UNRBA Nutrient Credit Development Project

PFC Meeting
June 2015

June 2, 2015

Status Update on Batch 1 Practices

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Batch 1 Practices

- Preliminary documents were submitted to the SME
  - Filter Strips with Design Variants
  - Infiltration Devices
  - Soil Amendment
- We received comments back in last week
- We will be drafting practice standards in June and July
- Informal review process (PFC, DWR, NSAB)

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Summary of Preliminary Notes for SME: Batch 1 of 3

Andrew Anderson, P.E.
Erin Carey, M.S.
William F. Hunt, III, Ph.D., P.E.

Summary of Progress

1. NCSU has reviewed 3 preliminary practice documents to date
   - Level Spreaders / Vegetated Filter Strips
   - Infiltration devices
   - Soil amendment
2. Load reduction or volume reduction confirmed as most appropriate current metric for crediting most practices
3. Primary feedback given:
   - Suggestions on other possible studies or papers
   - Ways of looking at data

BMP Performance Metrics

- Many ways to quantify performance in literature

$$\text{Efficiency Ratio} = 1 - \frac{\text{average outlet EMC}}{\text{aveage inlet EMC}}$$

$$\text{Mean Concentration} = 1 - \frac{\text{average outlet concentration}}{\text{average inlet concentration}}$$

$$\text{Achievable Efficiency} = \frac{(C_{influent} - C_{limit})}{C_{influent}}$$

$$\text{Storm Efficiency} = 1 - \frac{Load_{out}}{Load_{in}}$$

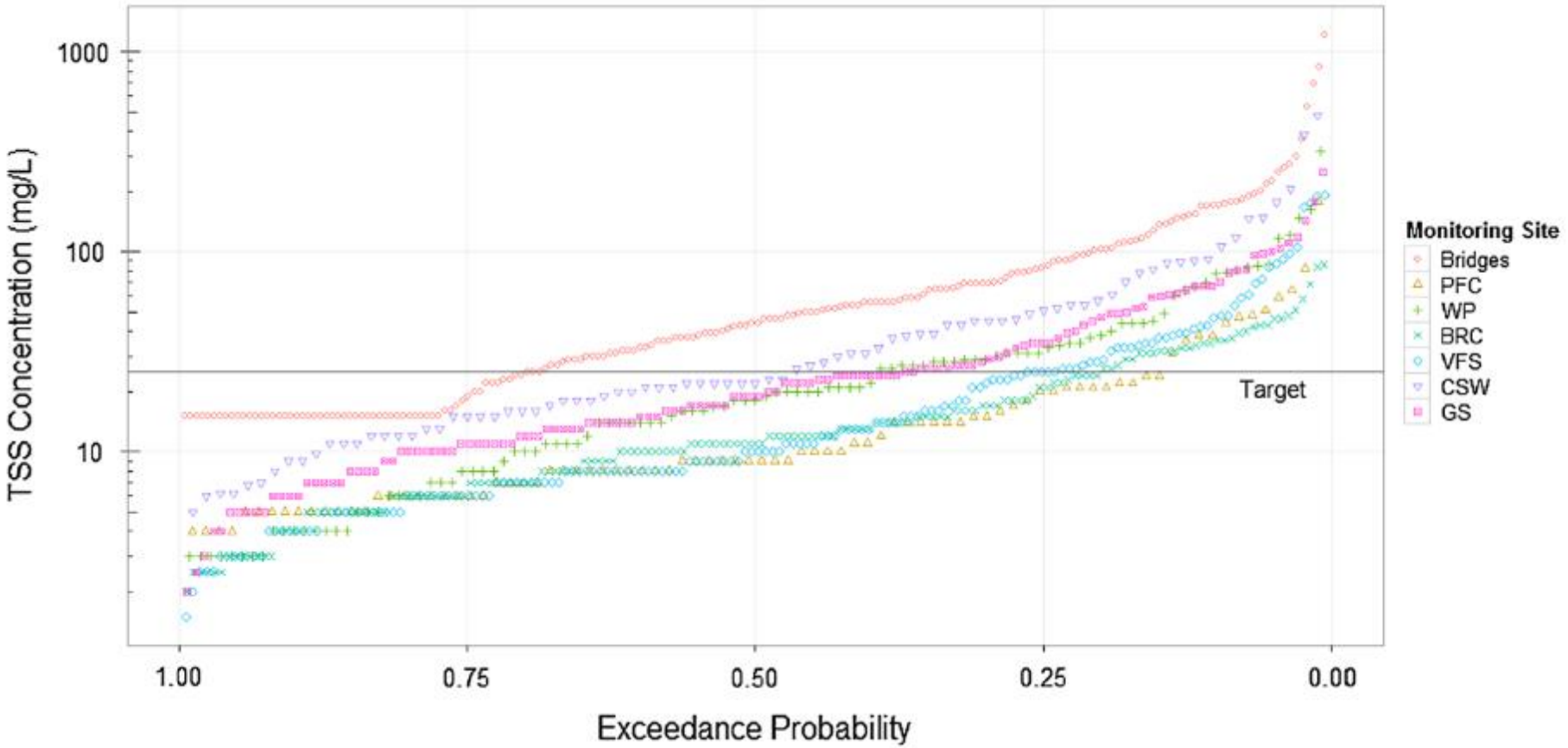
$$\text{Summation of Loads} = 1 - \frac{\text{sum of outlet loads}}{\text{sum of inlet load}}$$

