Converting Dry Detention Basins to Constructed Stormwater Wetlands for Enhanced Pollutant Removal



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Dry Ponds







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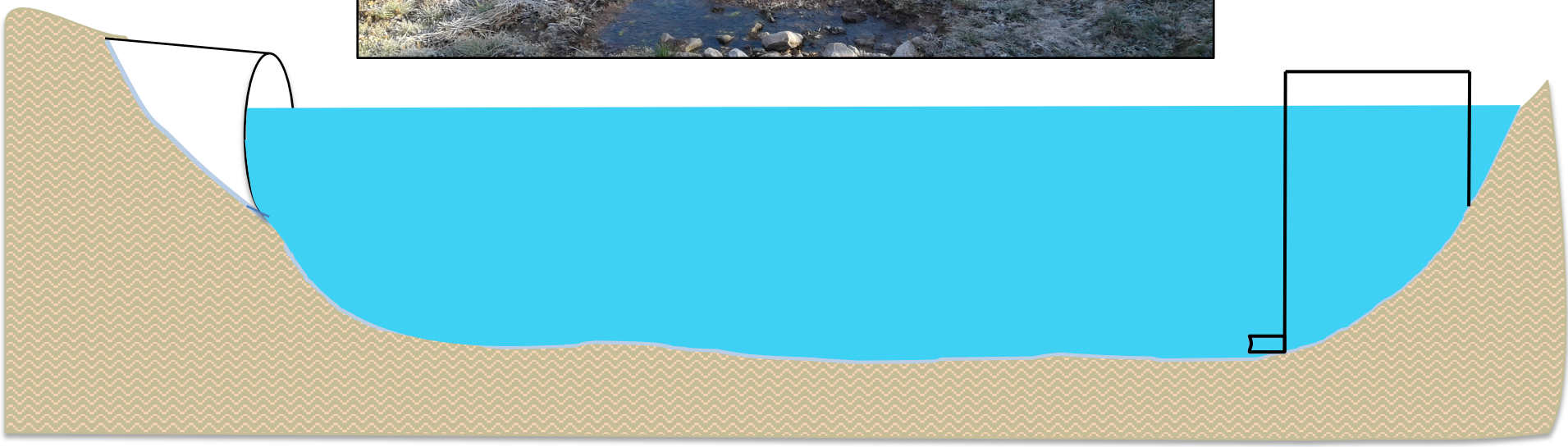
And Connecticut's Very Own…





Dry Ponds





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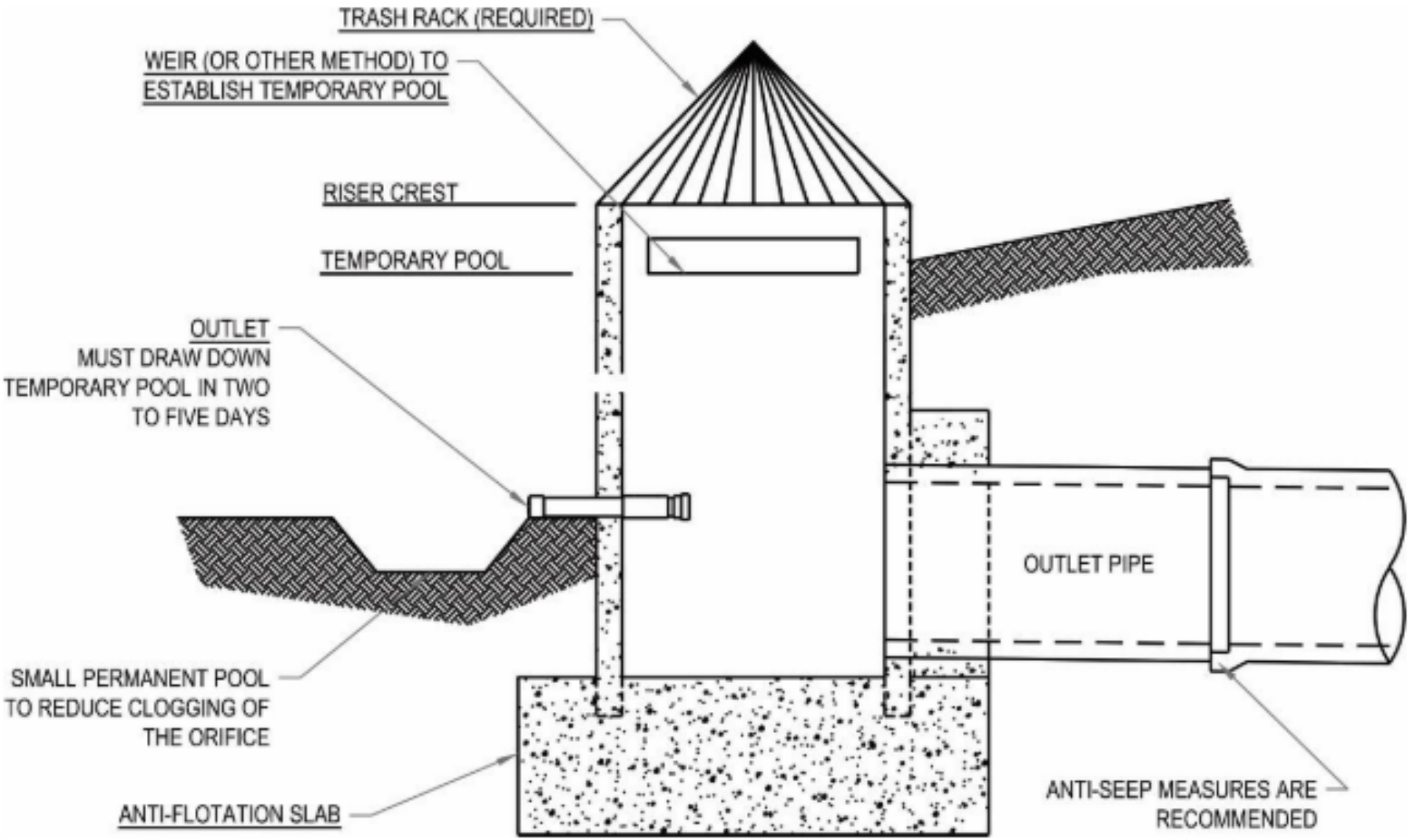

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Dry Pond Water Quality Treatment

- Sedimentation main pollutant removal mechanism
- Short detention times
- Initial flows can cause erosion in basin
- Maintenance issues from being consistently wet



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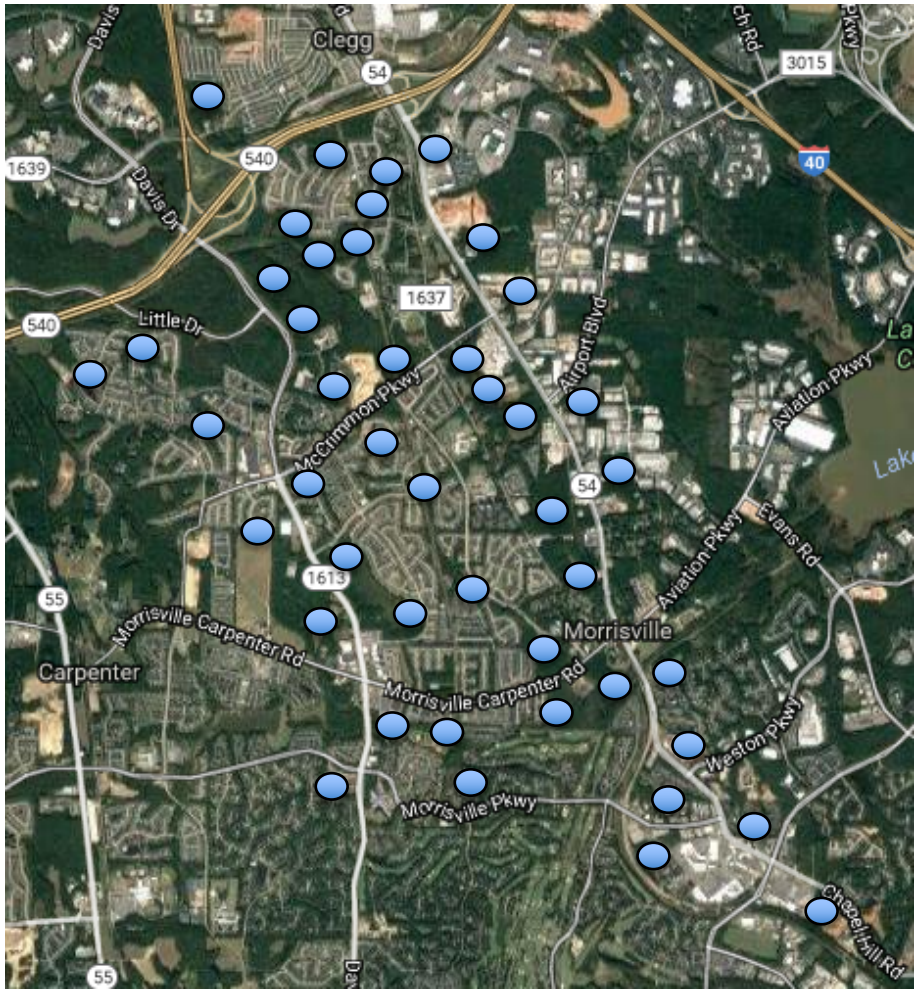
How Can We Improve These Dry Ponds?

- Countless dry ponds throughout U.S.
- Poor water quality treatment contributes large pollutant loads
- Overhauling these systems would be cost-prohibitive
- How can we enhance dry ponds without major investments?



