DEP POST-CONSTRUCTION STORMWATER MANAGEMENT (PCSM) SPREADSHEET INSTRUCTIONS

Revised, August 28, 2020

Introduction

The Department of Environmental Protection (DEP) has developed the DEP PCSM Spreadsheet (spreadsheet) to facilitate calculations necessary for completing the stormwater analysis required by § 102.8(g) for PCSM Plans. The spreadsheet is intended to streamline PCSM calculations and help applicants demonstrate compliance with the regulations when a permit under Chapter 102 is required. The spreadsheet was designed using the latest version of Microsoft Excel® and is in Excel binary workbook (XLSB) format.

The Volume Worksheet of the spreadsheet utilizes the Curve Number method from TR-55 to estimate runoff volumes from land covers. The Rate Worksheet utilizes the Graphical Peak Discharge Method from TR-55; as noted below, this method is limited in use and may not be appropriate in many cases. The Quality Worksheet utilizes the volumes determined in the Volume Worksheet to calculate pollutant loads from land cover concentrations using the National Stormwater Quality Database and BMP outflow concentrations from the International BMP Database. The Quality Worksheet includes a Certification statement that must be acknowledged by the user of the spreadsheet for submission to DEP or delegated county conservation districts (CCDs) as part of a Chapter 102 permit application.

The spreadsheet contains default calculations that may in some cases be overridden by the user's own calculations through manual entry (e.g., runoff volumes), providing flexibility. However, if the user overrides any of the spreadsheet's calculations, the applicant should attach additional documentation explaining what specifically was overridden with justification. The use of the spreadsheet and attachment of spreadsheet printouts to Chapter 102 applications is encouraged, and in certain cases is required, because the reviewing agency will receive calculations in a consistent format, which is intended to provide for more efficient and timely reviews.

Questions on the use of the spreadsheet can be directed to the Bureau of Clean Water at:

RA-EPCHAPTER102@pa.gov.

General Information

> **NOTE 1** – It is important that the user follow these instructions carefully. Omission of data in any cell designed for data entry may result in the failure of important calculations on the same or different worksheets.

If prompted by Excel after opening the spreadsheet, enable editing and macros. *Note that you may need to add additional Trusted Locations in the Trust Center Settings of Excel in order to run the macros*. These locations may include server drives and/or locations where you intend to save the file for use. The following steps may be taken:

1. Excel Options > Trust Center > Trust Center Settings > Trusted Locations
2. Check the box to "Allow Trusted Locations on my network"
3. Select "Add new location"
4. Browse to select the folder (or server) where the file will be saved, check the "Subfolders of this location are also trusted" box, and then OK.

The spreadsheet consists of five hyperlink tabs: Instructions, General, Volume, Rate and Quality. Each tab has a corresponding worksheet. A Versions Worksheet is also visible to identify changes made to the spreadsheet over time. To begin, click on the General tab.

The top of each worksheet contains a "Clear Form" button. The user may click on the "Clear Form" button at any time to delete **all** data from the current worksheet. There is also a "Clear Project" button at the top of the General Worksheet that may be used to remove all entries throughout the entire spreadsheet. If the user wants to revise the information in only one cell, the user should select that cell and use the backspace or delete key to remove the current value and then enter the new value into the cell.

NOTE 2 - The spreadsheet is intended for the evaluation of volume, rate, and water quality for discharges to a **single receiving surface water**. If for example there are 3 post-construction discharge points to Mud Run and 3 post-construction discharge points to Clear Creek, two spreadsheets should be completed (one for Mud Run and one for Clear Creek). Alternatively, the spreadsheet can be used on a discharge point basis.

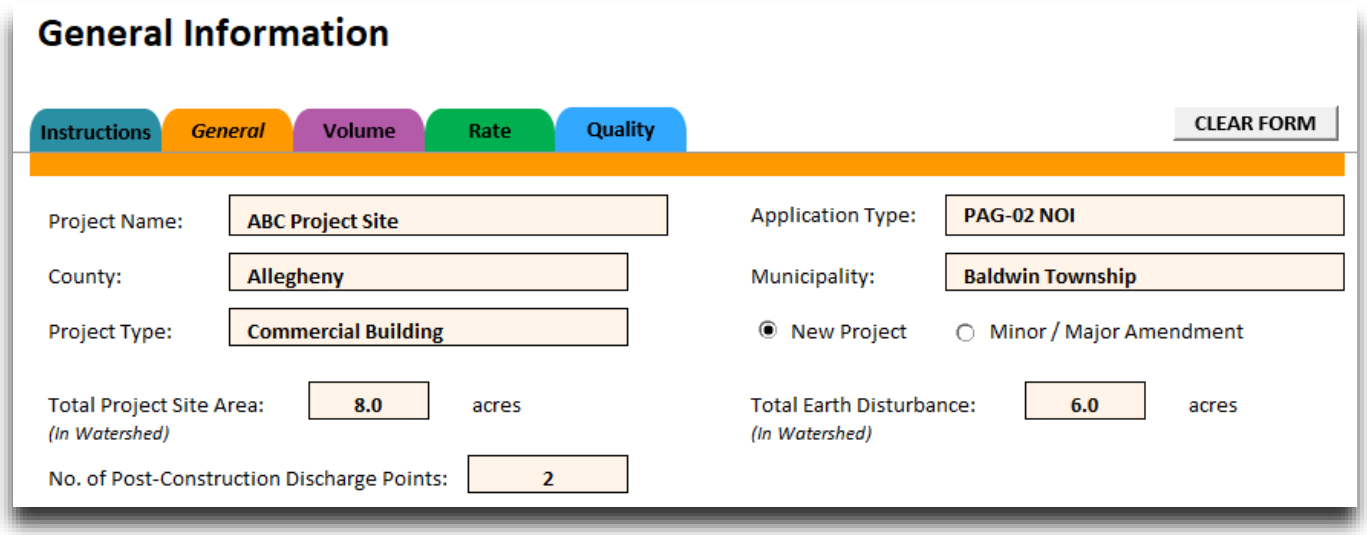
All cells available for data entry or selection from a drop-down menu are highlighted. **The user may use the Tab, arrow, or Enter keys to move from cell to cell. Using the mouse to click from cell to cell may result in validation errors**.

Care must be taken to enter the data in the correct order identified in these instructions to avoid potential errors with the calculations and logic. For example, skipping a cell may prevent a calculation or produce an error message. The spreadsheet is protected. Formulas are not visible but are explained in this document. Validation that exists in the spreadsheet is highlighted and explained in this document.

NOTE 3 – Throughout the spreadsheet decisions were made concerning cell formatting with respect to the number of decimal places displayed. The number displayed in a cell is not necessarily the number that is stored by the spreadsheet. Therefore, you may not be able to replicate a calculated value using only the numbers displayed in the cells due to the spreadsheet's rounding of input values to meet formatting requirements.

