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BMP Interpretation White Paper : Biochar as an Enhancement to Bioretention Practices

Presentation to the
CBP Urban Stormwater Workgroup

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March 18, 2025

Agenda

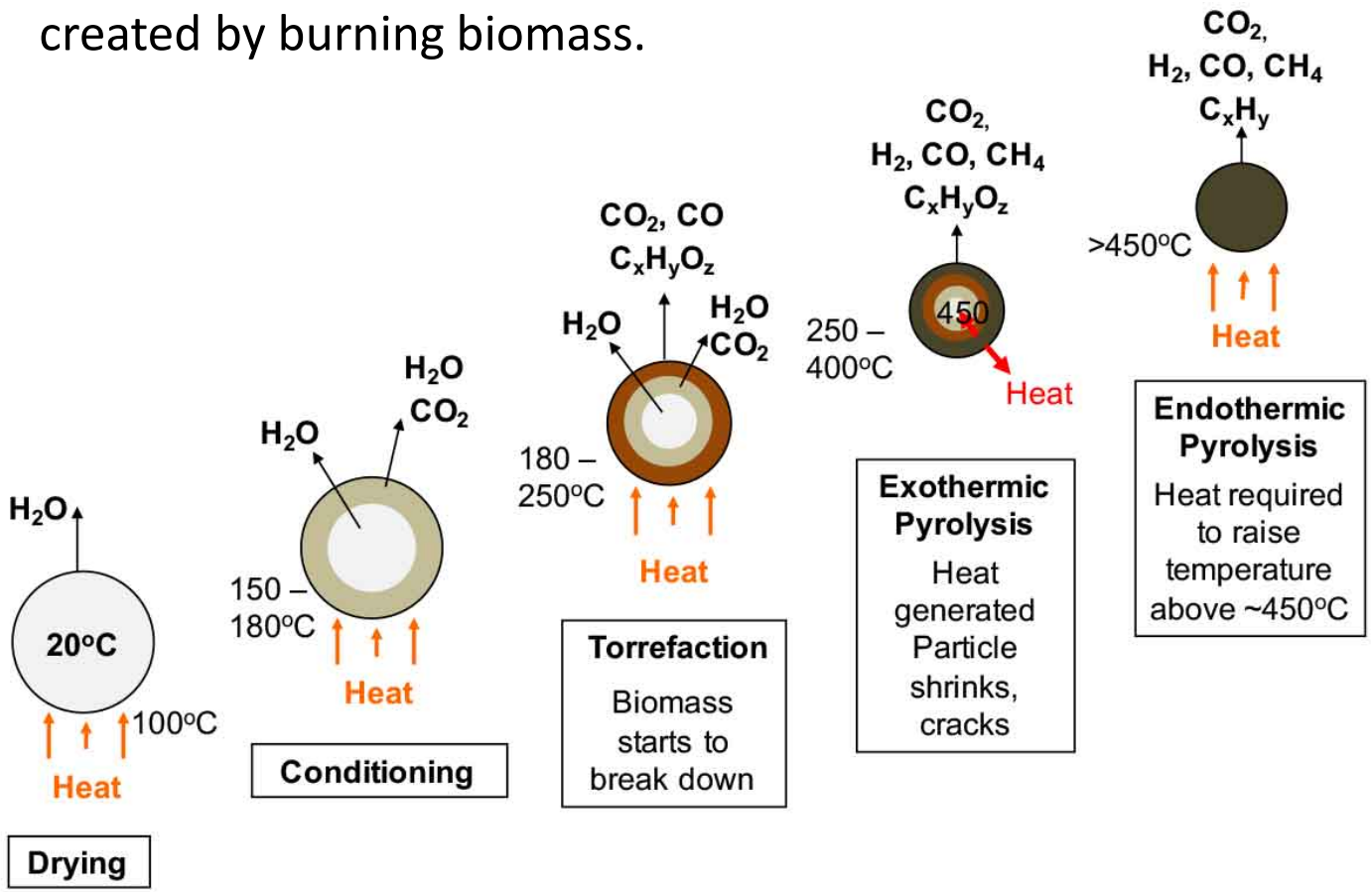
- Introduction
- Typical Applications in the Chesapeake Bay Watershed
- Crediting Considerations
- Examples
- Conclusion

Introduction

Biochar Basics

What is Biochar?