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Fact is: they can be WET

Makes for "Safe" Wetland Conversion



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Another Example



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Potential Conversion: Constructed Stormwater Wetlands

- Treat both sediment and nutrients
- Permanent pool aids in treatment
- Plants serve to treat some pollutants
- Include flow path to maximize detention time
- Designed to treat first 1 in of runoff with 18 in of ponding





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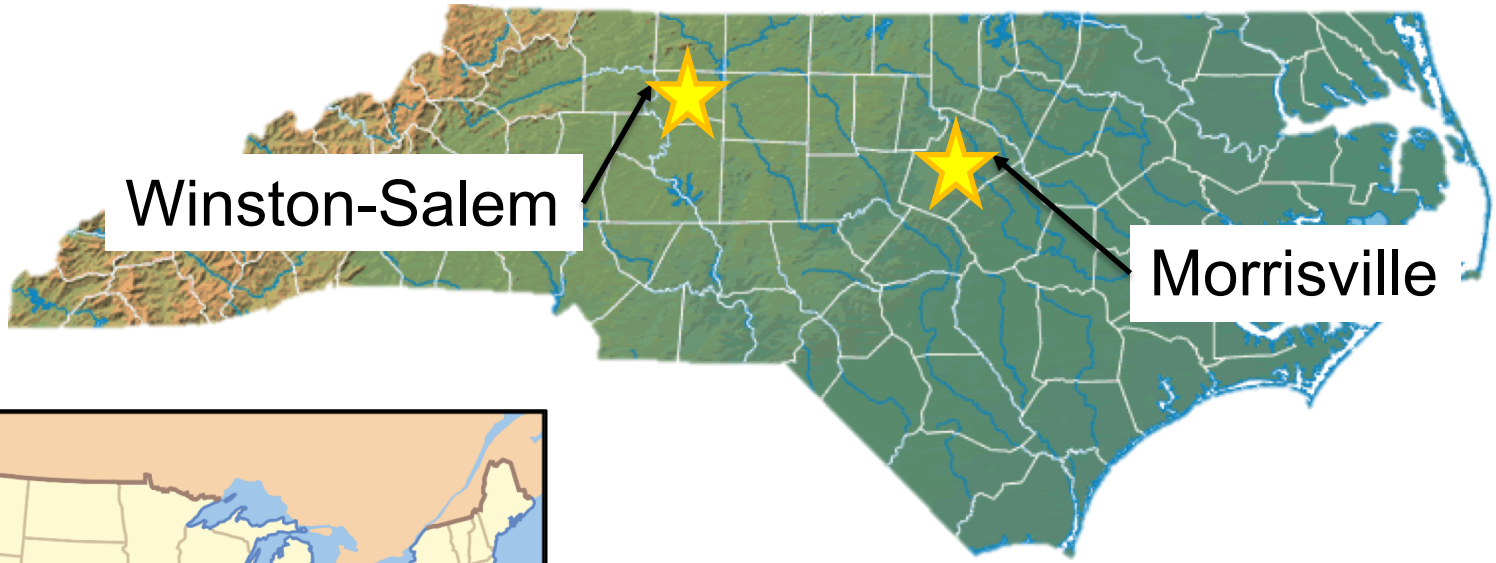
Project Location





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Research Sites

Pond Name	Location	Treatment	Paired Watershed
MOV1	Morrisville	Retrofit	Yes
MOV2	Morrisville	Control	Yes
WS	Winston-Salem	Retrofit	No



MOV1



MOV2



WS

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Stormwater Nutrient Crediting: A Major Opportunity?

SCM	$EMC_{effluent}$ (mg/L)	
	TN	TP
Bioretention per MDC	0.58	0.12
Wet Pond per MDC	1.22	0.15
Stormwater Wetland per MDC	1.12	0.18
Dry Pond per MDC	1.65	0.66

https://stormwater.bae.ncsu.edu/

Current Buy Down Credits

Service Area	Nutrient	DMS Rate (per pound) (through 9/30/2020)
Jordan Lake Watershed	Nitrogen	$107.88
Jordan Lake Watershed	Phosphorus	$301.95
Neuse Program (03020202, 03020203, 03020204)	Nitrogen	$14.45
Neuse 03020201 Outside the Falls Lake Watershed	Nitrogen	$24.53
Neuse- Falls Lake Watershed	Nitrogen	$10.86
Neuse- Falls Lake Watershed	Phosphorus	$164.67

Deq.nc.gov/about/divisions/mitigation-services/dms-customers/fee-schedules

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Water Quality Monitoring

- Pre- and post-retrofit
- Flow-paced, composite water quality samples
- Analyzed using US EPA protocols
- TSS, TAN, $NO_{2,3}$-N, TKN, TP and OP (TN and ON)
- Pollutant loads inlet versus outlet



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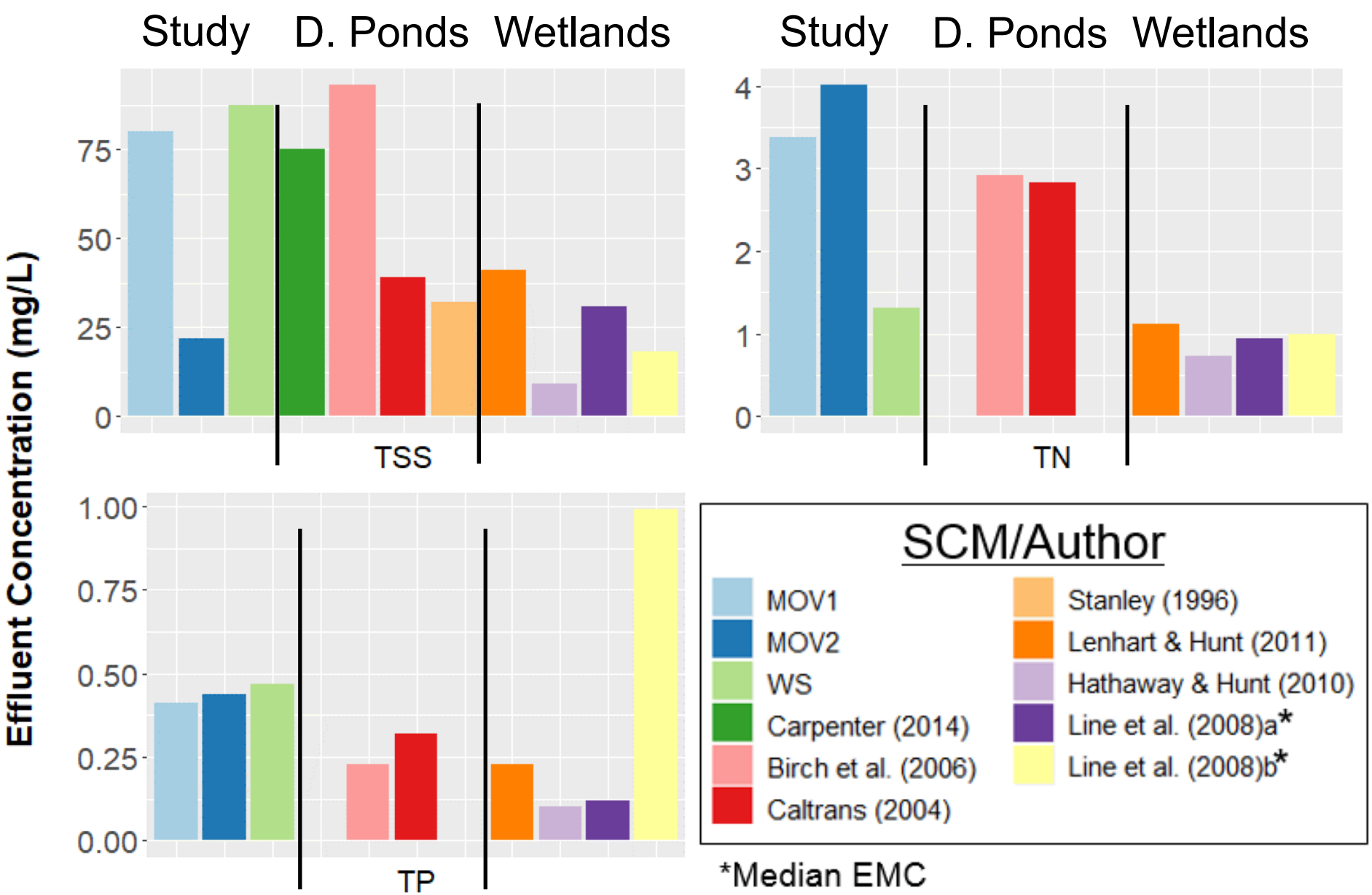

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Dry Pond Monitoring Conclusions

- MOV1 and MOV2 did not effectively remove pollutants from runoff
- Better water quality treatment was observed by some metrics in WS
- Dry pond water quality treatment does not meet NC water quality thresholds



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Dry Pond Monitoring Conclusions

- Dry ponds provide less water quality treatment than other SCMs
- Low pollutant removal in dry ponds: an opportunity to enhance structures to improve water quality treatment