Example 1 – Cell A1 is formatted to 1 decimal place. The user enters "2.171", which is displayed as "2.2". Cell A2 is formatted to 1 decimal place also. The user enters "0.5421", which is displayed as "0.5". Cell A3 is the product of A1 and A2 and is formatted to 2 decimal places. The actual result calculated by the spreadsheet is "1.1768991" and "1.18" is displayed. This is different than the product of the input values displayed on the screen (i.e., 2.2 x 0.5 = 1.10).

General Worksheet



- **Project Name** – Enter the name of the project as it will be recorded on the Chapter 102 permit application.
- **Application Type** – Select the type of Chapter 102 permit application that will be submitted to DEP or a county conservation district (CCD) for the project.
- **County** – Select the county where the project is located from the drop-down list. If the project is located in multiple counties, select the county with the greatest area of earth disturbance.

- **Municipality** – Select the municipality where the project is located from the drop-down list. If the project is located in multiple municipalities, select the municipality with the greatest area of earth disturbance.

- **Project Type** – Select the applicable project type from the drop-down list. If the project type is not shown, select "Other". For mixed uses select the primary use or select "Other".

- **New Project or Minor / Major Amendment** – Select the appropriate radio button to indicate whether the spreadsheet is being completed for a new project or for a minor or major amendment to an existing project (e.g., additional phases of a larger common plan of development or sale).

- **Total Project Site Area** – Enter the total number of acres for the project site **in the watershed of interest**. See 25 Pa. Code § 102.1 for the definition of Project Site. Note that Total Project Site Area does not mean the entire tributary drainage area to the site or to BMPs on the site.

  NOTE 4 – If there will be post-construction discharges to two or more surface waters, and therefore multiple spreadsheets must be completed in order to analyze all sitewide discharges, the Total Project Site Area must be divided amongst the analyses. For example, if the Total Project Site Area is 10 acres and there will be post-construction discharges to Mud Run and Clear Creek, the user should determine the portion of the project site area that drains to each surface water (e.g., 6 acres to Mud Run and 4 acres to Clear Creek).

- **Total Earth Disturbance** – Enter the total number of acres of earth disturbance (i.e., disturbed area) within the project site **for the watershed of interest**. **This area may not be exceeded when entering land cover areas for pre- and post-construction conditions in the Volume Worksheet**.

  VALIDATION – The value for ***Total Earth Disturbance*** may not exceed the value for ***Total Project Site Area***.

  NOTE 5 – The entire disturbed area should be accounted for in the Volume Worksheet. For example, if the value entered for ***Total Earth Disturbance*** is 5 acres, the sum of areas for land covers for both pre- and post-construction conditions in the Volume Worksheet should be 5 acres, unless the project site includes multiple watersheds and earth disturbance activities will result in changes to drainage areas, as noted above.

- **No. of Post-Construction Discharge Points** – Select the number of post-construction discharge points ("DPs") (also known as "points of interest") that are proposed for a specific receiving surface water. The term "discharge point" means all engineered structures, drainageways and areas of concentrated flow where runoff leaves a project site, except for areas of shallow concentrated flow that are controlled by perimeter BMPs during construction. Discharge points are not only pipes (outlets from BMPs) but may also include areas where stormwater flows will concentrate by design and areas of concentrated flow prior to level spreaders or other diffusion of flows. Discharge points may be situated at or near surface waters or at another location, at or prior to the project site boundary.

  NOTE 6 – All discharge points reported on the spreadsheet should be identified on site maps and/or PCSM Plans.

  A maximum of 20 discharge points can be selected; if a project involves more than 20 discharge points, additional discharge points should be recorded on a separate spreadsheet. Selection of the number of post-construction discharge points will open a table for data entry.

No. of Post-Construction Discharge Points: 3 Start DP Numbering at: 001

Discharge Point (DP) No.	Drainage Area (DA) (acres)	Earth Disturbance in DA (acres)	Existing Impervious in DA (acres)	Proposed Impervious in DA (acres)	Receiving Waters	Ch. 93 Class	Structural BMP(s)
001	3.00	3.00	0.00	1.50	Mud Run	WWF	Yes
002	3.00	3.00	0.25	1.00	Mud Run	WWF	Yes
003	3.00	3.00	0.00	2.50	Mud Run	WWF	Yes
Undetained Areas	1.00	0.00	0.00	0.00	Mud Run	WWF	
Totals:	**10.00**	**9.00**					

Enter a number in the cell next to "**Start DP Numbering at:**". Normally this should be "001" (the user can enter "1"). However, if a project site contains drainage area to two or more surface waters, and therefore multiple instances of the spreadsheet will be used for the project, you may enter a different number to avoid the use of duplicate discharge point numbers on plan drawings.

An explanation of the columns in this table is as follows:

- **Discharge Point (DP) No.** – Sequential discharge point numbers are assigned after the user enters a value for the starting number. In addition to discharge points, at the bottom of the table the user is requested to enter information on "**Undetained Areas**." These are areas that are part of the project site but do not drain to (i.e., bypass) a BMP; for example, areas that due to final grade will not drain to a BMP should be considered undetained areas.

- **Drainage Area (DA) (acres)** – For each discharge point, report the post-construction drainage area tributary to the discharge point. The surface area of BMPs, if present, should be included in this value.

  VALIDATION – The ***Drainage Area*** for individual discharge points and undetained areas may not exceed the ***Total Project Site Area*** entered on this worksheet. In addition, the sum of all drainage areas and undetained areas may not exceed the ***Total Project Site Area***.

- **Earth Disturbance in DA (acres)** – For each discharge point, report the area of earth disturbance within the post-construction drainage area.

  VALIDATION – The ***Earth Disturbance*** area for individual and all discharge points and undetained areas may not exceed the ***Total Earth Disturbance Area*** entered on this worksheet. In addition, the ***Earth Disturbance*** area for any discharge point or undetained areas may not exceed the value entered for ***Drainage Area***.

- **Existing Impervious in DA (acres)** – For each discharge point, enter the actual acres of impervious surface – prior to construction – within the post-construction drainage area.

  VALIDATION – The ***Existing Impervious in DA (acres)*** may not exceed the value entered for ***Drainage Area*** for the discharge point.

- **Proposed Impervious in DA (acres)** – For each discharge point, enter the acres of impervious surface that are planned within the post-construction drainage area.

  VALIDATION – The ***Proposed Impervious in DA (acres)*** may not exceed the value entered for ***Drainage Area*** for the discharge point.

- **Receiving Waters** – The user may select a value from the dropdown list, if applicable, or enter the name of the surface water receiving stormwater discharges from the discharge point. If the surface water is not named, use "unnamed tributary to XXX", where "XXX" is the name of the first named surface water downstream.

