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Hydro-Climate Automation Module (HCAM) Instructions: Version 2

Office of Research and Development Center for Environmental Measurement and Modeling

Hydro-Climate Automation Module (HCAM) Instructions: Version 2

Naomi Detenbeck¹ Marilyn ten Brink¹

> Alyssa Le² Karl Dickman² Isabelle Morin²

Amy Piscopo³

Chris Weaver⁴

¹U.S. EPA Atlantic Coastal and Environmental Sciences Division, Center for Environmental Monitoring and Modelling, Narragansett, RI 02882

²ICF, 100 Cambridgepark Drive, Suite 501, Cambridge, MA 02140

³formerly at US EPA ACESD, CEMM, Narragansett, RI 02882

⁴US EPA Health and Environmental Effects Assessment Division, Center for Public Health and Environmental Assessment, Research Triangle Park, NC 27709

> Center for Environmental Measurement and Modeling Office of Research and Development U.S. Environmental Protection Agency Washington, DC 20460

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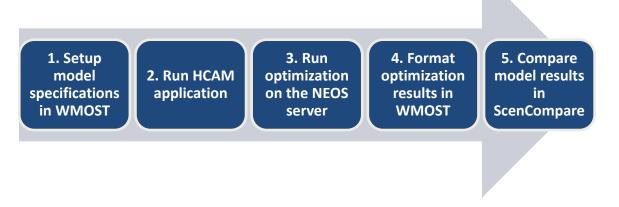
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Introduction

The Watershed Management Optimization Tool (WMOST) is an Excel-based tool designed to aid decision making in integrated water resources management. It is meant to be run for small watersheds (HUC10 to HUC12 scale) and over a range of planning years. The Hydro-Climate Automation Module (HCAM) is a WMOST version 3.1 add-on that allows the user to automate the creation of runoff and recharge time series that reflect varying climate scenarios and then run WMOST scenarios using those time series sets. Following model optimization setup using HCAM, users should utilize ScenCompare, the WMOST Climate Scenario Viewer and Comparison Post Processor (EPA 2018c) to compare optimization results across climate scenarios.

The HCAM automates the functionality of the Baseline Hydrology and Stormwater Hydrology Modules within WMOST v3.1. In particular, HCAM allows the user to batch run stormwater Best Management Practice (BMP) simulations with the Storm Water Management Model (SWMM) to generate managed runoff/recharge time series over varying climate scenarios. HCAM facilitates the use of multiple watershed model runs driven by multiple scenarios of future changes in temperature and precipitation, for example, as obtained from downscaled General Circulation Models (GCMs) and prepared as time series inputs to the model. There are numerous sources for downscaled GCMs. For example, EPA provides the online LASSO tool which allows users to estimate change factors for temperature and precipitation between current and future climate scenarios across multiple GCMs (https://lasso.epa.gov/). Users would need to apply these change factors to current climate time series and rerun base watershed models with updated weather files to generate new hydrology and loading time series for use in HCAM. Such functionality is needed to support applications such as evaluating the outcome of a prescribed management strategy - e.g., a Watershed Implementation Plan (WIP) to meet Total Maximum Daily Load (TMDL) requirements - over multiple plausible future temperature and rainfall scenarios to determine under what conditions the strategy might be expected to fail to meet performance requirements. In other words, the HCAM application allows the user to evaluate the robustness of various management options in meeting hydrology or water quality targets under varying future climate conditions.

HCAM users who are unfamiliar with the WMOST model inputs and outputs should refer to the WMOST documentation (EPA, 2018a; EPA, 2018b). These instructions provide information on HCAM's software requirements (section 1), data requirements (section 2), and module usage (section 3). In order to run WMOST for varying climate or management scenarios, you will generally be using the following process.



1. Software Requirements

The tool can be downloaded from EPA's WMOST website. After downloading the HCAM.zip folder, unzip the contents to create the HCAM folder. Within the HCAM folder, double click "StormwaterBMP.application" to install and launch HCAM. When prompted, click "Install". Once installed, HCAM can be launched by double clicking "StormwaterBMP.application".

1.1 SWMM Executable

EPA's Storm Water Management Model (SWMM)1 simulates water runoff quantity and quality in primarily urban areas and helps to support the evaluation of reduction of runoff and harmful discharges to water bodies through infiltration and retention in stormwater control measures. The HCAM is compatible with SWMM 52, and an .exe file has been included in the HCAM download. Therefore, you do not need to download and install SWMM separately. However, the link below can be used to download relevant documentation.

https://www.epa.gov/water-research/storm-water-management-model-swmm

2. Data Requirements

The following files are required for running the HCAM:

- WMOST Hydrology and Loadings Databases
- WMOST Log File
- WMOST Model Files (Wmodel.mod, Wdata.dat, Wcommand.amp, Wopt.opt)
- BMP Parameter File (BMP-Config.csv)
- HRU Parameter File (HRU-Config.csv)

¹ <u>https://www.epa.gov/water-research/storm-water-management-model-swmm</u>

² The HCAM is only compatible with SWMM 5.1.013, the version included in the download and is not backwards or forwards compatible with different versions of SWMM.

Each of these files or sets of files will be described in more detail in the subsections below. First, create a folder entitled "Time Series". This folder will hold the WMOST hydrology and loadings databases (see Figure 2.).