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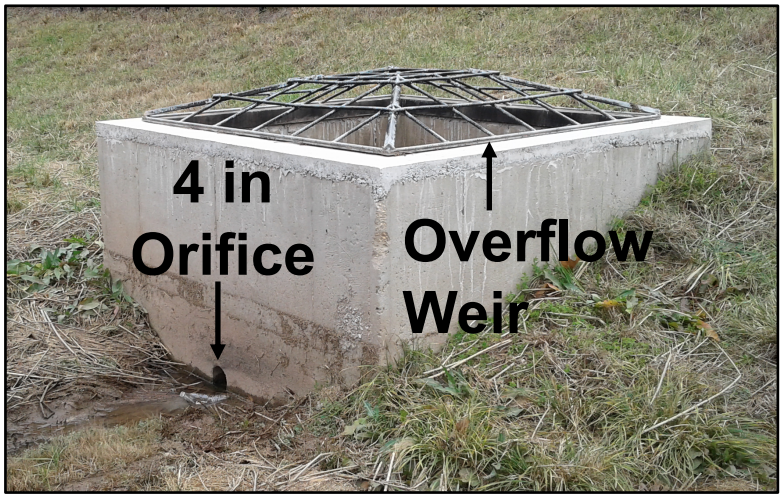
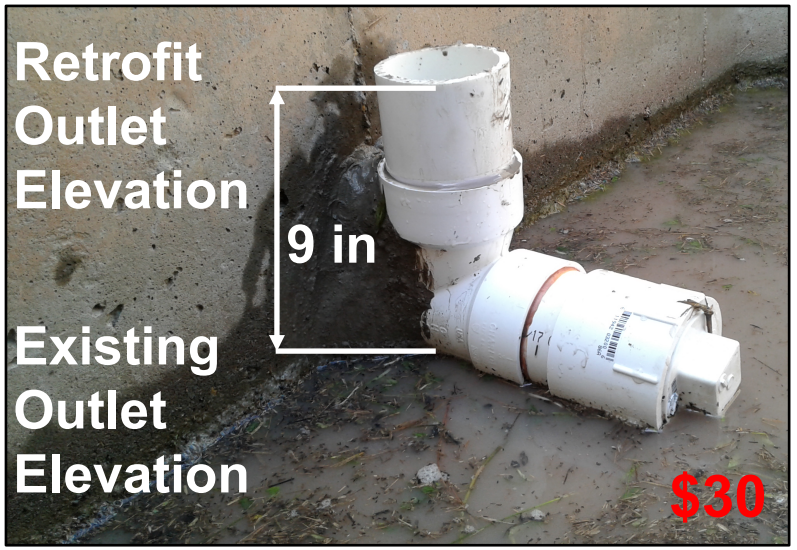
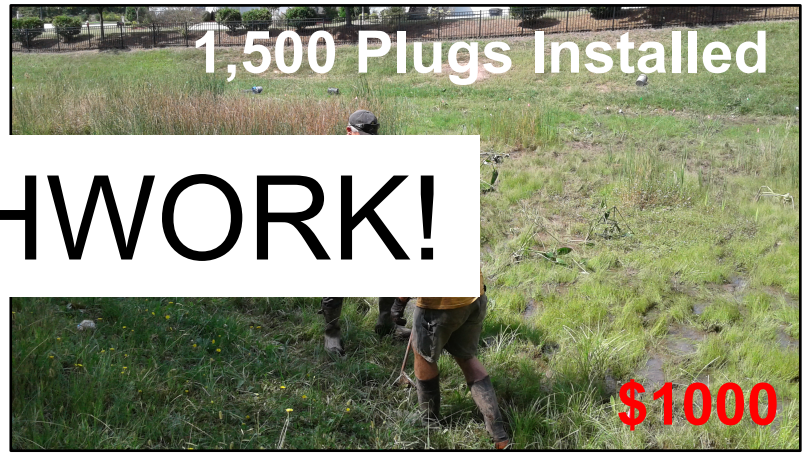
MOV1 Retrofits









NO EARTHWORK!

Hydrology

Total Cost < $2000

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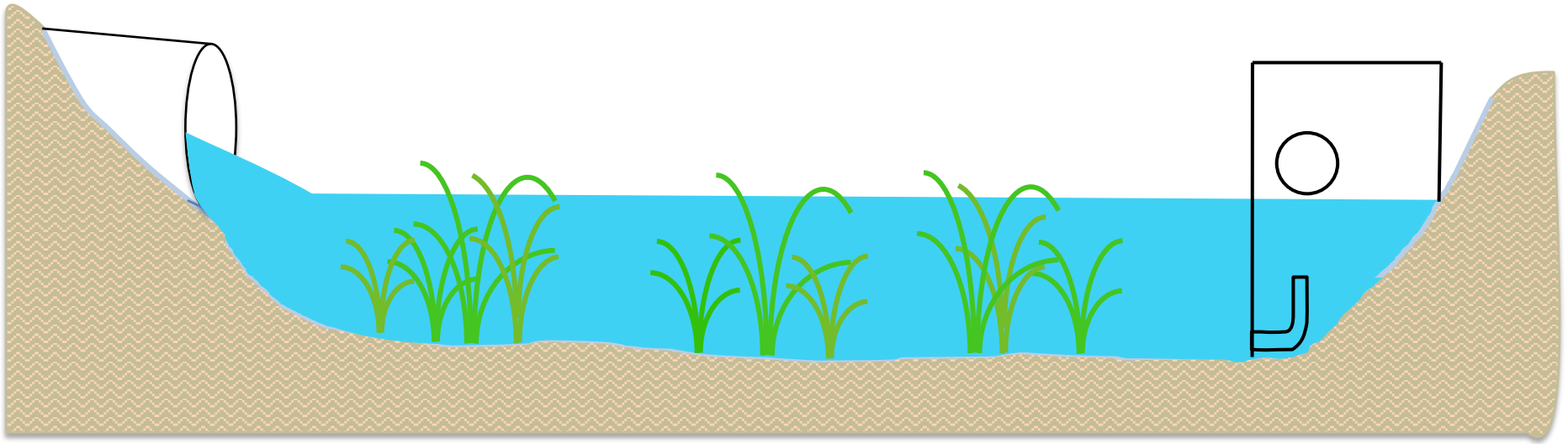

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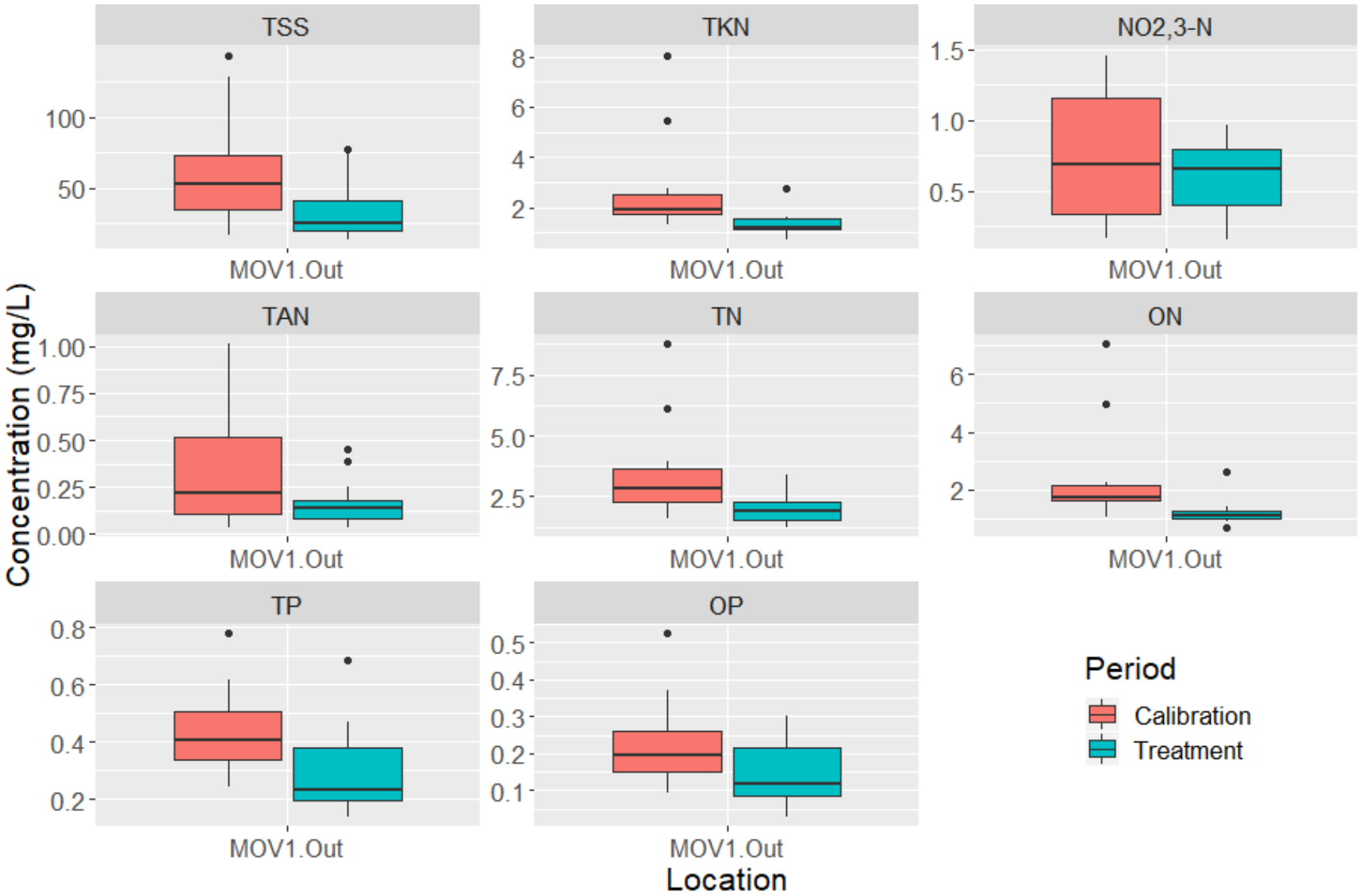
MOV Pre- vs Post-Retrofit Concentrations



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Retrofit Load Reduction in MOV1