$$\text{Average Efficiency} = \frac{\sum_{j=1}^{m} \text{Storm Efficiency}_j}{m}$$

BMP Performance Metrics

- After reviewing documents and checking the literature, agree that **load reduction** is generally the best metric for this crediting group
  - Watershed nutrient reductions are load-based
  - Accounts for storm size vis-à-vis volume
- However…
  - Future efforts based on more complex modeling, research, and regulations should include effluent concentrations

Effluent Concentrations and Probabilities



From: Winston, R.J., Lauffer, M.S., Narayanaswamy, K., McDaniel, A.H., Lipscomb, B.S., Nice, A.J., Hunt, W.F., 2015. Comparing Bridge Deck Runoff and Stormwater Control Measure Quality in North Carolina. J. Environ. Eng. 1–14.

Effluent Concentrations and Probabilities

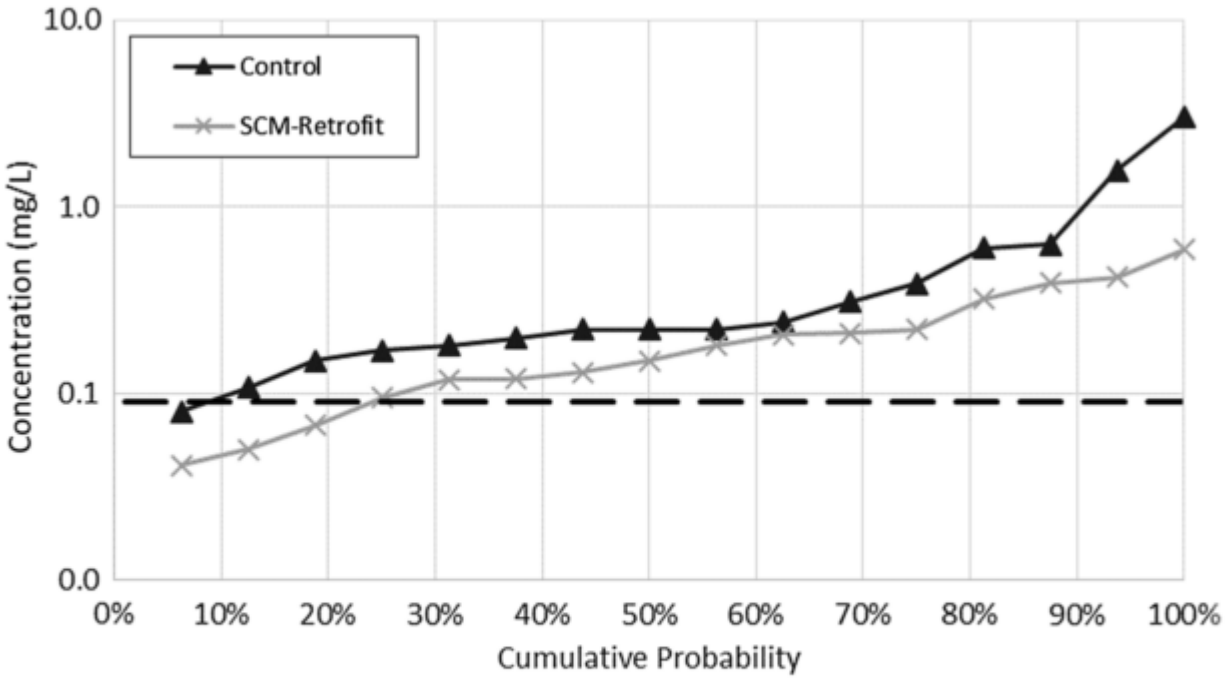


Fig. 13. Cumulative probability plot for TP with 0.09 mg/L water quality threshold

Page, J.L., Winston, R.J., Mayes, D.B., Perrin, C.A., Hunt, W.F.I., 2015. Retrofitting Residential Streets with Stormwater Control Measures over Sandy Soils for Water Quality Improvement at the Catchment Scale. J. Environ. Eng. 5, 654–662.

