

Model My Watershed BMP Spreadsheet Tool

User Manual

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- Repository & Archives: <https://github.com/WikiWatershed/MMW-BMP-spreadsheet-tool>
- Latest Version of Tool: https://raw.githubusercontent.com/WikiWatershed/MMW-BMP-spreadsheet-tool/master/MMW_BMP_Spreadsheet_Tool.xlsx
- Latest Version of Manual: https://raw.githubusercontent.com/WikiWatershed/MMW-BMP-spreadsheet-tool/master/docs/MMW_BMP_Spreadsheet_Tool_UserManual.docx

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A. Overview

This tool was developed to support the evaluation of potential pollutant load reductions that might result from the implementation of various Best Management Practices (BMPs) and similar mitigation measures in a watershed where loads from a wide range of rural and urban sources have been quantified. Although it was designed to readily accept simulated output from the multi-year model in Model My Watershed, load estimates from other models and load estimation tools could theoretically be used as well to evaluate potential reductions.

The tool was initially developed to assist municipalities in Pennsylvania in meeting their obligations with respect to achieving load reductions specified by the Pennsylvania Department of Environmental Protection as part of the NPDES permit renewal process. However, the tool is generic enough that it can be used for similar evaluations undertaken by a much wider range of users. Once model output results have been entered into the appropriate tab within the spreadsheet tool, other tabs are automatically populated with data in a way that facilitates the analysis of various load reduction strategies that deal with sediment, nitrogen and phosphorus loads from both urban and rural upland sources, as well as from streambanks that might be eroded due to grazing animals and excess runoff from impervious surfaces in urbanized areas.

In this document, instructions are provided for doing load/BMP analyses for two basic scenarios:

- 1) Analysis of pollutant loads and potential BMP scenarios for a given watershed. In this case, the Multi-Year Model in MMW (i.e., the GWLF-E model) is used to estimate mean annual nutrient and sediment loads (kg/yr) and loading rates (kg/ha) from a variety of sources within the user-specified area of interest (AOI). The resulting model output is then entered into the customized Excel-based tool to estimate potential load reductions that might result from the implementation of BMPs and other remedial measures in both rural and urban areas throughout the watershed.
- 2) Analysis of pollutant loads and potential BMP scenarios for specific subareas within a larger watershed. In this case, specific functionality has been built into the tool to assist municipalities in Pennsylvania meet pollutant load reduction requirements mandated as part of their cyclical NPDES permit review process. In utilizing the tool, MMW model output is used to estimate pollutant loads and loading rates for the larger watershed area as described above. Then, portions of the watershed loads are subsequently “assigned” to one or more subareas (e.g., municipalities or “urban areas” located within that watershed) based on the landscape characteristics of those areas (e.g., size, land cover type, and extent of impervious surface). Once the load assignments have been made, users of the tool can then simulate various BMP scenarios to evaluate potential load reductions. (Note: although this tool was initially developed for use in Pennsylvania, it could easily be used in other geographic regions for similar applications as well).

The following two sections briefly describe the steps for conducting analyses associated with the two basic situations outlined above.

B. Analysis of Pollutant Loads and Potential BMP Scenarios for a Single Watershed

Step 1: Load Output Data from Model My Watershed

Upon using the multi-year model in Model My Watershed, the user is presented with tabular results to the left of the “area of interest” map as shown in the example in Figure 1 below. (Note: see the Appendix to this document if you are unsure of how to use Model My Watershed to simulate pollutants loads for any given area of interest).

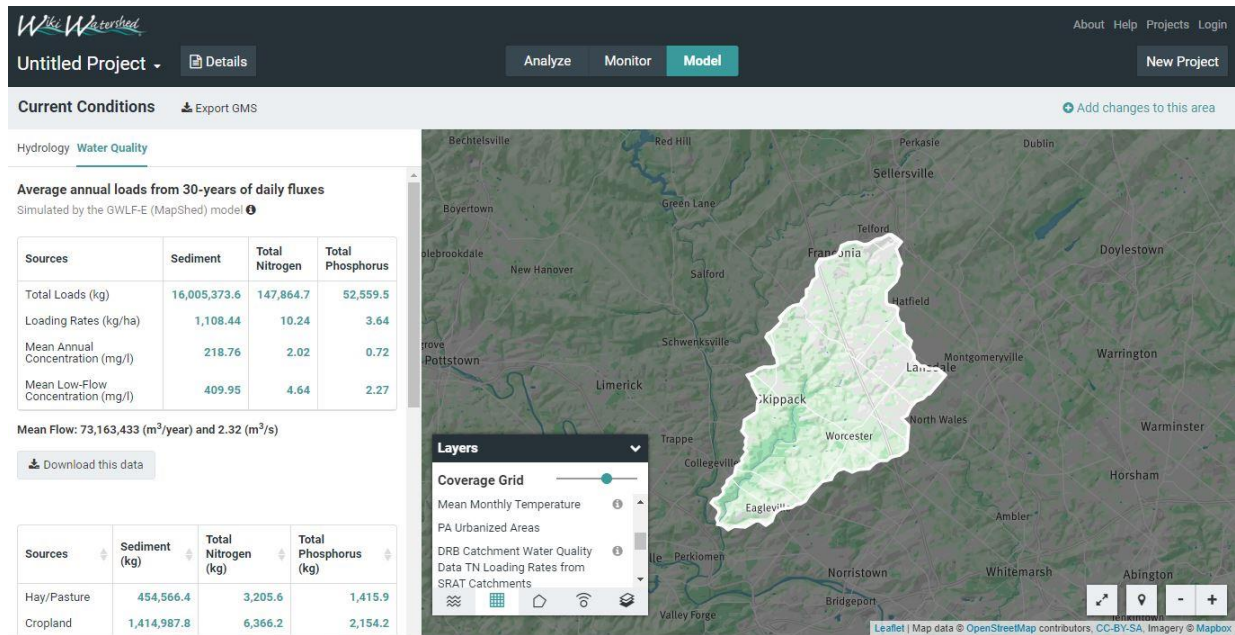


Figure 1. Tabular results from a Model My Watershed run.

The data required by the spreadsheet tool is included in an additional table which provides more detailed load information by source category (e.g., land cover type, point sources, streambank erosion, etc.). As shown in Figure 2, this data can be downloaded in csv format by clicking on the “Download this data” button. (Note: the spreadsheet tool itself can be downloaded via the link provided below the results table as also highlighted in Figure 2. In using this tool, it is recommended that the original Excel file be left un-altered, and that copies of it be used for individual projects).

Once downloaded, these data can be copied and pasted into the appropriate places in the “MMW Output” tab in the tool. (Note: As shown in Figure 2, make sure you download the csv file from the “Water Quality” section and not the “Hydrology” section). Similarly, information on the areal extent of the different source areas also needs to be copied and pasted from the “csv” file that can be downloaded from the “Analyze” results for the particular area of interest as shown in Figure 3. Figure 4

illustrates the specific locations within the “MMW Output” tab (high-lighted in green) where these model results should be inserted.

Once these data are inserted as shown, the table in the upper left-hand corner of this tab (shown in blue in Figure 4) is automatically populated with the correct model results required to populate other tabs in the spreadsheet and to support the various functions built into the tool. *(Important Note: In using the spreadsheet tool as it is currently configured, it is assumed that the model output from MMW is metric, which is the default, since metric-to-English unit conversions are made within the spreadsheet tool).* Note also in Figure 5 that there is a spot in the “MMW Output” tab where the user can insert information on the length of streams in a given watershed that can be used for implementing various stream protection activities such as streambank fencing and streambank stabilization. In this case, the values for length of streams in agricultural areas (typically a combination of cropland and pasture land), non-agricultural areas, and total length of streams in the watershed can be entered by the user manually or obtained from the “Streams” section of the “Analyze” tab as shown in Figure 6. Similarly, data on farm animal populations can be obtained from the “Animals” section of the “Analyze” tab and copied into the appropriate location as also shown in Figure 5 or entered manually by the user.

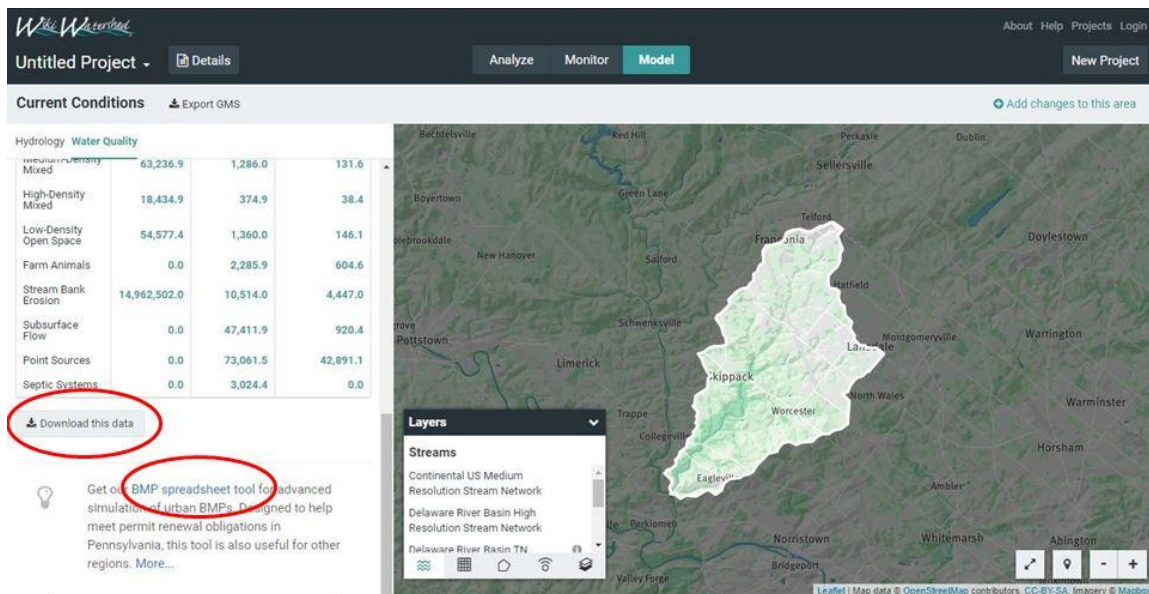


Figure 2. Links for downloading tabular results and the BMP spreadsheet tool.

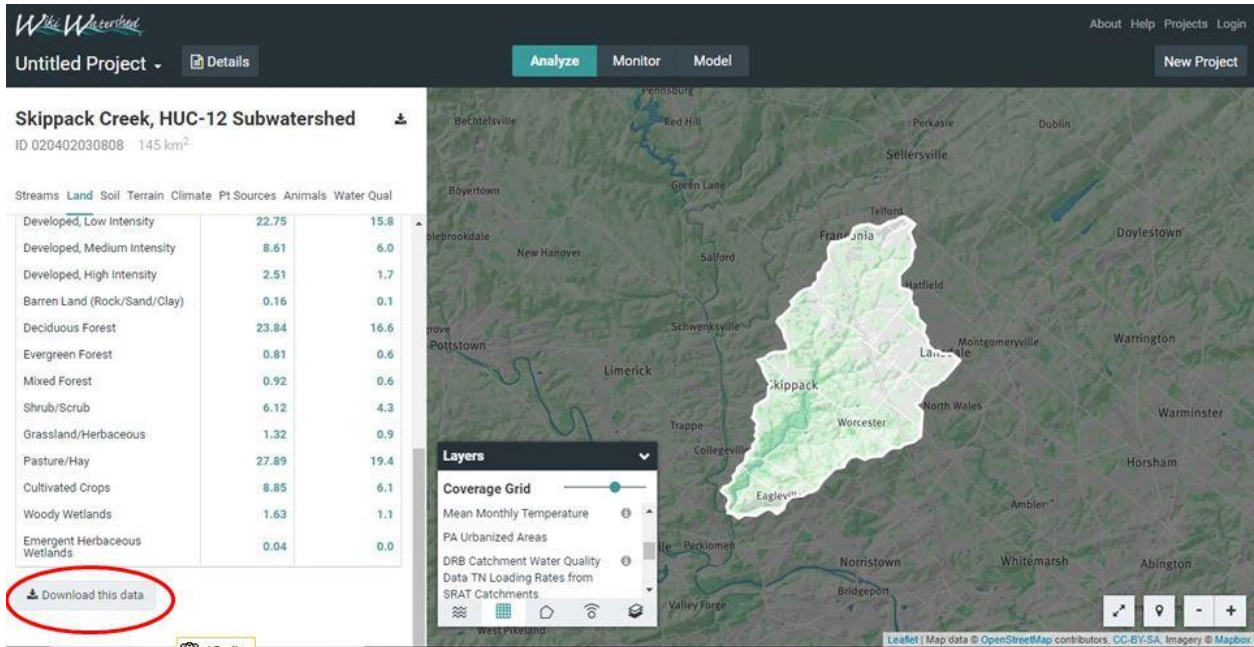


Figure 3. Link for downloading table with model results.