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 $\alpha = 0.05$

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WS Retrofits

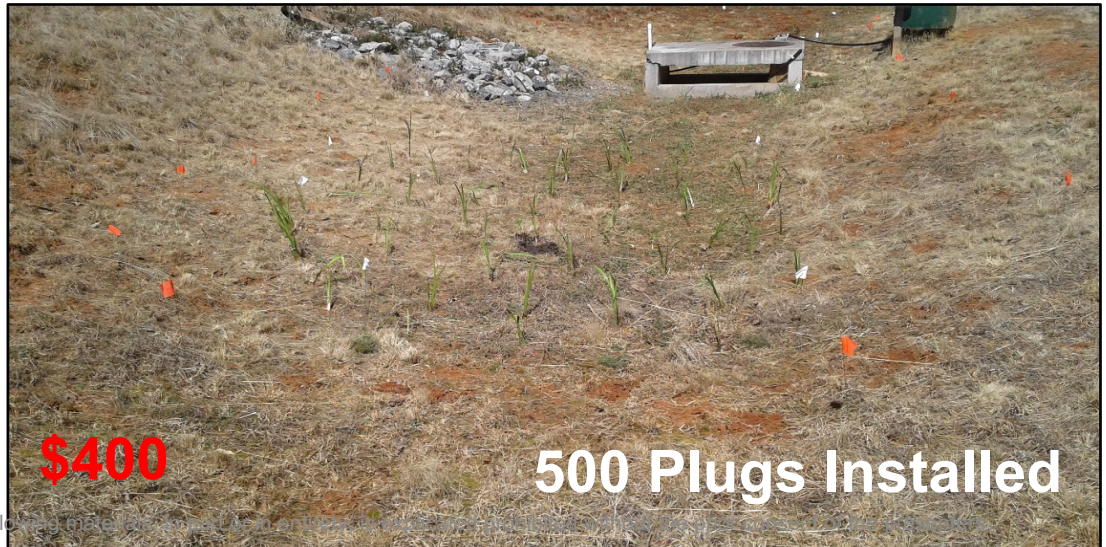
Infiltrated within 48 hr

Cost = $420









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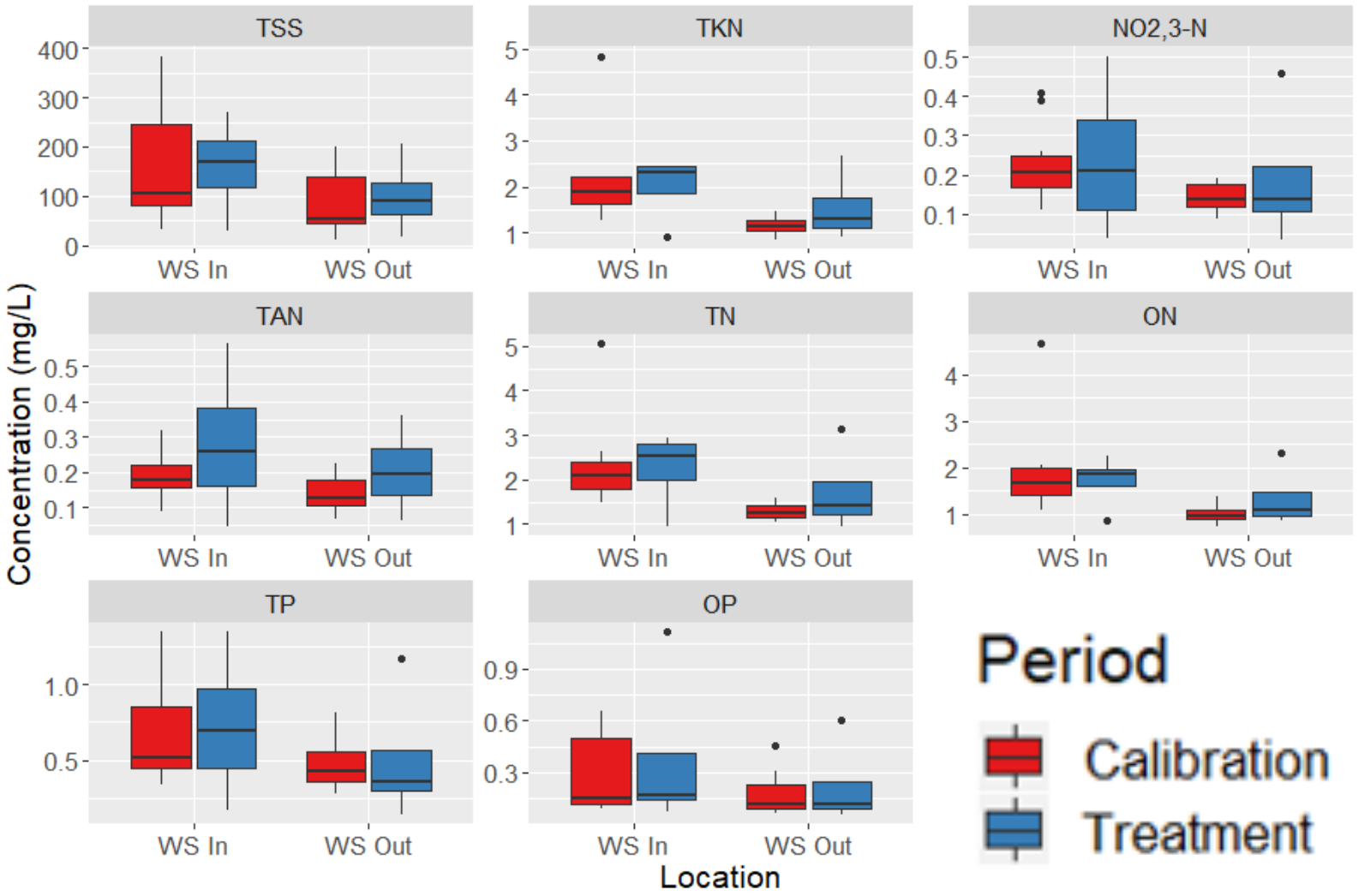
WS Pre and Post-Retrofit Concentrations



No Real Change in WQ, because no real change in PRMs!

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Comparing Morrisville (wetland) to Winston-Salem (infiltration basin)

- The Wetland discharged substantially lower nutrient concentrations (~50%) than DDBs, but had minimal impact on flow mitigation
  - Roughly 50% nutrient load removal (due to retrofit)
- The Infiltration Basin discharged the ~same nutrient concentrations as the DDB, but reduced ~50% more outflow
  - Roughly 50% nutrient load removal (due to retrofit)
- Either Result is GREAT!



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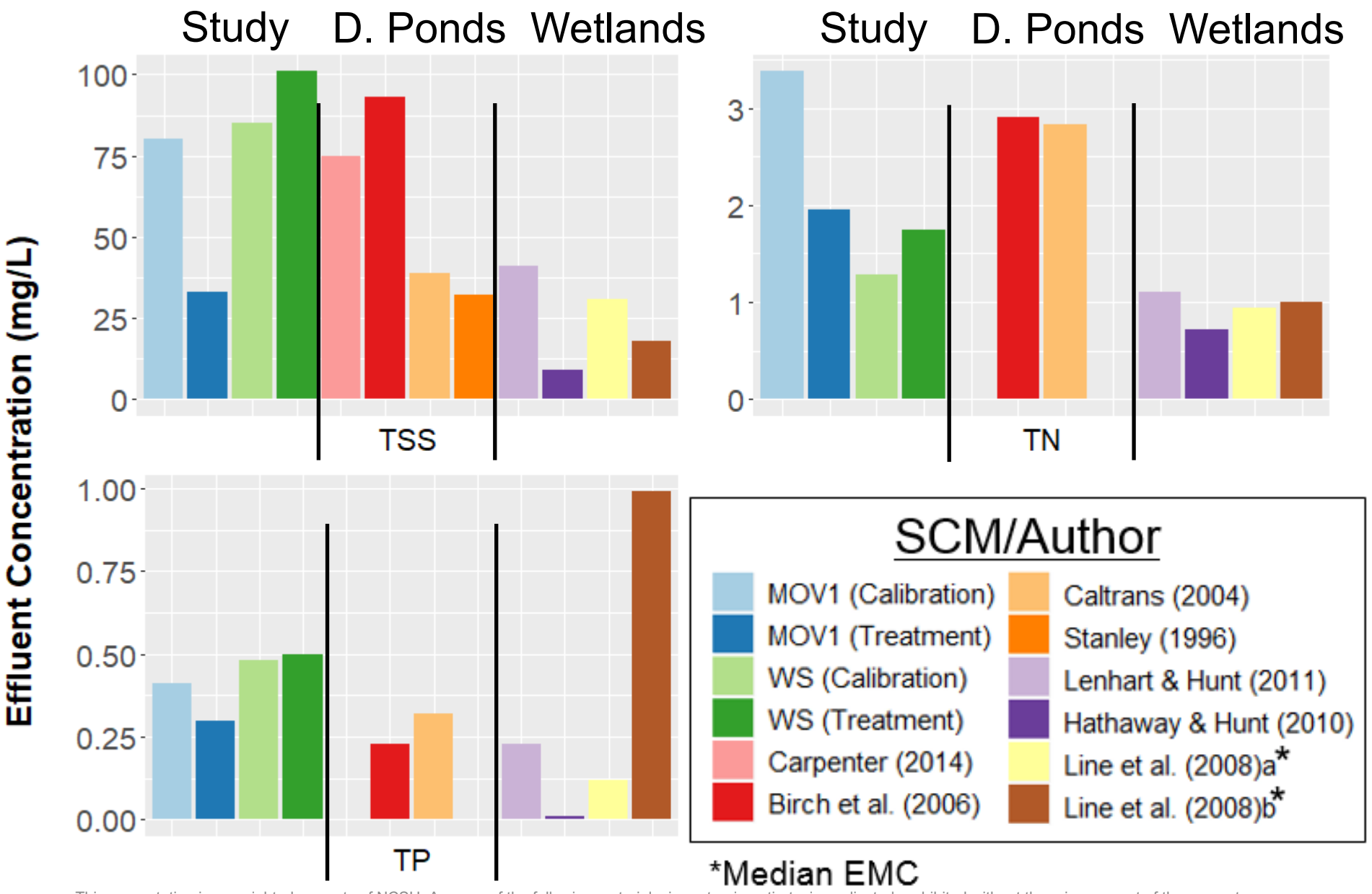

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So How Much is our Extra Treatment Worth?

Service Area	Nutrient	DMS Rate (per pound) (through 9/30/2020)
Jordan Lake Watershed	Nitrogen	$107.88
Jordan Lake Watershed	Phosphorus	$301.95
Neuse Program (03020202, 03020203, 03020204)	Nitrogen	$14.45
Neuse 03020201 Outside the Falls Lake Watershed	Nitrogen	$24.53
Neuse- Falls Lake Watershed	Nitrogen	$10.86
Neuse- Falls Lake Watershed	Phosphorus	$164.67

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Retrofit Cost Savings Over 30 Years

	TN	TP
Load Reduction (lb/yr)	67	10
Jordan Buy Down Credit Equivalency	$216,800	$90,600
Falls Buy Down Credit Equivalency	$21,800	$49,400
Neuse -Triangle Buy Down Credit Equivalency	$49,300	n/a
Cost of Retrofits	**$2-$10K**	**$2-10K**

- Buy down credit ($/lb) * Load reduction (lb/yr) * 30 yr

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Summaries and Conclusions

- Easy-to-implement retrofits could provide water quality improvements at minimal cost and…
  - Maybe Pay for Itself (& more!) on Nutrient Market
- Concentrations and load reduction greatly improved after retrofit to Wetland (Morrisville)
- Loads likely reduced after retrofit to Infiltration Basin (W-S)



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Opportunities Galore!