Figure 2. Time Series Folder and Contents

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▶ Name	Date modified	Туре	Size						
swmm_taunton32_huc12_polygon_hydrology_1.csv	9/12/2019 4:24 PM	Microsoft Excel Com	1,562 KB						
swmm_taunton32_huc12_polygon_hydrology_2.csv	9/12/2019 4:24 PM	Microsoft Excel Com	1,562 KB						
swmm_taunton32_huc12_polygon_loadings_tn_1.csv	8/15/2019 5:37 PM	Microsoft Excel Com	824 KB						
swmm_taunton32_huc12_polygon_loadings_tn_2.csv	8/15/2019 5:37 PM	Microsoft Excel Com	824 KB						

Next, create a folder entitled "HCAM Processing". This folder will hold the remaining required data3 and will also be where the HCAM will create a "model_outputs" folder that will contain all of the model outputs (see Figure 3.).

Figure 3. HCAM Processing Directory

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\leftarrow \rightarrow \checkmark \uparrow \blacksquare \Rightarrow This PC \Rightarrow Desktop \Rightarrow HCAM Processing \checkmark \heartsuit								
Name	Date modified	Туре	Size					
model_outputs	9/26/2019 8:10 AM	File folder						
BMP-Config.csv	9/25/2019 1:52 PM	Microsoft Excel Com	4 KB					
HRU-Config.csv	8/1/2018 5:24 AM	Microsoft Excel Com	1 KB					
HRU-Reference.csv	9/7/2017 3:22 PM	Microsoft Excel Com	5 KB					
Taunton_Climate_LogFileTEMP.csv	9/5/2019 10:25 AM	Microsoft Excel Com	263 KB					
Wcommand.amp	9/25/2019 2:56 PM	AMP File	1 KB					
Wdata.dat	9/25/2019 2:43 PM	DAT File	339 KB					
📄 Wmodel.mod	9/25/2019 2:56 PM	MOD File	54 KB					
WMOSTv3.1.xlsm	9/20/2019 3:52 PM	Microsoft Excel Macr	27,378 KB					
Wopt.opt	9/25/2019 2:56 PM	OPT File	1 KB					

2.1 WMOST Hydrology and Loadings Databases

WMOST requires WMOST-formatted databases containing hourly runoff and recharge data for your study area and representing various climate scenarios. These databases are described in detail in the WMOST User Guide (EPA, 2018b) Section 3.2. There are two options for developing these databases:

- Databases ready for input into WMOST are available online via EPA's Estuary Data Mapper (EDM) server⁴, including watershed model output from current and future climate scenarios. Watersheds, land-use scenarios, and climate change scenarios covered in the EDM set are described in the edm_wmost_database_inventory.xlsx found at https://www.epa.gov/ceam/wmost-30-download-page.
- 2) Datasets derived from an existing or user-developed calibrated/validated simulation model run under various climate scenarios. If using outputs from a Hydrological Simulation Program Fortran (HSPF)⁵ or Soil and Water

³ Make sure there is only one version of each of the files represented in the example. HCAM will encounter errors if you have two WMOST .xlsm files, for example.

⁴ The Estuary Data Mapper (EDM) application uses the Remote Sensing Information Gateway (RSIG) web servers as conduits for accessing data. The datasets that are available can be viewed through the EDM application or found on the EDM Data Inventory site, <u>https://www.epa.gov/edm</u>. These databases can also be accessed through the WMOST interface within the Baseline Hydrology Module (see WMOST User Guide Section 3.2).

⁵ <u>http://water.usgs.gov/software/HSPF/</u>

Assessment Tool (SWAT)⁶ model, you can reformat the outputs for use in WMOST using the HydroProcessor⁷, available for download from the WMOST v3.0 download page.

If you are not using data from an existing WMOST database (option 1) nor did you use the HydroProcessor to reformat HSPF or SWAT model outputs, you will want to adjust your runoff and recharge time series to take into account the effects of evaporation. In order to avoid double counting evaporation within the HCAM, use the evaporation or potential evapotranspiration time series included with model outputs to adjust the runoff time series.

Check that the time frame (*e.g.*, length of time and actual dates) represented in the climate scenario runoff and recharge time series match the time frame of the baseline runoff and recharge time series. These climate scenario time series are typically new sets of input hourly temperature and precipitation data generated by uniformly adjusting the baseline temperature and precipitation records by the corresponding ΔT (absolute) and ΔP (percentage) values, respectively, where ΔT and ΔP are typically obtained from climate models. Using these adjusted temperature and precipitation data, hourly runoff and nutrient loading rates can then be generated for each scenario using SWMM.

These databases are required by the HCAM as the baseline and climate scenario runoff and recharge time series. Each WMOST Hydrology and associated Loadings Database should have the following characteristics⁸ in the order specified as shown in the example below:

- Indication of model name: e.g., "swmm", "swat"
- Watershed name
- Indication of the type of information included in the database: "hydrology" or "loadings"⁹
- If "loadings" data, the constituent of interest: "tn", "tp", "tss", or "zn"
- A unique numerical ID as the final character in the file name

Figure 4. HCAM Processing Directory – Hydrology and Loadings Files

swm_taunton24_huc12_polygon_hydrology_2.csv	9/8/2017 10:17 AM	Microsoft Excel Co	7,636 KB
Swmm_taunton24_huc12_polygon_loadings_tn_2.csv	9/8/2017 10:17 AM	Microsoft Excel Co	3,946 KB
Swmm_taunton32_huc12_polygon_hydrology_1.csv	9/8/2017 10:18 AM	Microsoft Excel Co	8,024 KB
swmm_taunton32_huc12_polygon_loadings_tn_1.csv	9/8/2017 10:18 AM	Microsoft Excel Co	4,122 KB

Double check the files to make sure there is only one runoff and recharge time series for each HRU.

2.2 WMOST Model Setup (Step 1 of Figure 1)

When you first open WMOST, you will see the familiar Excel interface with one active worksheet entitled Intro. Overall, interaction with the WMOST 3.1 interface will largely be the same as for earlier versions except for the entry of runoff and recharge hydrology and loadings time series, including the Baseline Hydrology and Stormwater Hydrology Modules.10 In order to use HCAM, you must be running a Hydrology & Loadings model analysis and follow the general steps as outlined.