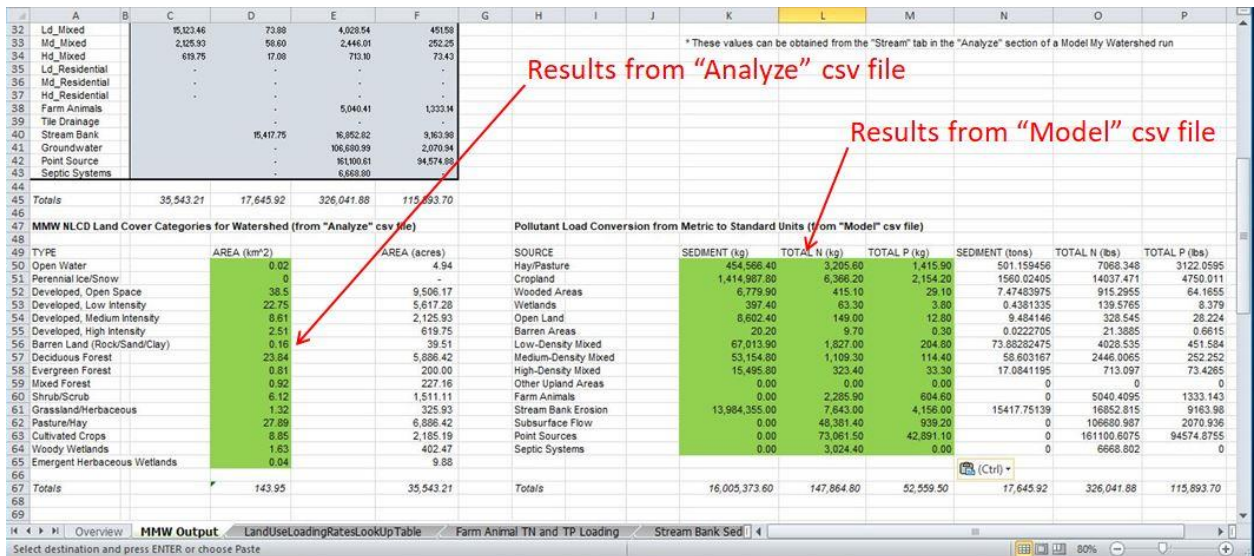


Figure 4. Locations for inserting model results.

One of the more important tabs populated with the MMW model results is the “Land Use Loading Rate Look-Up Table” shown in Figure 7. In this case, model results drawn from the “MMW Output” tab are used to calculate “upland” pollutant loading rates as well as “streambank” loading rates that are attributed to the different land use areas. As described later, various BMPs can be simulated to evaluate potential load reductions from “upland” areas and streambanks. In the case of developed (urban) areas, various BMPs are simulated that have an effect on both “upland” loads as well as “downstream” loads caused by streambank erosion. Additionally, with urban stormwater BMPs, “composite” loading rates

that combine loads from both upland and streambank sources are used in the simulation of potential load reductions as described in a later section.

To support loading rate calculations in the “Land Use Loading Rate Look-Up Table” tab, information is drawn from the “MMW Output” tab as well as other intermediate locations such as the “Streambank Sediment Loading”, “Streambank Nitrogen Loading”, and “Streambank Phosphorus Loading” tabs. While users of this BMP spreadsheet tool are not required to add or modify data in these latter three tabs (which are automatically populated from other tabs), some users may find them informative with regard to how streambank-eroded loads are assigned to various upland sources as a result of runoff emanating from these areas.

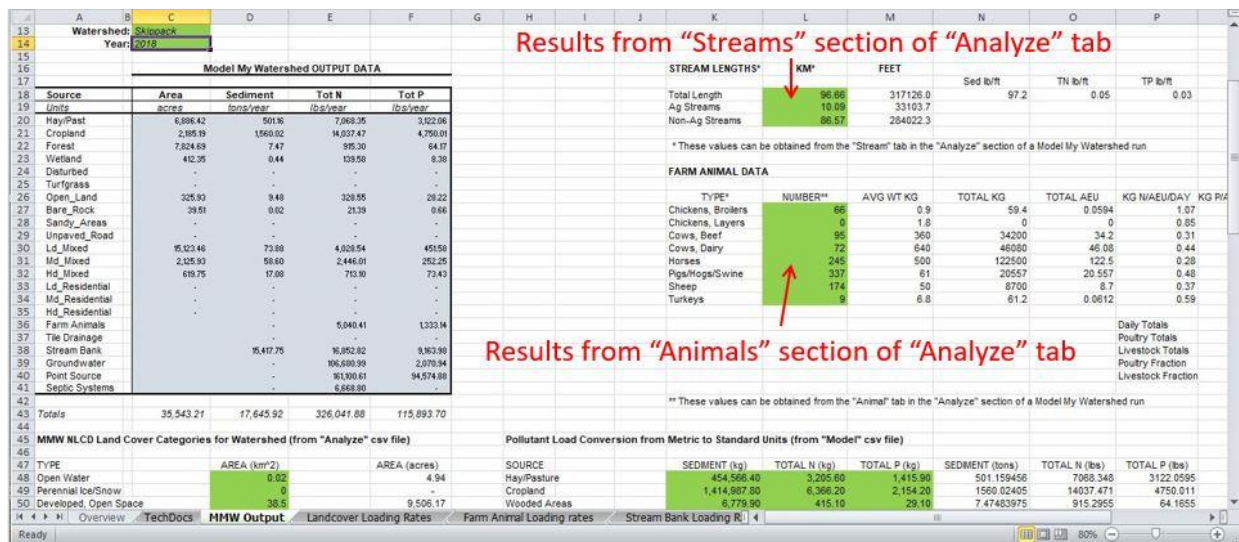


Figure 5. Locations for inserting stream length and farm animal data.

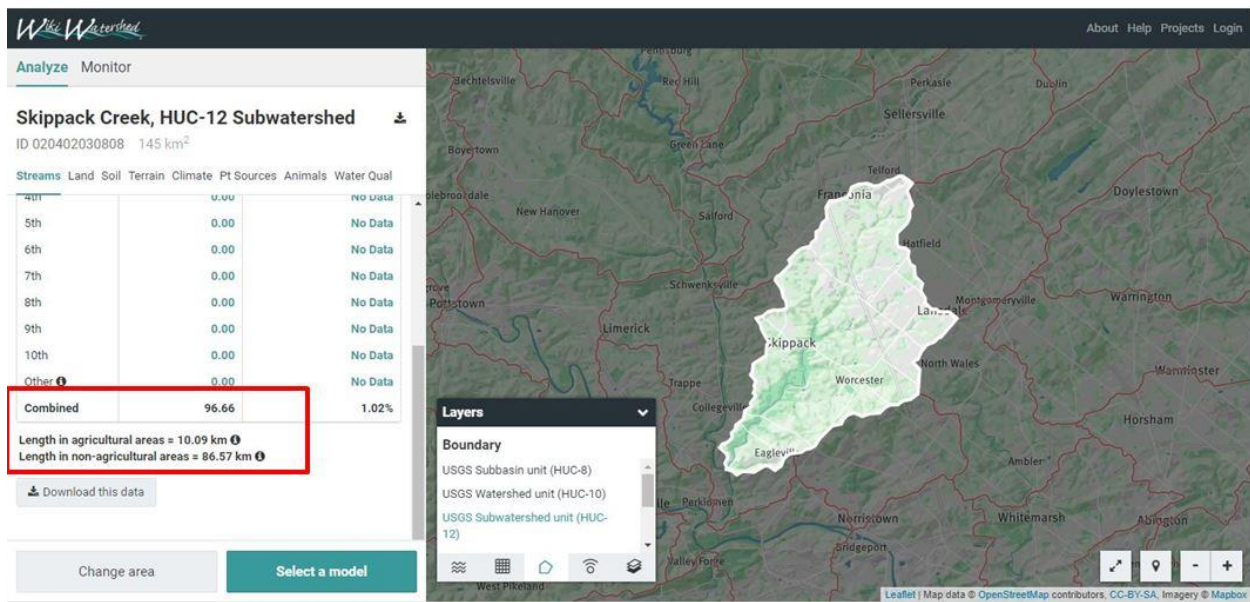


Figure 6. Location of stream data under the “Analyze” tab.

Watershed: Skippack
Year: 2018
Source File: User Specified

Section 2: Land Use Loading Rates Look-Up Table

TOTAL WATERSHED ANNUAL LOADS					ANNUAL LAND USE LOADING RATES (lbs/acre)											
Source	Area	Sediment	Total Nitrogen	Total Phosphorus	SEDIMENT			NITROGEN			PHOSPHORUS			TOTAL PHOSPHORUS LOADING RATE		
					From Land Use	From Stream Banks	TOTAL SEDIMENT LOADING RATE	From Land Use	From Stream Banks	From Farm Animals	TOTAL NITROGEN LOADING RATE	From Land Use	From Stream Banks		From Farm Animals	
lbs/acre	Acres	Tons	Pounds	Pounds	lb/acre	lb/acre	lb/acre	lb/acre	lb/acre	lb/acre	lb/acre	lb/acre	lb/acre	lb/acre		
HayPast	6,888.42	5016	1,068.35	3,122.06	445.55	650.66	196.21	1.03	0.36	0.56	1.35	0.45	0.13	0.15	0.79	
Cropland	2,185.19	1560.02	16,037.47	4,190.01	1,427.82	650.66	2,078.48	6.42	0.36	0.56	1.34	2.17	0.19	0.15	2.51	
Forest	7,824.65	7.47	395.50	44.11	1.91	650.66	652.57	0.12	0.36	n/a	0.46	0.01	0.19	n/a	0.20	
Wetland	432.35	0.44	139.59	8.38	2.13	650.66	652.79	0.34	0.36	n/a	0.70	0.02	0.19	n/a	0.21	
Disturbed	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	n/a	0.00	0.00	0.00	n/a	0.00	
Turfgrass	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	n/a	0.00	0.00	0.00	n/a	0.00	
Open_Land	328.93	3.48	329.55	29.22	59.20	650.66	100.86	1.01	0.36	n/a	1.37	0.03	0.19	n/a	0.23	
Blow_Bank	29.51	0.02	21.93	0.64	1.13	650.66	651.79	0.54	0.36	n/a	0.90	0.02	0.19	n/a	0.21	
Sandy_Areas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	n/a	0.00	0.00	0.00	n/a	0.00	
Upgraded_Road	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	n/a	0.00	0.00	0.00	n/a	0.00	
Ld_Mixed	15,204.41	73.88	4,029.54	451.99	3.17	346.95	955.93	0.27	0.48	n/a	0.75	0.03	0.28	n/a	0.31	
Md_Mixed	2,125.93	58.60	2,448.01	282.25	55.13	1,615.05	1,730.18	1.15	1.08	n/a	2.23	0.12	0.50	n/a	0.62	
Hd_Mixed	619.75	17.08	713.10	73.43	55.13	2,364.54	2,419.67	1.15	1.65	n/a	2.80	0.12	0.70	n/a	0.82	
Ld_Residential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	n/a	0.00	0.00	0.00	n/a	0.00	
Md_Residential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	n/a	0.00	0.00	0.00	n/a	0.00	
Hd_Residential	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	n/a	0.00	0.00	0.00	n/a	0.00	

Figure 7. Loading rate data included in the “Land Use Loading Rate Lookup Table” tab.

Step 2: Evaluate Potential Load Reductions from BMPs in Rural Areas

Using the “Agricultural BMPs” tab, various mitigation measures (both existing and proposed) can be simulated to evaluate potential load reductions in both upland areas (primarily agricultural land) and in streams due to streambank erosion. To facilitate this activity, information from other tabs is extracted and used to populate key cells in this tab. More specifically, information is drawn from other tabs (primarily the “MMW Output” tab) to assign values to cells pertaining to watershed loads and the extent of available land on which various BMPs might be applied. For example, the cells highlighted in blue in Figure 8 provide available land areas or stream lengths to which measures such as conservation tillage, cover crops, riparian buffers, streambank stabilization, etc. might be applied. (Note: these cells are highlighted for illustration purposes only, and do not appear this way in the actual BMP spreadsheet tool). In the same figure, the cells highlighted in orange are used to specify the existing and/or proposed extent of such measures. (Note that with this tab, as “existing” BMPs are applied, the availability of land area and/or loads for future BMPs are subsequently reduced). Based on user input, the potential load reductions are summed for all existing and proposed measures and provided towards the bottom of this tab as illustrated in Figure 9.