Naturalization of Dry Ponds

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Overgrown Dry Pond





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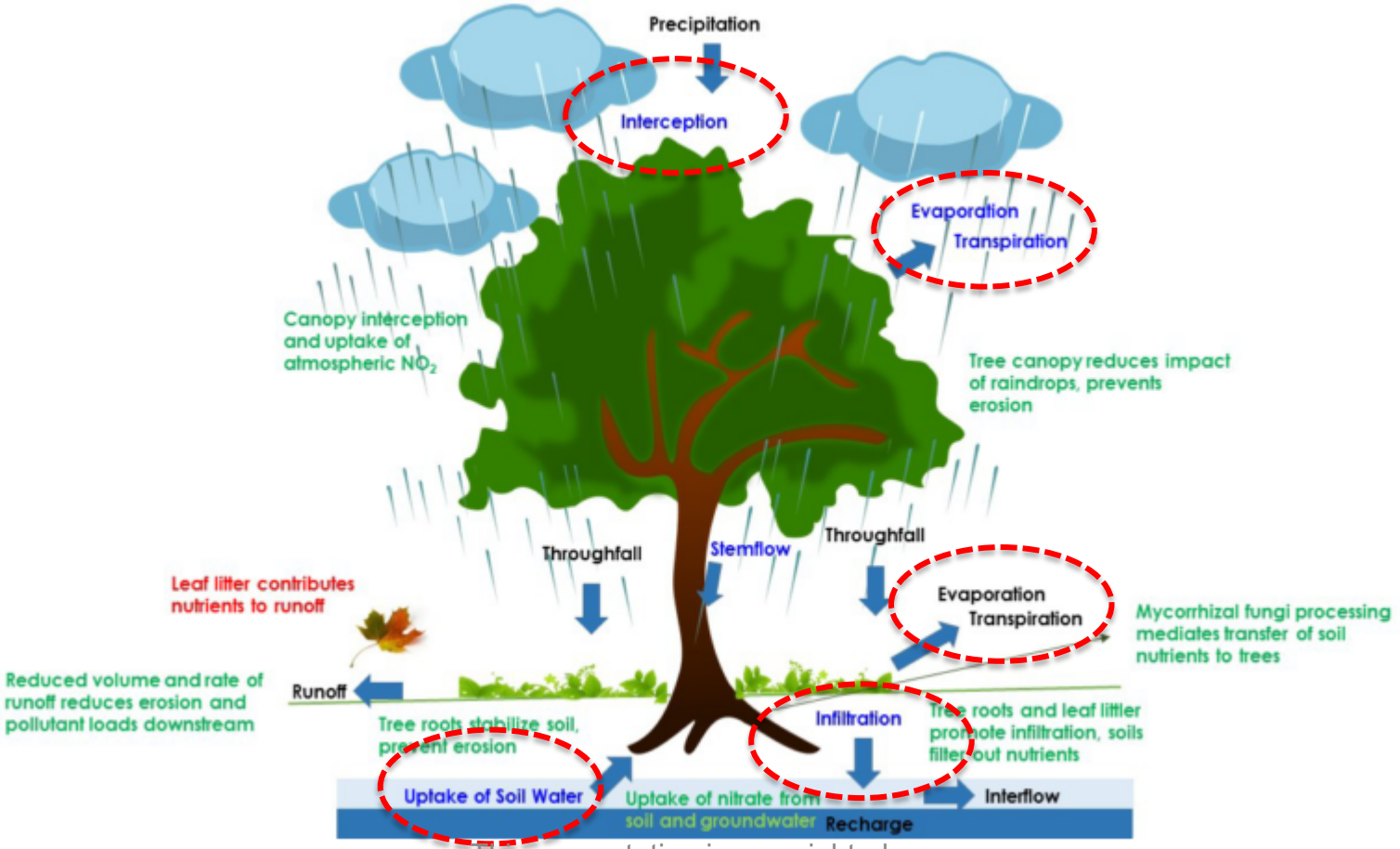
Trees as a Stormwater Tool



Center for Watershed Protection (2016)

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Field Site Locations





Raleigh – Overgrown Sites



Archdale – Maintained Sites





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N.C. Wildlife Resources Commission (2018)

Maintained Sites



Maintained 1

Water Quality: 13 Storms
Hydrology: 50 Storms



Maintained 2

Water Quality: 18 Storms
Hydrology: 48 Storms

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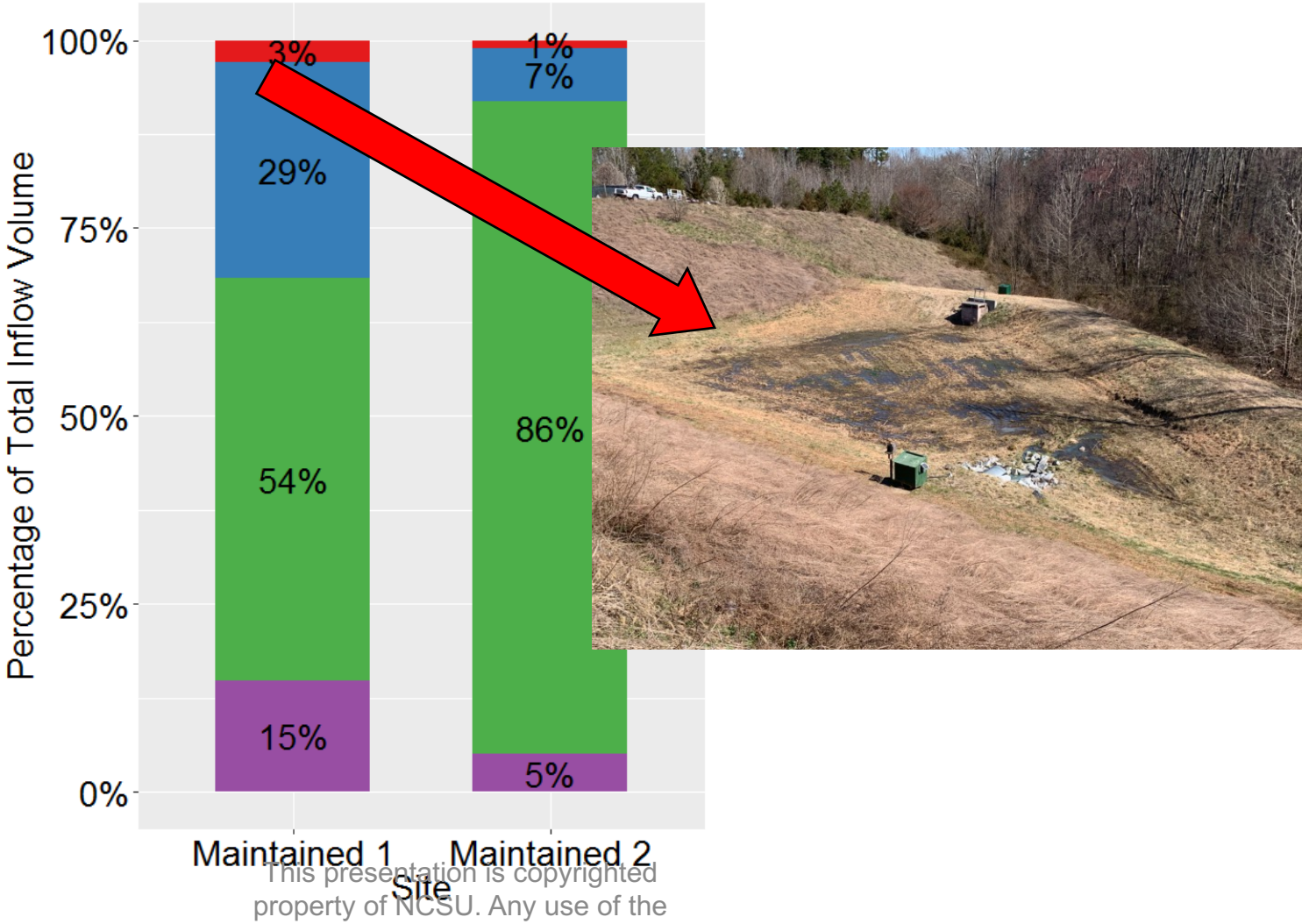
Maintained Sites – Hydrologic Balance



