Chesapeake Bay Program
Science. Restoration. Partnership.

CENTER FOR
WATERSHED
PROTECTION

BMP Proposal: Biochar as an Amendment to Bioretention Practices

Presentation to the
CBP Urban Stormwater Workgroup

Carol Wong
Alexandria Wilkins
Lisa Fraley-McNeal
Paul Imhoff

October 15, 2024

Agenda

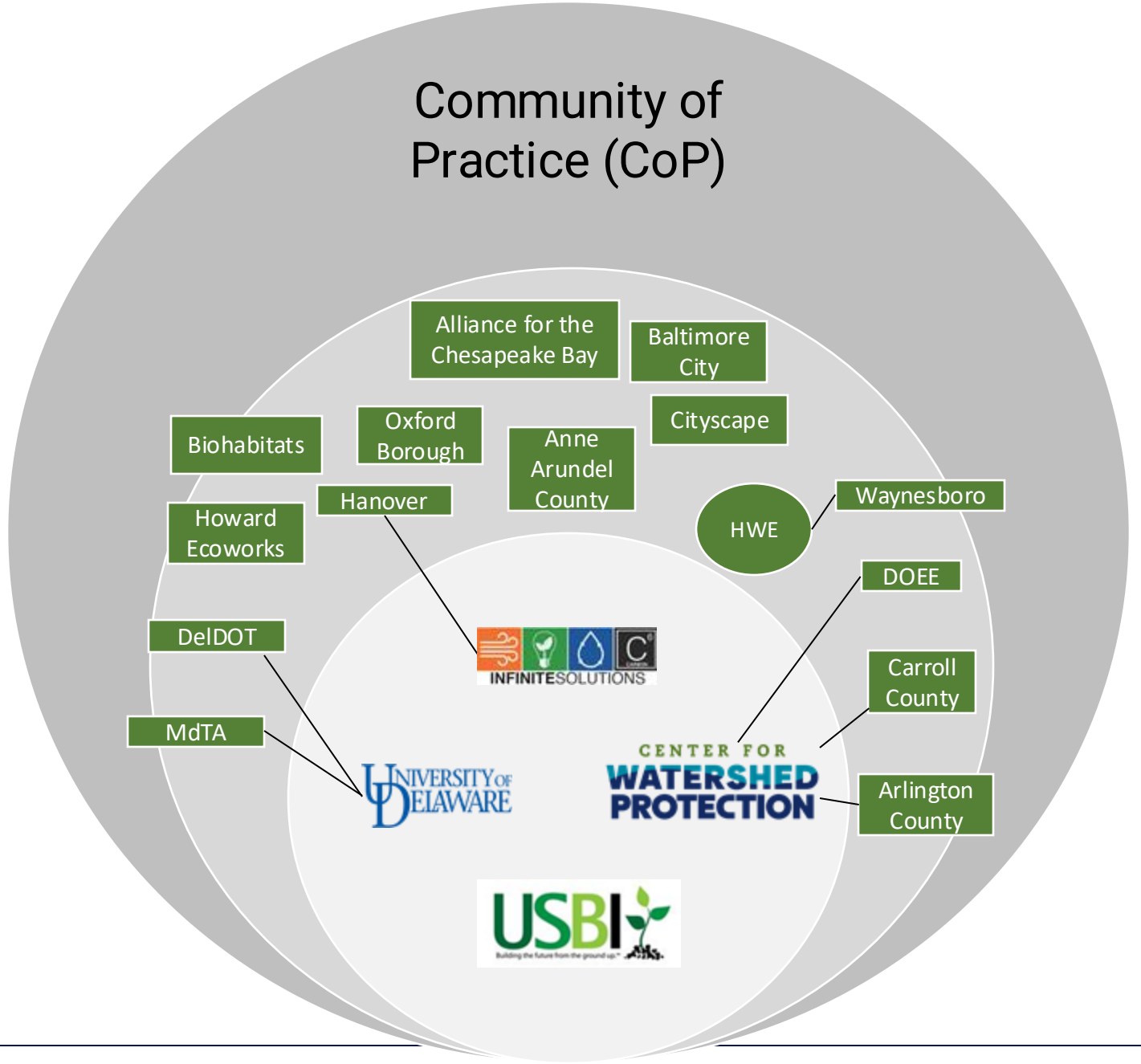
- Introduction to Scaling Up Biochar
- Why Add Biochar as an Enhancement to Existing BMPs?
- Runoff Reduction and Cost Comparison
- Suggested Crediting Approach
- Literature Review
- Conclusion