Level Spreader-Vegetated Filter Strip

- NCDENR Stormwater BMP Manual-
  - A level spreader consists of a concrete linear structure constructed at virtually zero percent grade
  - The filter strip is defined as the land between the outlet of the level spreader continuing downslope to the top of the stream bank or other surface water

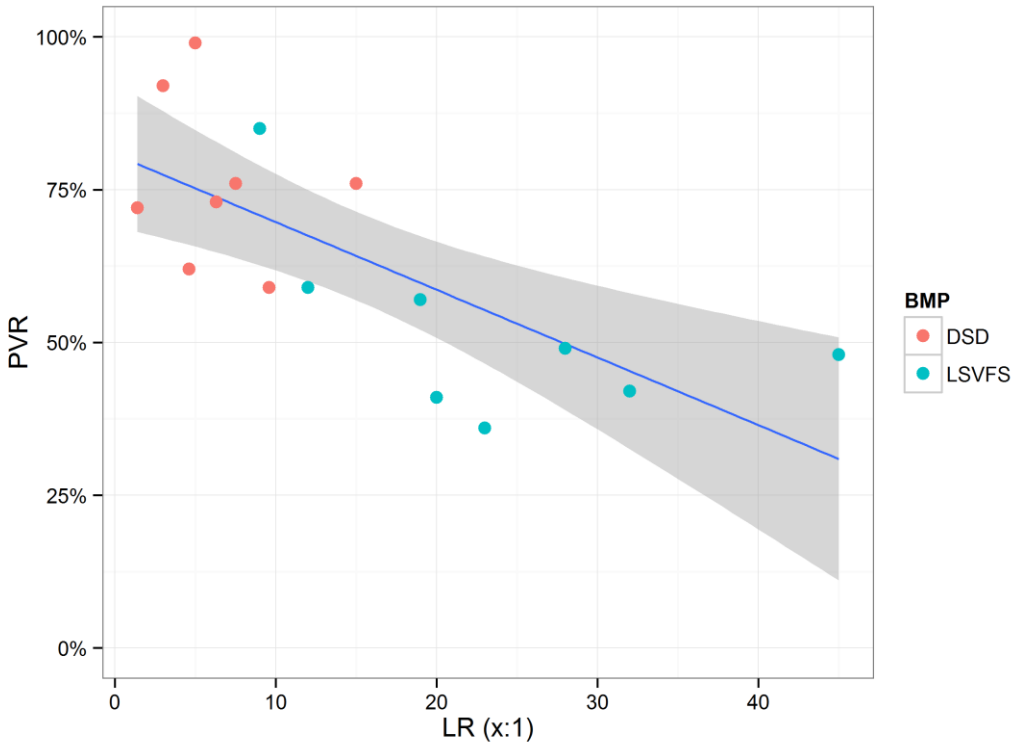
Level Spreader-Vegetated Filter Strip

- **Status Update:** While basic specifications pulled from design manual for the proposed credits process…
  - Minimum Design Criteria (Session Law 2013-82)
  - Stakeholder team of government, private practitioners, and academia
  - Encompass all requirements for siting, design, construction and maintenance of stormwater BMPs.
  - Applies to fast-track permitting only, does not affect credit development

Level Spreader-Vegetated Filter Strip

- Some studies reported mean load reductions of **22 individual load reductions**, some were **cumulative load efficiencies**
  - General conclusions of the studies and values of the metrics are often the same, however.
- >25 foot filter strips should get a better amount of TSS credit than is currently offered in the manual
  - Current work undertaken by Winston, Hunt, and Anderson with a sediment hydraulics and trapping model support the data of filter strip performance with respect to TSS

Level Spreader-Vegetated Filter Strip



We agree that loading ratio seems to be the strongest predictor of **Percent Volume Reduction**

- NEW: Data in thesis by Natalie Carmen *supports* strong correlation Cardno elucidated between Loading Ratio
- Think of downspout disconnection as a micro-filter strip

Level Spreader-Vegetated Filter Strip

- Level spreaders with “amendments”
  - Current literature has multiple definitions, including proprietary phosphorus-sorptive media
  - Consider common interpretations and uses of “amendment” in credit decision making:
    - Lime
    - Soil tilling
    - Stabilized compost or organic matter

Infiltration Devices

- NCDENR Stormwater BMP Manual- Infiltration devices are trenches or basins that fill with stormwater runoff and allow the water to exfiltrate, i.e., exit the device by infiltrating into the soil.