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Overgrown Sites



Overgrown 1

Water Quality: 26 Storms
Hydrology: 67 Storms



Overgrown 2

Water Quality: 20 Storms
Hydrology: 49 Storms

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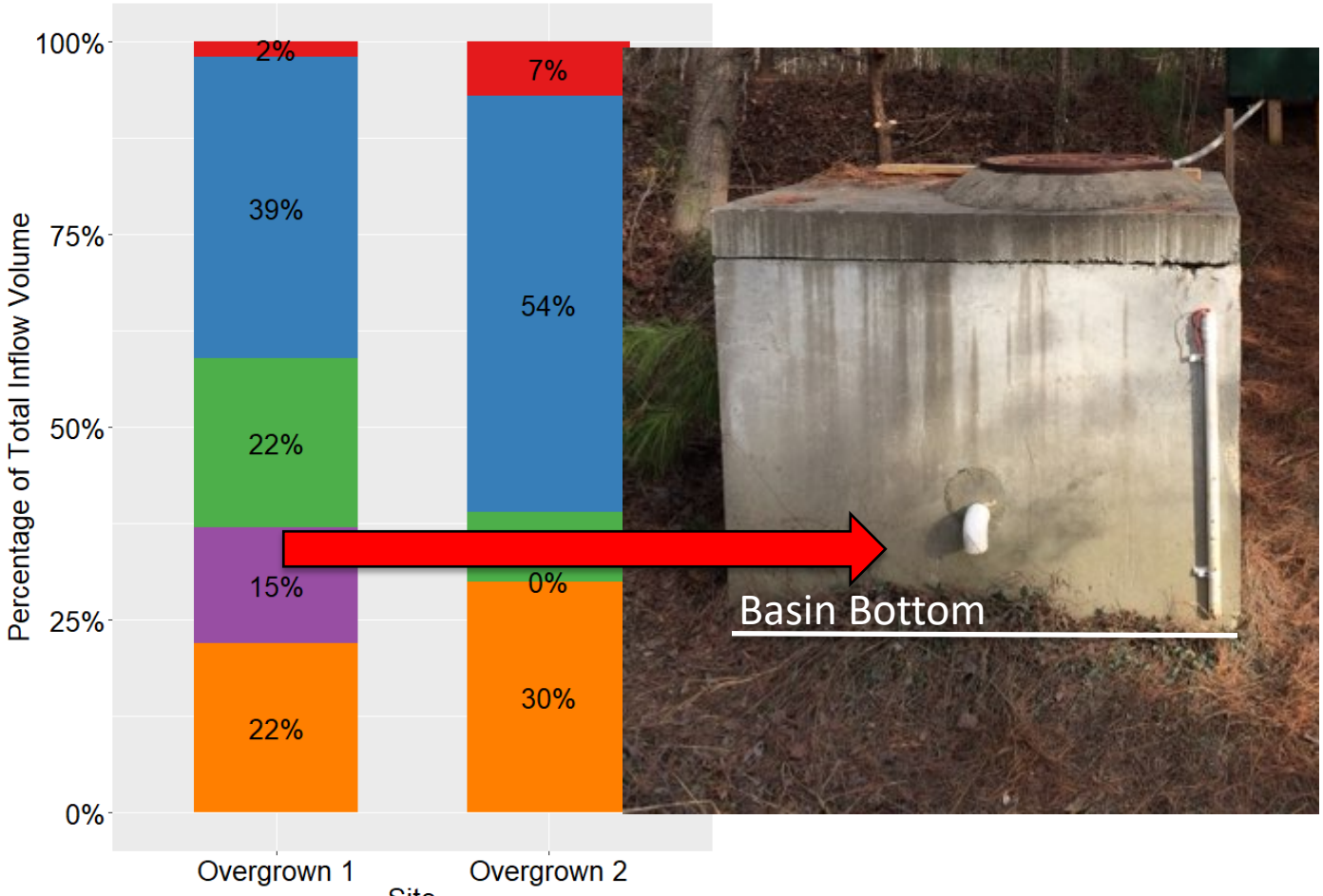
Overgrown Sites – Hydrologic Balance



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What About Pollutant Loads?

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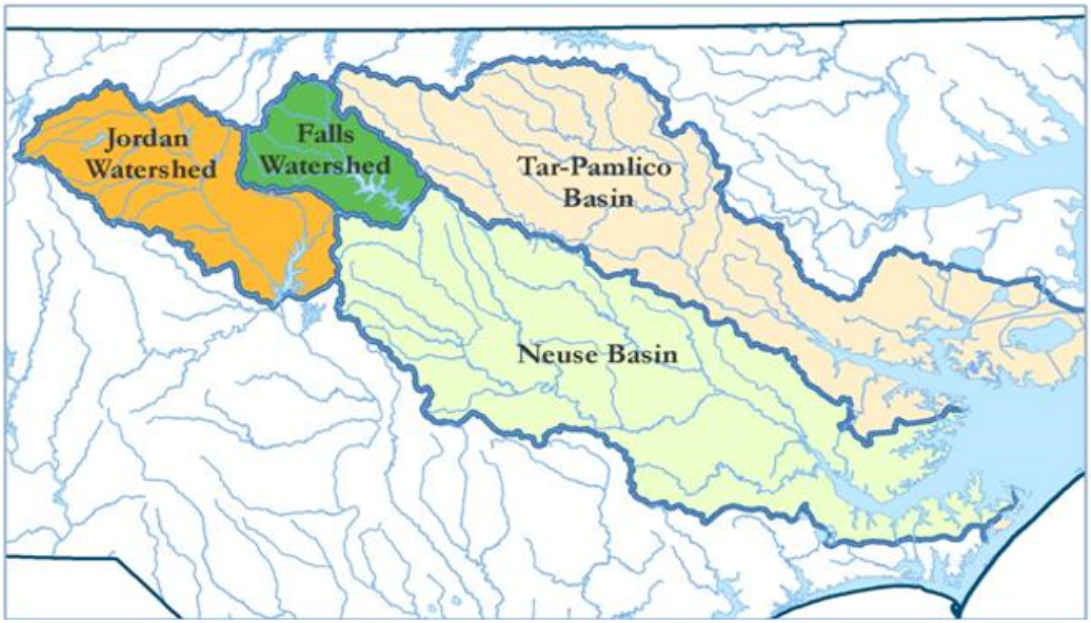
Quick Aside: SNAP

Stormwater Nitrogen and Phosphorus Tool (SNAP) Version 4.1

effective date September 10, 2018

Project Information
Land Cover Characteristics
SCM Characteristics
Overall Summary
Individual SCM Summaries
Nutrient Offset Form



Where Do I Start?
User's Manual & Listserv
Export .csv Summary File
Import An Existing Project
Save Spreadsheet

NC Environmental Quality

DWR Division of Water Resources

NCSU Stormwater Design Webpage | DWR Nonpoint Source Webpage | DWR Nutrient Practices & Crediting | DEMLR Stormwater Design Manual

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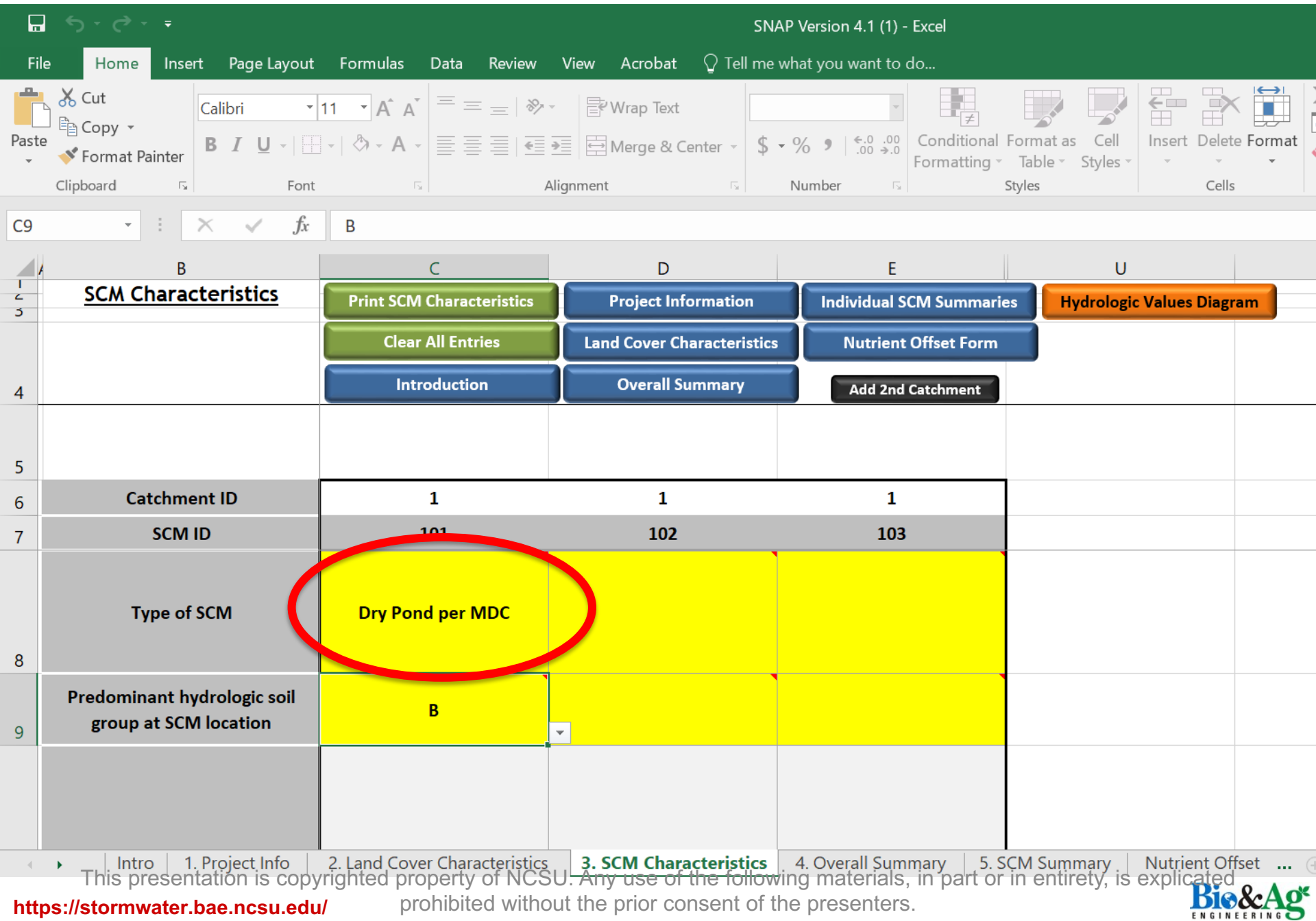
Intro | 1. Project Info | 2. Land Cover Characteristics | 3. SCM Characteristics | 4. Overall Summary | 5. SCM Sum