Below the summary values provided by this tab as shown in Figure 9, various “error checking” calculations are also made to see if user-supplied information on BMP acres, stream length treated, or animal waste treated exceeds the amounts available based on model-derived or user-supplied information. In cases where discrepancies occur, potential errors are identified at the bottom of the tab (see Figure 10) and potential corrective actions are suggested.

	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1						Existing BMPs	Sediment	Total N	Total P		Proposed BMPs	Sediment	Total N	Total P	
2						Cover Crops					Cover Crops				
3		Tot N (pounds)	Tot P (pounds)		Sediment (pounds)										
4		1,861.5	687.5		273,230.8										
5		3,203.4	838.1		632,813.2										
6		1,136.9	73.6		15,886.8										
7		254.5	14.6		1,450.4										
8		0.0	0.0		0.0										
9		0.0	0.0		0.0										
10		67.7	4.6		3,569.0										
11		117.1	4.0		108.6										
12		0.0	0.0		0.0										
13		0.0	0.0		0.0										
14		7,172.0	771.8		292,038.4										
15		4,522.7	462.8		223,161.0										
16		1,286.4	131.6		63,478.4										
17		0.0	0.0		0.0										
18		0.0	0.0		0.0										
19		0.0	0.0		0.0										
20		4,895.8	1,294.1		53,400,141.0										
21		0.0	0.0		0.0										
22		33,247.0	13,291.7												
23		132,221.1	2,404.6												
24		121,109.6	67,820.9												
25		10,858.3	0.0												
26		321,753.8	87,800.0		54,905,878.6										
27															
28															

Figure 8. Extent of available land and/or stream length for BMP options.

	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
1						Existing BMPs	Sediment	Total N	Total P		Proposed BMPs	Sediment	Total N	Total P	
122						Tons (Dry Wt) of Poultry Manure	5.00				Tons (Dry Wt) of Poultry Manure	5.00			
123						Tons (Dry Wt) of Livestock Manure	10.00				Tons (Dry Wt) of Livestock Manure	5.00			
124						Avg Percent N and P in Dry Poultry Manure		0.033	0.018		Avg Percent N and P in Dry Poultry Manure		0.033	0.018	
125						Avg Percent N and P in Dry Livestock Manure		0.019	0.007		Avg Percent N and P in Dry Livestock Manure		0.019	0.007	
126						Lbs/Yr Reduced	0.00	710.00	320.00		Lbs/Yr Reduced	0.00	520.00	250.00	
127															
128						Contour Farming/Strip Cropping					Contour Farming/Strip Cropping				
129						Available Acres	491.36				Available Acres	461.96			
130						Acres Implemented	30.00				Acres Implemented	10.00			
131						Reduction Coefficient	0.25	0.08	0.15		Reduction Coefficient	0.25	0.08	0.15	
132						Lbs/Yr Reduced	3,659.1	15.6	7.7		Lbs/Yr Reduced	3,219.7	5.2	2.6	
133															
134						Dirt & Gravel Road Repair					Dirt & Gravel Road Repair				
135						Feet of Road Length Repaired	1000.00				Feet of Road Length Repaired	1000.00			
136						Reduction Coefficient	2.96	0.00	0.0000		Reduction Coefficient	2.96	0.00	0.0000	
137						Lbs/Yr Reduced	2960.00	0.00	0.00		Lbs/Yr Reduced	2960.00	0.00	0.00	
138															
139						Ag E&S / Soil & Water Conservation Plan					Ag E&S / Soil & Water Conservation Plan				
140						Available Acres	491.36				Available Acres	441.96			
141						Acres Treated	50.00				Acres Treated	50.00			
142						Reduction Coefficient	0.25	0.08	0.15		Reduction Coefficient	0.25	0.08	0.15	
143						Lbs/Yr Reduced	16,098.58	26.08	12.79		Lbs/Yr Reduced	16,098.58	26.08	12.79	
144															
145						TOTAL LBS REDUCED	279,083.0	1,841.7	699.2		TOTAL LBS REDUCED	236,628.6	1,071.4	417.0	
146						ORIGINAL LOAD (LBS)	54,905,878.6	321,753.8	87,800.0		ORIGINAL LOAD (LBS)	54,905,878.6	321,753.8	87,800.0	
147						Percent of Original Load (0-100)	0.51	0.57	0.80		Percent of Original Load (0-100)	0.43	0.33	0.47	
148															
149															
150															

Figure 9. Summary of potential load reductions.

	G	H	I	J	K	L	M	N	O	P	Q	R	S
1				Existing BMPs	Sediment	Total N	Total P		Proposed BMPs	Sediment	Total N	Total P	Comments
152				ERROR CHECKING									
153													
154				*** Ag Field BMP DATA CHECK ***									
155													
156													
157				491.36	Total cropland acres available for both existing and proposed Cover Crops, Conservation Tillage (all types), Ag E&S / Conservation Plans, Cropland Retirement and Contour Farming/Strip Cropping								
158				550.00	Total acres of the above BMPs (both existing and proposed) that have been allotted in this tab								
159				-58.64	The agricultural BMPs listed above cannot overlap. If the value to the left is less than zero, acres for one or more of the BMPs listed above must be reduced to bring this value at or above zero.								
160				471.36	Total acres available for Nutrient Management (i.e., total available cropland [B5] - acres of retired cropland [J50 + O50]).								
161				400.00	Total acres of Nutrient Management (both existing and proposed) that have been allotted in this tab								
162				71.36	If the value to the left is less than zero, acres for one or more of the BMPs listed above must be reduced to bring this value at or above zero.								
163													
164				*** Riparian Buffer DATA CHECK ***									
165													
166				491.36	Total cropland acres available for conversion and/or treatment								
167				46.80	Total acres of cropland used for existing and future buffers								
168				444.56	If the value to the left is less than zero, cropland acres associated with existing and/or future buffers must be reduced to bring this value at or above zero.								
169													
170				*** Streambank Fencing DATA CHECK ***									
171													
172													
173				1,666.67	Total pasture acres available for conversion and/or treatment								
174				216.0	Total acres of pasture used for or treated by existing and future fencing/buffers								
175				1,645.07	If the value to the left is less than zero, pasture acres associated with existing and/or future buffers must be reduced to bring this value at or above zero.								
176													
177				*** Animal Manure DATA CHECK ***									
178													
179				4.996	Animal waste N available for treatment								
180				3,863	Available animal waste N reduced by existing and proposed systems (including AWMS, Thermo Chemical treatment, Composting and Transport)								

Figure 10. Results of error checking routine.

Step 3: Evaluate Potential Load Reductions from BMPs in Urban Areas

In the case of rural landscapes, various agricultural BMPs and stream restoration measures are simulated to predict potential pollutant load reductions from either upland areas or in streams due to eroded streambanks. With urban areas, similar reductions are also considered with this spreadsheet tool (as is the case with streambank stabilization, forest buffers and street sweeping). However, most of the load reductions in urban areas are simulated by considering the combined load reduction effects of urban BMPs on both upland and streambank loads. As has been shown in numerous studies, stormwater runoff from impervious surfaces in developed areas not only transports pollutants that have accumulated on such surface in between precipitation events, but the increased runoff (relative to more pervious surfaces) also significantly contributes to downstream streambank erosion.

Accordingly, with this spreadsheet tool, the application of most urban BMPs that result in reduced overland and sub-surface flows to streams is assumed to result in reduced upland and streambank loads as well. To estimate such load reductions, the initial “treated” loads are calculated by multiplying the extent of the urban area treated by a given BMP by the “composite” loading rate discussed previously that considers both the upland and streambank loads attributed to that particular land use type (e.g., in this case, higher-density land use types result in higher composite loads due to greater amounts of impervious surface). As described below, a reduction coefficient that represents the removal rate of sediment and nutrients for the BMP is then applied to estimate the reduced load.

In this spreadsheet tool, the pollutant reduction coefficient for a number of urban stormwater BMPs are calculated by using what is referred to as the “Performance Standard” approach. In this case, the removal efficiency rates are dynamically calculated based on the amount of runoff water captured. This approach was originally developed for use within the Chesapeake Bay watershed model, and has been adopted by the states within the Chesapeake Bay watershed. With this approach, regression curves have been developed for two basic types of BMPs (RR – runoff reduction, and ST – stormwater treatment). Most urban BMP types used within the Bay watershed have been assigned to either of these two categories, and the value of sediment and/or nutrient removal efficiency varies as a function of runoff volume that is captured via detention and/or infiltration (see Figures 11-13). For example, as shown in Figure 12, if a water volume equivalent to 0.5 inches of runoff per acre of impervious surface is captured by an “RR-type” BMP, a sediment removal rate of 53% would be calculated.

As can be shown in the “Tech Docs” tab, a number of “non-Performance Standard” urban BMPs are also available in the “Urban BMPs” tab of the spreadsheet tool. In this case, the reduction coefficients are not set dynamically based on runoff volume captured. Rather, they are fixed values based on those used in the Chesapeake Bay model and CAST.