  NOTE 7 – If the discharge is to non-surface waters (e.g., via a level spreader or other flow diffusing device), the applicant must investigate the flow path and ultimate discharge point to verify safe and non-erosive conveyance to the surface water.

- **Ch. 93 Class** – Select the existing or designated use of the named surface water from the drop-down list. Users should check DEP's Existing Use website first, and if not found on this website, use the designated use as contained in Chapter 93.

- **Structural BMP(s)** – Select "Yes" if stormwater in the drainage area of the discharge point will be treated by a structural BMP, otherwise select "No".

Based on the project and entries made on this worksheet, the following message may be displayed below the table:

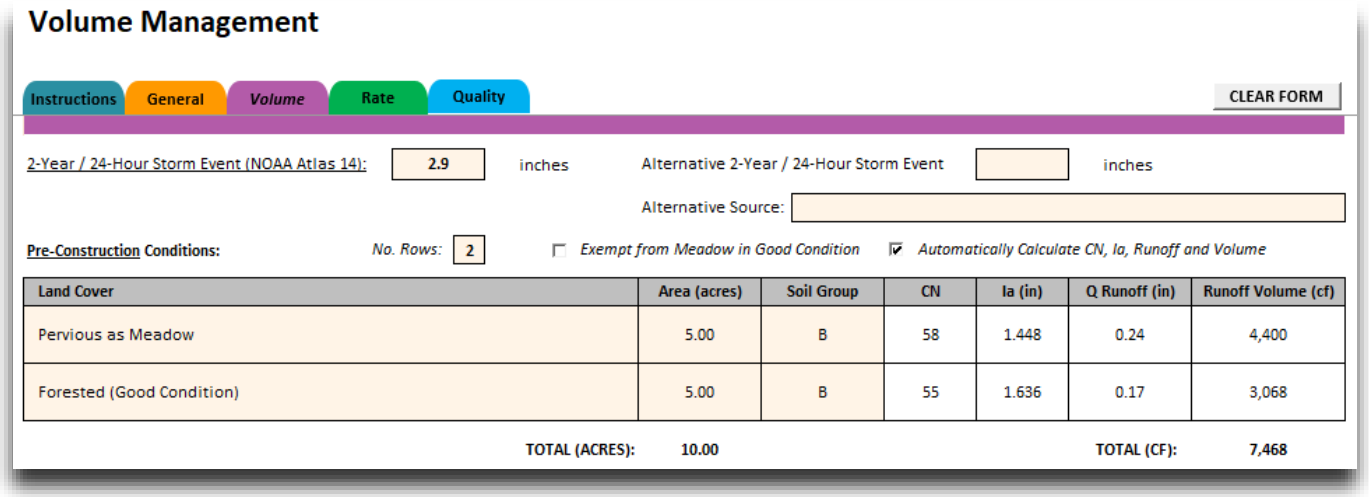
PROJECT SITE MEETS SMALL SITE EXCEPTION - RATE WORKSHEET NOT REQUIRED

If the following two items are true, the applicant does not need to complete the Rate Worksheet or otherwise complete an analysis of peak rates: 1) the ***Total Earth Disturbance*** area is less than 5 acres; and 2) the area of post-construction impervious surface within the watershed is less than or equal to one acre.

Volume Worksheet

The Volume Worksheet utilizes the design standard under 25 Pa. Code § 102.8(g)(2) that applicants must manage the net change in volume for storms up to and including the 2-year/24-hour storm event when compared to pre-construction runoff volume. Use of the Volume Worksheet may not be appropriate when a design standard under an approved Act 167 Plan or other alternative design standards are used. However, completion of the Volume Worksheet is necessary in order to complete the Rate and Quality Worksheets. Notices of Intent (NOIs) and individual permit applications for Chapter 102 NPDES permits require the submission of the Quality Worksheet, at a minimum. Calculations (including modeling software results) that clearly demonstrate how the volume management requirements of 25 Pa. Code § 102.8(g)(2) are met may be submitted in lieu of the Volume Worksheet.

NOTE 8 – **A stormwater analysis under 25 Pa. Code § 102.8(g) considers only the disturbed area, as this area is subject to changes in land cover**. While stormwater runoff originating from areas outside the disturbed area must be considered in the design of BMPs, such areas are not considered in the stormwater analysis because there is no net change in volume, water quality and rate. Therefore, there is no credit available under 25 Pa. Code § 102.8(g) in terms of volume, water quality, or rate for the management of stormwater outside of the disturbed area. However, for projects where treatment of stormwater runoff from new impervious surfaces could result in the disturbance of sensitive features such as riparian buffers or when there are limited opportunities to treat runoff from the new impervious surface, existing, undisturbed impervious that drains to the same surface waters as the new impervious may be treated to compensate, assuming there will not be an increased potential for erosion by not treating the new impervious. In such cases the user may include the existing impervious as disturbed area in the Volume Worksheet, solely for the purpose of calculating appropriate credits, and should attach an explanation stating that the surface used for compensation is not earth disturbance.



Volume Management

Instructions | General | Volume | Rate | Quality | CLEAR FORM

2-Year / 24-Hour Storm Event (NOAA Atlas 14): 2.9 inches

Alternative 2-Year / 24-Hour Storm Event: inches

Alternative Source:

Pre-Construction Conditions: No. Rows: 2 ☐ Exempt from Meadow in Good Condition ☑ Automatically Calculate CN, Ia, Runoff and Volume

Land Cover	Area (acres)	Soil Group	CN	Ia (in)	Q Runoff (in)	Runoff Volume (cf)
Pervious as Meadow	5.00	B	58	1.448	0.24	4,400
Forested (Good Condition)	5.00	B	55	1.636	0.17	3,068
TOTAL (ACRES):	10.00				TOTAL (CF):	7,468

- **2-Year / 24-Hour Storm Event (NOAA Atlas 14)** – DEP recommends that applicants utilize the NOAA Atlas 14 online service to locate the weather station closest to the project site and select the 2-year / 24-hour storm event total, in inches. If this value is entered, it will be used throughout the spreadsheet for calculations.

  - **Alternative 2-Year / 24-Hour Storm Event** - If the user decides to use a different source of information for precipitation data, the NOAA Atlas 14 field may remain blank and the user may enter an alternative rainfall amount in the appropriate box, in inches. If an alternative is selected, the user should report the source of the alternative data.

- **Pre-Construction Volume Calculation Table** – The purpose of this table is to calculate the total pre-construction runoff volume for the disturbed area (or portion of the disturbed area within a specific watershed). All existing land covers within the disturbed area must be identified in this table. By default, the program will automatically calculate curve number ("CN"), initial abstraction ("Ia"), "Q Runoff (in)", and "Runoff Volume (cf)." If the user prefers to calculate these values independently, uncheck the box for ***Automatically Calculate CN, Ia, Runoff and Volume***.