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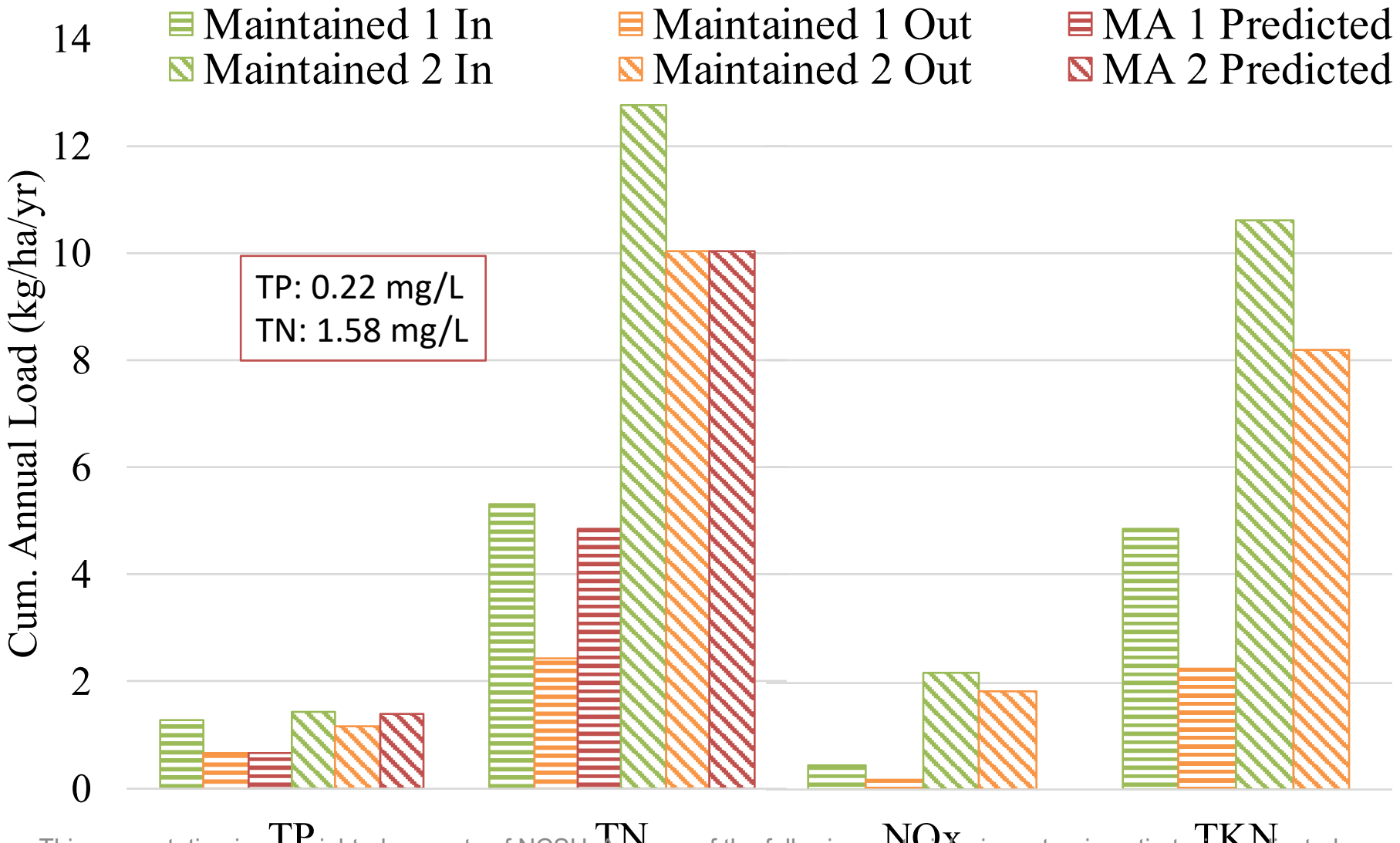
Maintained – Cumulative Annual Loads



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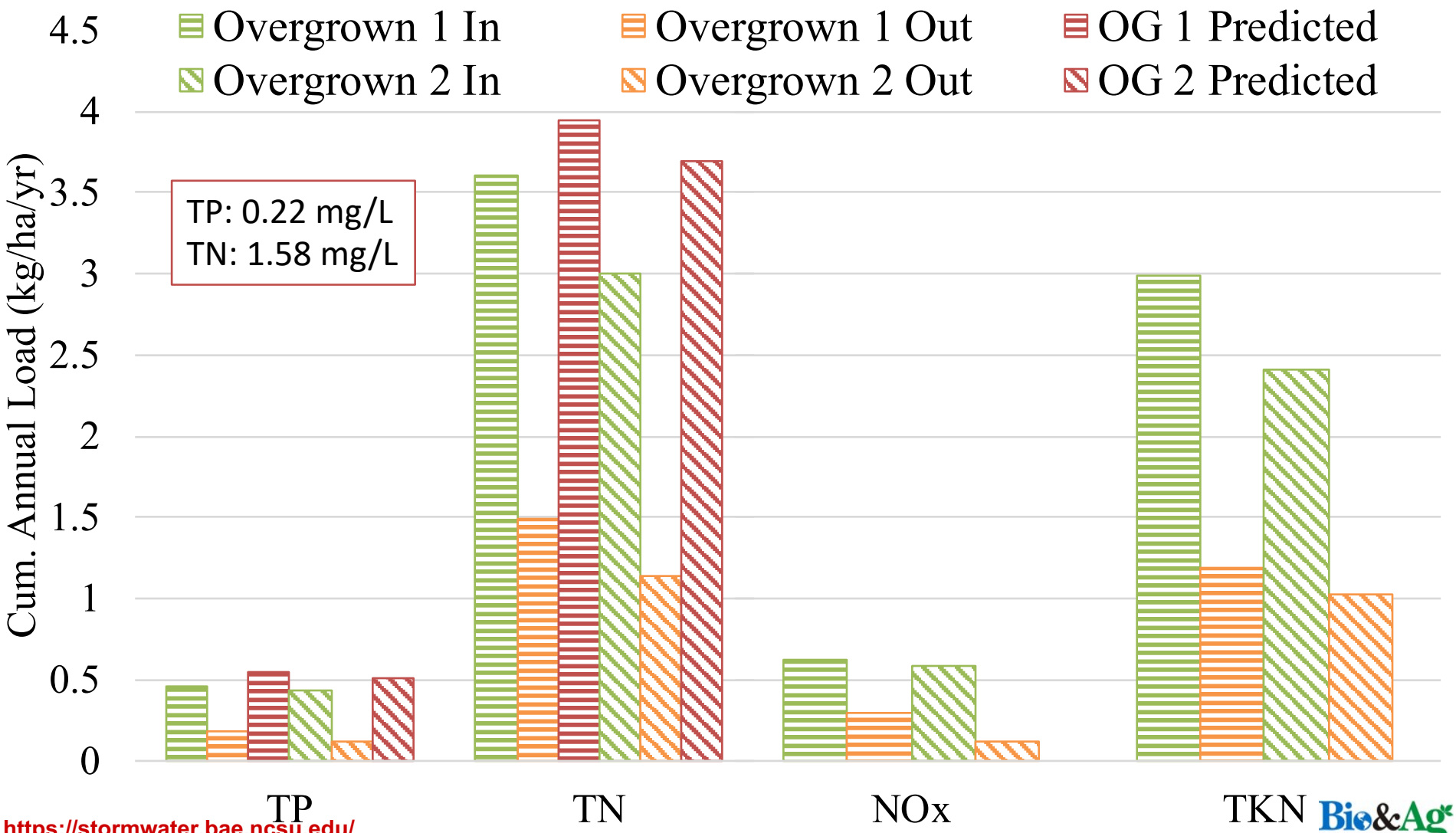
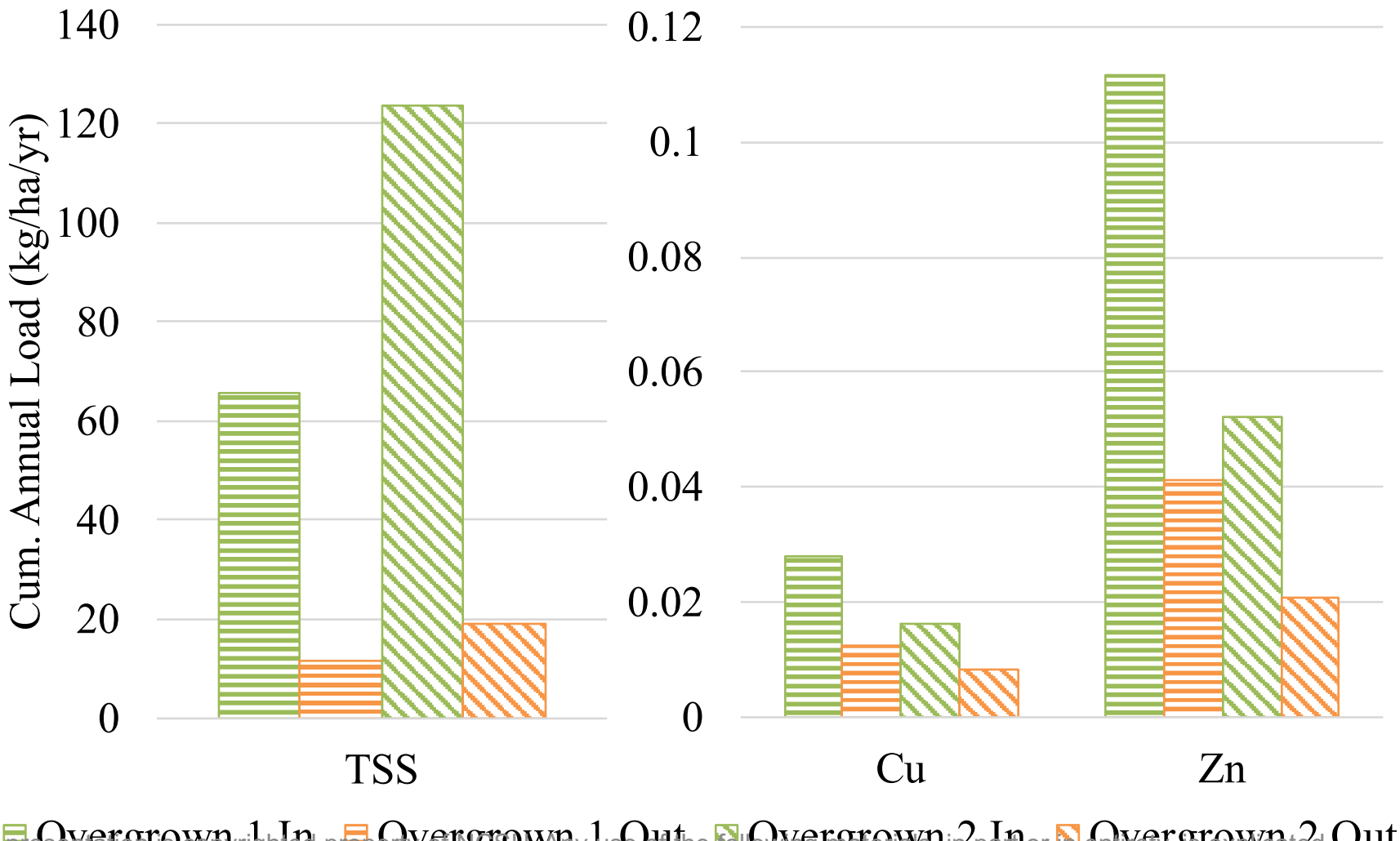
Overgrown – Cumulative Annual Loads



Overgrown – Cumulative Annual Loads



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Take Home Point/s

- While SNAP generally did a GREAT job of modelling standard DDB's…
- It reliably UNDERPREDICTED the performance of Naturalized DDB's.