SCALING UP BIOCHAR

Core Team

Implementation Support

Implementation Partner



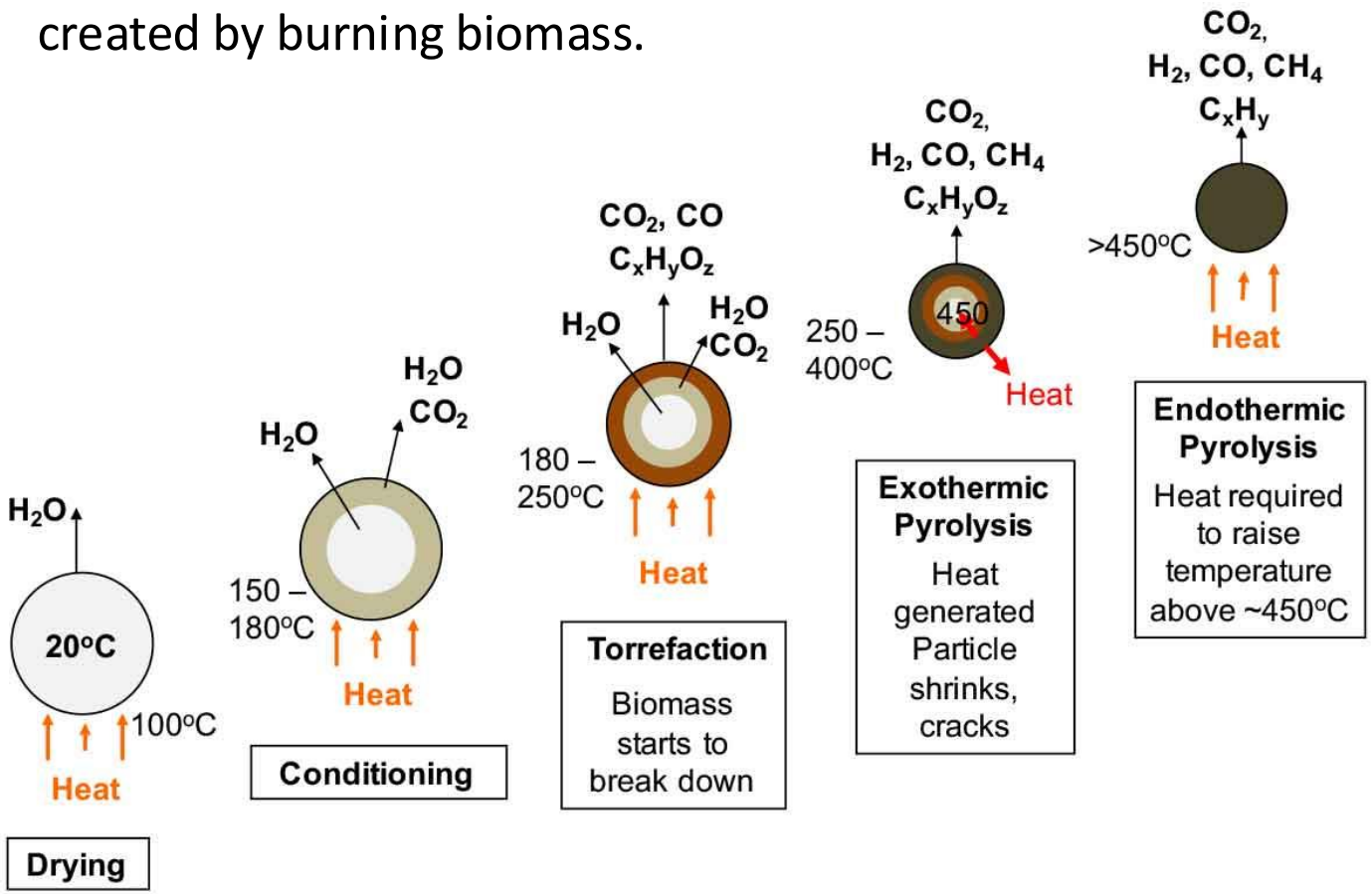
Statement: This material is based on work supported by the U.S. Environmental Protection Agency (Assistance Agreement No. CB96358201) and the National Fish and Wildlife Foundation's Chesapeake Bay Stewardship Fund, which promotes community-based efforts to develop conservation strategies to protect and restore the diverse natural resources of the Chesapeake Bay.