  By default, the box for ***Exempt from Meadow in Good Condition*** is unchecked. This box may be checked only for those projects that do not need to consider pre-development non-forested pervious area as meadow in good condition (25 Pa. Code § 102.8(g)(2)(i)), and 20% of existing impervious surface to be disturbed as meadow in good condition (25 Pa. Code § 102.8(g)(2)(ii)). Such projects would include the repair, reconstruction or restoration of roadways or rail lines, or construction, repair, reconstruction or restoration of utility infrastructure when the site will be returned to existing condition. The box for ***Exempt from Meadow in Good Condition*** may also be checked when an applicant is proposing a demonstration that treating 20% of existing impervious surface as meadow in good condition is not practicable due to public health, safety or environmental limitations under existing site conditions (and such demonstration is attached to the NOI or application). The effect of checking this box is to allow for additional pre-construction land cover options, as explained below.

  NOTE 9 – The user may select the number of rows, up to 20, for the number of pre-construction land covers to be reported.

  NOTE 10 – The ***Automatically Calculate CN, Ia, Runoff and Volume*** box controls the user's ability to manually enter values for CN, Ia, Runoff and Volume for both pre-construction and post-construction tables. In addition, when checked, this box allows the user to select Land Cover options from a drop-down list (otherwise Land Covers must be entered manually).

  - **Land Cover** – Select the Land Cover description(s) that best characterize pre-construction conditions within the disturbed area. For pre-construction conditions, the Land Cover options when the ***Exempt from***

Meadow in Good Condition box is not checked are Impervious, Impervious as Meadow, Pervious as Meadow, and Forested (Good Condition). The Land Cover options when the ***Exempt from Meadow in Good Condition*** box is checked are the same as described below for post-construction conditions. If the ***Automatically Calculate CN, Ia, Runoff and Volume*** box is not checked, the user must enter pre-construction Land Covers manually.

NOTE 11 – Care should be given to properly selecting the correct land cover types, as different types may have the same Curve Number for runoff purposes but may have different pollutant loading concentrations for water quality purposes.

- **Area (Acres)** – Enter the area of earth disturbance, in acres, associated with the Land Cover selected.

  VALIDATION – The entry of an area for an individual ***Land Cover*** as well as the sum of all ***Land Cover*** areas may not exceed the ***Total Earth Disturbance Area*** that was entered in the General Worksheet.

- **Soil Group** – Select a Hydrologic Soil Group (HSG) from the drop-down list for the ***Land Cover***. Soil groups are based on NRCS' National Engineering Handbook (Chapter 7, Hydrologic Soil Groups). The NRCS Web Soil Survey tool may be used to determine the soils present at a site (instructions on using the Survey tool to determine HSG are available – use this link). For soils assigned dual soil groups (e.g., A/D, B/D, etc.), use the first group for your selection.

  NOTE 12 – An option of "N/A" is available to select for impervious surfaces where any HSG would result in a CN value of 98. If accidentally selected for any other Land Cover, the spreadsheet assumes that HSG "D" was intended.

- **Curve Number (CN)** – The spreadsheet uses CN values from TR-55 by looking up the combination of Land Cover and Soil Group. If the ***Automatically Calculate CN, Runoff and Volume*** box is unchecked, the user may enter user-defined values for CN (from 30 to 98). DEP/CCD may request additional documentation for user-defined CN values.

  The following CN values are used when pre-construction Land Cover (where ***Exempt from Meadow in Good Condition*** is not checked) is selected in combination with the Hydrologic Soil Group (HSG):

Pre-Construction Land Cover	Curve Numbers			
	HSG A	HSG B	HSG C	HSG D
Impervious	98	98	98	98
Impervious as Meadow	30	58	71	78
Pervious as Meadow	30	58	71	78
Forested (Good Condition)	30	55	70	77

The CN values are based on NRCS' Urban Hydrology for Small Watersheds (TR-55) ("TR-55"), as follows:

Pre-Construction Land Cover	Equivalent TR-55 Land Cover
Impervious	Impervious Areas: Paved Parking Lots, Roofs, Driveways, Etc. (Excluding ROW)
Impervious as Meadow	Meadow-Continuous Grass, Protected from Grazing and Generally Mowed for Hay
Pervious as Meadow	Meadow-Continuous Grass, Protected from Grazing and Generally Mowed for Hay
Forested (Good Condition)	Woods (Good Condition)

NOTE 13 – Select "Impervious" and "Impervious as Meadow" as appropriate to implement the requirement at 25 Pa. Code § 102.8(g)(2)(ii) that 20% of the existing impervious area to be disturbed must be considered meadow in good condition or better (unless exempt as described above). For example, if a redevelopment project will disturb one acre of existing impervious surface, enter 0.8 acre as "Impervious" and 0.2 acre as "Impervious as Meadow."

- **Initial Abstraction (Ia)** – The initial abstraction, in inches, is calculated and displayed based on methodology in TR-55 (**Equation 1**): 0.2 x (1000 / CN) – 10.

- **Q Runoff (in)** – The depth of runoff, in inches, is calculated by the following equation based on TR-55, where P equals the 2-year/24-hour storm event rainfall in inches (**Equation 2**):

$$(P - Ia)^2 / (P + 0.8 \times ((1000 / CN) - 10))$$

  Where the user does not utilize the default calculation, the user must attach a copy of the runoff calculation. If P - Ia is less than or equal to zero, there is no runoff.

- **Runoff Volume (cf)** – Runoff volume, in cubic feet (cf), is calculated from Q Runoff and Area as follows (**Equation 3**):

$$\text{Runoff Volume (cf)} = \text{Area (acres)} \times 43{,}560\ ft^2/\text{acre} \times (\text{Q Runoff (in)} \times 1\ ft / 12\ \text{inches})$$

  Where the user does not utilize the default calculation, the user must attach a copy of the runoff calculation.

- **Post-Construction Volume Calculation Table** – The purpose of this table is to calculate the total post-construction runoff volume for the project site. This table is completed the same way the Pre-Construction Volume Calculation Table is completed. The only difference between the tables is that the Post-Construction Volume Calculation Table provides all TR-55 Land Cover options.

  NOTE 14 – In addition to the TR-55 Land Covers, three additional options are provided for impervious surfaces: 1) Impervious Areas: Commercial, 2) Impervious Areas: Industrial, and 3) Impervious Areas: Institutional. These additional options, all of which have CN values of 98, have been provided to allow for more precise estimates of pollutant loads (Quality Worksheet). The following provides DEP's recommendations on the selection of impervious cover:

  - **Impervious Areas: Paved Parking Lots, Roofs, Driveways, Etc. (Excluding ROW)** – select this impervious land cover for all parking lots, roofs, and driveways that are not associated with commercial, industrial or institutional sites. For example, roofs on residential and agricultural structures would fall into this category.