Biochar - A charcoal-like material created by burning biomass.



Source: Biochar International

Biochar as an Enhancement for Bioretention Practices

Wood-based biochar + bioretention media =

Biochar-Enhanced Bioretention Media (BEBM)

- ↑Soil porosity
- ↑Water holding capacity
- ↑Infiltration

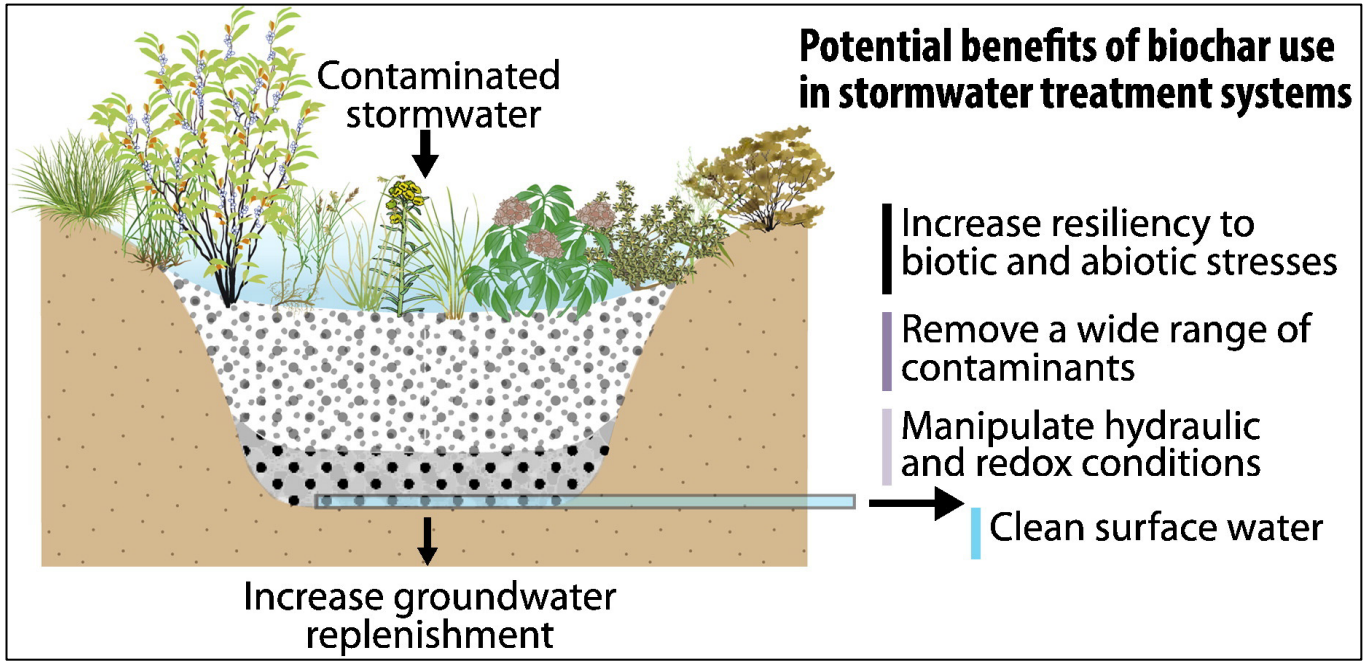


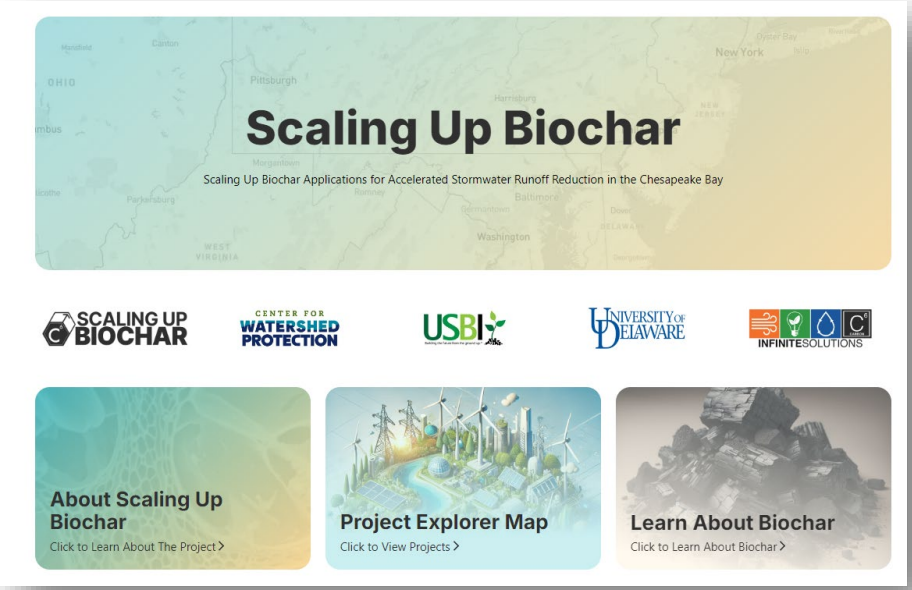
Image Source: Mohanty et al., 2018, Plenty of room for carbon on the ground: Potential applications of biochar for stormwater treatment. https://doi.org/10.1016/j.scitotenv.2018.01.037

Why add Biochar as an Enhancement to Bioretention Practices?

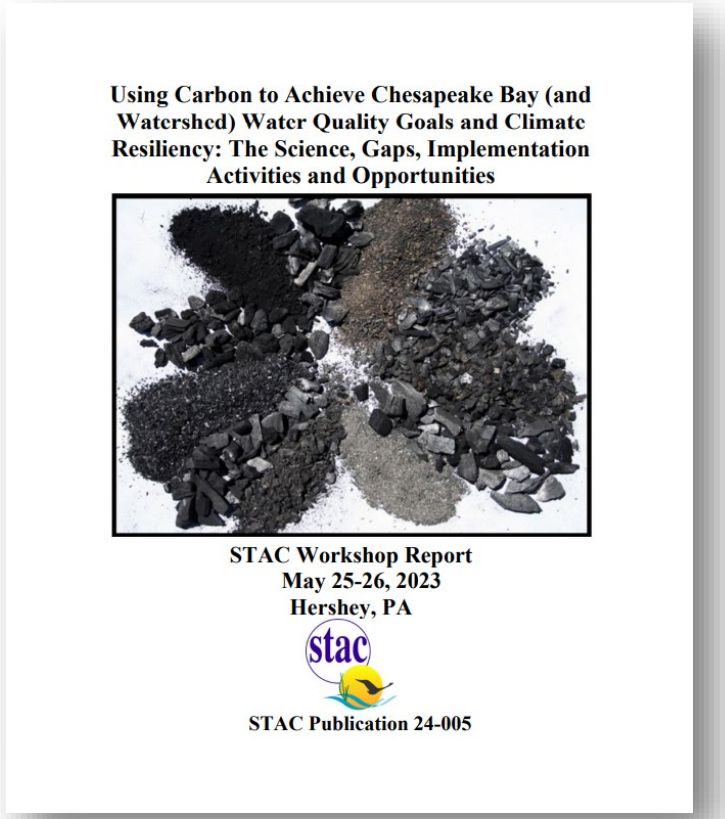
Biochar enhancement relies on existing approved BMPs for treatment, but has significant additional benefits:

- Supports water storage and infiltration, decreasing the volume of stormwater and nuisance flooding
- Higher pollutant removal efficiencies
  - 34.5%-52% increase in nitrate removal compared to control (Tian, 2019)
  - 0.7-3.8h increase in residence time (Tian, 2019)
- Improves surface water quality for habitat, aesthetics, and recreational use
- Increases water holding capacity which promotes plant growth
  - 82.3% increase in root growth (Akpinar et al, 2023)
  - 18.2-77.8% increase in plant available water (Akpinar et al, 2023)
- Revives compacted or degraded BMPs
- Carbon sequestration and storage
- Emerging toxic contamination mitigation
- Utilizes waste material
- May mitigate salt effects