Infiltration Devices

- Erickson Work Promising
  - Iron filings in infiltration media show significant reduction in phosphate (88%)
  - Additional studies suggested for support
- Additional Peer- Reviewed References Suggested
  - **Birch, G. F., et al (2005)**. Efficiency of an infiltration basin in removing contaminants from urban stormwater.
    - Study is from Australia where infiltration basins have similar definition/design as in North Carolina
    - TSS, heavy metal concentration reductions
    - TKN, Phosphate removal efficiency

Infiltration Devices

- **Reddy, K. R., et al (2014).** Evaluation of Biochar as a Potential Filter Media for the Removal of Mixed Contaminants from stormwater
  - Column study evaluates efficacy of biochar which could be added to infiltration devices
  - Observes reduction in TSS, Nitrate and phosphate concentration
  - Decrease in heavy metal concentrations- variable by metal
- **Hatt, B. E. et al (2007).** Treatment performance of gravel filter media: Implications for design and application of stormwater infiltration systems. Simulation experiments on gravel infiltration system.
  - Observed good removal of TSS and heavy metals
  - Less effective with nutrients, particularly dissolved nutrients

Soil Amendments

- Tillage practices or organic or inorganic additions to in situ soils, or media placed on top of in situ soils to increase stormwater treatment potential

Soil Amendments

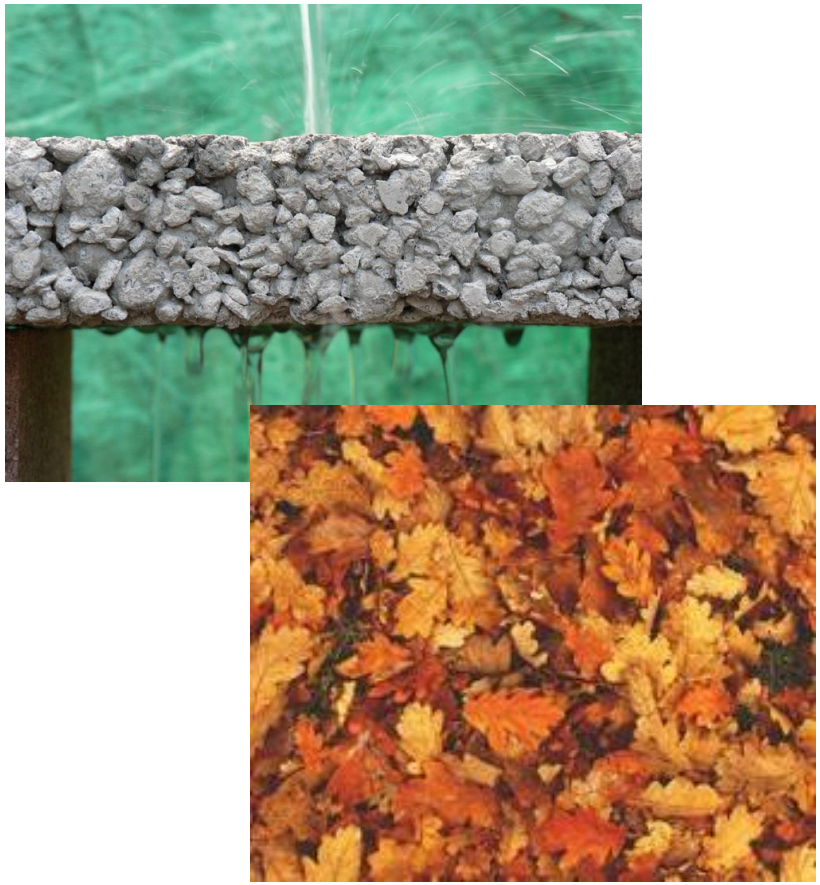
- Clarified the scope, definition, and extent of “soil amendment”
  - Applicable to any controlled soil modification in the watershed that is not defined in the North Carolina rules as *agriculture*.
  - Rural, grassland, industrial, commercial, residential

Soil Amendments

- **Conclusion**: Agreement in that it is difficult to accurately credit
  - Lack of adequate literature specifically on nutrient load reductions
- Very limited data
  - Studies only have a few storms
- Alternatively, could infer annual performance via surrogate measurements. Possibilities:
  - *Curve Number adjustment? (Storm-EZ)*
  - *Infiltration rate-based Hydrologic Soil Group pre- / post-amendment? (Jordan Tool)*

Other Practices and NCSU Data Timeline

- Permeable Pavement (with design variants): Multiple studies in Ohio involving permeable pavement set to be finalized in report form in late June early July (Winston)
- Leaf litter: 16 catch basins across 4 cities, 4 land uses, monitored for gross solid nutrients for 1 year. Masters thesis results expected in late July/early August 2015.