  - **Impervious Areas: Streets and Roads - Paved; Curbs and Storm Sewers (Excluding ROW**) – select this impervious land cover for all streets and roads that are paved, are curbed, and direct stormwater to storm sewers, including such streets and roads located on commercial, industrial and institutional sites.

  - **Impervious Areas: Streets and Roads - Paved; Open Ditches (Including ROW)** – select this impervious land cover for all streets and roads that are paved but are not curbed, and direct stormwater to roadside ditches, including such streets and roads located on commercial, industrial and institutional sites.

  - **Impervious Areas: Streets and Roads - Gravel (Including ROW)** – select this impervious land cover for all gravel roads, including such roads located on commercial, industrial and institutional sites.

  - **Impervious Areas: Streets and Roads - Dirt (Including ROW)** – select this impervious land cover for all dirt roads, including such roads located on commercial, industrial and institutional sites.

  - **Impervious Areas: Commercial** – select this impervious land cover for all impervious surfaces (including roofs, parking lots, walkways, etc.) on commercial sites except for streets and roads, in which one or more of the selections above should be made.

- **Impervious Areas: Industrial** – select this impervious land cover for all impervious surfaces on industrial sites except for streets and roads, in which one or more of the selections above should be made.

- **Impervious Areas: Institution** – select this impervious land cover for all impervious surfaces on institutional sites (e.g., college campuses) except for streets and roads, in which one or more of the selections above should be made.

- **Net Change in Volume to Manage (cf)** – After the Pre- and Post-Construction Volume Calculation tables are completed, the Net Change in Volume to Manage (cf) will be displayed in the red box, based on the total runoff volume for pre-construction conditions subtracted from the total runoff volume for post-construction conditions at the 2-year, 24-hour storm event.

  The remainder of the worksheet deals with management of this net change in volume.

  NOTE 15 – IMPORTANT NOTE ABOUT PROJECT SITES IN MULTIPLE WATERSHEDS THAT WILL INVOLVE CHANGES TO PRE-CONSTRUCTION DRAINAGE AREAS: If a project site drains to two or more different surface waters, and earth disturbance activities will result in changes to pre-construction drainage areas, the applicant must account for the change across all spreadsheets prepared for the project. While normally users would enter a Total Earth Disturbance value in the General Worksheet corresponding to post-construction conditions, when a project site drains to two or more different surface waters and there will be changes to post-construction drainage areas, the user must enter the maximum earth disturbance area between pre- and post-construction conditions.

  Example 3: A project site consists of two drainage areas and 60 acres of total earth disturbance, with 30 acres draining to Mud Run and 30 acres draining to Clear Creek. As a result of earth disturbance activities, the drainage areas will change. Following construction, 38 disturbed acres will drain to Mud Run and 22 disturbed acres will drain to Clear Creek. Two instances of the PCSM Spreadsheet are prepared. The spreadsheet prepared for Mud Run will use a Total Earth Disturbance value of 38 acres in the General Worksheet, and the sum of pre-construction and post-construction land cover areas will be 30 acres and 38 acres, respectively, in the Volume Worksheet. The spreadsheet prepared for Clear Creek will use a Total Earth Disturbance value of 30 acres in the General Worksheet, and the sum of pre-construction and post-construction land cover areas will be 30 acres and 22 acres, respectively, in the Volume Worksheet.

- **Non-Structural BMP Volume Credits** – Select one or more of the optional checkboxes to pursue credit for non-structural BMP volume credits.

  NOTE 16 – The spreadsheet does not enforce a limit on the amount of non-structural BMP volume credit that can be claimed where valid non-structural BMPs from the Pennsylvania Stormwater BMP Manual (363-0300-002) will be implemented.

  NOTE 17 – Any Non-Structural BMP is still considered a PCSM BMP, and adequate plan information must be provided (details, notes, long-term operation and maintenance schedule, etc.).

  - **Tree Planting Credit** – Check the box if native trees (minimum 2-inch caliper, minimum height 6 feet) will be planted within disturbed areas following construction. <u>However, do not include trees planted as part of a riparian forest buffer</u>. Enter the number, if any, of deciduous and evergreen trees planted. Credits of 6 and 10 cubic feet are provided per deciduous and evergreen tree planted, respectively, per DEP's Stormwater BMP Manual.

  - **Other Credit** – The user may enter a description of any other non-structural BMP volume credit that is calculated separately and those supporting calculations are attached to the permit application or Volume Worksheet. Enter the amount of the credit, if applicable, in the space provided. These credits should be consistent with the Pennsylvania Stormwater BMP Manual.

- **Structural BMP Volume Credits**

Identify all proposed structural BMPs for the project site in the table provided to calculate volume reduction credits. Select the number of structural BMPs that will be installed (***No. Structural BMPs:***), up to 50. If the proposed number of BMPs will exceed 50, a separate spreadsheet will need to be completed.

NOTE 18 – The selection of BMPs in this section will carry through to the Rate and Quality Worksheets. If there are planned BMPs that are intended only for water quality purposes, such water quality BMPs should be identified in this table.

NOTE 19 – The user should be familiar with the three basic functions of BMPs: infiltration, evapotranspiration and water quality. Some BMPs provide one, two or all three of these functions. Proper use of and entry of infiltration, media and storage parameters is the responsibility of the user.

NOTE 20 – If the Rate Worksheet is not used to calculate peak rates and demonstrate rate controls, the user may identify only those structural BMPs that will be used for volume and water quality management in the Structural BMP table. If this is done, please note that all PCSM BMPs, including rate control BMPs, must be identified in PCSM Module 2, and the BMP numbers should correctly identify the same BMP across all documents used to complete a Chapter 102 permit application. Users may also identify all PCSM BMPs in the Structural BMP table, including rate control BMPs.

Structural BMP Volume Credits: *No. Structural BMPs:* 2 *Start BMP Numbering at:* 1

DP No.	BMP No.	BMP Name	MRC?	Discharge	Incremental BMP DA (acres)	Volume Routed to BMP (CF)	Infiltration / Vegetated Area (SF)	Infiltration Rate (in/hr)	Infiltration Period (hrs)	Vegeta-ted?	Media Depth (ft)	Storage Volume (CF)	Infiltration Credit (CF)	ET Credit (CF)
010	1	Vegetated Swale	-	to BMP No. 4	4.00	1,000	300	0.20	60	Yes	1.0	10,000	270	92
001	2	Rain Garden / Bioretention	-	to BMP No. 3	3.00	2,000	500	0.40	60	Yes	1.0	12,000	900	154
												Totals:	3,981	349

Select a number in the cell next to "**Start BMP Numbering at:**". Normally this should be "1." However, if a project site contains drainage area to two or more surface waters, and therefore multiple instances of the spreadsheet will be used for the project, you may enter a different number to avoid the use of duplicate BMP numbers on plan drawings.