- Suggesting that Naturalized DDB's > Standard DDB's.

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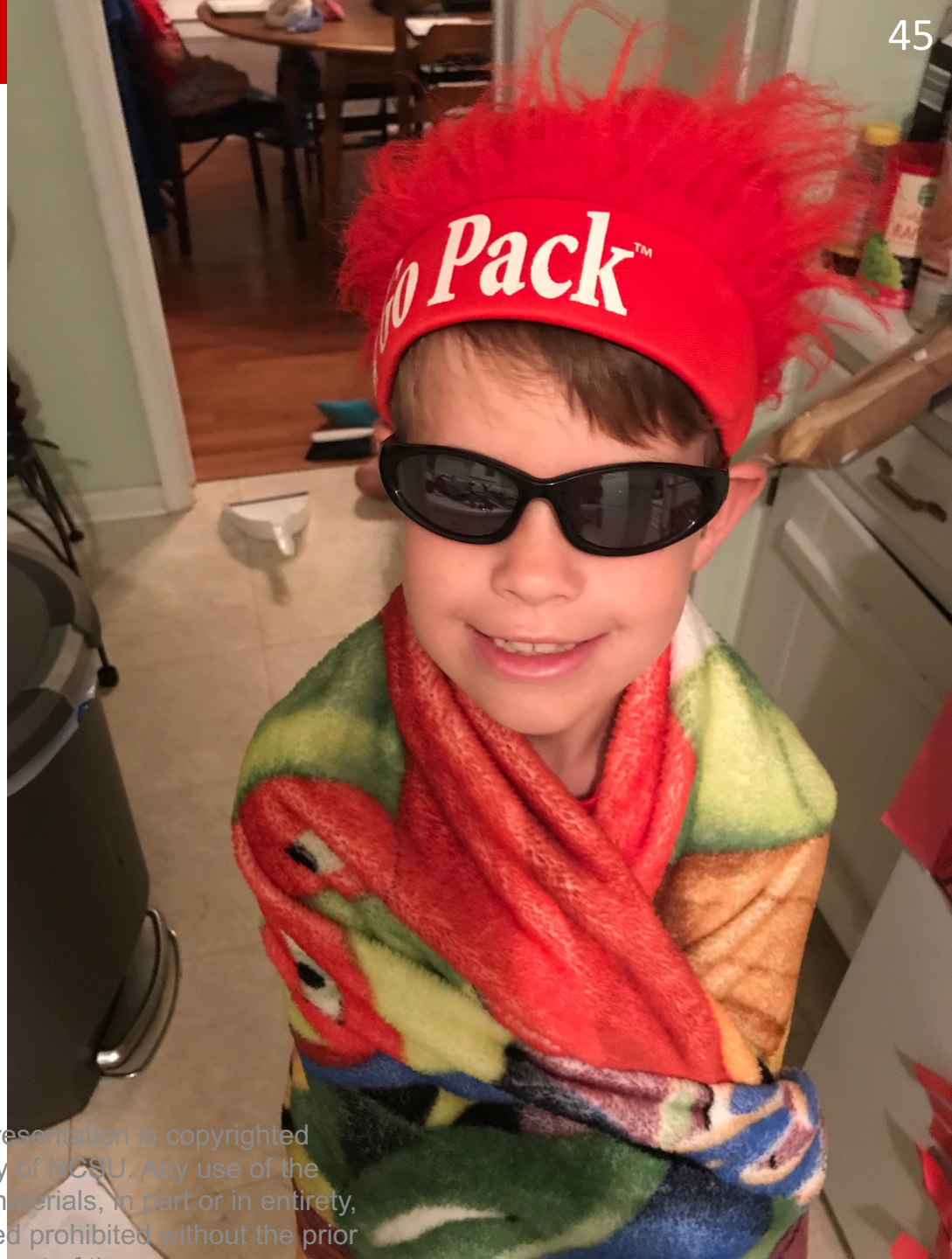
So… what's holding us back from just "letting them go??



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Is the DDB within 500’ of people?

Yes – This retrofit is a no-go

No – Then, we might be on to something…

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Summary of "Letting them go"

- Maintenance is simple – and cheaper
  - Check inlets & outlets
  - No mowing
- They likely reduce outflow (relative to standard DDB)
  - And therefore pollutant loads
- Must be careful where this retrofit is implemented
  - b/c of mosquitoes



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So Where from Here?

- NC DEQ NPS Unit is considering creating a new category of Dry Detention Basins for their crediting purposes
  - Trish D'Arconte
- Naturalized DDB's would receive lower nutrient effluents and move volume mitigation





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For More Information

Journal of Environmental Management 255 (2020) 109853

Contents lists available at ScienceDirect

Journal of Environmental Management

journal homepage: http://www.elsevier.com/locate/jenvman

Research article

Hydrologic and water quality performance of two aging and unmaintained dry detention basins receiving highway stormwater runoff

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ARTICLE INFO

Keywords:
Highway
Stormwater
Dry detention basin
Maintenance
Non-point source pollution
Carbon sequestration

ABSTRACT

Dry detention basins (DDBs) are a type of stormwater control measure (SCM) designed to provide flood storage, peak discharge reduction, and some water quality improvement through sedimentation. DDBs are ubiquitous in the urban environment, but are expensive to maintain. In this study, two overgrown DDBs near Raleigh, NC, receiving highway runoff were monitored for up to one year to quantify their water quality and hydrologic performance. Both basins, B1 and B2, have not received vegetation maintenance since construction in 2007. Flow-weighted composite samples were collected during storm events and analyzed for nutrients (Total Phosphorus (TP), Ortho-phosphorus (OP), Ammonia-N (NH_3), NO_{2-3}-N (NO_X), and Total Kjeldahl Nitrogen (TKN)), total suspended solids (TSS), and total Cd, Cu, Pb, and Zn. An annual water balance was also conducted to quantify runoff volume reduction. Despite low influent concentrations from the highway, significant removal efficiencies were found for all constituents except NH_3 in B1. TP, OP, NO_X, TSS, and Zn were reduced in B2. Both basins achieved greater than 41% volume reduction through soil infiltration and evapotranspiration, resulting in significant pollutant load reductions for all detected constituents, between 59% and 79% in B1 and 35% and 81% in B2. This study provides evidence that overgrown and unmaintained DDBs can reduce pollutant concentrations comparable to those reported for maintained DDBs, while reducing more volume than standard DDBs. Moreover, carbon sequestration likely increases while maintenance costs decrease.

1. Introduction

Urbanization and widespread development over the last century have increased the presence of impervious areas (e.g., roadways, parking lots, rooftops) and altered the natural hydrologic regime (National Research Council, 2009). In these conditions, stormwater runoff travels overland faster and in greater volume, carrying pollutants, sediment, trash, and debris to downstream lakes, rivers, and streams (Schueler, 1996). This runoff contributes to flooding, downstream erosion, and aquatic habitat disturbance (Paul and Meyer, 2001). Traditional stormwater control focused on temporarily detaining stormwater volume to reduce flooding and the peak flowrate discharging to streams (Debo and Reese, 2002). More recently, water quality control has become an integral component of urban stormwater management. However, traditional, detention-based systems are still common in the urban environment, and there is potential to improve the design or management strategy of these outdated systems to provide additional water quality and runoff reduction (Wissler, 2019).

Dry detention basins (DDBs) are a traditional type of stormwater control measure (SCM) designed to temporarily collect and detain stormwater runoff for flood control and peak flow mitigation rather than water quality improvement (Papa et al., 1999). DDBs consist of a large, earthen depression that collects runoff (usually from impervious areas) and an outlet structure that slowly discharges stormwater after a storm over 1–5 days (Erickson et al., 2013; North Carolina Department of Transportation (NCDOT), 2014). DDBs are designed to remain dry in between storm events as standing water encourages mosquito proliferation (Greenway et al., 2003; Hunt et al., 2005; MacKay et al., 2016).

Although ubiquitous in the urban landscape due to their simple design and function, DDBs are one of the least effective SCMs in terms of water quality and runoff volume reduction (Stanley, 1996; Harper et al., 1999; Shammaa et al., 2002; Fassman, 2012). Sedimentation of particulate pollutants constitutes the only pollutant removal mechanism (PRM) encouraged by their design (Papa et al., 1999; Erickson et al., 2013), which limits the removal of soluble pollutants (Guo et al., 2000; Shammaa et al., 2002). Existing studies on DDB performance conclude

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https://doi.org/10.1016/j.jenvman.2019.109853
Received 30 July 2019; Received in revised form 23 October 2019; Accepted 11 November 2019
Available online 21 November 2019
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Time for Q&A !







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