- 1) Setup the baseline and stormwater managed runoff and recharge tables using either:
 - a) "Import HRUs" button within the Baseline Hydrology Module (Figure 5) or

⁶ <u>http://swat.tamu.edu/</u>

⁷ https://www.epa.gov/ceam/wmost-30-download-page

⁸ All file name characteristics are case sensitive.

⁹ "loading" will cause HCAM errors.

¹⁰ For detailed information on how to fill out the rest of the WMOST input pages, please refer to the WMOST User Guide (Sections 3.4 through 3.8).

b) "Setup Baseline Tables" and "Setup Stormwater Tables" buttons on the Input sheet (Figure 6).



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Paste Copy - Format Painter Control - B I U - Clipboard Control - B I U - E - Clipboard Control - B I U - E - E - Clipboard Control - E
F G H J K L M N O P Q R S T U V W 2 Return to Input Baseline Hydrology Module Image: Construction of the set of
Baseline Hydrology Module Below the step-by-step directions below to obtain hydrology data for your study area including baseline runoff and recharge time series and groundwater recession coefficient. Based on your selections, the model will populate input fields on the appropriate sheets. 7 1. HRU Characteristics: Import the HRU characteristics for your watershed or subbasin using the Automatic EDM Import or the Manual File Selection Option. 9 14. Retrieve Data from U.S. EPA's Estuary Data Mapper (EDM): Make watershed selections and retrieve the HRU characteristics and weather data for your model.
Baseline Hydrology Module Baseline Hydrology Module Follow the step-by-step directions below to obtain hydrology data for your study area including baseline runoff and recharge time series and groundwater recession coefficient. Based on your selections, the model will populate input fields on the appropriate sheets. T. I. HRU Characteristics: Import the HRU characteristics for your watershed or subbasin using the Automatic EDM Import or the Manual File Selection Option. J. A Retrieve Data from U.S. EPA's Estuary Data Mapper (EDM): Make watershed selections and retrieve the HRU characteristics and weather data for your model.
 1. HRU Characteristics: Import the HRU characteristics for your watershed or subbasin using the Automatic EDM Import or the Manual File Selection Option. 14. Retrieve Data from U.S. EPA's Estuary Data Mapper (EDM): Make watershed selections and retrieve the HRU characteristics and weather data for your model.
12
13 2. Enter the name of your watershed: 3. Select the model type: 4. Select the land use scenario: 5. Select the climate scenario: 6. Enter the HUC ID for your subbasin: 14
7. After you have made the above selections, use "Retrieve Charcteristics & Weather Data" to initiate the EDM data request: Retrieve Characteristics & Weather Data 17
18 19 18. Manual File Selection: Select the file that contains the HRU characteristics for the watershed or subbasin that encompasses your study area. Import HRUs
21 2. Hydrologic Response Units (HRUs). The following HRU types are available in the selected watershed. 22 2A. Select which HRUs exist in your study area by placing an x in blue box next to the HRU type. 2B. Then press "Populate Land Use" to populate Land Use table with each HRU's name,
Intro Input Hydro ⋮ ▶ Ready III III III III ▶

Figure 6. Input Data

□		
	WMOSTv3.1.xlsm - Excel	
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A Cut Paste ♦ Copy + • ♦ Format Painter Clipboard r Font r A Font Font A	Formatting Table Styles T	∑ AutoSum ~ A T P ↓ Fill ~ Sort & Find & Clear ~ Filter ~ Select ~ Editing ^
A1 · : × ✓ fx		^
As you complete each section, click the box in front of the button to indicate	Input Data completion. This will change the color to grey and help you track your progress. Once all are co	Return to Intro
1. Baseline: Data for unmanaged land conditions.		
A. Time series data: Use Baseline Hydrology module for assisted data acquisition and entry Baseline Hydrology Module Name of Constituent 1:	OR manually enter your own data. 1. Enter the number of HRUs in your study area: 2. Press "Setup Baseline Tables" button to prepare baseline land use, rrunoff, and recharge input tables 3. Navigate to each input table and enter data: Runoff Runoff Recharge Runoff Loadings	Setup Baseline Tables
B. Land use data: Enter HRU areas available for land conservation and assoc	ated costs	
2. Stormwater Management: Data for stormwater managed land cond	litions. This section is only required if you wish to consider stormwater management.	
A. Time series data: Use Stormwater Hydrology module for assisted data acquisition and entry Stormwater Hydrology Module	OR manually enter your own data. 1. Enter the number of HRU sets (baseline plus managed): 2. Press "Setup Stormwater Tables" button to prepare managed land u runoff, and recharge input tables: 3. Navigate to each input table and enter data:	Setup Stormwater Tables
< → Intro Input ⊕		
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The fields in the baseline and stormwater managed runoff and recharge tables will be left blank. In a later step, you will fill out the time period column on the **Runoff** sheet. 2) Provide the baseline and managed set land use data for the tables on the Land Use sheet. If you are modeling green roofs, be sure to include nonzero values for roof area and roof percent effective impervious. If you are not modeling green roofs, you may enter "-9" for all HRUs.