An explanation of the columns in this table is as follows:

- **DP No.** – Select the discharge point (DP) associated with the structural BMP. Only those DPs where the user indicates a structural BMP will be installed on the General Worksheet will be available for selection. This entry must be made in order for the Quality Worksheet to calculate pollutant loads.

  NOTE 21 – BMPs that receive and discharge stormwater runoff as sheet flow should be identified in the Structural BMP Volume Credits table in order to demonstrate infiltration and evapotranspiration credit. For example, where a vegetated filter strip discharges stormwater as sheet flow to a riparian buffer, the vegetated filter strip and the riparian buffer should be identified in the table although neither may receive or discharge concentrated flows. A DP No. must nonetheless be selected in order to generate credit.

- **BMP No.** – A sequential ID number is assigned to each BMP after the starting number is selected.

- **BMP Name** – Select a BMP name from the drop-down list. BMP names generally correspond with the names identified in the Stormwater BMP Manual. If the name of a structural BMP is not available, the user may manually enter it. If the user manually enters a BMP name, the box for ***Use default BMP Outflows and Median BMP Outflow Concentrations*** on the Quality Worksheet must be unchecked (see below).

NOTE 22 – Select "Riparian Forest Buffer (Min 150 Ft)" only if a new riparian forest buffer with a minimum width of 150 feet will be established as a BMP. Credit is provided for all volume routed to this BMP (see below). Select "Riparian Buffer" only if a new riparian buffer will be established. There is no minimum width required in order to select this BMP – credit will be generated as a function of the vegetated area and soil infiltration properties.

- **MRC?** – Select "Y" in this column if the BMP has been designed as a Managed Release Concept (MRC) BMP, as described in DEP's Alternative E&S and PCSM BMPs listing. Note that additional materials such as the MRC Design Summary Sheet must accompany the PCSM Plan for all MRC BMPs. If MRC = "Y" and Discharge (described below) = "Off-Site", the Volume Routed to BMP minus Infiltration and ET credits is automatically reported as Managed Release Credits, below the Structural BMP table.

  NOTE 23 – MRC BMP design standards are based on a 1.2-inch/2-hour storm event. However, MRC credit is provided for volume routed to the MRC BMP up to the 2-year/24-hour storm event. An applicant may not take credit for volume routed to the MRC BMP up to the 2-year/24-hour storm event if the volume exceeding the 1.2-inch/2-hour storm event is designed to bypass the MRC BMP.

- **Discharge** – Select "Off-Site" if outflows from the BMP will discharge off-site to surface waters, storm sewers, or other off-site conveyance rather than another BMP (except as noted below). When Off-Site is selected, outflows from BMPs will be used in the Quality Worksheet to calculate pollutant loads leaving the site at the 2-year/24-hour storm event.

  Select "to BMP No. X" (where X is the BMP No. shown in the table) when the discharge from the BMP will be to a downstream BMP.

  Users should select "Off-Site" for all standalone BMPs and final BMPs in series. For example, a vegetated swale that is followed by a rain garden should be entered into the spreadsheet as shown below:

DP No.	BMP No.	BMP Name	MRC?	Discharge
001	1	Vegetated Swale	-	to BMP No. 2
001	2	Rain Garden / Bioretention	-	Off-Site

Attachment A provides a detailed example of how BMPs in series can be entered into the spreadsheet and how volume and water quality credits are calculated.

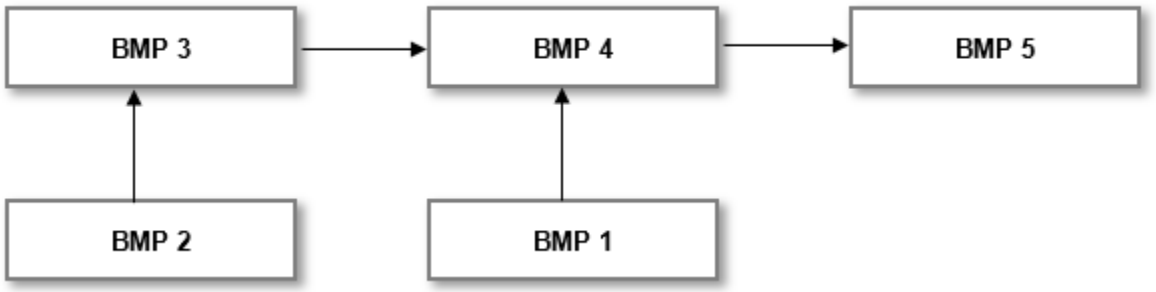
NOTE 24 – If a BMP is in series with another BMP that is off-site, and the owner of the off-site BMP has provided permission for stormwater flows from the project site to enter the BMP, select "Another BMP" for the Discharge, even though the discharge will be routed off-site. The off-site BMP will then need to be identified in the Structural BMP table as the final BMP in series.

NOTE 25 – BMPs that are in series are separate and distinct BMPs, such as a vegetated swale followed by a rain garden. A BMP's components cannot be broken down and treated as separate BMPs. For example, a rain garden that dewaters in more than 24 hours cannot be broken into soil amendments followed by a dry extended detention basin.

- **Incremental BMP DA (acres)** – Enter the drainage area, in acres, that is tributary to the reported BMP **within the disturbed area**. This value may be different than the drainage area reported on the General Worksheet for the discharge point (i.e., the discharge point may receive flows that are not treated by the BMP).

For downstream BMPs in series enter "0" if the only flows received are from an upstream BMP. If a downstream BMP receives flow from drainage areas that do not flow to upstream BMPs, enter the incremental BMP drainage area.

Example 4: There are five BMPs on a project site as shown below. BMPs Nos. 1 and 3 discharge to BMP No. 4, BMP No. 2 discharges to BMP No. 3, and BMP No. 4 discharges to BMP No. 5. The drainage areas to BMPs Nos. 1 and 2 are 4 acres and 3 acres, respectively. BMP No. 3 receives flow from an additional 2 acres, as well as the discharge from BMP No. 2. BMP Nos 4 and 5 only receive the discharges from upstream BMPs.



Entries into the Structural BMP table for this example would be as follows:

DP No.	BMP No.	BMP Name	MRC?	Discharge	Incremental BMP DA (acres)
001	1	Vegetated Swale	-	to BMP No. 4	4.00
001	2	Rain Garden / Bioretention	-	to BMP No. 3	3.00
001	3	Vegetated Swale	-	to BMP No. 4	2.00
001	4	Infiltration Basin	-	to BMP No. 5	0.00
001	5	Infiltration Basin	-	Off-Site	0.00

VALIDATION – The ***Incremental BMP DA*** may not exceed the value entered for ***Earth Disturbance in DA*** in the General Worksheet for the same discharge point, and the sum of ***Incremental BMP DA*** for all BMPs may not exceed the value entered for ***Total Earth Disturbance*** in the General Worksheet.