Why Add Biochar as an Enhancement to Existing Practices?

Biochar Basics

What is Biochar?

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



Source: Biochar International

Biochar Basics

Biochar Type by Source Material

Materials used for biochar production include:

- Field residues and processing residues (i.e., nut shells, fruit pits, etc.)
- Yard waste (i.e., leaf litter, grass clippings)
- Wood or Forestry waste (i.e., tree trimming waste, mulch, etc.)
- Food and Animal waste (i.e., compost, manure)

For enhancing stormwater practices, our focus is on biochar created from wood, or forestry waste, materials.

Biochar as an Enhancement for Bioretention Practices

Wood-based biochar + bioretention media =

Biochar Enhanced Bioretention Media (BEBM)

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

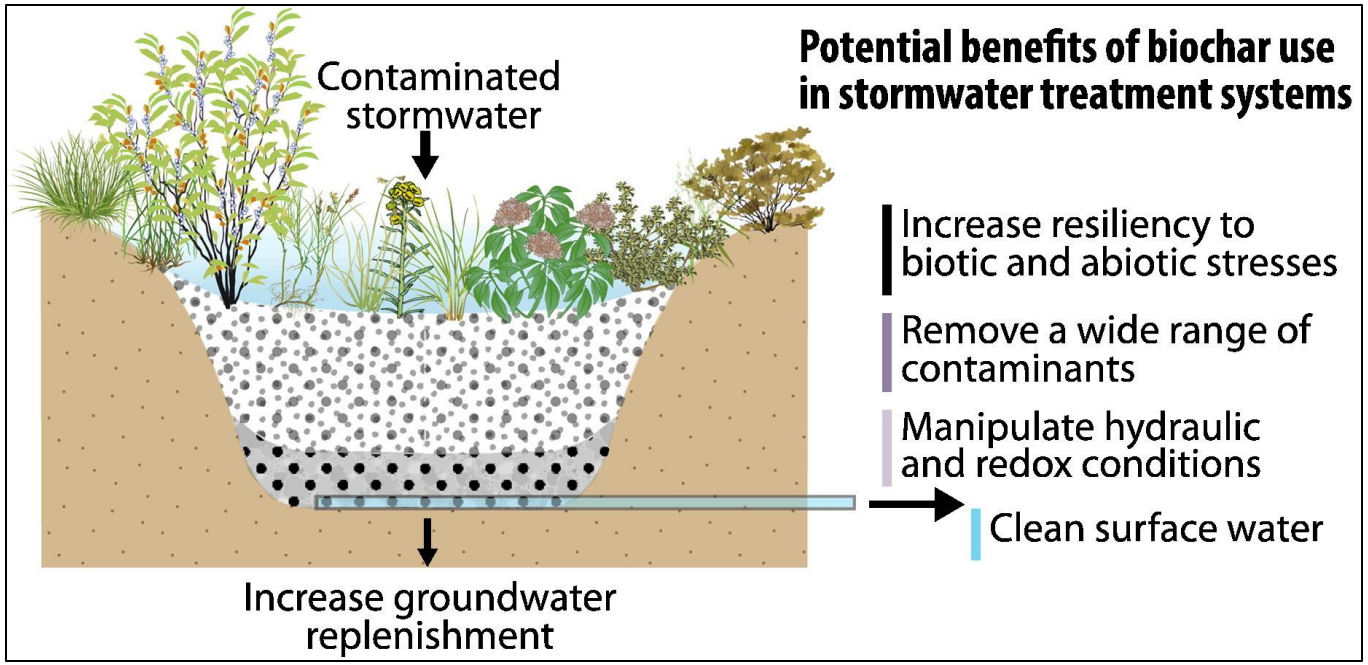


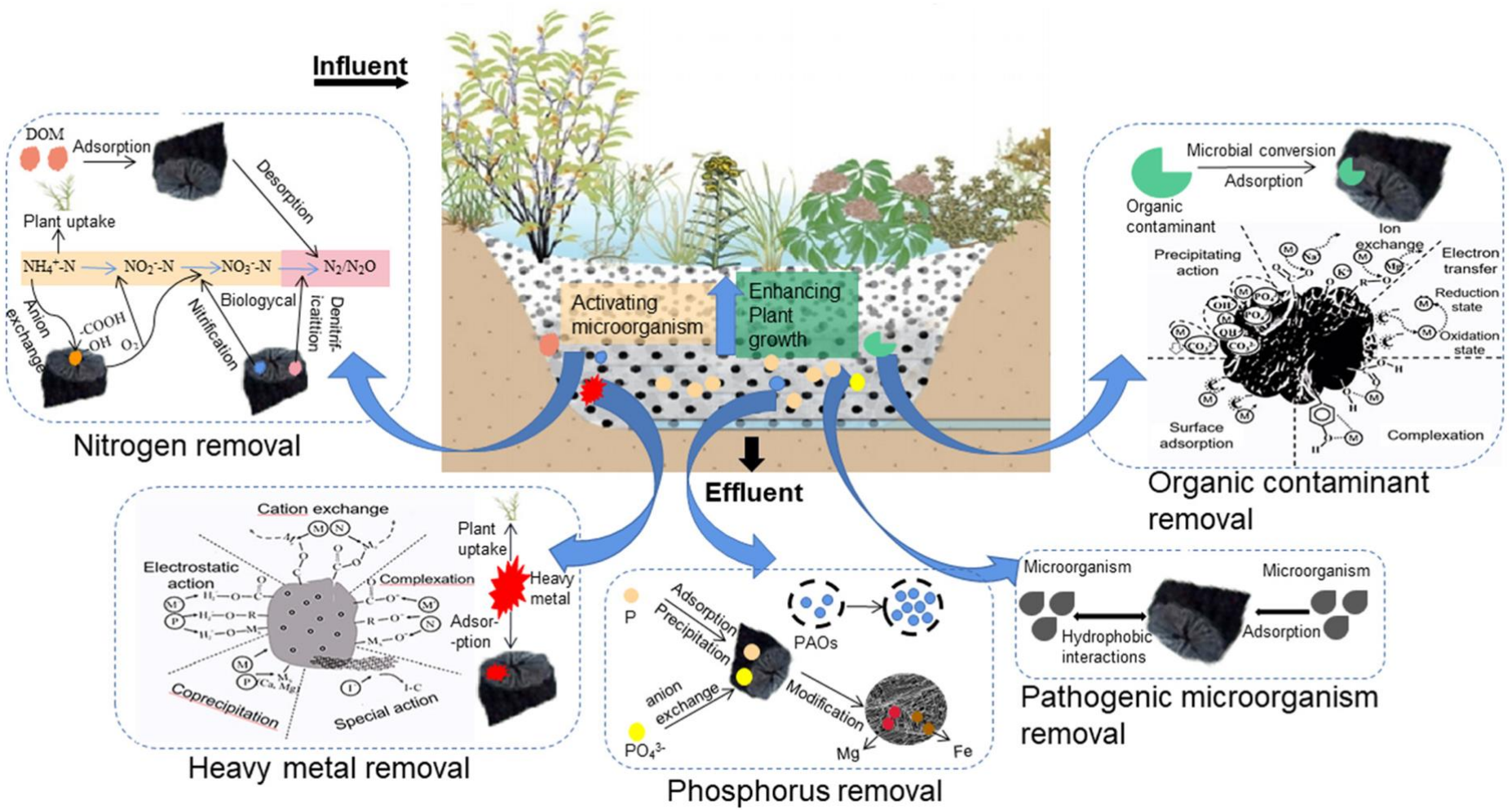
Image Source: Mohanty et al., 2018, Plenty of room for carbon on the ground: Potential applications of biochar for stormwater treatment. https://doi.org/10.1016/j.scitotenv.2018.01.037

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

Why add Biochar as an Enhancement to Bioretention Practices?



Source: Chen et al., 2022, Application of biochar as an innovative soil ameliorant in bioretention system for stormwater treatment. DOI: 10.2166/wst.2022.245

Biochar as an Enhancement for Bioretention Practices

Project Implementation with Biochar

Biochar Quantity

- 15 – 20% biochar by volume(bv) up to a depth of 1-3 feet is the recommended amount to include in a BMPs bioretention media.

How to Add Biochar to a Bioretention Practice

During installation biochar enhanced materials should avoid over handling and running tools over the material. Leveling should be done with hand tools or a smooth-edged bucket to avoid crushing the biochar particles.