Total Nitrogen Removal for RR and ST New Development Practices

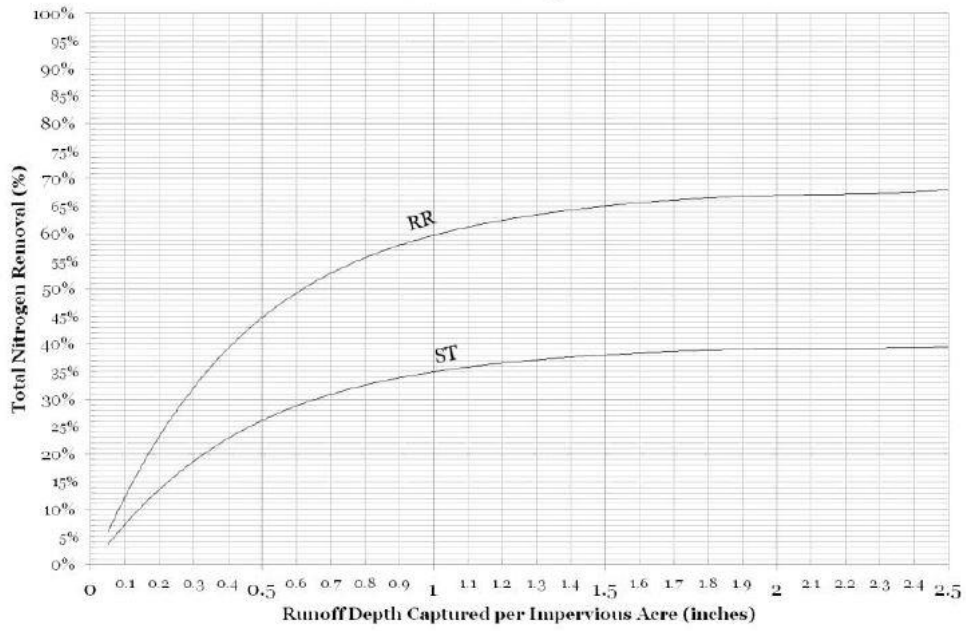


Figure 11

Total Phosphorus Removal for RR and ST New Development Practices

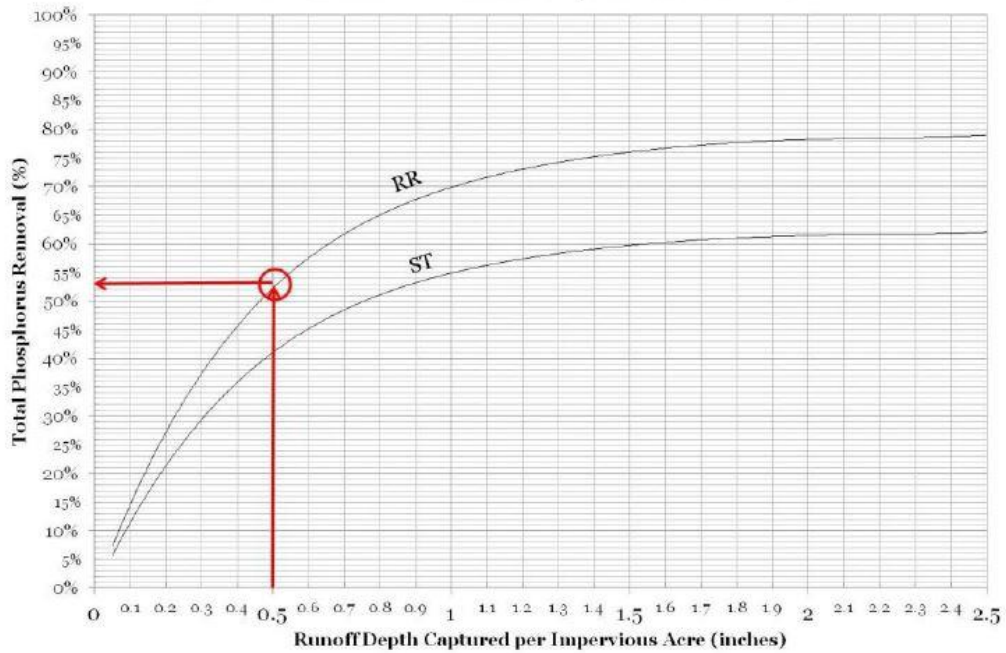


Figure 12

Sediment Removal for RR and ST Stormwater Retrofit Practices

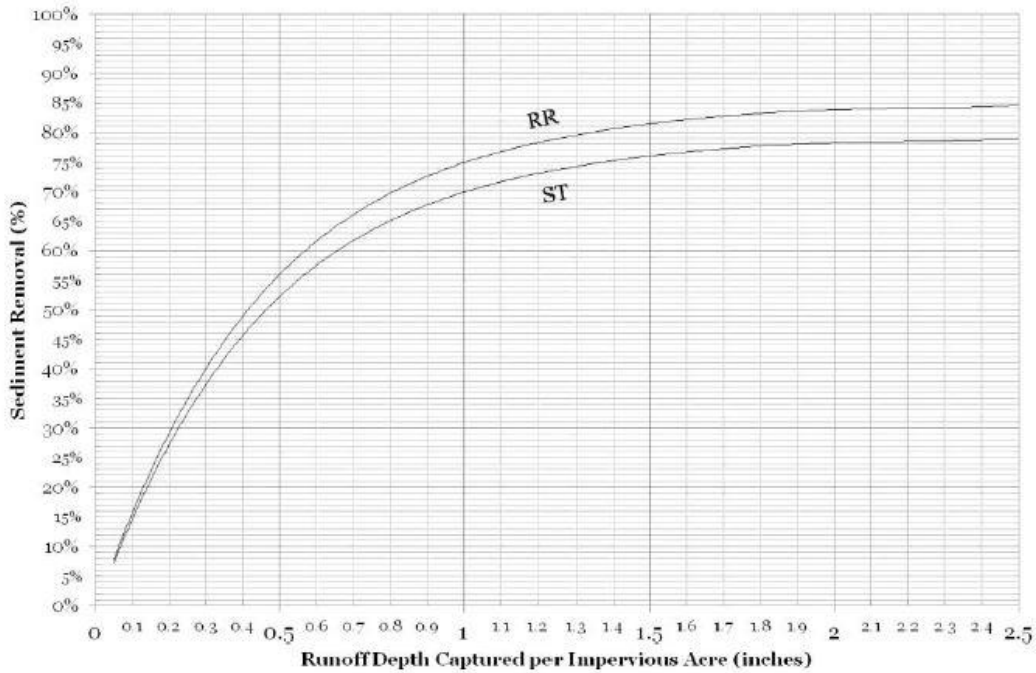


Figure 13

With the BMP spreadsheet tool, data about urban BMPs are entered using the “Urban BMPs” tab. First, the user must enter general information such as Project Name (any name), the BMP type (e.g., RR, ST, forest buffer or others), and whether it is “Existing” or “Proposed” as shown by the red arrows in Figure 14. (For reference purposes, the “Tech Docs” tab shows a table of the different BMPs that have been assigned to either the RR or ST category for Performance Standard-based BMPs). As also shown, the user may enter an optional BMP Name (which can be a single BMP or collection of BMPs that drains a single area) and an optional installation date. Then, as shown in Figure 15, the user must enter information on: 1) the type of land use treated by a BMP or collection of BMPs, 2) the extent to which different land use types are treated by the BMP or BMP system (i.e., number of acres), and 3) the quantity of rainfall (runoff depth) captured by the BMP. (Note that “treatment (runoff) depth” is only required for Performance Standard-based BMPs, and that “drainage area” [i.e., the contributing area that drains to the specific stormwater BMP] is not required for Streambank Restoration, Street Sweeping or Forest Buffer BMPs). Upon entering this information, the removal efficiency values for sediment, nitrogen and phosphorus, as well as potential load reductions, are automatically calculated for Performance Standard-type BMPs. For all other BMPs, these reduction coefficients are fixed as shown in the “Tech Docs” tab.

Depending upon the type of urban BMP simulated, other user-supplied information may also be required in additional columns as indicated by the red arrows shown in Figure 16. For “infiltration-type” BMPs, the size (in square feet) of the actual BMP (excluding the “contributing area”) must be provided, and for “detention-type” BMPs, the volume of water designed to be detained by the BMP must be

provided (see the Tech Docs tab for a listing of these types). The size (in square feet) of the area planted for Forest Buffers must also be specified. In the case of Streambank Restoration, the length of stream restored or stabilized (in feet) must be specified, and in the case of Street Sweeping (all types), the length of road treated (i.e., total feet swept) must be specified. In this latter instance, an average road width of 20 feet is used to calculate total acres of road swept.

1 Urban BMP Load Reduction Calculation Table

2 INSTRUCTIONS: Each row in the table below can represent either different areas of land use/cover within a single planning area (e.g., municipality), or different BMP

3 If an individual planning area has multiple "developed land" types, each type can be represented in separate rows, with each row having the same "Project Name".

4 Similarly, a given planning area can have multiple "BMP drainage areas" (i.e., areas treated by different BMP systems). If a BMP drainage area has multiple "developed

5 If runoff from a land use/cover type with NO impervious cover (e.g., Cropland) is treated by a BMP system (either existing or proposed), use the Manual Override (col.

6 Examples of various options for characterizing different types of project areas are provided in the "Example" spreadsheet that is also available for downloading from

7

Project Name	BMP Name	BMP Type	Existing or Proposed	Year Installed	BMP (S
Existing	Mall	RR	Existing	1998	
System 1	Area 1	Bioretention/raingardens - A/B soils, underdrain	Proposed	2020	
System 1	Area 2	ST	Proposed	2020	
System 2	Area 1	ST	Proposed	2020	
System 2	Area 2	ST	Proposed	2020	
Pine Creek	Streambank Stabilization	Stream Restoration	Proposed	2021	
BMP3	New project	Permeable Pavement w/o Sand, Veg. - A/B soils, no underdrain	Proposed	2022	
BMP4	New project	Dry Extended Detention Ponds	Proposed	2022	
BMP5	New project	Street Sweeping, SCP-1	Existing	2022	
BMP6	New project	Forest Buffer	Proposed	2022	

25 NOTE: the above table is an Excel Table, which has spec <https://support.office.com/en-us/article/overview-of-excel-tables-7ab0bb7d-3a9e-4b56-a3c9-6c94334e45>

Figure 14. Locations where user input is required for urban BMPs.

Id	SquareFeet	Acres	CubicFeet	drainageLandCoverClass	drainageArea_ac	treatmentDepth_in	lengthTreatedStream_ft	lengthTreatedRoad_ft2
998		0.00		Hd_Mixed	20	1.80		
020	230000	5.28		Hd_Mixed	20			
020		0.00		Ld_Mixed	150	2.40		
020		0.00		Md_Mixed	100	2.00		
020		0.00		Cropland	85			
021		0.00					800	
022	300000	6.89		Md_Mixed	100			
022		0.00	530000	Hd_Mixed	75			
022		0.00		Md_Mixed				52000
022	12000	0.28		Md_Mixed				
		0.00						
		0.00						
		0.00						

Figure 15. Locations where user input is required for urban BMPs (cont.).

id	SquareFeet	Acres	CubicFeet	drainageLandCoverClass	drainageArea_ac	treatmentDepth_in	lengthTreatedStream_ft	lengthTreatedRoad_ft2
1998		0.00		Hd_Mixed	20	1.80		
1020	230000	5.28		Hd_Mixed	20			
1020		0.00		Ld_Mixed	150	2.40		
1020		0.00		Md_Mixed	100	2.00		
1020		0.00		Cropland	85			
1021		0.00					800	
1022	300000	6.89		Md_Mixed	100			
1022		0.00	530000	Hd_Mixed	75			
1022		0.00		Md_Mixed				52000
1022	12000	0.28		Md_Mixed				
		0.00						
		0.00						

Figure 16. Locations where user input is required for urban BMPs (cont.).

Within the urban BMP tab, some error-checking routines have been included to identify individual BMPs that may potentially be under-sized on the basis of user-supplied input. Specifically, these routines have been applied to the calculations related to “infiltration” and “detention” type BMPs using the concept of “loading ratios”. For example, as determined previously by PADEP, it is assumed that the amount of impervious area treated by a given “infiltration-type” stormwater BMP should not be greater than 5 times the size of the surface area of the actual BMP (i.e., greater than a 5:1 ratio). Similarly, it is assumed that the volume of water contained by a “detention-type” BMP should not be less than the volume of water that would be created by a 2.5-inch rainfall over the acres of impervious area treated by the BMP (i.e., less than a 1:1 ratio). If in the former case, the “SquareFeet” value for a given “infiltration-type” BMP results in a loading ratio greater than 5 (i.e., LoadRatio1), or if in the latter case, the “CubicFeet” value for a given “detention-type” BMP results in loading ratio less than 1 (i.e., LoadRatio2), the corresponding loading rate value(s) will be high-lighted in red as shown in Figure 17. If these values are less than 5 in the first case or greater than 1 in the second case, then these values are not high-lighted (as also shown in Figure 17). Therefore, decreasing or increasing the appropriate BMP size values (i.e., “SquareFeet” and/or “CubicFeet”) will cause these values to be highlighted or not.

	M	N	O	P	Q	R	S
Street Sweeping* Road Length Swept (ft) - Qualified Projects only		Impervious Area (ac)	BMP Loading Ratio1 (Impervious Area / BMP Surface Area)	BMP Loading Ratio2 (BMP Water Vol / Runoff Vol from 2.5" Rain)	Treatment Depth (in/imp. ac)	Treatment Depth (in/ac) for Manual Override - use if no impervious area	Effective Treatment Depth (in/imp. ac)
lengthTreatedRoad_ft2	impervArea_ac	LoadRatio1	LoadRatio2	treatmentDepthNorm	treatmentDepthNo	treatmentDepthN	
	17.40	#N/A	#N/A	2.07		2.07	
	17.40	3.30	#N/A	0.00		0.00	
	22.50	#N/A	#N/A	2.50		2.50	
	52.00	#N/A	#N/A	2.50		2.50	
	0.00	#N/A	#N/A	#N/A	1.00	1.00	
	#N/A	#N/A	#N/A	#N/A		#N/A	
	52.00	7.55	#N/A	0.00		0.00	
	65.25	#N/A	0.90	0.00		0.00	
52000	0.00	#N/A	#N/A	#N/A		#N/A	
	0.00	0.00	#N/A	#N/A		#N/A	
	#N/A	#N/A	#N/A	#N/A		#N/A	
	#N/A	#N/A	#N/A	#N/A		#N/A	
	#N/A	#N/A	#N/A	#N/A		#N/A	

Figure 17. Examples where user input has been identified for potential correction.

After supplying the appropriate responses (e.g., BMP type and size, land cover type, rainfall depth, drainage area, etc.), other values such as percent impervious and reduction coefficients are used to calculate initial and reduced pollutant loads such as those shown in the example in Figure 18.