NOTE 26 – BMPs must be designed considering the entire drainage area that is tributary to the BMP and the resultant flows. BMP design calculations must reflect these flows. A stormwater analysis under 25 Pa. Code § 102.8(g) is different in that only the disturbed area is of interest.

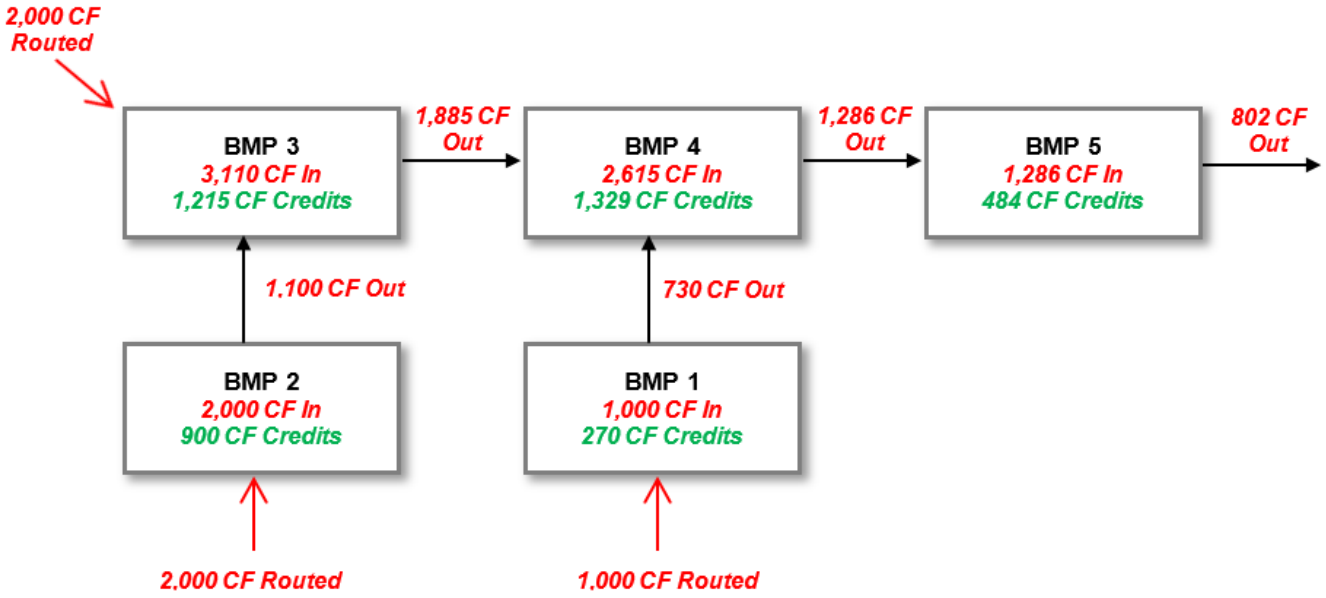
- **Volume Routed to BMP (CF)** – Calculate and report the volume routed to the BMP during the 2-year/24-hour storm event, in cubic feet (CF). The spreadsheet does not calculate this volume automatically due to

the possibility that additional flows may be routed to a BMP that are outside of the BMP's drainage area. **Report only the volume routed to the BMP from the disturbed area**. Additional volume from outside the disturbed area (within or outside of the project site) may indeed flow into the BMP and would need to be accounted for in the design; however, for the purpose of crediting volume reduction or management to meet regulatory compliance, this additional volume cannot be considered.

NOTE 27 – Include the area associated with the BMP as part of the volume calculation, as applicable. For example, the volume routed to an infiltration basin must include stormwater from the drainage area routed to the BMP along with direct precipitation on the infiltration basin.

NOTE 28 – A BMP that is in series with another BMP for the same discharge point should have a volume routed to the BMP that is no less than the preceding BMP in the series, minus infiltration and ET credits. Volume that is permanently removed by infiltration or ET cannot be counted as volume contributing to a subsequent BMP in a series. Applicants should develop a water balance for complex BMPs in series scenarios (see Example 5).

Example 5 – BMPs are in series as described in Example 4. Stormwater from the disturbed area is routed to BMP Nos. 1, 2, and 3 as shown below, and the following water balance is generated upon entry of design parameters into the Structural BMPs table:



The spreadsheet enforces a rule that downstream BMPs in series must receive volume routed to it that is at least as large as the outflow from upstream BMPs. The following (abbreviated) table illustrates how this scenario appears in the Structural BMPs table:

DP No.	BMP No.	BMP Name	MRC?	Discharge	Incremental BMP DA (acres)	Volume Routed to BMP (CF)
001	1	Vegetated Swale	-	to BMP No. 4	4.00	1,000
001	2	Rain Garden / Bioretention	-	to BMP No. 3	3.00	2,000

001	3	Vegetated Swale	-	to BMP No. 4	2.00	3,100
001	4	Infiltration Basin	-	to BMP No. 5	0.00	2,615
001	5	Infiltration Basin	-	Off-Site	0.00	1,286

The following (abbreviated) table illustrates how this scenario appears in the Structural BMP Water Quality Credits table in the Quality Worksheet:

DP No.	BMP No.	BMP Name	MRC?	BMP DA (acres)	Vol. Routed to BMP (CF)	Inf. & ET Credits (CF)	Outflow (CF)
001	1	Vegetated Swale	-	4.00	1,000	270	730
001	2	Rain Garden / Bioretention	-	3.00	2,000	900	1,100
001	3	Vegetated Swale	-	2.00	3,100	1,215	1,885
001	4	Infiltration Basin	-	0.00	2,615	1,329	1,286
001	5	Infiltration Basin	-	0.00	1,286	484	802

NOTE 29 – All values input into the Volume Routed to BMP column should have corresponding calculations that support the reported volume. Flow charts, diagrams, or other graphical depictions are recommended, especially for more complex sites. This will also provide for more timely reviews.

NOTE 30 – When the Capture and Reuse BMP is selected, the volume that is captured and reused should be entered in "Volume Routed to BMP". For example, a retention basin is used in conjunction with capture and reuse, where 20,000 CF is routed to the BMP but only 5,000 CF is captured and re-used, the "Volume Routed to BMP" for the Capture and Reuse BMP would be 5,000 CF. A water budget should be developed and attached to the worksheet. Also, all of the volume reused must be collected and dispersed in a timely manner.