Key Resources



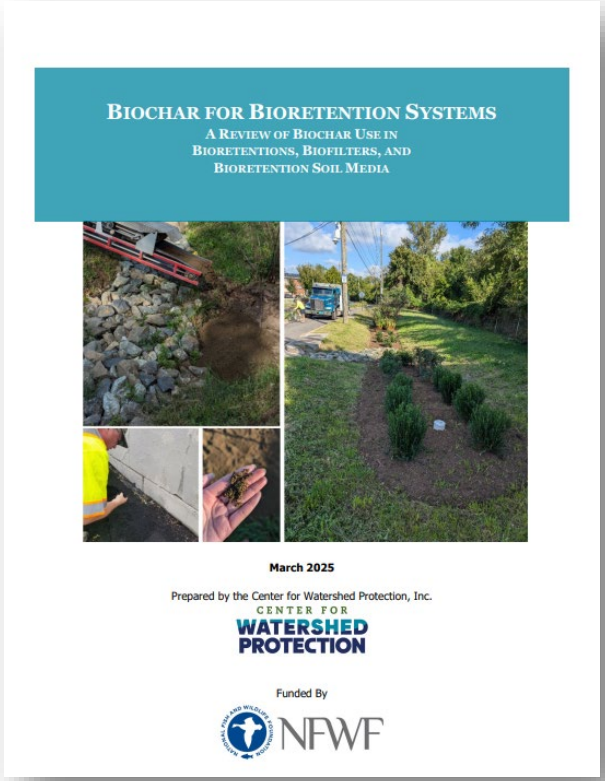
https://www.scalingupbiochar.com/


Using Carbon to Achieve Chesapeake Bay (and Watershed) Water Quality Goals and Climate Resiliency: The Science, Gaps, Implementation Activities and Opportunities

STAC Workshop Report
May 25-26, 2023
Hershey, PA

STAC Publication 24-005

https://www.chesapeake.org/stac/wp-content/uploads/2024/06/STAC-Report_Biochar_24-005.pdf


BIOCHAR FOR BIORETENTION SYSTEMS
A REVIEW OF BIOCHAR USE IN BIORETENTIONS, BIOFILTERS, AND BIORETENTION SOIL MEDIA

March 2025

Prepared by the Center for Watershed Protection, Inc.
CENTER FOR WATERSHED PROTECTION

Funded By
NFWF

Typical Applications in the Chesapeake Bay Watershed

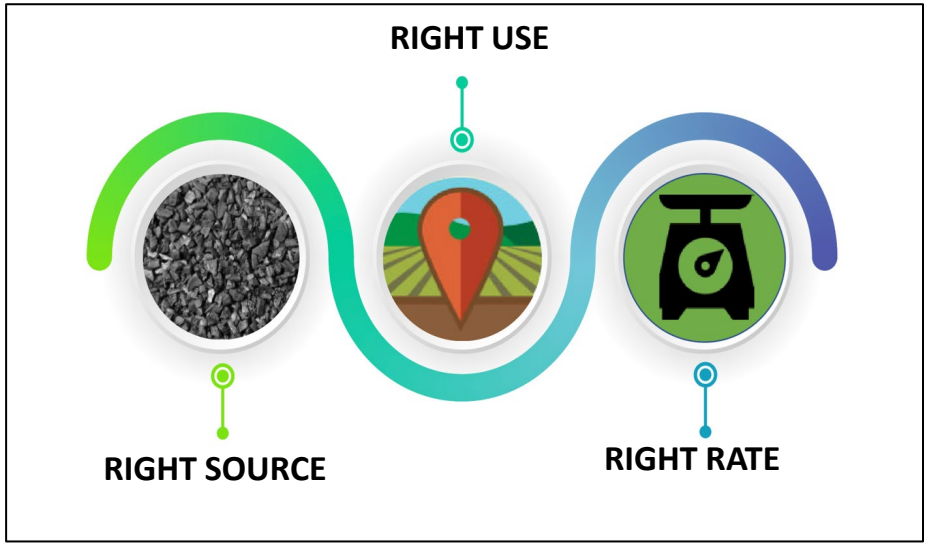
Typical Applications in the Chesapeake Bay Watershed

Design and Construction

No significant design or construction changes to bioretention practices required.