Figure 7. Baseline HRU Characteristics

Land Use	and Its Man	agement		For management options that are not applicable or desired for an HRU, e				
Return to Input Return to Baseli Hydrology Mod				For Minimum and Maximum Areas, enter -9 if there is no lim Allocation of area among Managed HRU sets is mutually excl O&M = Operations and maintenance ¹ Data are automatically populated if you use the Hydrology				
			Baseline Area	Percent Effective	Infiltration	Roof Area	Roof Percent Effective	
HRU ID	HRU Name1		[acre]	Impervious ¹	Rate [in/hr] ¹	[acre]	Impervious	
HRU1B								
HRU2B								
HRU3B								
HRU4B								
HRU5B								
HRU6B								
HRU7B								
HRU8B								

You can do this manually using your own data, or with the assistance of the Baseline Hydrology Module. If you are using the Baseline Hydrology Module, follow Steps 1-4 as usual, including using the "Populate Land Use" button.

Figure 8. Hydro Tab – Populate Land Use

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F G H I J K L M N O P Q R S T U V 18 19 18. Manual File Selection: Select the file that contains the HRU characteristics for the watershed or subbasin that encompasses your study area. Import HRUs 20	W	AD A	EA				
2. Hydrologic Response Units (HRUs). The following HRU types are available in the selected watershed. 22. As Select which HRUs exist in your study area by placing an x in blue box next to the HRU type. 3. HRU types in the selected watershed 4. Select which HRUs exist in your study area by placing an x in blue box next to the HRU type. 5. HRU types in the selected watershed 6. Populate Land Use 7. Note: 6. One:							
3. Time period View Precipitation Data 38 Hydrology data for the selected watershed is available for the following time period: to 9 Five years of data is the maximum recommended model time period length. You can view the daily precipitation time series to help you determine the period of interest. View Precipitation Data							
SA. If you used EPA's EDM to retrieve your data, the precipitation data is available on the "Precipitation" sheet. You may use "View Precipitation Data" at any time to refer to the data. SA. If you used EPA's EDM to retrieve your data, the precipitation data is available on the "Precipitation" sheet. You may use "View Precipitation Data" at any time to refer to the data. Load Precipitation Data Load Precipitation Data".							
63 Enter the time period of interest for your modeling study: Start (mm/dd/yyyy) 65 End (mm/dd/yyyy)							
67 4. Model time step To use the Stormwater Module, you must setup a daily model. Would you like to setup a daily or monthly model? Daily To use the Stormwater Module, you must setup a daily model. Would you like to setup a daily or monthly model? Daily To use the Stormwater Module, you must setup a daily model. Would you like to setup a daily or monthly model?							
intro input Hydro 🛞			•				
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3) Enter the model start dates on the Hydro sheet (Baseline Hydrology Module). Whether you are using the Baseline Hydrology Module or not, skip steps 5A and 5B and go to step 5C to finish downloading the hydrology and loadings data and enter the time period onto the Runoff sheet (as referred to in Step 1).

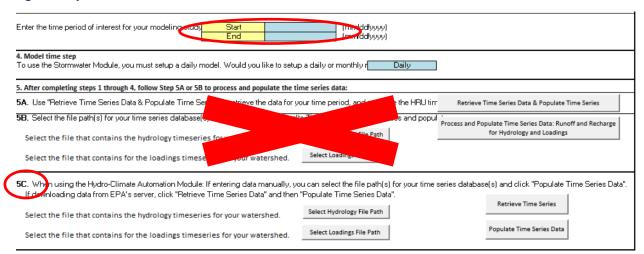


Figure 9. Hydro Tab – Time Period of Interest

If you are entering data manually, select the file paths for your time series databases and click "Populate Time Series Data". If downloading data from EPA's server, click "Retrieve Time Series Data" and then "Populate Time Series Data".

- 4) Specify BMPs¹¹ on the **Stormwater** sheet (Stormwater Hydrology Module) and enter their characteristics for design depth and constituent removal rate
- 5) If desired, use the "Populate capital and O&M costs for stormwater management" button on the **Stormwater** sheet to automatically populate the stormwater costs for each BMP set. Otherwise, be sure to enter your own stormwater BMP costs on the **Land Use** sheet.

Figure 10. Calculate Capital and O&M Costs

6. If you are using the Hydro-Climate Automation Module, use the button below to calculate capital and O&M costs Populate capital and O&M costs for stormwater management

¹¹ The HCAM application cannot be used to model agricultural BMPs as it is only calculating BMP performance based on runoff from impervious surfaces, which do not exist for agricultural BMPs.

Just as a reminder, you do *not* need to process or enter any runoff/recharge time series data or create any managed sets. However, you should fill in all of the other WMOST input pages, such as the Potable and Nonpotable Demand pages and Infrastructure page (WMOST User Guide Sections 3.3 through 3.8, Sections 2c through 6 on the **Input** sheet).

£ - -WMOSTv3.1 xlsm - Excel File Home Le, Alyssa 🙎 Share Insert Page Layout Σ AutoSum -🔏 Cut AT P . ≠ • 11 • A A = = = 🗞 • 🗗 Wrap Text 🖶 💌 🖬 Calibri General 😺 Fill -Copy -Sort & Find & Filter - Select -Paste Font Alianment Numbe Clipboard Styles Cells Editing т45 - : × ~ fx WQ BMPs /ater Quality BMPs: If you wish to consider water quality management options to change loadings on HRU area or to a waterbody, proceed to the WQ BMPs module. г г Riparian Buffers parian Buffer BMPs: If you wish to consider converting riparian buffer land areas to change runoff and loadings on an HRU, proceed to the Riparian Buffers module. ater use and demand management. ter the number of water use types but do not include unaccounted water; it is automatically included: ress "Setup Input Tables" button to prepare appropriately sized input tables for potable and nonpotable demand and septic systems data based on number of water use types ite to each input tab associated with water use Setup Input Tables Nonpotable Potable Demand Septic and Г Demand Demand Management Sewer Systems ater supply sources and infrastructure. Navigate to each input tab to enter data. Surface Water & Interbasin Transfer Groundwater Infrastructure System Targets od module. If you wish to consider the cost of flood damages in the total annual management costs, proceed to the flood module. Flood Module Neasured data. available, enter measured streamflow and water quality data. Г Measured Data Intro Input 🕀 Ready Uploading to SharePoint + 90

Figure 11. Input Tab

After you have input the necessary data, press the "Create Model Files and Data File Shell" button on the **Intro** sheet. You do not need to press the "Optimize" button anymore.

