Methodologies and Tools to Support Climate-Resilient Stormwater Best Management Practices

RAND

Community Health and Environmental Policy Program

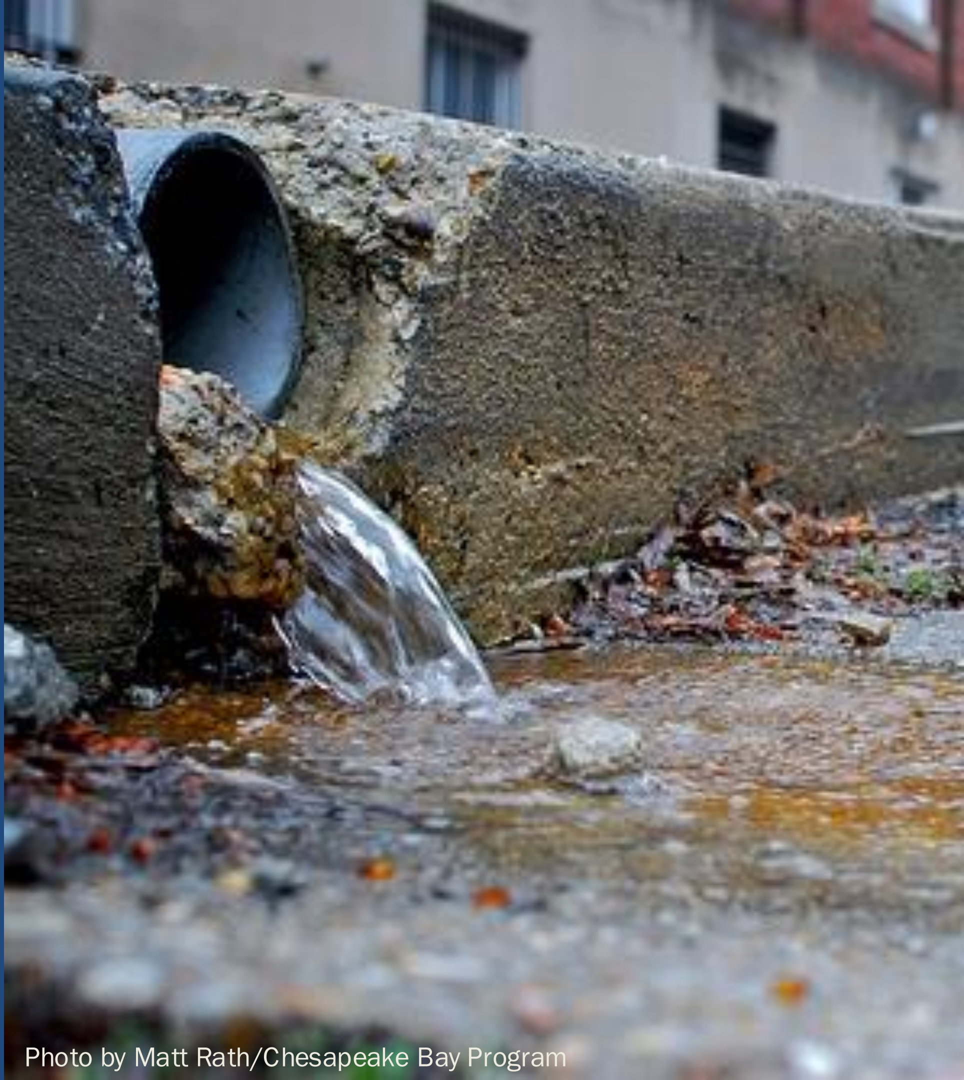

Photo by Matt Rath/Chesapeake Bay Program

Project Overview

- **Objective:** Create an integrated toolkit of guidance materials, web-based tools, and references for integrating climate considerations into stormwater planning, management and/or design, as well as enhancements to Chesapeake Bay modeling. Including:
  - i) a two-part vulnerability assessment tool,
  - ii) a decision-support tool and framework for integrating the information from a widely-used future precipitation tool,
  - iii) guidance on resilient design adaptations for stormwater infrastructure and restoration, and
  - iv) modeling enhancements to characterize the sensitivity of BMPs to climate change.