- Specs: Must have a supplier proof of lab analysis that meets International Biochar Initiative (IBI) Standards or World Biochar Certificate (WBC) and the following general specifications for biochar in stormwater applications.
  - Bulk density of 6-12 lbs/cf (dry wt)
  - Total ash <10%
  - Fixed carbon ≥ 80%
  - Particle size distribution

>6 mm	0%
1-4 mm	0-50%
2-4 mm	20-50%
<1mm	<15%

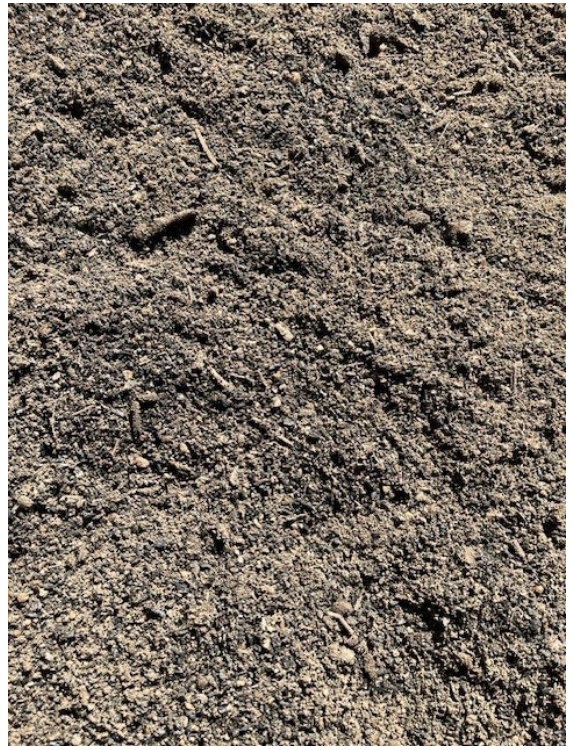


The 3 R's (Adapted from original graphics provided by K.M. Trippe, Ph.D. (2022).

Typical Applications in the Chesapeake Bay Watershed

Design and Construction

- Amount: Biochar should constitute 14-18% of the bioretention media by volume and be incorporated up to a depth of 1-3 ft.
- Method of Incorporation:
  - Soil Vendor: See guidelines in white paper



Partner: Luck Ecosystems

Typical Applications in the Chesapeake Bay Watershed

Design and Construction

- Method of Incorporation:
  - On-Site:
    - Follow proper biochar storage and handling requirements.
    - Incorporate into the bioretention media stockpile in the same manner as any other soil amendment.
    - Refrain from crushing with heavy equipment.
    - Mix into already placed bioretention media following soil amendment and restoration guidelines in white paper

Partner: SLC Excavating

Typical Applications in the Chesapeake Bay Watershed

Design and Construction

- Method of Incorporation:

  For Maintenance: Remove the top 1’ of material and replace with BEBM, then replant.

  For a New Practice: The bioretention shall be built per the appropriate regional specifications, substituting BEBM for the regular bioretention media material.




Partner: SMC, WeCare Denali, DOEE

Typical Applications in the Chesapeake Bay Watershed

Life Cycle Costs

BEBM costs 37% more than typical bioretention media ($5/CY increase for mixing and $23/CY increase for biochar material).

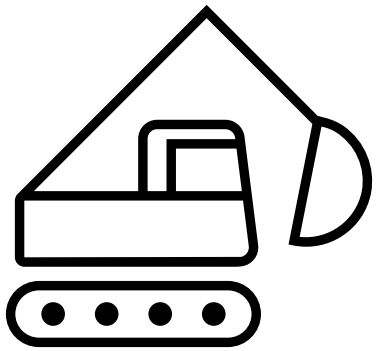
Adding biochar to a bioretention increases the total cost of the bioretention by 2%-5.5% (assuming an average media cost of 5%-15% of the entire construction cost).

**Does not include decreases in O&M costs and increase in lifecycle.*

Operation and Maintenance

There are no additional operation and maintenance needs for BEBM beyond what is already required for bioretention.