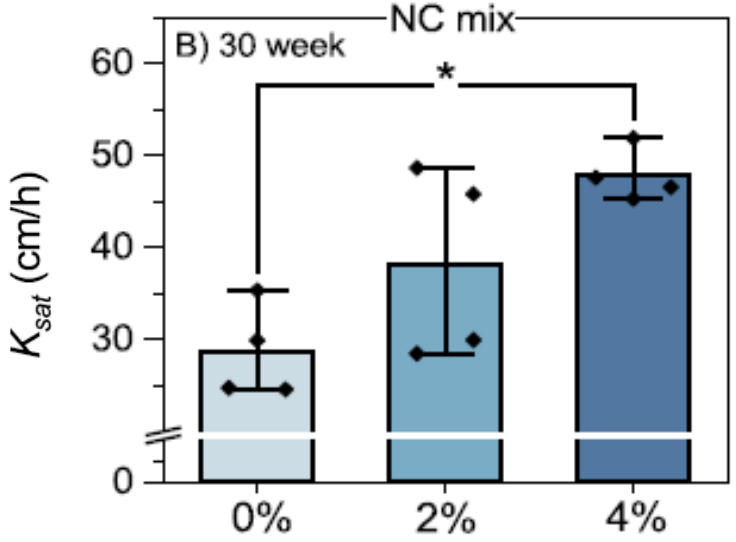
- For Maintenance: Remove the top 1’ of material and replace with a Biochar Enhanced Bioretention Media (BEBM) material, then replant.
- For a New Practice: The bioretention shall be built per the appropriate specifications substituting the regular filter media material for the BEBM material.

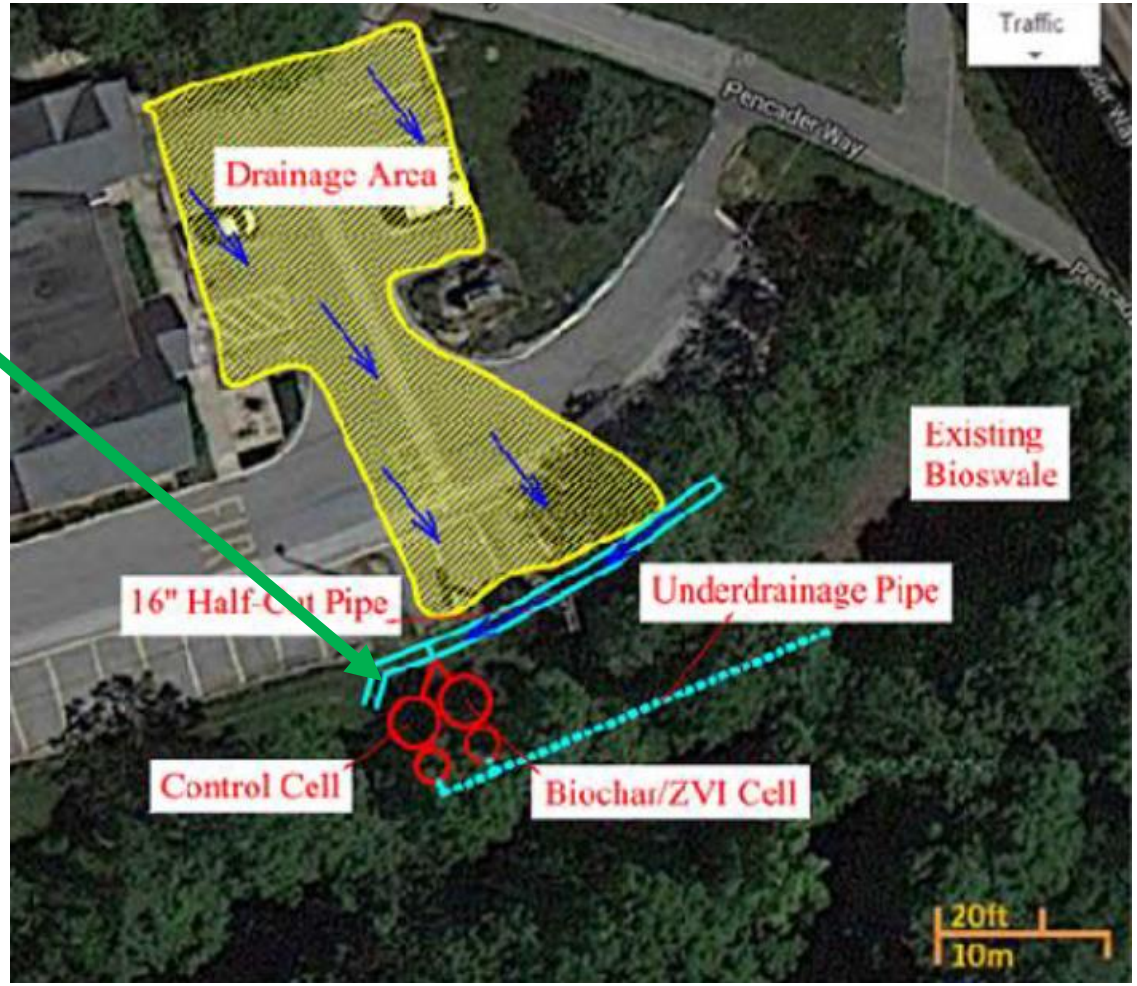
Runoff Reduction and Cost Comparison

Scaling Up Biochar Applications for Accelerated Stormwater Runoff Reduction in the Chesapeake Bay