	T	U	V	W	X	Y	Z	AA	AB	AC	AD
Impervious Surface (%)											
TSS Load (lbs/yr)											
TP Load (lbs/yr)											
TN Load (lbs/yr)											
TSS Reduction (%)											
TP Reduction (%)											
TN Reduction (%)											
TSS Reduction (lbs/yr)											
TSS Reduction (tons/yr)											
TP Reduction (lbs/yr)											
TN Reduction (lbs/yr)											
impervFrac	TSS_Load_lb	TP_Load_lb	TN_Load_lb	TSS_Reduct	TP_Reductio	TN_Reductio	TSS_Reduction_lbPer	TSS_Reduction_to	TP_Reductio	TN_Reductio	
87.0%	59,069.87	17.20	81.20	84.1%	78.3%	66.9%	49,660.66	24.83	13.46	54.35	
87.0%	59,069.87	17.20	81.20	80.0%	75.0%	70.0%	47,255.89	23.63	12.90	56.84	
15.0%	199,110.67	54.00	154.50	78.8%	62.0%	39.3%	156,922.86	78.46	33.48	60.74	
52.0%	218,890.19	67.00	308.00	78.8%	62.0%	39.3%	172,511.46	86.26	41.54	121.09	
0.0%	193,385.40	217.60	799.00	69.9%	54.9%	35.0%	135,176.40	67.59	119.51	279.25	
#N/A	#N/A	#N/A	#N/A	0.0%	0.0%	0.0%	92,000.00	46.00	139.20	153.60	
52.0%	218,890.19	67.00	308.00	85.0%	80.0%	75.0%	186,056.66	93.03	53.60	231.00	
87.0%	221,512.00	64.50	304.50	60.0%	20.0%	20.0%	132,907.20	66.45	12.90	60.90	
52.0%	816.05	1.74	16.51	21.0%	10.0%	4.0%	171.37	0.09	0.17	0.66	
52.0%	36.22	0.08	1.47	50.0%	50.0%	25.0%	18.11	0.01	0.04	0.37	
#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	

Figure 18. Calculation of reduction coefficients and loads based on user input.

Additionally, the pollutant load reductions are summed various ways as shown in Figure 19. For example, they are summed automatically for both “Existing” and “Proposed” BMPs. Within the summary section, a “pull-down” window is also provided so that load reductions for different parts of an urban area, or for sub-areas treated by different BMPs/collection systems, can be estimated as shown in Figure 20. With this function, the load reductions for multiple “Project Name” entries with the same name can be aggregated. Although this section only allows for a limited number of different “Project Names” to be aggregated by default, additional names can be added by simply copying the cells in the last row of the calculated cells under the “Project Name” heading and pasting them into the next line below.

	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	A
20	#N/A		#N/A	52.0%	36.22	0.08	1.47	50.0%	50.0%	25.0%	18.11	0.01	0.04	0.37	
21	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
22	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
23	#N/A		#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
26	If this tab is being used for MS4 reductions, the total acres of developed land used should not exceed those given below).									TOTAL LBS REDUCED	972,680.61	486.34	426.80	1,018.80	
29										Existing TOTAL LBS REDUCED	49,832.03	24.92	13.64	55.01	
31										Proposed TOTAL LBS REDUCED	922,848.57	461.42	413.16	963.79	
34									Project Name	LBS REDUCED	49,660.66	24.83	13.46	54.35	
35									Existing	LBS REDUCED	204,178.75	102.09	46.38	117.58	
36									System 1	LBS REDUCED	307,687.86	153.84	161.04	400.34	
37									System 2	LBS REDUCED	92,000.00	46.00	139.20	153.60	
38									Pine Creek	LBS REDUCED	186,056.66	93.03	53.60	231.00	
39									BMP3	LBS REDUCED	132,907.20	66.45	12.90	60.90	
40									BMP4	LBS REDUCED	171.37	0.09	0.17	0.66	
41									BMP5	LBS REDUCED	18.11	0.01	0.04	0.37	
42									BMP6	LBS REDUCED					

Figure 19. Summary of potential load reductions for urban BMPs based on user input.



Figure 20. Example of load reduction results summarized by Project Name.

Step 4: Evaluate Potential Load Reductions from Floodplain Restoration Projects

In early 2022, a new “Floodplain Restoration” tab was added to the BMP spreadsheet tool. This new option conforms closely to how this measure is used by the Chesapeake Bay Program in modeling potential loads and reductions. In the Bay Program, this measure is referred to as “Wetland Restoration – Floodplain” or “Wetland Creation – Floodplain”, and for modeling purposes, a 6:1 treatment ratio is assumed (i.e., 1 acre of restored wetland in a floodplain will treat 6 upland acres). In this new tab, credit is also given for reducing streambank erosion due to the fact that some decrease in streambank height would need to occur in order to create or restore a wetland in the riparian zone.

The core section of this new tab is shown in Figure 21. In this case, the user specifies values for “Stream Feet Stabilized” and “Acres Restored/Created” in Parts 1 and 2 of the tab, respectively. Upon entering these values, load reductions from both parts are calculated and summed. For loads associated with “upland” areas treated by the restored/created floodplain wetland, average pollutant loading rates for sediment, nitrogen and phosphorus are calculated for the entire watershed using MMW load output (see Line 33 in the “Floodplain Restoration” tab), and these are multiplied by the acres of upland area treated to estimate the pollutant loads treated. As with the Urban and Agricultural BMP tabs, the user can provide information for both existing and proposed projects.

Existing Floodplain Restoration	Sediment	Total N	Total P	Proposed Floodplain Restoration	Sediment	Total N	Total P
<i>Part 1: Streambank Load</i>				<i>Part 1: Streambank Load</i>			
Available Stream Feet	5,479.00			Available Stream Feet	5,329.00		
Stream Feet Stabilized	150.00			Stream Feet Stabilized	620.00		
Pollutant Reduction (lb/ft)	115.0	0.19	0.17	Pollutant Reduction (lb/ft)	115.0	0.10	0.04
Lbs Streambank Load Reduced	17250.00	28.80	26.10	Lbs Streambank Load Reduced	71300.00	59.50	23.79
<i>Part 2: Upstream Load</i>				<i>Part 2: Upstream Load</i>			
Acres Restored/Created	4.50			Acres Restored/Created	6.60		
Acres Treated per Acre Restored	6.00			Acres Treated per Acre Restored	6.00		
Total Acres Treated	27.00			Total Acres Treated	39.60		
Upstream Load	31,453.0	824.0	67.4	Upstream Load	46,131.0	1,208.5	98.8
Reduction Coefficients	0.31	0.42	0.40	Reduction Coefficients	0.31	0.42	0.40
Lbs Upstream Load Reduced	9,750.4	346.1	26.9	Lbs Upstream Load Reduced	14,300.6	507.6	39.5
Total Floodplain Lbs Reduced	27,000.4	374.9	53.0	Total Floodplain Lbs Reduced	85,600.6	567.1	63.3
User-Supplied Values							

Figure 21. Example input and calculations for new Floodplain Restoration tab.

Step 5: Review Total Load Reductions and Repeat Previous Steps as Necessary

The final tab in the spreadsheet (“Total Load Reductions”) summarizes the results based on the application of all the BMPs and measures specified by the user. As shown in Figure 22, load estimates are given for “pre-BMP” conditions, “current BMP” conditions, and conditions after all proposed (future) BMPs are considered. Typically, plans for future reductions are compared against current or “baseline” loads. Depending on any sediment and/or nutrient load targets that the user might be comparing the simulated results against, additional simulations may need to be conducted before any final results are achieved with the spreadsheet tool. Also, as described earlier, multiple “project areas” are provided in the urban tab in case individual sub-areas need to be considered within a larger urban area. Additionally, if multiple areas or scenarios need to be addressed, the user can make as many copies of the tool as needed.

	Entire Watershed			
	Sediment (lbs/yr)	TN (lbs/yr)	TP (lbs/yr)	
Initial MMW Loads	54,905,879	321,754	87,800	← Total "No-BMP" Loads
Loads Removed w/Existing Urban BMPs	49,832	55	14	} Load Reductions from "Existing" and "Proposed" BMPs
Loads Removed w/Proposed Urban BMPs	922,849	964	413	
Loads Removed w/Existing Agricultural BMPs	279,083	1,842	699	
Loads Removed w/Proposed Agricultural BMPs	236,629	1,071	417	
Loads Removed w/Existing Floodplain Restoration BMPs	27,000	375	53	
Loads Removed w/Proposed Floodplain Restoration BMPs	85,601	567	63	
Total Loads Removed	1,600,993	4,874	1,659	} Total Reductions from "Existing" and "Proposed" BMP s
New Reduced Load	53,304,885	316,880	86,141	
Percent Reduction (0-100)	2.9%	1.5%	1.9%	
Total Baseline Load (1)	54,549,963	319,482	87,034	} Total Load Reductions from Baseline
Total Loads Removed from Baseline (2)	1,245,078	2,602	893	
Percent Reduction from Baseline Load	2.3%	0.8%	1.0%	
<i>(1) After existing BMPs have been accounted for</i>				
<i>(2) After proposed BMPs have been accounted for</i>				

Figure 22. Summary of load results for all BMP simulated within a watershed.

C. Analysis of Pollutant Loads and Potential BMP Scenarios for Specific Subareas or "Targeted" Areas within a Larger HUC12 Watershed

As of January 2020, a new routine has been implemented within Model My Watershed that provides for automated entry of land cover and pollutant load information into the Excel-formatted BMP Spreadsheet tool (see Section 7.3 of the Technical Documentation for MMW for a more detailed description of the purpose and use of this new tool). When this option is used, "auto-populated" spreadsheets are automatically provided for download by the user, thereby negating the need for manual "copying and pasting" of data as described for a single watershed in the above section. For this type of analysis, the larger (i.e., HUC12) watershed in which the smaller area is located is used to determine pollutant loading rates for the smaller area. With this new tool, two separate steps are needed to set up the spreadsheet for subsequent analyses as described below.

Step 1: Define the Boundary of the Target Area

The process for estimating the land cover distribution for a smaller target area (e.g., municipality or other user-defined urban area or BMP area) is essentially the same as when a boundary is selected or created for any watershed or area of interest (AOI) in Model My Watershed. In this case, instead of using either the "Select boundary" or "Delineate watershed" option to define an AOI, either the "Draw area" or "Upload file" options as shown in Figure 23 are used to define the AOI. (See the Appendix for more details on how to use these two options for defining an AOI for this purpose).

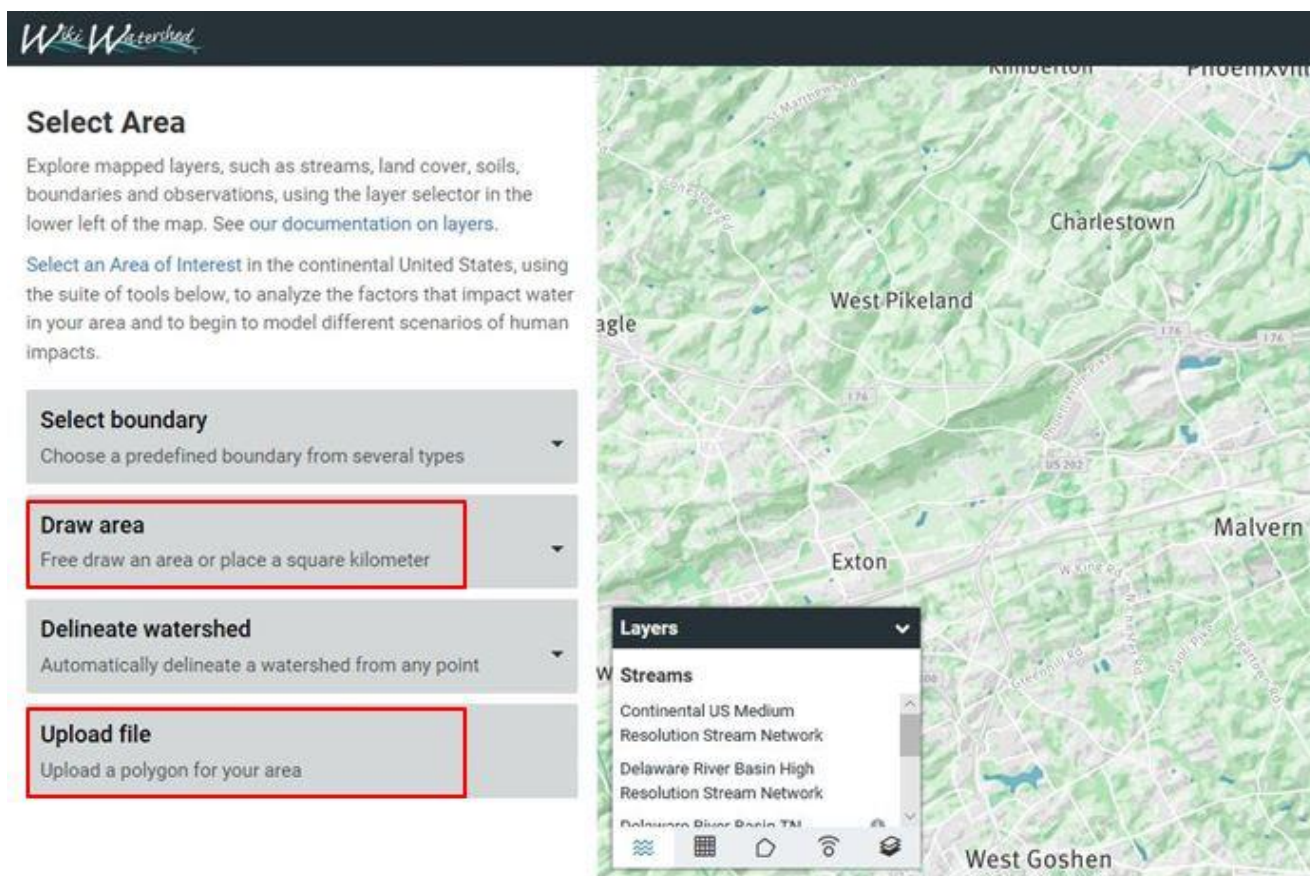


Figure 23. Tools used for identifying smaller “target” areas within larger HUC12 watershed.