- The bioretention media will need replacement before the biochar.
- Biochar has been shown to decrease the rate of compaction in soils.



Typical Applications in the Chesapeake Bay Watershed

Potential Risks and Unintended Consequences

- Contaminants adsorbed to biochar particles may be co-transported with the movement of fine or nano biochar particles. This was not found in the research conducted by University of Delaware. Care must be taken to not breakdown the biochar into fine or nano particles.
- Biochar-derived dissolved organic matter can mobilize copper. However, this is less of a concern with wood-based biochar used in stormwater applications.
- Competition for adsorption sites on biochar particles may affect the pollutant removal potential. Since the focus for this application is based on runoff reduction, this shouldn’t be a concern.

Crediting Considerations

Crediting Considerations

SWMM Modeling

Bioretention Parameters

- Drainage area: 0.5 acre parking lot, 100% impervious
- Surface area: 800 SF
- 1’ ponding, 3’ media, 8” stone
- Captured 1” storm (Maryland SWM Manual)
- Mimics bioretention used for anchor point in retrofit curves

Bioretention Media Parameters

Soil Media Parameters	Scenario A (without biochar)	Scenario B (with biochar)
Conductivity (in/hr)	0.25	1.2625
Porosity (volume fraction)	0.40	0.47
Wilting Point (volume fraction)	0.275	0.366
Field Capacity (volume fraction)	0.166	0.138

Crediting Considerations

SWMM Modeling

Limitations of SWMM

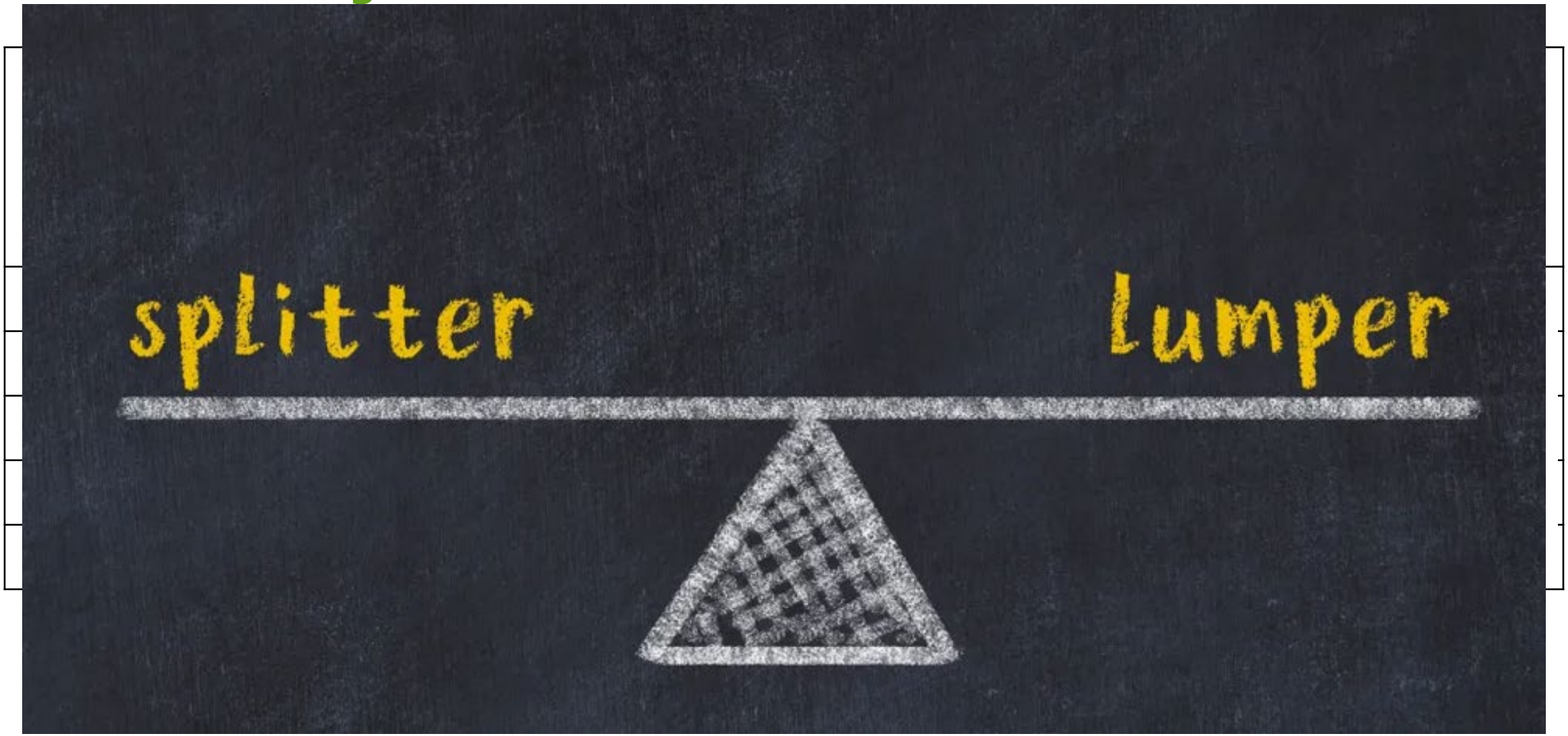
- Plant/water interactions, including evapotranspiration, are not modeled
- SWMM is a 1-D model, where once it reaches the underdrain, it immediately exits the system

