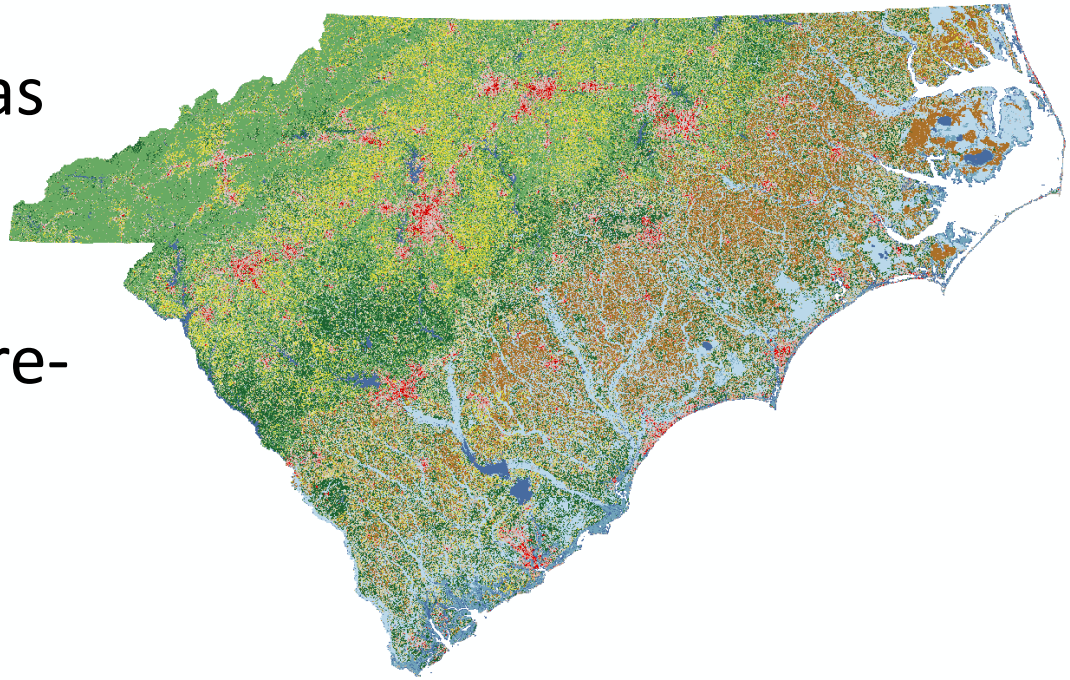


Predictors **Responses** **Machine-learning Regression**

Acknowledgement to Charlie Stillwell

Applications

Predictions of hydrologic metrics in ungauged areas



Predict the theoretical pre-development hydrologic metric in disturbed watersheds

Thank you to Project Partners

cleanwater MANAGEMENT TRUST FUND

STATE OF NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

NCDOT Highway Stormwater PROGRAM

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

TOWN OF MORRISVILLE NORTH CAROLINA 1852

TOWN OF CHAPEL HILL

CITY OF BURLINGTON, NORTH CAROLINA FEB. 14, 1893

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Questions

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