Step 2: Run the Multi-Year Watershed Model to Create Data for the Spreadsheet Tool

After creating or uploading a polygon file for the smaller target area, select the “Watershed Multi-Year Worksheet” option under the “Model” tab as shown in Figure 24. Upon selecting this option, the watershed model is run on the HUC12 that the smaller area is located within, and the resulting output is used to calculate loads for the smaller area. These loads and the land cover distribution for this subarea are then automatically written to a copy of the BMP spreadsheet tool at the location shown on the left side of Figure 25, and this file is then made available for the user to download.

Also shown to the right in Figure 25 is information on stream length in the smaller area (Note: this needs to be manually entered by the user). Once these data are copied into this location in the spreadsheet, information on land cover and stream length for the target area is then carried over to the “Urban BMPs” tab to help the user determine the potential land area and stream length that might be available for different BMPs. (Note that for this particular type of analysis, if the boundary of the smaller target area extends into one or more other HUC12 watersheds, separate BMP spreadsheets will be created for each HUC12 containing a portion of the smaller area).

(Note: in addition to using either the “Draw area” or “Upload file” options, it is also possible to just manually enter information on the areal extent of different land cover types in the target [urban] area if these are already known. In this case, MMW could be used to run the Watershed Multi-Year Model on a HUC12 basin that the smaller area is located within using the steps described in the previous section, and then download the spreadsheet tool for further editing).

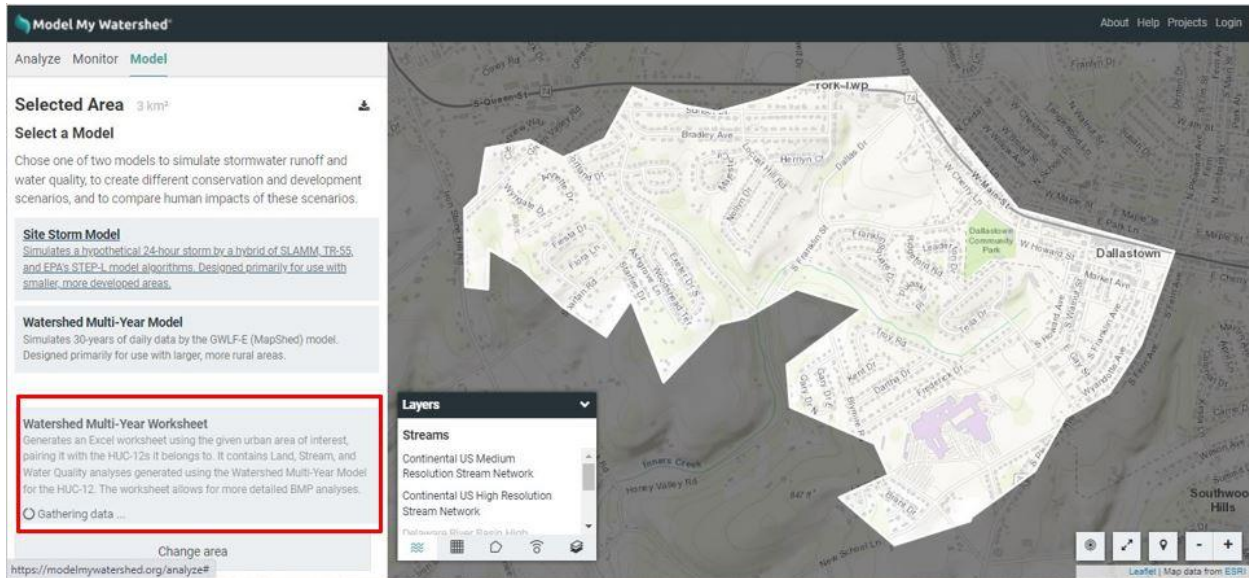


Figure 24. Using the Watershed Multi-Year Worksheet for calculating loads for a smaller sub-area.

Note: The information below is only used for allocation of "urban" loads within a larger watershed boundary

MMW NLCD Land Cover Categories for Urban Area (from second, smaller "Analyze" csv file)					
TYPE	AREA (km ²)	AREA (acres)	TN (lb/yr)	TP (lb/yr)	Sediment (lb/yr)
Open Water	0	-	-	-	-
Perennial Ice/Snow	0	-	-	-	-
Developed, Open Space	5.27	1,301.23	975.93	403.38	1,243,887.93
Developed, Low Intensity	2.79	688.89	516.67	213.56	658,528.90
Developed, Medium Intensity	0.84	207.41	462.52	128.59	358,852.33
Developed, High Intensity	0.2	49.38	138.27	40.49	119,489.98
Barren Land (Rock/Sand/Clay)	0	-	0.00	0.00	0.00
Deciduous Forest	1.49	367.90	176.59	73.58	240,082.35
Evergreen Forest	0.02	4.94	2.37	0.99	3,222.58
Mixed Forest	0.06	14.81	7.11	2.96	9,667.75
Shrub/Scrub	0.7	172.84	82.96	34.57	112,790.37
Grassland/Herbaceous	0.15	37.04	17.78	7.41	24,169.36
Pasture/Hay	4.66	1,150.62	2,243.70	908.99	916,135.67
Cultivated Crops	1.2	296.30	2,174.81	743.70	615,848.18
Woody Wetlands	0.06	14.81	10.37	3.11	9,670.92
Emergent Herbaceous Wetlands	0.01	2.47	1.73	0.52	1,611.82
Totals	17.45	4,308.64	6,810.81	2,561.85	4,313,956.14

(Note: The values below only pertain to the smaller target area)		
STREAM LENGTH	KM'	FEET
Total Length	21.6	70866.1
Ag Streams	4.27	14009.2
Non-Ag Streams	17.33	56857.0

* These values can be obtained from the "Stream" tab in the "Analyze" sector

Figure 25. Example load results for smaller sub-area within a HUC12 watershed

Subsequent Steps

After entering information for the smaller target area of interest as described in the two previous steps, an assessment of potential load reduction scenarios using various BMPs can be conducted by following Steps 2 through 4 outlined in the previous section. After any given scenario, the potential load reductions are then shown in the “Total Load Reductions” tab as shown earlier in Figure 22. In this case, however, the load reduction results are also displayed in the “Urban Area” portion of this tab as shown in Figure 26, and any BMPs simulated are assumed to be applied in the target (urban) area first until potential BMP opportunities based on available rural/urban land areas and stream lengths within that particular area have been exhausted. Therefore, the percent load reduction values for the target area are usually higher than those for the larger watershed within which it is located.

	Entire Watershed			Urban Area*		
	Sediment (lbs/yr)	TN (lbs/yr)	TP (lbs/yr)	Sediment (lbs/yr)	TN (lbs/yr)	TP (lbs/yr)
Initial MMW Loads	54,905,879	321,754	87,800	5,850,120	10,764	3,268
Loads Removed w/Existing Urban BMPs	49,832	55	14	49,832	55	14
Loads Removed w/Proposed Urban BMPs	922,849	964	413	922,849	964	413
Loads Removed w/Existing Agricultural BMPs	279,083	1,842	699	279,083	1,842	699
Loads Removed w/Proposed Agricultural BMPs	236,629	1,071	417	236,629	1,071	417
Loads Removed w/Existing Floodplain Restoration BMPs	28,578	101	34	28,578	101	34
Loads Removed w/Proposed Floodplain Restoration BMPs	53,415	156	56	53,415	156	56
Total Loads Removed	1,570,385	4,189	1,633	1,488,392	3,932	1,543
New Reduced Load	53,335,493	317,565	86,167	4,361,728	6,832	1,725
Percent Reduction (0-100)	2.9%	1.3%	1.9%	25.4%	36.5%	47.2%
Total Baseline Load (1)	54,548,385	319,756	87,054	5,521,205	8,867	2,556
Total Loads Removed from Baseline (2)	1,212,892	2,191	886	1,159,477	2,035	830
Percent Reduction from Baseline Load	2.2%	0.7%	1.0%	21.0%	23.0%	32.5%

(1) After existing BMPs have been accounted for
 (2) After proposed BMPs have been accounted for

Figure 26. Summary of loads and reductions for a smaller sub-area within a larger HUC12 watershed.

APPENDIX - Selecting/Defining an Area of Interest for use in Watershed Modeling

As shown in Figure A1 below, there are a number of tools available within Model My Watershed for selecting or defining an Area of Interest (AOI) for analysis or water quality simulation purposes, including “Select boundary”, “Draw area”, “Delineate watershed”, and “Upload file”. Some of the options included with these tools (e.g., “Square km” with the “Draw area” tool, and “County Lines” under the “Select boundary” tool) are not usually suitable since they do not necessarily represent watersheds or basins that are defined by topographic divides or stream networks. Brief descriptions of the most appropriate tools for use in hydrologic/water quality modeling are provided below.

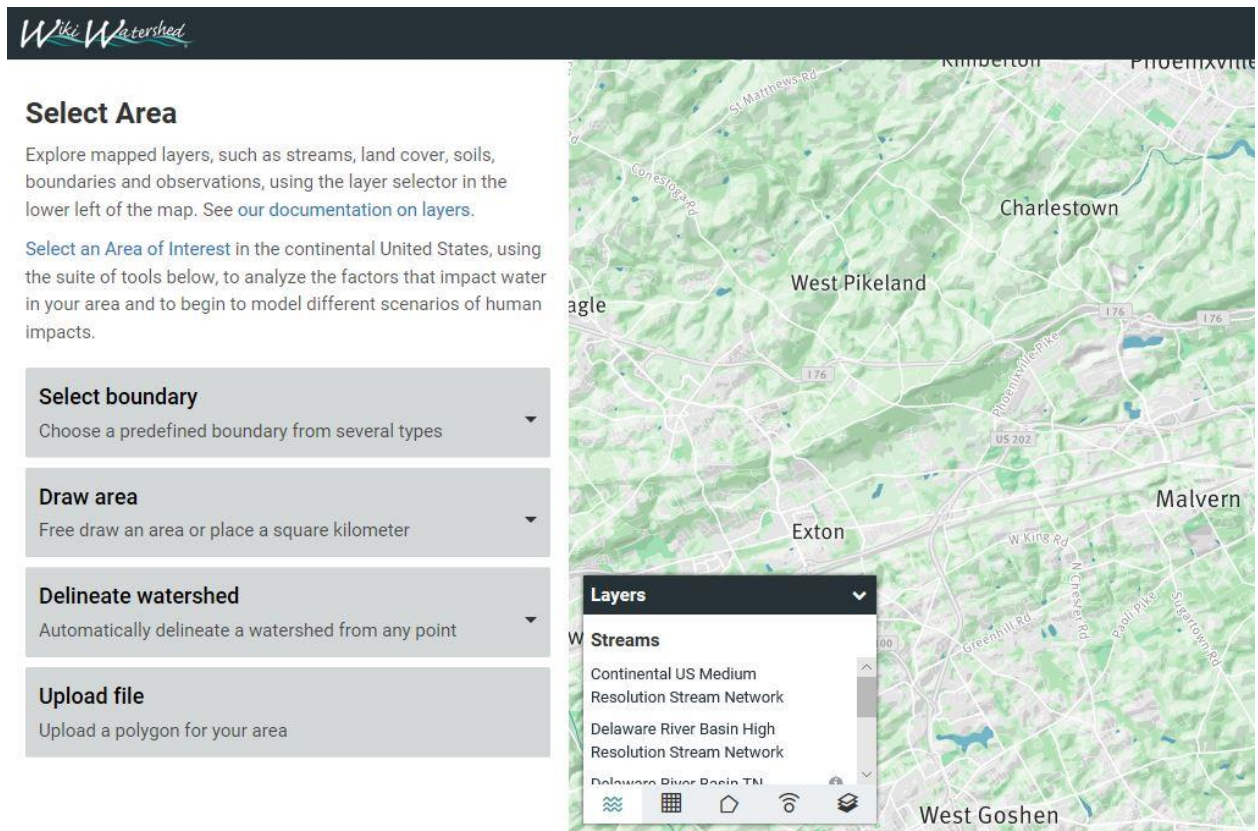


Figure A1.