Biochar Amendment to Bioretention Test Cells

- Biochar increased stormwater retention by 11-27%
- Biochar increased hydraulic conductivity by 30-70% in similar greenhouse tests



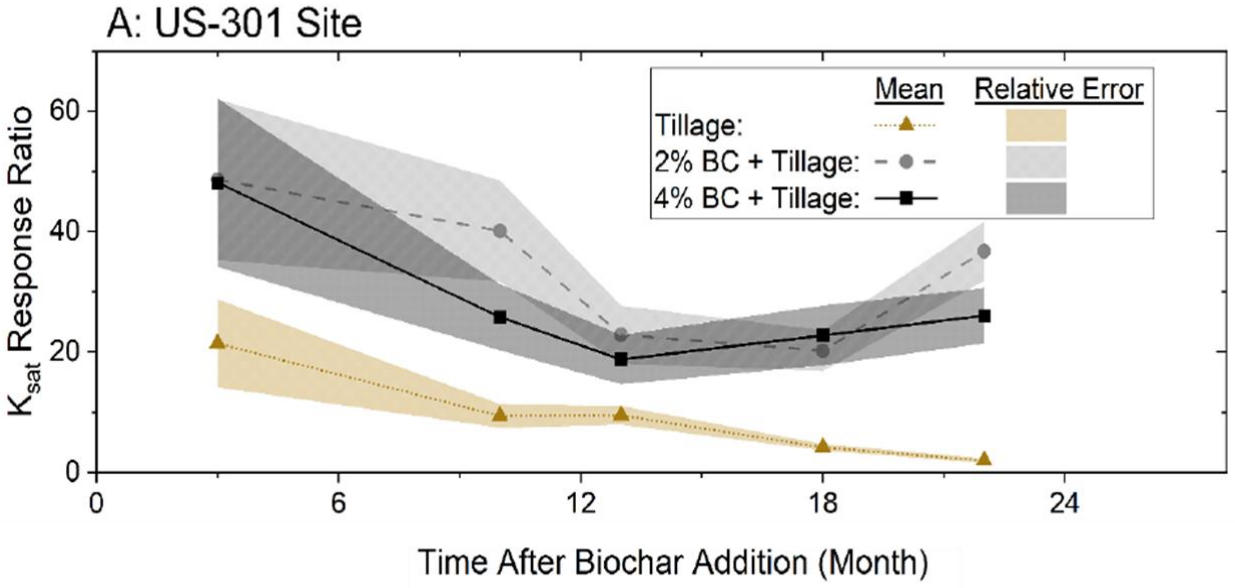


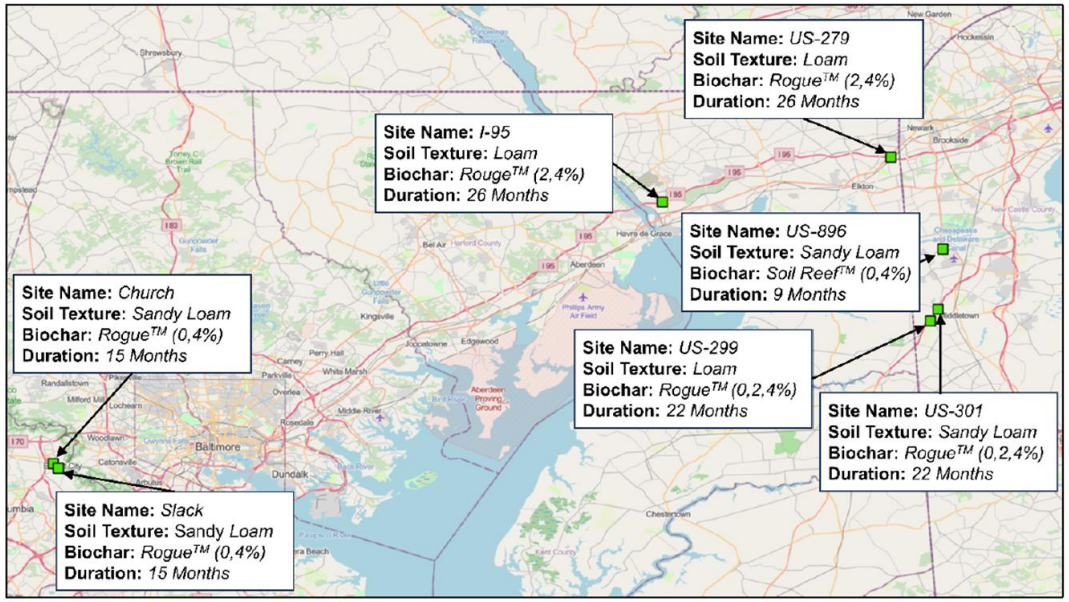
UNIVERSITY OF DELAWARE

Scaling Up Biochar Applications for Accelerated Stormwater Runoff Reduction in the Chesapeake Bay

Biochar Amendment to Soils at Impervious/Pervious Disconnections

- 7 field applications monitored up to 36 mo.
- Hydraulic conductivity increased <u>typically</u> factor of 10-20





K_{sat} response ratio = K_{sat} (biochar amendment) / K_{sat} (native)

UNIVERSITY OF DELAWARE

Comparison of Life Cycle Costs