Figure 12. Intro Tab – Create Model Files and Data File Shell

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A Cut Paste ✓ Format Painter Clipboard □	111 • A* A* = = ■ ≫ • ▷ Wrap Text General Image: Conditional Formatas Image: Conditional Formatas	Sort & Find & Filter * Select Editing		^
A1 • : ×				^
Proceed to Input Data	Summarizes all input data necessary and/or available for specification. Enter input tables and values on the sheet(s) accessed using this button.			
RUN OPTIMIZATION				
Scenario Name:	Enter the name of the scenario. Convert loading units to metric tonnes (Yes o Tolerance value of cost objective function: Initiates the writing of the optimization program and processes the output for viewing. Maxiumum number of iterations for NEOS Se	0.0001	1	
Create Model Files and Data File Shell	Initiates the writing of the optimization program for use with the Hydro-Climate Automation Module.		<i>.</i>	
Hybrid (B-Hyb)	Select the appropriate solver algorithm for your model, the default algorithm typically results in the shortest solve time. Please refer to the theoret	ical documentation	for additional i	nforn
Process Results	Processes the optimization results from the NEOS server.			
Process HCAM Results	Processes the optimization results from the NEOS Server for climate scenarios run with the Hydro-Climate Automation Module.			
EVALUATE RESULTS				
Results Table	Summary table of management decisions and costs for meeting user-specified goals (e.g., demand, in-stream flow targets, in-stream concentrations)		
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Pressing the button will create five files: 1) a model file, 2) a command file, 3) a data file, 4) an options file, and 5) an input data log file (a csv file ending in "LogFileTEMP"). The data file (Wdata.dat) and log file will both be updated by the HCAM.

If you entered your HRU and hydrology and loadings data manually, check the log file to make sure all of the required data is there. In particular, check the *Units* column for the "NLuName" variables and make sure that the integer listed in the *Units* column corresponds to the HRU ID in your model characteristics file and hydrology and loadings databases (refer to the following example).

NLuName	1	forest sand	1
NLuName	2	open nonres sand	2
NLuName	3	MLD res sand	3
NLuName	4	MHHD resid sand	6
NLuName	5	comindtr sand	7
NLuName	6	ag sand	8
NLuName	7	forest till	9
NLuName	8	open nonres till	10
NLuName	9	MLD res till	11
NLuName	10	MHHD resid till	14
NLuName	11	comindtr till	15
NLuName	12	ag till	16
NLuName	13	cranberry bog	17
NLuName	14	forested wetland	18
NLuName	15	nonforested wetInd	19
NLuName	16	water	100

Table 2. NLuName Variables in Hydrology and Loadings Log File

2.3 BMP Parameters

Included in the download of the HCAM is a file entitled BMP-Config.csv that includes parameters associated with the BMPs available in WMOST. These are default BMP design parameters that were originally set by the EPA Region 1 office during development of the Opti-Tool (EPA, 2017). In some cases, the BMP design parameters from Opti-Tool were adjusted to be compatible with SWMM BMP parameter requirements (see Appendix A). A data dictionary is included within the file beginning on row 21.

These BMP parameters can be edited within the .csv file itself or within the HCAM application. However, it is highly recommended that parameters are only edited within the HCAM application itself to minimize data input errors.

2.4 HRU Parameters

Included in the download of the HCAM is a file entitled HRU-Reference.csv that can be used to set buildup and washoff coefficient values¹² by HRU in the HRU-Config.csv file when running a WMOST "Hydrology and Loadings" optimization run. The HRU-Reference.csv file includes parameter values for a variety of different pollutant, land use types, and infiltration types beginning in column G. Use this information to fill out the HRU-Config.csv file (columns B through E). If you have regionally-specific values for your study area, fill in columns B through E in the HRU-Config.csv file with the appropriate values for your WMOST model's HRUs to replace the default values derived for New England. The SWMM water quality reference manual (EPA, 2016) includes a table summary of linear buildup rates and methodology for developing watershed-specific washoff functions. A crosswalk of HRU-Config.csv column and parameters name is summarized Table 2.

Table 2. HRU References for Column and Parameter Names

Column Name	Parameter Name
bup1	Maximum Buildup (lbs/ac)
bup2	Buildup Rate (1/day)
wsh1	Washoff Coefficient
wsh2	Washoff Exponent

These HRU parameters can only be edited within the HRU-Config.csv file itself.

¹² SWMM defines pollutant buildup and washoff for each land use category. The buildup and washoff functions are described in detail in Chapter 3 Section 3.3.9 of the SWMM user guide (EPA, 2015) and Chapters 3 and 4 of SWMM's water quality reference manual (EPA, 2016).

3. HCAM Usage

3.1. HCAM Steps

Once installed, HCAM can be launched by double clicking "StormwaterBMP.application". The following section walks through the steps of the HCAM (Steps 2 and 3 in Figure 1).

Step 1: Welcome to the Hydro-Climate Automation Module.

The tool will ask for the file path for the folder holding the WMOST Hydrology and Loadings Databases and the file path for the HCAM Processing folder. See Section 2 for a detailed description of these folders and associated file contents. Click on Folder Path buttons to navigate to directory of interest. The HCAM processing folder must also contain the HRU-Config.csv file and the BMP-Config.csv file.