Limitations of Model

- 4 different scenarios were modeled, with one design
  - Used retrofit curve data as baseline
- Model has not been calibrated, only useful to understand how may effect water balance

Crediting Considerations

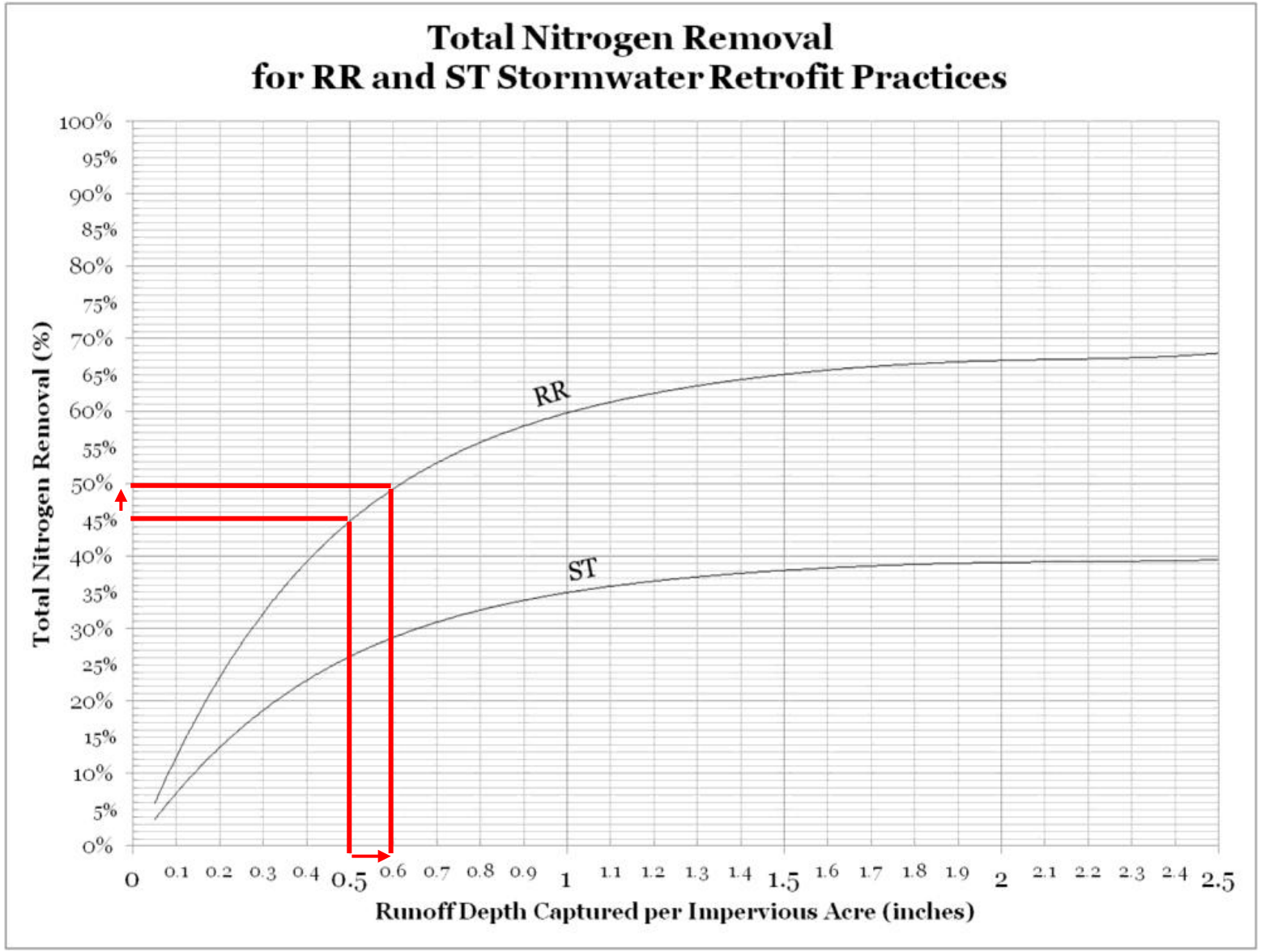
SWMM Modeling



Suggested Crediting Approach

New Bioretention with BEBM

1. Determine runoff depth captured per impervious acre for traditional bioretention without BEBM.
2. Multiply the runoff depth captured per impervious acre by 1.2 (representing a 20% increase in runoff reduction).
3. Use the RR curve to determine pollutant removal percentage.



Suggested Crediting Approach

Reporting, Tracking, and Verification

- General accounting procedures for using BEBM follow Section 6 of the Stormwater Retrofit Expert Panel.
- Typical credit duration is 5 years and can be extended with verification that the bioretention is still functioning as designed. Verification is the same as bioretention without biochar.
- When BEBM is incorporated into existing bioretention that have been previously reported, the higher pollutant load reduction achieved can be reported in subsequent years after the enhancement is competed.
- If the bioretention enhanced with BEBM was not previously reported to EPA, it is considered a new retrofit, and the RR curve is used to define the removal rate based on the total treatment volume provided.

Examples

Example 1

New Bioretention with BEBM

Bioretention Parameters

- Impervious Acres (IA) =1.03 acres
- Runoff storage (RS) volume: 3,028 cubic feet (0.07 acre-foot)