- **CAST Estimated Construction Costs (2018 $/IA) of a Bioretention: Underdrain with C/D Soils: $185,901**
- **Increase in construction cost for bioretention media w/biochar: 5%**
  - Assuming bioretention media is 14% of the total cost (5-14%)
  - Assuming BEBM is 37% increase in media cost (expected to go down)
- **Increase in impervious area treated by incorporating biochar into media (n from .25 to .3): 9%**

	Bioretention underdrain C/D soils, Median, Retrofit	Bioretention underdrain C/D soils with biochar
Total Annual Cost ($/total acres treated/yr) Watershed-wide	$17,417	$17,288

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

Suggested Crediting Approach

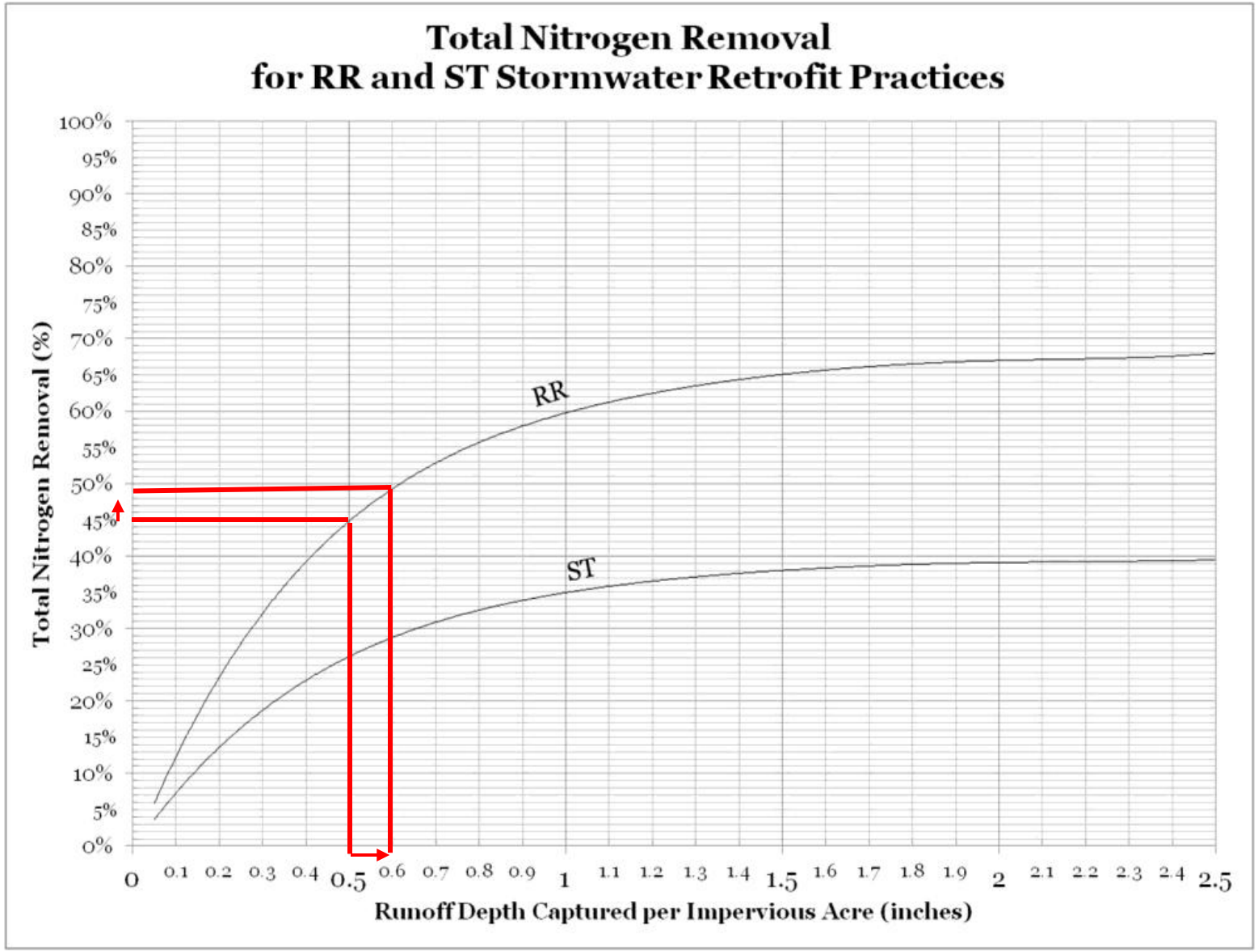
Why Include Biochar Enhancement as a Creditable Practice?