Step 2: Confirm the HRU buildup/washoff parameter values.

HCAM includes default buildup/washoff parameter values in the HRU-Config.csv file. Users should confirm values and edit if necessary. The HRU buildup/washoff parameter values can only be set in the HRU-Config.csv file so if the parameters are incorrect, close the application, and return to the HRU-Config .csv file to make the necessary changes. Close the HRU-Config.csv before returning to HCAM.

Step 3: Confirm the BMP specifications.

The BMP specifications summarized in the table can be edited within the application in the lower table. However, it is important to keep parameter values within acceptable ranges as designated by the SWMM documentation¹³. If you are modeling green roofs, you can adjust the nutrient rain concentration on this page as well.

Step 4: Summary of data processing specifications.

This page allows you to verify your data processing specifications before proceeding to run SWMM. Make note of the baseline database names and corresponding Wdata#.dat file names to ensure that you understand which model run is associated with each scenario.

Step 5: Run SWMM Simulations.

When SWMM begins to run, you will see an additional screen pop up that gives you an indication of model processing. In the meantime, if you hover your cursor over the HCAM application, it will give you an indication of if it is still processing. You will be informed when SWMM simulations are complete, SWMM outputs have been processed, and optimization data files have been written. The following outputs from SWMM and the HCAM will be written to the folder *model_outputs* within the HCAM Processing folder.

- SWMM outputs
 - Detailed summary text files (detailed_out_managementset#_HRU#.txt)
 - SWMM output files (swmm_managementset#.out)
 - SWMM report files (swmm_managementset#.rpt)
- Updated WMOST data file (Wdata_scenario#.dat)
- Updated WMOST log file

This folder will be rewritten if the HCAM is used to run alternative climate scenarios.

Step 6: Run Optimization (Step 3 in Figure 1)

¹³ https://nepis.epa.gov/Exe/ZyPURL.cgi?Dockey=P100N3J6.txt

When you pressed the "Create Model Files and Data File Shell" button within WMOST, you generated one equations file (.MOD file), one AMPL commands file (.AMP file), and one options file (.OPT file). HCAM generated several data files (.DAT file), one for each climate scenario. These files need to be uploaded to the NEOS server for optimization. You will run NEOS once for each unique data (.dat) file. See Section 4.1 in the WMOST Users Guide for more detailed instructions on submitting model files to the NEOS server.

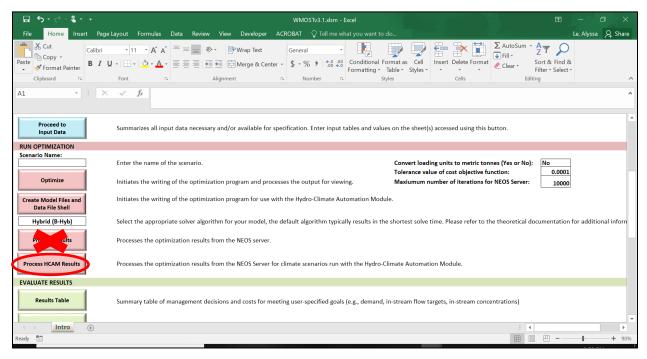
Step 7: Results Processing

The NEOS server will send you an email when your model run has completed. The optimization results must be copied into a new text file so it can be evaluated within WMOST. See Section 4.1 in the WMOST User Guide for more detailed instructions on processing results from the NEOS server.

3.2 Post-HCAM WMOST Steps

HCAM produces a log file for each scenario (saved to the HCAM Processing folder with the names in the form of "[StudyAreaName]_[ScenarioName]_SpecsResults_[ScenarioID].csv), which contain the input data and monthly runoff and recharge hydrology and loading statistics for each scenario.

WMOST must complete the processing of the SpecsResults file to include the climate statistics (average annual precipitation and average temperature for the time period) and the results from each scenario input by the user (Step 4 in Figure 1). To do this, open your WMOST file and select the "Process HCAM Results" button on the **Intro** sheet.



This button initiates the writing of the climate statistics and appends the results for each scenario in its corresponding scenario log file based on the file paths of the hydrology database file and scenario log files in the "outFiles.txt" file saved to the folder *model_outputs*. WMOST will prompt you to select the results file path for each scenario log file, and then uses that file to append the results to the scenario log file. When the scenario log file processing is complete, a message box appears that says "HCAM Scenario Log File processing complete". At this point, you can view and analyze your results in the WMOST ScenCompare¹⁴ tool (Step 5 in Figure 1).

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¹⁴ <u>https://www.epa.gov/ceam/wmost-301-download-page</u>

References

- United States Environmental Protection Agency (U.S. EPA). 2015. "Storm Water Management Model User's Manual Version 5.1" Publication No. EPA/600/R-14/413b).
- United States Environmental Protection Agency (U.S. EPA). 2016. "Storm Water Management Model Reference Manual: Volume III – Water Quality" Publication No. EPA/600/R-16/093).
- United States Environmental Protection Agency (U.S. EPA). 2017. "Opti-Tool for Stormwater and Nutrient Management (Version 1)." Developed by TetraTech. https://www3.epa.gov/region1/npdes/stormwater/ma/opti-tool-user-guide.pdf
- United States Environmental Protection Agency (U.S. EPA). 2018a. "Watershed Management Optimization Support Tool (WMOST) v3: Theoretical Documentation." Publication No. EPA/600/R-17/220).
- United States Environmental Protection Agency (U.S. EPA). 2018b. "Watershed Management Optimization Support Tool (WMOST) v3: User Guide." Publication No. EPA/600/R-17/255).
- United States Environmental Protection Agency (U.S. EPA). 2018c. "ScenCompare: WMOST Climate Scenario Viewer and Comparison Post Processor. Version 1." EPA/600/R-19/039, 2018.