Preliminary Analysis for Batch 2 Practices

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Batch 2 Practices

- Preliminary documents were submitted to the SME in late May
  - Bioretention with Design Variants
  - Land Conservation
  - Pervious Area Nutrient Management
- We are anticipating comments back in late June
- We will be drafting practice standards in July and August
- Informal review process (PFC, DWR, NSAB)

Bioretention with Design Variants

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Bioretention with Design Variants - Studies

- There is a significant amount of published data available on bioretention performance
- Most of this performance data has already been summarized by the NCSU stormwater group and used to build the HyperModel

North Carolina Long-Term Bioretention Hydrologic Performance Tool

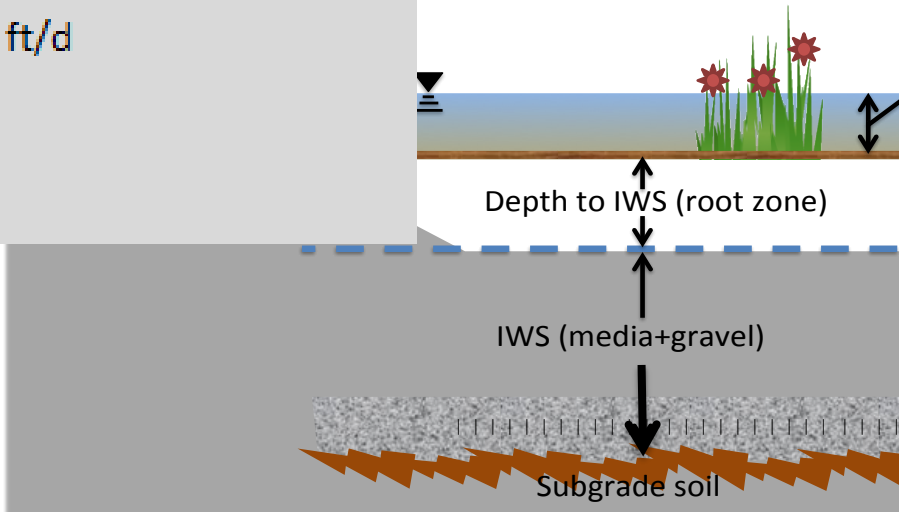
LONG-TERM MODELING OF BIORETENTION HYDROLOGY WITH DRAINMOD

Developed by: Drs. Robert A. Brown, William F. Hunt, and R. Wayne Skaggs
User Interface by: Brad J. Wardynski
Department of Biological and Agricultural Engineering
North Carolina State University, Raleigh, North Carolina
Contact: Dr. William (Bill) F. Hunt, 919-515-6715, bill_hunt@ncsu.edu
Funded by: Water Resources Research Institute (WRRI) of the University of North Carolina

LAUNCH BRC HyPerTool

Screen Capture of HyperModel Input

DESIGN INPUT PARAMETERS		
Units	English	
Hydrologic Soil Group	A	
Soil Media Depth	3	ft
Depth to IWS	1	ft
Average Surface Ponding	9	in
Surface Storage Ratio	100%	relative to WQ volume
Drainage Coefficient	2	ft/d
BRC Area : Drainage Area Ratio	11.1%	
Factor of Safety	NONE	



HyperModel Output Becomes JFSAT Input

DESIGN OUTPUT PARAMETERS		
Maximum Subgrade Ksat	1.180	in/hr

HYDROLOGY	Total (in/yr)	Percent of Total
Runoff	419	
ET	39	9%
Overflow	20	5%
Exfiltration	360	86%
Drainage	0	0%

VOLUME REDUCTION	95%
TREATS 90% OF RUNOFF?	YES

WATER QUALITY	Total (lb/ac-yr)	Percent Reduction
Influent Avg Total N	17.2	
Effluent Avg Total N	0.8	95%
Influent Avg Total P	2.0	
Effluent Avg Total P	0.1	95%

Hydrologic fate on the custom BMP tab of JFSAT

Percent mass removal on the custom BMP tab

Future Design Variants to Consider for Bioretention

- Current research on enhanced media shows potential reductions in effluent concentrations
- Studies have raised many questions and indicate that additional research is needed
- For now, the credit for bioretention with design variants would be calculated using a combination of the HyperModel and JFSAT models
- In the future, adjustments to effluent concentrations in JFSAT may be warranted

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Pervious Area Nutrient Management

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Pervious Area Nutrient Management - Studies

- Research on the impact of fertilizer on water quality is wide-ranging
- The applicability of the research for credit development is limited
  - Many studies focus on nitrogen leachate losses (percolation through the soil rather than surface runoff)
  - Well-control experimental greenhouse or column studies, or
  - Are outside of the region
- Eight of 12 studies originally included in the Screening Analysis database were omitted from the Credit Estimation database
- Based on the lack of directly usable scientific data, we see two options for moving forward with this practice