- **Timeline:** April 2024 – 12/31/2028

- **Funder:** U.S. EPA

Project Team

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Activity 4: BMP Climate Sensitivity Modeling

- **Objectives:**
  - Estimate impact of future hydrology on a range of widely used BMPs in Chesapeake Bay watershed.
  - Produce model simulations that provide pollutant removal efficiencies for different BMPs and uncertainties associated with future hydrological conditions.
- **Research Steps:**
  - Develop two types of rainfall-runoff hydrologic models to evaluate different urban and agricultural water quality BMPs.
  - Mechanistic models for urban and agricultural settings will be used to quantify nutrient and sediment removal efficiencies for range of BMPs on representative sites, under a broad set of climate futures.
  - Each individual BMP will be evaluated under an ensemble of downscaled climate projections using a subset of global climate models.
- **Output:**
  - One technical report that contains: literature review of existing urban and agricultural BMPs; synthesis of model simulations that provide pollutant removal efficiencies for BMPs; look up tables for pollutant removal efficiencies under a range of conditions
  - One to two peer reviewed journal articles

General Approach

1. Research design

a. Literature Review

- Understand past efforts
- Evaluate data availability
- Ensure consistency with larger modeling efforts

b. Stakeholder input

- Prioritize BMPs
- Identify representative sites

2. Implementation

a. Baseline scenario

- Model calibration
- Historic simulation (1991 – 2000)
- No BMPs or existing BMPs

b. Future climate scenarios

- Multiple climate projections
- BMP scenarios (one-at-a-time)

c. Output analysis

- Hydrologic changes (runoff timing, magnitude, frequency)
- Loading of TN, TP, TSS (exceedances, frequency, totals)
- Relative BMP removal efficiencies
- Uncertainty analysis

3. Synthesis of Outputs

a. Technical Report

- Literature review
- Detailed modeling procedure and outputs

b. BMP Curves/Tables

- Simplified relationships for BMP type, hydrologic condition, and removal efficiency

Proposed Modeling Approach

- **Agricultural Model Selection:**
  - Agricultural: <u>APEX</u>
    - Updated model selection
- **Model Development:**
  - Simplified representations of physiographic regions and land uses using prior calibrated parameters
  - Allows for more complex design of experiments
- **Design of Sensitivity Experiments**
  - Climate (1 base period, 2 future hydrologic regimes)
  - Physiographic regions (4 types)
  - Land use
    - Agriculture: 4 types (row crops, hay land, forest, pasture)
    - Urban: varying levels of development
  - BMPs (prioritize based on most implemented and most effective)

APEX Model Selection

- **Mechanistic representation of nutrient cycling and transport (key advantage)**
  - Both empirical and process-based representations available
- **BMP implementation**
  - Compared to other models considered (HSPF, SWAT), can model a wider range of agricultural BMPs (model was specifically developed for this purpose)
- **Precedent in literature**
  - Existing body of work using APEX to simulate non-point source BMPs in CBW (e.g., USDA NRCS Conservation Effects Assessment Project (CEAP)
  - Availability of documentation for user support
- **Additional considerations**
  - Subdaily (hourly or less) time steps for rainfall-runoff simulation; other processes modeled at daily time steps
  - Infiltration-excess runoff: SCS curve number or Green and Ampt for runoff

Proposed Modeling Approach

Hydrologic regimes

1. Base (e.g., 1991-2000)
2. Future 1 (e.g., 2035)
3. Future 2 (e.g., 2065)

Watershed Settings

Land Use (LU)

Physiographic Region (PR)	Row crops	Hay land	Pasture	Forest
Ridge & Valley	LU1 PR1	LU2 PR1	LU3 PR1	LU4 PR1
Appalachia	LU1 PR2	LU2 PR2	LU3 PR2	LU4 PR2
Coastal Plain	LU1 PR3	LU2 PR3	LU3 PR3	LU4 PR3
Piedmont	LU1 PR4	LU2 PR4	LU3 PR4	LU4 PR4

Test BMPs

1. Cover crops
2. Buffers (grass, riparian)
3. Tillage (high residue, conservation)
4. More (in progress)

Looking for feedback on initial short list and narrowing definitions

Thank you.

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