$$Runoff\ Depth\ Treated\ per\ Impervious\ Acre\ (inches) = \frac{RS * 12}{IA}$$

Traditional Bioretention	Bioretention with Biochar
$\frac{0.07 * 12}{1.03} = 0.81\ inches$	$\frac{(0.07) * (1 + 20\%) * 12}{1.03} = 0.97\ inches$

Example 2

Adding BEBM into Existing Bioretention

Bioretention Parameters

- Impervious Acres (IA) =1 acres
- Runoff storage (RS) volume: 1815 cubic feet (0.042 acre-foot)
- Currently has 2 feet of bioretention media, replace 1 foot with BEBM

$$\frac{Biochar\ replacement\ depth}{Existing\ media\ depth} x20\%\ increase = \frac{1'}{2'} x20\% = 10\%$$

Traditional Bioretention	Bioretention with Biochar
$\frac{0.042 * 12}{1} = 0.5\ inches$	$\frac{(0.042) * (1 + 10\%) * 12}{1} = 0.55\ inches$

Conclusion

Why Include Biochar Enhancement as a Creditable Practice?

- The exponential increase in the number of scientific publications on biochar applications for stormwater management has documented the runoff reduction and pollutant removal capability.
- Biochar amendment in new or existing BMPs represents a relatively small incremental cost that can improve runoff reduction and enhance pollutant removal rates.
- Could accelerate achieving the Chesapeake Bay and other MS4/TMDL goals.
- Does not require significant design or construction changes to already approved BMPs.
- Local governments are reluctant to implement due to the lack of credit and accepted technical specifications.
- Additional benefits beyond nutrient and sediment removal.

Thank You!

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