The following tables indicate where the BMP-Config.csv BMP parameters have been updated from the default Opti-Tool values. References are linked in the footnotes. Parameter units are listed within the BMP-Config.csv file for reference.

WMOST	StorVolume	BermH	VegVol	SurfRough	SurfSlope	SwaleSlope	SoilThick	SoilPor	SoilFC	SoilWP
BMP Name										
Biofiltration w/ UD		MA Stormwater Guidance Manual ¹⁵	SWMM User Manual ¹⁶		SWMM User Manual ¹⁵	SWMM User Manual ¹⁵	MA Stormwater Guidance Manual ¹⁴		SWMM WQ Reference ¹⁷	SWMM WQ Reference ¹⁷
Bioretention Basin		MA Stormwater Guidance Manual ¹⁴			SWMM User Manual ¹⁵	SWMM User Manual ¹⁵			SWMM WQ Reference ¹⁷	SWMM WQ Reference ¹⁷
Enhanced Biofiltration w/ ISR Extended Dry Detention			SWMM User Manual ¹⁵ SWMM User Manual ¹⁵		SWMM User Manual ¹⁵ SWMM User Manual ¹⁵	SWMM User Manual ¹⁵ SWMM User Manual ¹⁵			SWMM WQ Reference ¹⁷ SWMM WQ Reference ¹⁷	SWMM WQ Reference ¹⁷ SWMM WQ Reference ¹⁷
Basin Grass Swale w/D			SWMM User Manual ¹⁵	SWMM WQ Reference ¹⁷	SWMM WQ Reference ¹⁷	SWMM WQ Reference ¹⁷	WMOST Theoretical Documentation ¹⁷	WMOST Theoretical Documentation ¹⁶	SWMM WQ Reference ¹⁷	SWMM WQ Reference ¹⁷
Gravel Wetland			SWMM User Manual ¹⁵		SWMM User Manual ¹⁵	SWMM User Manual ¹⁵			SWMM WQ Reference ¹⁷	SWMM WQ Reference ¹⁷
Green Roof		SWMM WQ Reference ¹⁸	SWMM User Manual ¹⁵		Literature review ¹⁹	SWMM User Manual ¹⁵	SWMM WQ Reference ¹⁷	SWMM WQ Reference ¹⁷	SWMM WQ Reference ¹⁷	SWMM WQ Reference ¹⁷
Infiltration Basin			SWMM User Manual ¹⁵		SWMM User Manual ¹⁵	SWMM User Manual ¹⁵	SWMM User Manual ¹⁵	SWMM User Manual ¹⁵	SWMM User Manual ¹⁵	SWMM User Manual ¹⁵
Infiltration Chamber			SWMM User Manual ¹⁵		SWMM User Manual ¹⁵	SWMM User Manual ¹⁵	SWMM User Manual ¹⁵	SWMM User Manual ¹⁵	SWMM User Manual ¹⁵	SWMM User Manual ¹⁵
Infiltration Trench			SWMM User Manual ¹⁵		SWMM User Manual ¹⁵	SWMM User Manual ¹⁵	SWMM User Manual ¹⁵	SWMM User Manual ¹⁵	SWMM User Manual ¹⁵	SWMM User Manual ¹⁵

WMOST	StorVolume	BermH	VegVol	SurfRough	SurfSlope	SwaleSlope	SoilThick	SoilPor	SoilFC	SoilWP
BMP Name										
Porous		SWMM WQ	SWMM		UNH	SWMM User		SWMM WQ	SWMM	SWMM
Pavement		Reference ¹⁷	User		Stormwater	Manual ¹⁵		Reference ¹⁷	WQ	WQ
w/ SI			Manual ¹⁵		Center ²⁰				Reference ¹⁷	Reference ¹⁷
Porous		SWMM WQ	SWMM		UNH	SWMM User		SWMM WQ	SWMM	SWMM
Pavement		Reference ¹⁷	User		Stormwater	Manual ¹⁵		Reference ¹⁷	WQ	WQ
w/ UD			Manual ¹⁵		Center ¹⁹				Reference ¹⁷	Reference ¹⁷
Sand Filter			SWMM		SWMM	SWMM User			SWMM	SWMM
w/ UD			User		User	Manual ¹⁵			WQ	WQ
			Manual ¹⁵		Manual ¹⁵				Reference ¹⁷	Reference ¹⁷
Wet Pond			SWMM		SWMM	SWMM User			SWMM	SWMM
			User		User	Manual ¹⁵			WQ	WQ
			Manual ¹⁵		Manual ¹⁵				Reference ¹⁷	Reference ¹⁷