Pervious Area Nutrient Management: Option 1

- Define this measure as a combination of practices that account for major factors that reduce the nutrient loss from managed turfgrass

Factor	Threshold	
Behaviors		
Fertilizer Use	High Risk:	Low Risk:
Application	Broadcast on impervious surface	Targeted – turfgrass only
Lot Characteristics		
Lot Canopy Cover	20% or less	20% or more
Turfgrass density	Bare spots, thin cover	“Thick”, no bare spots
Soil Type	Compacted	High-Infiltration

Pervious Area Nutrient Management: Option 2

- Apply the results from a Fertilizer Loading Model previously developed by Cardno for a watershed in Florida
  - Based on an HSPF model developed by the Florida Department of Environmental Protection and
  - Refined by Cardno to directly simulate fertilizer management strategies
  - Estimates the fertilizer loss from managed turf in an example 100 ac medium density residential development
- Modifications to FLM would be needed to be representative of the North Carolina Piedmont

Land Conservation

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Land Conservation - Study

- One local study conducted by the NC Forest Service (Boggs et al. 2013) has been selected as the primary source of data for this credit.
  - Study was conducted in the Falls Lake watershed
  - November 2007 to June 2010
  - Measured flows and nutrient concentrations across the hydrographs of storms
  - Perennial streams of six forested (mixed pine-hardwood) catchments
  - Both Carolina Slate Belt and Triassic Basin soils were represented
  - Period represented dry and wet hydrologic conditions.

Average Areal Loading Rates Observed in Undisturbed Forests (Boggs et al 2013)

Geologic Province	Annual Nitrogen Loading Rate (lb/ac/yr)	Annual Phosphorus Loading Rate (lb/ac/yr)
Carolina Slate Belt	1.0	0.14
Triassic Basin	1.8	0.17

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Recommendations for Crediting Land Conservation

- Compare the areal loading rates from undisturbed areas in the Falls Lake Watershed to the new development targets for nutrient loading
  - 2.2 pounds per acre per year of nitrogen
  - 0.33 pounds per acre per year of phosphorus
- The credit associated with land conservation is calculated as the difference

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Proposed Nutrient Credits for Land Conservation

- These credits would vary based on geologic province and would represent average conditions over various hydrologic conditions

Geologic Province	Annual Nitrogen Credit (lb/ac/yr)	Annual Phosphorus Credit (lb/ac/yr)
Carolina Slate Belt	1.2	0.19
Triassic Basin	0.4	0.16

Schedule for Batch 3 Practices

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Preliminary Schedule for Batch 3 Practices

- Requested data from Deanna Osmond in late May based on recent data collected in the Jordan Lake watershed
  - Livestock Exclusion
  - Riparian Buffers
- Coordinating with John Cox to get the City's data on
  - Elimination of Illegal Wastewater Connections

Potential Reprioritization of Initial Ten Measures

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Initial 10 Priority Measures (Contracted for Development)

Batch 1
- Filter strip w/ design variants
- Infiltration devices
- Soil Amendment

Batch 2
- Bioretention w/ design variants
- Land or forest protection
- Pervious Area Nutrient Management

Batch 3
- Remove Illegal Wastewater Connections
- Livestock Exclusion
- Riparian buffer - urban / suburban
- Riparian buffer - rural

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5 Additional Priority Measures to be Completed with Available Funds (this contract or Tetra Tech/EPA Grant)

Model based

- Upland tree planting (i-tree model)
- Conversion to trees or grass (JFSAT or JL HSPF models)

Awaiting data in May/June 2015

- Leaf Litter Recovery
- Permeable Pavement with Design Variants
- Bioswales/Swales with Design Variants

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Potential to Reprioritize Certain Measures

- Preliminary analysis and SME feedback indicate that some of the initial ten measures may not be as strong as others
- Three measures will have data available in the near term
- Does the PFC want us to run through the preliminary analysis of these measures to see how they compare to the initial ten?
- We would likely stay on schedule for most of the practices (with submittal to DWR by December)
- For those where we are waiting for data, the work may be delayed by a couple of months

Tool Selection and Development: Model Comparison

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Task 2 Scope of Work

- Development of a sub-watershed tool that includes credit calculations for priority nutrient reducing measures
- Partial Task 2 funding used to recommend framework for tool development and compare up to 4 existing models
- Technical Memo drafted and reviewed by PFC in February
- Revised and final Memo distributed May 5

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Purpose of the modeling tool

Estimate the annual total nitrogen and total phosphorus **load reductions** achieved through implementation of nutrient reducing measures on existing development at the subwatershed-scale that **integrates output** from the existing tools and enables users to facilitate development of the local programs and assist local jurisdictions in compliance with the Falls Lake Rules **reporting requirements**.