- 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 significantly 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.

DRAFT Suggested Crediting Approach

Increase Runoff Depth Captured for RR Retrofit Removal Adjustor Curves

Example:
Adding biochar increases the runoff depth captured per impervious acre for a bioretention from 0.5 inches to 0.6 inch. The corresponding TN removal increases from 45% to 49% (assuming porosity from .25 to .3)

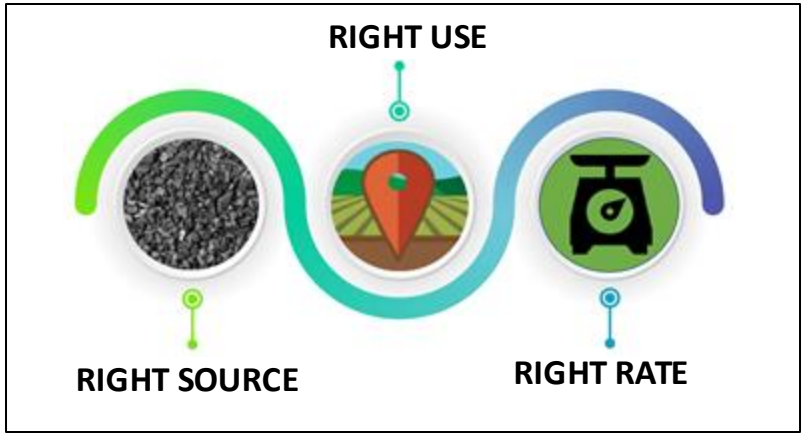


Suggested Crediting Approach

Proposed Qualifying Conditions

- Biochar must be certified or have a supplier proof of lab analysis that meets International Biochar Initiative (IBI) Standards and the general specifications for biochar in stormwater applications.
- Biochar should constitute 10% to no more than 20% of the soil media by volume.
- Appropriate mixing equipment must be used to consistently mix biochar throughout media.
- Draft Biochar Specifications
  - 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).

Literature Review

Literature Review

67 papers included in the review

- 52 from peer-reviewed journals
- 10 from white papers or grant reports
- 5 dissertations and theses

3 studies specifically studied biochar enhanced bioretention practices within and around the Chesapeake Bay watershed (Delaware).

- Additional literature:
  - 10 review papers
  - 26 biochar enhanced bioretention studies outside of the CBw
  - 27 studies discussing the stormwater treatment potential of biochar

Thank You!

Contributors

Dave Hirschman | Hirschman Water & Environment

Paul Imhoff | University of Delaware

Chuck Hegberg | Infinite Solutions

Lisa Fraley-McNeal | Center for Watershed Protection, Inc.

Alexandria Wilkins | Center for Watershed Protection, Inc.

Deb Caraco | Center for Watershed Protection, Inc.

Carol Wong, PE

Water Resources Engineer | Center for Watershed Protection, Inc.

ckw@cwp.org