Select Boundary

With this particular tool, the most suitable options for modeling include those which allow a user to depict and select pre-defined watershed/basin boundaries previously developed by the U.S. Geological Survey (i.e., the HUC12, HUC10 and HUC8 boundaries) as shown in Figures A2 and A3. Although all of these vary in average size depending upon where they are located geographically, across the country, HUC12 boundaries are typically on the order of 40 square miles in size, HUC10 boundaries are about 225 square miles in size, and HUC8 boundaries are about 700 square miles in size. Once a particular option is chosen, the user then moves the cursor over to the boundary of interest and clicks on it to begin the process of extracting the necessary data to begin the modelling process.

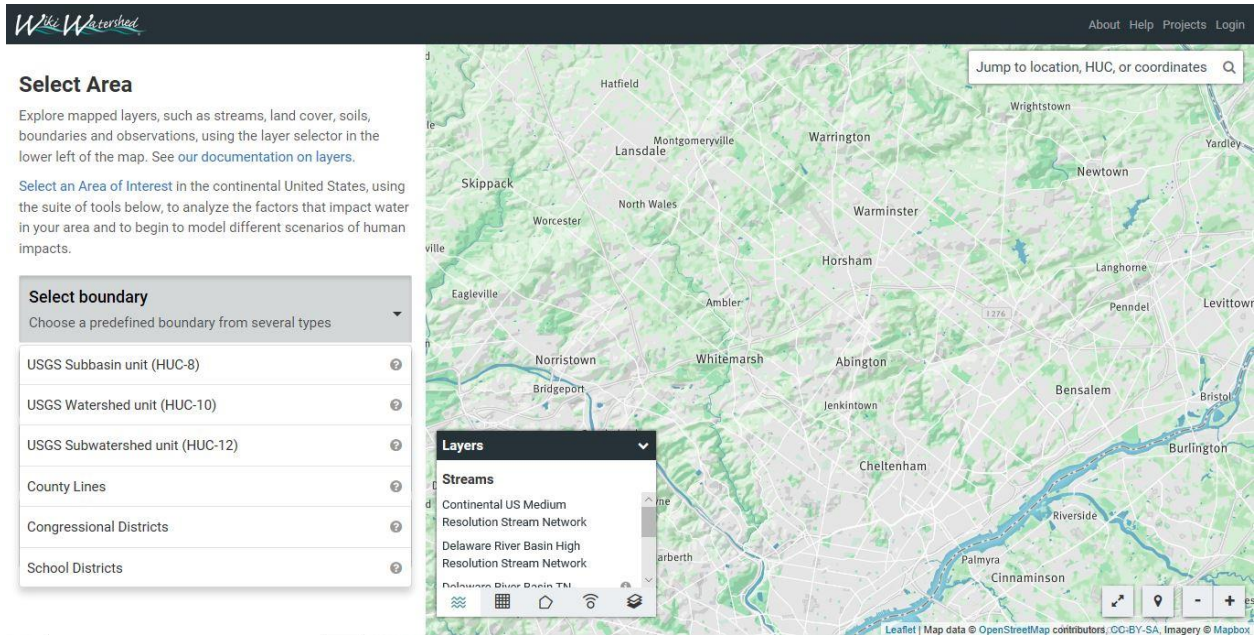


Figure A2

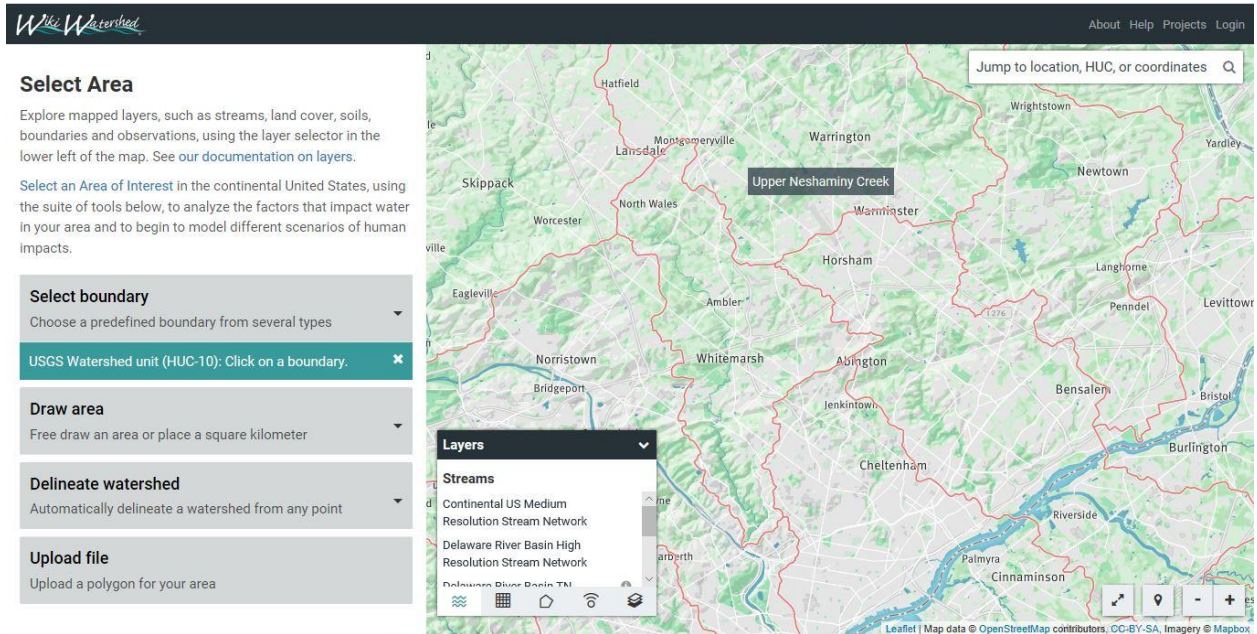


Figure A3

Draw Area

With this option, the user can manually draw a boundary of interest on the computer screen. In this case, the user begins by digitizing on-screen with the cursor by starting with a point and then finishing the polygon with that same point by clicking on it. Figure A4 shows a portion of such a polygon during the digitizing process. As soon as the polygon is finished, data will be extracted for that area as previously described. This procedure can be used for both defining a watershed boundary for subsequent analysis as well as the boundary for a smaller target (e.g., urban) area within the larger boundary. In drawing this boundary, the user may want to turn on other layers that can aid this process such as a satellite image (see Figure A5) or a layer that depicts a combination of municipal boundaries and “pre-defined” urban areas as shown in Figure A6. (Note: this latter option is only available in Pennsylvania).

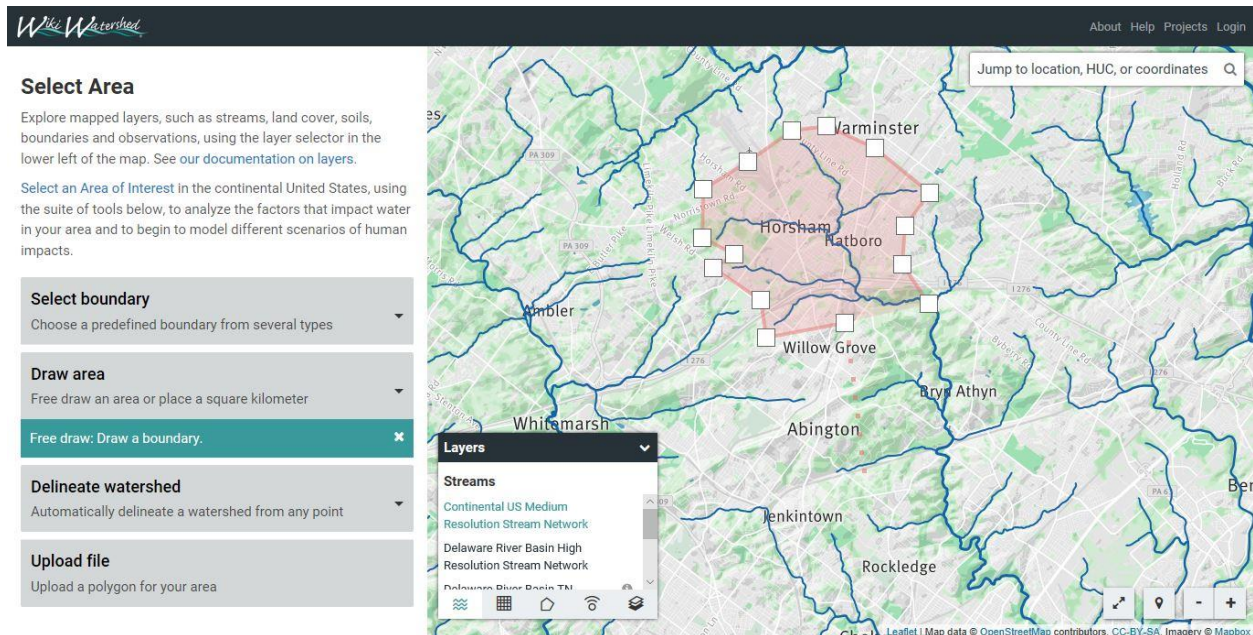


Figure A4.