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Modeling Framework for BMP Tracking & Calculation Tool

- Consistency with existing tools is key while providing new tool to comprehensively track and report BMPs for existing development to meet Stage I requirements
- Work with PFC to provide desired flexibility (model adaptability vs advanced user interface)
- Watershed Treatment Model (WTM) used as the modeling framework
  - Subwatershed scale of analysis, or other planning area
  - Non-structural BMPs
  - Adapt to include trapping factors
  - Output from State-approved tools (JFSAT) as ‘read in’ files to provide credit estimates for structural measures
  - Use JFSAT (version 3.0) to credit new structural measures as user defined BMPs

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Scope of Services: Crediting Tool Development

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Model Structure & Development

- PFC requested Cardno and CWP to develop scope and budget for tool development
- Available budget $71,908 based on initial proposed scope (not approved)
- Recent memo describes the Basic and Supplemental Features with budget estimates

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Development Process

- Technical Task Force of PFC representatives and DWR to provide key input on model development
- Phased Approach allowing opportunities for feedback from PFC during the development process
    1. Tool Scoping
    2. Draft Tool
    3. Draft Final Tool with Reporting
    4. Final Tool

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Model Features – Basic Tool (included in approved budget)

- Estimate or track pollutant load reductions at the sub-watershed scale that will allow the user to report load reductions from specific BMP implementation within a watershed or jurisdiction
- Utilize approved Tools for model input (JFSAT)
- Basic Features include
  - Pollution Sources
  - BMPs Implemented
  - Summary Report

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Step 1: Data Reader

- Reads data from the JFSLAT (and other approved tools)
- Creates a summary file that can be used in the WTM.
- We have been working on a beta data reader, which can read all of the data from JFSLAT versions 2 and 3.
- Can expand to include later versions.

	A	C	D	E	F	
1	Files to Read-In: From directory:	Step 1: Get File Names	Clear Data (if starting over)			
2	I:\SpreadsheetDev\UNRBA\JFSLAT\					
9	**File Name**	**JFSLAT Version**	**Project Name**	**Development Area (ft^2)**	**Physiographic Region**	**P**
10	JFSLAT-Version3.0.xlsm	3	0	0	0	
11	AAJFSLAT-Version3.0JunkRead.xlsm	3	lp	5000	Piedmont	A
12	Functional Jordan Falls Lake Stormwat	2	papa Test V2	6500	Piedmont	A
13	Jordan Falls Lake Stormwater Nutrien	3	junk V3Test	6000	Piedmont	A
14						
15						
16						
17						
18						
19						

Step 2: Produce Input File for the WTM

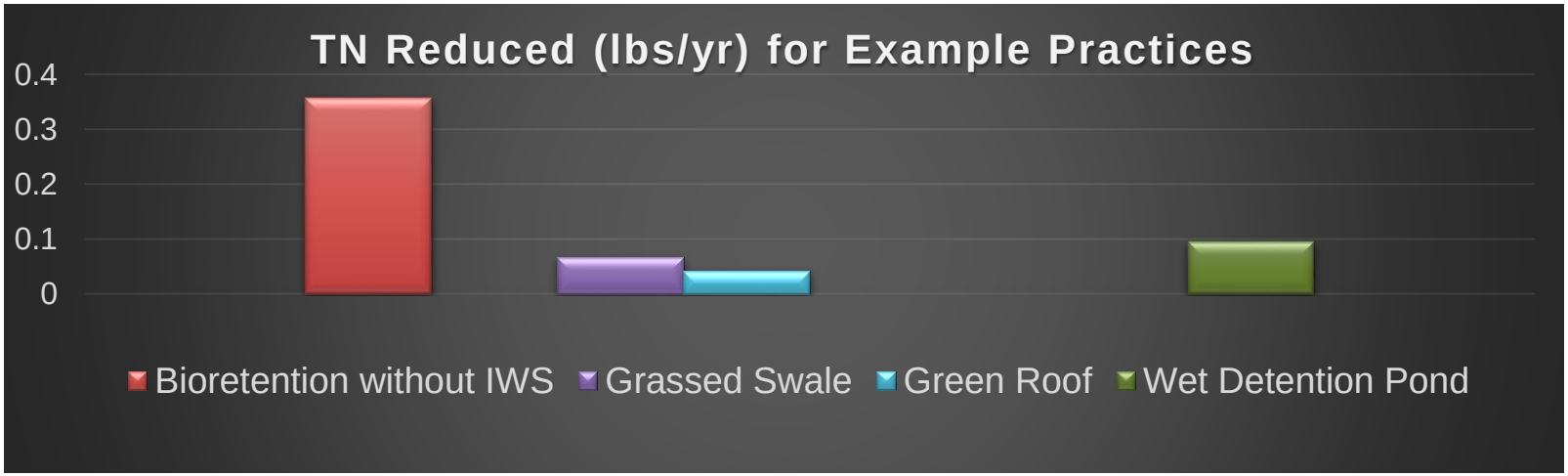
- Data from the JFSLAT will be used in a modified version of the WTM.
- The current WTM calculates benefits of individual retrofits
- This will be replaced with summary data from the JFSLAT Tool.