WMOST	SoilCond	SoilCondSlope	SoilSH	StorThick	StorVR	StorCF	FlowCoeff	FlowExp	FlowOH	PaveThick	PaveVR
BMP											
Name											
Biofiltration		SWMM WQ	SWMM			SWMM	SWMM	SWMM	WMOST		
w/ UD		Reference ¹⁷	Hydro			User	User	User	Theoretical		
			Reference ²⁰			Manual ¹⁵	Manual ¹⁵	Manual ¹⁵	Documentation ¹⁶		
Bioretention		SWMM WQ	SWMM	SWMM							
Basin		Reference ¹⁷	Hydro	User							
			Reference ²⁰	Manual ¹⁵							
Enhanced		SWMM WQ	SWMM			SWMM	SWMM	SWMM	WMOST		
Biofiltration		Reference ¹⁷	Hydro			User	User	User	Theoretical		
w/ ISR			Reference ²⁰			Manual ¹⁵	Manual ¹⁵	Manual ¹⁵	Documentation ¹⁶		
Extended			SWMM			SWMM	SWMM	SWMM	WMOST		
Dry			Hydro			User	User	User	Theoretical		
Detention			Reference ²⁰			Manual ¹⁵	Manual ¹⁵	Manual ¹⁵	Documentation ¹⁶		
Basin											
Grass Swale	WMOST Theoretical	SWMM WQ	SWMM			SWMM	SWMM	SWMM			
w/D	Documentation ¹⁶	Reference ¹⁷	Hydro			User	User	User			
			Reference ²⁰			Manual ¹⁵	Manual ¹⁵	Manual ¹⁵			
Gravel		SWMM Hydro	SWMM			SWMM	SWMM	SWMM			
Wetland		Reference ²¹	Hydro			User	User	User			
			Reference ²⁰			Manual ¹⁵	Manual ¹⁵	Manual ¹⁵			

WMOST BMP Name	SoilCond	SoilCondSlope	SoilSH	StorThick	StorVR	StorCF	FlowCoeff	FlowExp	FlowOH	PaveThick	PaveVR
Green Roof	SWMM WQ	SWMM WQ	SWMM			SWMM	SWMM	SWMM			
Green Kool	Reference ¹⁷	Reference ¹⁷	Hydro			User	User	User			
	Reference	Reference	Reference ²⁰			Manual ¹⁵		Manual ¹⁵			
Infilturation							Manual ¹⁵				
Infiltration			SWMM			SWMM	SWMM	SWMM			
Basin			Hydro			User	User	User			
			Reference ²⁰			Manual ¹⁵	Manual ¹⁵	Manual ¹⁵			
Infiltration			SWMM			SWMM	SWMM	SWMM			
Chamber			Hydro			User	User	User			
			Reference ²⁰			Manual ¹⁵	Manual ¹⁵	Manual ¹⁵			
Infiltration			SWMM			SWMM	SWMM	SWMM			
Trench			Hydro			User	User	User			
			Reference ²⁰			Manual ¹⁵	Manual ¹⁵	Manual ¹⁵			
Porous	SWMM WQ	SWMM Hydro	SWMM	UNH		SWMM	SWMM	SWMM		MA	
Pavement	Reference ¹⁷	Reference ²⁰	Hydro	Stormwater		User	User	User		Stormwater	
w/ SI			Reference ²⁰	Center ¹⁹		Manual ¹⁵	Manual ¹⁵	Manual ¹⁵		Guidance	
										Manual ¹⁴	
Porous	SWMM WQ	SWMM Hydro	SWMM	UNH		SWMM	SWMM	SWMM			
Pavement	Reference ¹⁷	Reference ²⁰	Hydro	Stormwater		User	User	User			
w/ UD			Reference ²⁰	Center ¹⁹		Manual ¹⁵	Manual ¹⁵	Manual ¹⁵			
Sand Filter		SWMM Hydro	SWMM			SWMM	SWMM	SWMM	WMOST		
w/ UD		Reference ²⁰	Hydro			User	User	User	Theoretical		
			, Reference ²⁰			Manual ¹⁵	Manual ¹⁵	Manual ¹⁵	Documentation ¹⁶		
Wet Pond		SWMM WQ	SWMM			SWMM	SWMM	SWMM			
		Reference ¹⁷	Hydro			User	User	User			
			Reference ²⁰			Manual ¹⁵	Manual ¹⁵	Manual ¹⁵			

WMOST	PavePerm	PaveCF	MatThick	MatVR	MatRough	PercentRem_TN	PercentRem_TP	PercentRem_TSS	PercentRem_ZN
BMP Name					_	_		_	_
Biofiltration w/ UD									
Bioretention Basin									
Enhanced Biofiltration w/ ISR									
Extended Dry Detention Basin									
Grass Swale w/D									
Gravel Wetland									
Green Roof			SWMM WQ Reference ¹⁷	SWMM WQ Reference ¹⁷	SWMM WQ Reference ¹⁷				
Infiltration Basin									
Infiltration Chamber									
Infiltration Trench									
Porous Pavement w/ SI									
Porous Pavement w/ UD									
Sand Filter w/ UD									
Wet Pond									

WMOST BMP Name	RainConc_TN	RainConc_TP	RainConc_TSS	RainConc_ZN
Biofiltration w/ UD				
Bioretention Basin				
Enhanced Biofiltration w/ ISR				
Extended Dry Detention Basin				
Grass Swale w/D				
Gravel Wetland				
Green Roof				
Infiltration Basin				
Infiltration Chamber				
Infiltration Trench				
Porous Pavement w/ SI				
Porous Pavement w/ UD				
Sand Filter w/ UD				
Wet Pond				

¹⁵ <u>https://www.mass.gov/files/documents/2016/08/qi/v2c2.pdf</u>

¹⁶ https://www.epa.gov/sites/production/files/2019-02/documents/epaswmm5 1 manual master 8-2-15.pdf

¹⁷ https://www.epa.gov/sites/production/files/2018-02/documents/2018 wmostv3 theoreticaldoc epa600r17 220final508.pdf

¹⁸ https://nepis.epa.gov/Exe/ZyPDF.cgi/P100P2NY.PDF?Dockey=P100P2NY.PDF

¹⁹ Berndtsson, J. C. 2010. Green roof performance towards management of runoff water quantity and quality: A review. Ecological Engineering, 36, 351-360.

²⁰ https://www.unh.edu/unhsc/sites/unh.edu.unhsc/files/pubs_specs_info/unhsc_pa_spec_10_09.pdf

²¹ https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100NYRA.txt