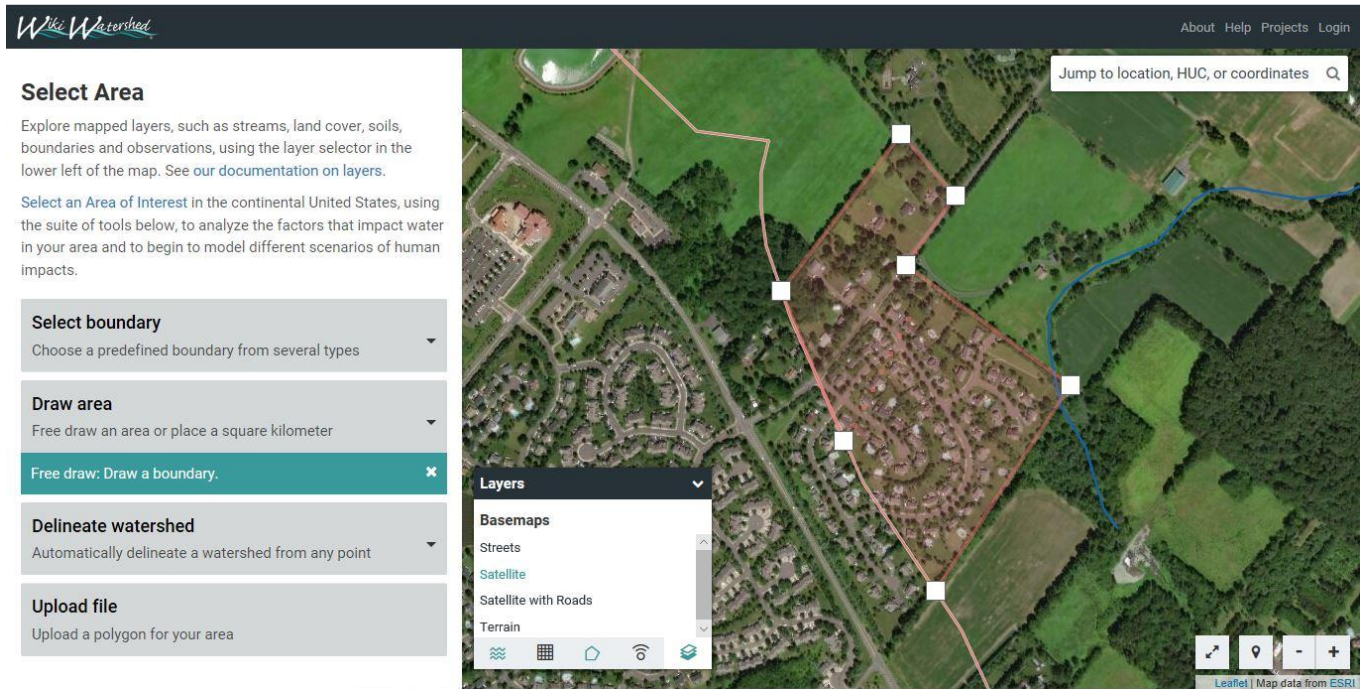


Figure A5

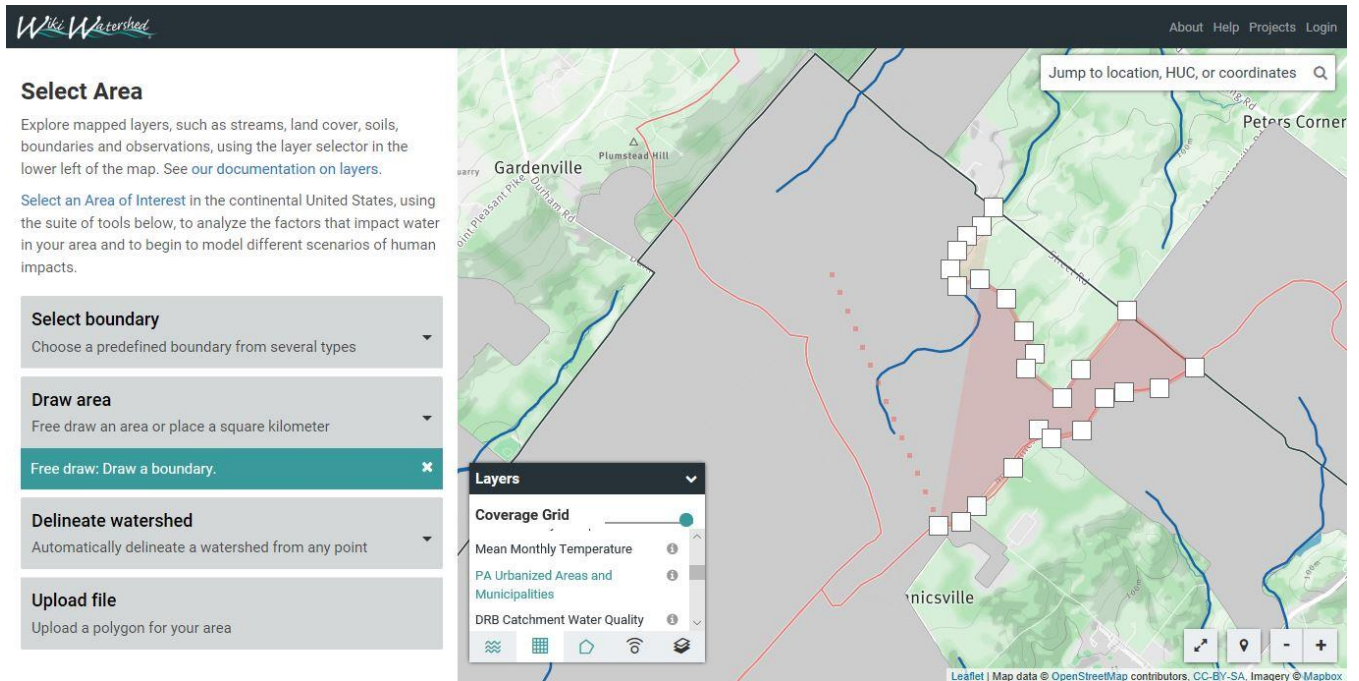


Figure A6

Delineate Watershed

With this option, a user can drop a point on a stream and have the boundary that defines the land area draining to that point (i.e., watershed boundary) automatically generated. Upon selecting a stream point, digital elevation data is used to find the topographic divides that separate adjacent drainage areas, and then delineate the appropriate boundary of interest. In utilizing this option, the user can select either of two stream networks for generating the polygon: 1) a high-resolution stream network that was specifically produced for the Delaware River Basin on the East Coast, or 2) a mid-resolution NHD stream network produced by the U.S. Geological Survey that is available for the entire country. A comparison between Figures A7 and A4 (which show the same geographic area) illustrates how much more accurate this approach is than manually digitizing such a boundary.

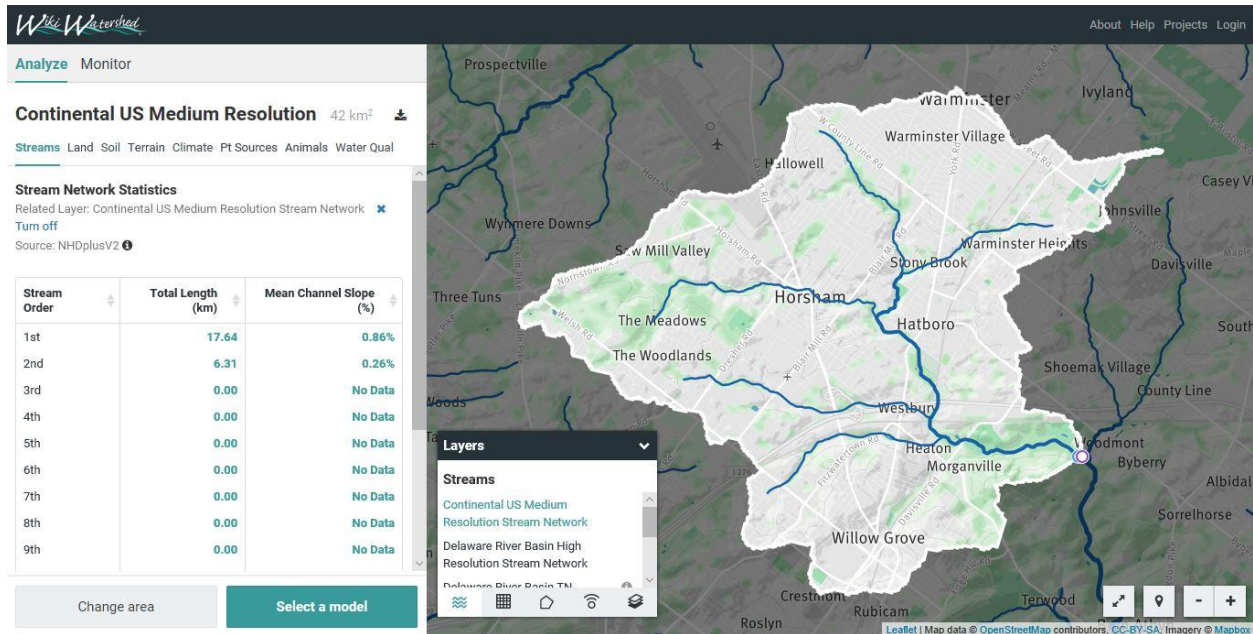


Figure A7

Upload File

With this option, a user can upload a digital boundary that has been previously created (either with MMW or elsewhere) to define the area of interest. This can be used to define either a watershed boundary or a smaller target (urban) area within the larger watershed as described earlier in this document. Upon selecting this option, the user is presented with a screen as shown in Figure A8. Upon clicking on the “Select a file” button, the user is then asked to browse to the file to be uploaded. As noted in Figure A8, this can either be a zipped shapefile or a “geojson” file. Figure A9 shows an example of a boundary file uploaded for an area in eastern Pennsylvania.

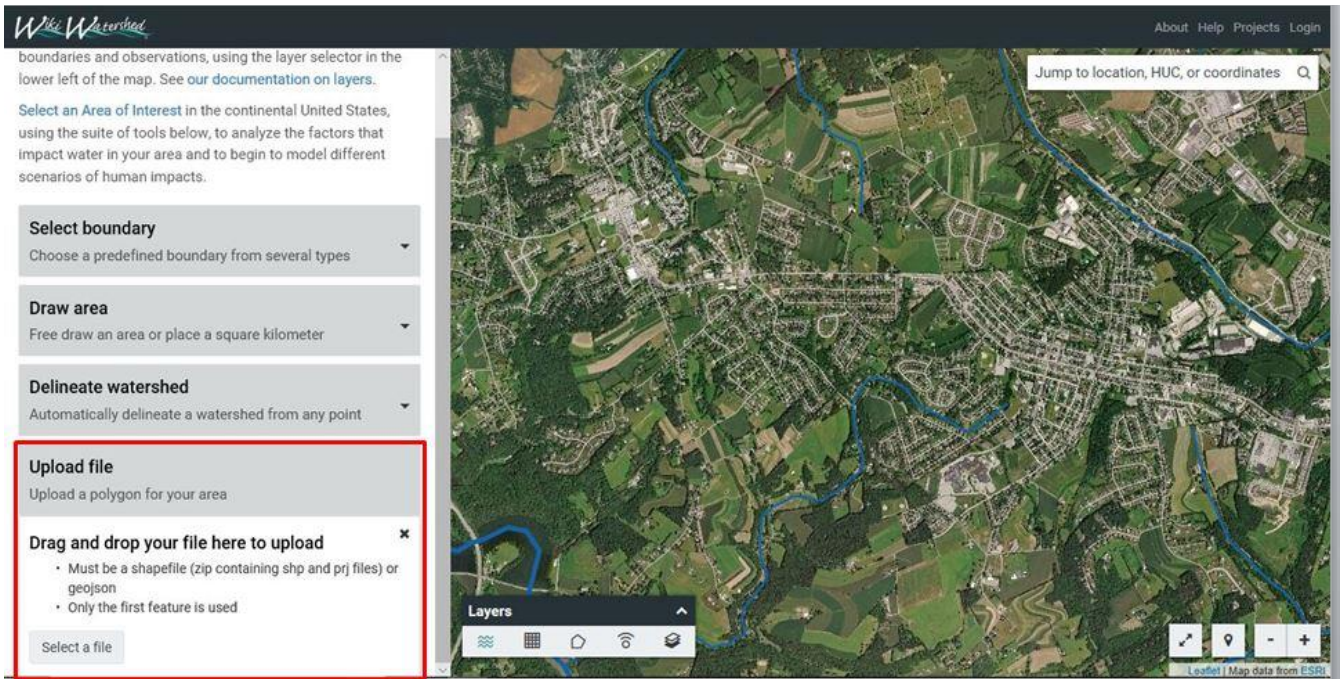


Figure A8

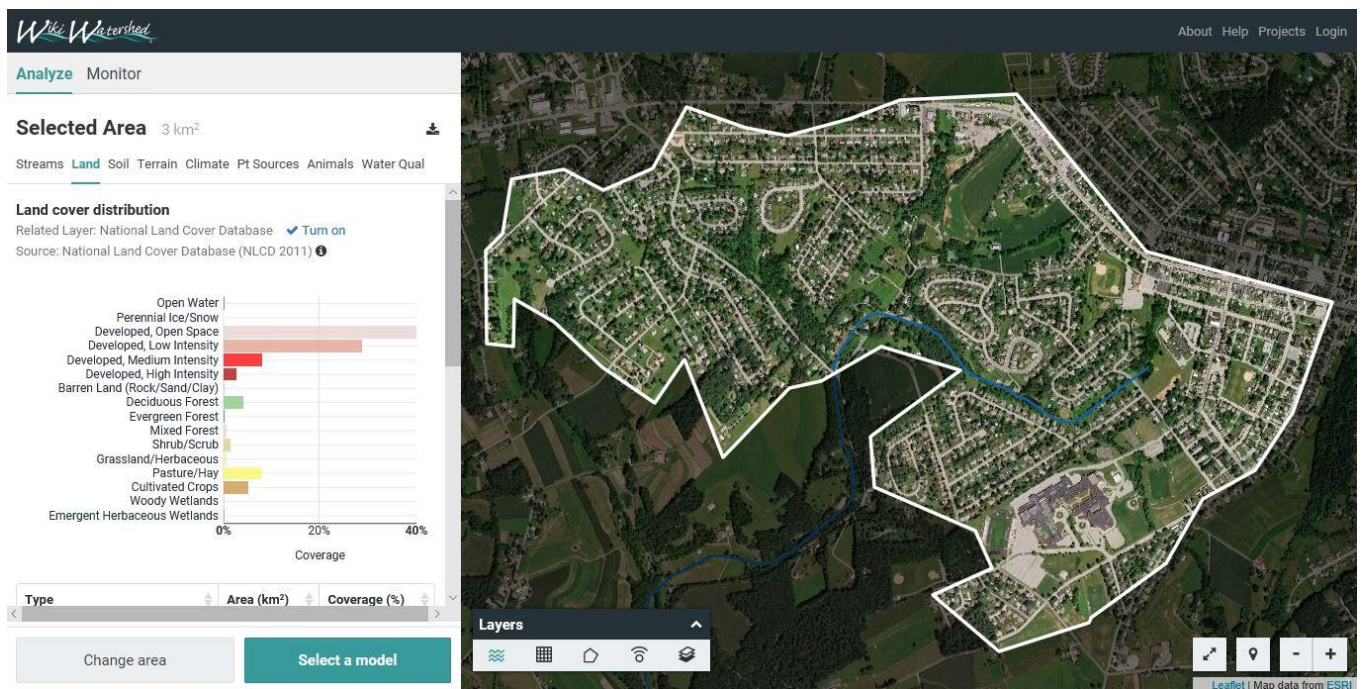


Figure A9.