Stormwater Retrofits Summary

		Annual Practice Effective		
BMP Type	Total Area Captured (Acres)	TN	TP	TSS
Dry Water Quantity Pond	0.0	0.00	0.00	0.00
Dry Extended Detention Pond	0.0	0.00	0.00	0.00
Wet Pond	0.0	0.00	0.00	0.00
Wetland	0.0	0.00	0.00	0.00
Filters	0.0	0.00	0.00	0.00
Green Roof	0.0	0.00	0.00	0.00
Rooftop Disconnection	0.0	0.00	0.00	0.00
Permeable Pavement	0.0	0.00	0.00	0.00
Grass (open) Channel	0.0	0.00	0.00	0.00
Dry Swale (bioswale, WQ swale)	0.0	0.00	0.00	0.00
Wet Swale	0.0	0.00	0.00	0.00
Raintanks and Cisterns	0.0	0.00	0.00	0.00

Step 3: WTM Reads in and Summarizes Data

- In the final tool
  - Summaries will also include non-structural practices.
  - Practices may be grouped differently.



Supplemental Features (not included in approved budget)

H. Planning level analysis of future practices

- "Scenario" type add-on feature allowing user to estimate effect of future implementation of BMPs
- Work with Task Force to identify appropriate land use distribution
- Two options have been suggested

Land Use Options for Planning Level Analysis (H)

- Option 1: $12,700
  - Some local governments may have good information about the amount of land that could be used to implement future practices
  - CWP and Cardno would develop a framework and assumptions
    - Estimating the area of land treated
    - The credits associated with future practices
  - Future land treated would be input by the user
  - Each local government would be responsible for verifying that this land would be available
  - The UNRBA WTM tool would not include guidance on land area available

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Land Use Options for Planning Level Analysis (H)

- Option 2: $20,400
  - Use the 2006 USGS National Land Cover dataset to estimate the land use types present in the watershed during the baseline period (2006).
  - Land use area would be adjusted by the user to account for interim development (2006 to 2012).
  - The Center and Cardno would work with the Task Force to determine how to incorporate this information into the UNRBA WTM.

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Supplemental Features (not included in approved budget)

I. Advanced tracking

- Integrate data from other tracking tools or databases to provide additional reporting and tracking information to support the Falls Rules

J. Hydrology options

- Incorporate additional hydrologic calculations to estimate runoff such as SCS CN using in Storm-EZ (JFSAT using Simple Method)

K. Advanced GUI

- Enhance the user-interface retainer user adaptability

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Specific Tasks	Phase 1: Tool Scoping	Phase 2: Draft final tools	Phase 3: Draft final tool & reporting	Phase 4: Final Tool	Budget
	Approximate Hours and Budget				
A. Modify WTM Framework	30	40	12	0	$11,193
B. Calculation Methods	8	24	8	0	$5,460
C. Add in New Priority Measures	32	136	60	0	$31,122
D. Summary report and tracking implementation	8	8	28	20	$8,736
E. Present draft tool final phase to UNRBA	0	0	0	57	$7,746
F. Present final tool to UNRBA	0	0	0	16	$2,184
G. Develop User Guidance	0	16	16	8	$4,460
					$71,908

Supplemental Features	Phase 1: Tool Scoping	Phase 2: Draft final tools	Phase 3: Draft final tool & reporting	Phase 4: Final Tool	Budget
	Approximate Hours and Budget				
H. Future Scenario	16-32	17-57	40	20	$12,695-$20,339
I. Advanced Tracking	8	32	30	10	$10,920
J. Hydrology Options	8	16	8	8	$5,460
K. Most Automated GUI	0	0	24	24	$6,559
TOTAL (supplemental tasks)	32-48	65-105	102	62	$35,634 - $43,278
Total (basic tool with supplemental tasks)	110- 126	289-329	226	169	$107,542-$115,186

Discussion, Questions, and Feedback Welcome

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