VALIDATION – The volume routed to any individual BMP and the sum of all volumes routed to BMPs may not exceed the total runoff volume for post-construction conditions. In addition, where BMPs are in series, the volume routed to a downstream BMP may not be less than the volume routed to the preceding BMP(s), minus infiltration and ET credits.

- **Infiltration / Vegetated Area (SF)** – Enter the infiltration area of the BMP in square feet (SF), if applicable. If the BMP is not designed as an infiltration BMP, but will maintain vegetation, enter the area of vegetation in which the root zone is expected to be in contact with stormwater at the 2-year/24-hour storm event.

NOTE 31 – The spreadsheet does not consider hydraulic loading to BMPs. The BMP designer is responsible for selecting appropriate design criteria using the Stormwater BMP Manual or other published and defensible resources.

- **Infiltration Rate (in/hr)** – Report the design infiltration rate or saturated hydraulic conductivity (Ksat) associated with the infiltration area, in inches per hour (in/hr) utilizing methods contained in Appendix C of the Stormwater BMP Manual or other published and defensible methods. If the BMP is not designed as an infiltration BMP, leave this field blank. The value entered is reduced by 10% as a factor of safety in the calculation of Infiltration Credit. The design infiltration rate value entered should be the tested infiltration rate adjusted with factors of safety (and other additional factors) where appropriate.

- **Infiltration Period (hours)** – Select the infiltration period (i.e., dewatering time), in hours, for BMPs that will rely on infiltration. DEP may accept infiltration periods up to 4 days (96 hours). However, 1) the maximum ponding depth for infiltration and bioretention BMPs may not exceed 2 feet at the 2-year/24-hour storm event, and 2) local ordinance requirements must be met, where applicable. Many local ordinances require infiltration periods no greater than 3 days (72 hours).

  NOTE 32 – The actual computed dewatering time should be entered here. Exaggerated (i.e., too short or too long) durations will negatively affect the infiltration credit calculations.

- **Vegetated?** – Select "Yes" if the structural BMP will be "vegetated." A vegetated PCSM BMP is a permanent BMP where vegetation is a dominant or significant component within the storage area. Vegetation must include species other than grasses. Grasses may be used, but may not be the only species planted, because other species with deeper penetrating root systems are needed to achieve the infiltration and ET credits calculated by the spreadsheet. The choice of seed mixes and plantings is to be made by the designer in consultation with the site owner.

- **Media Depth (ft)** – Enter the design depth of media used for the BMP, in feet (e.g., 1.5 feet of planting soil for a rain garden or 2 feet of stone for an infiltration trench). This does not apply to certain BMPs. If an underdrain is used, report the depth from the bottom of the media to the invert of the underdrain.

  NOTE 33 – The media depth must be greater than or equal to 6 inches (0.5 ft) to obtain ET credits. If the design depth is less than 6 inches, leave this cell blank.

- **Storage Volume (CF)** – Enter the design storage volume for the BMP – associated with the 2-year/24-hour storm event – in cubic feet (CF). This would include both surface and subsurface storage, as applicable. For storage within media, utilize an appropriate void space percentage for the chosen media (typically 30-40%).

  NOTE 34 – Storage volume is not calculated automatically due to the number of variables required for certain BMPs to do so. Storage volume is not a credit because it does not represent volume reduction; when storage volume infiltrates, evapotranspires, is released or otherwise reused, storage volume converts to credit. **Storage volumes should be calculated based on the lowest outlet elevation** (either an underdrain, overflow, or outlet to BMP in series), as the volume of water must be stored within the BMP for infiltration and ET credit following the storm event. If the design water level within a BMP at the 2-year/24-hour storm event exceeds the lowest outlet elevation, it may not be counted as storage volume. If the user believes that the release of stormwater from a control such as an orifice is sufficiently slow that water is available to be infiltrated or evapotranspired after the infiltration period, the user may use a more complex model to demonstrate additional volume reduction credit.

  VALIDATION – Storage volume may not exceed the value entered for Volume Routed to BMP. It is understood that BMPs may be designed for storms larger than the 2-year/24-hour storm event, but storage volume as used in the Volume Worksheet pertains only to storage of stormwater associated with the 2-year/24-hour storm event.

- **Infiltration Credit (CF)** – The infiltration credit for a BMP is automatically calculated once the Infiltration Rate, Infiltration Period, Infiltration Area, Storage Volume and Volume Routed to BMP data are entered. The calculation in narrative form is as follows (**Equation 4**):

  Infiltration Credit (CF) = Infiltration Rate (in/hr) x 0.9 (factor of safety) / 12 in/ft)) x 12 hrs (infiltration during storm) x Infiltration Area (ft^2) + (the lesser of Storage Volume or (Infiltration Period (hrs) – 12 hrs x (Infiltration Rate (in/hr) x 0.9 (factor of safety) / 12 in/ft) x Infiltration Area (ft^2)), where Infiltration Credit may not exceed the Volume Routed to the BMP.

  This equation conservatively estimates infiltration in a manner consistent with soil physics models and assumes that infiltration at saturated hydraulic conductivity occurs at only 12 hours of a 24-hour storm event.

- **ET Credit (CF)** – The evapotranspiration credit for a vegetated BMP is automatically calculated when the user selects "Yes" in the "**Vegetated?**" column and when Volume Routed to BMP and Media Depth data are entered.

  DEP recognizes that over the infiltration period there will be evapotranspiration (ET) that occurs in these vegetated BMPs, even in poorly drained soils. ET credit is based on DEP-funded research conducted by Villanova University[1] on volume reduction credit within rain gardens (or generally, bioretention facilities). The research is most applicable to stormwater control measures utilizing vegetative growth in engineered media above native soils, but may also be used to estimate ET in native soils.

  Although DEP has categorized this credit as ET, the research on which the credit is based evaluated the full volume reduction credit potential for vegetated systems, including infiltration during storm events as well as void space credit. In order to put the findings of this research into practice, DEP decided to utilize total void space credit results from experiments on sandy loam soil with a medium-range crop coefficient at various soil/rooting depths over a six-day period following a one-inch storm event (see "Appendix M" of research). This is highly simplified but is nonetheless considered to be representative of actual volume reduction potential for most vegetated systems. The spreadsheet utilizes Table 1, below, to determine the percentage of captured stormwater that is reduced through vegetated systems.

  The spreadsheet executes the following calculation in narrative form (**Equation 5**):

  ET Credit (CF) = ET Volume Reduction (%) (from Table 1) x Media Depth (ft) x Infiltration Area (ft^2), where ET Credit plus Infiltration Credit may not exceed Volume Routed to BMP.

  NOTE 35 – This calculation assumes that all infiltrating area is vegetated.

  DEP recognizes that this method is a simplification of the site-specific and regional factors that go into estimating potential ET. If an applicant wishes to pursue estimation of ET Credit in a different or more comprehensive manner, a separate analysis may be conducted and attached to the permit application or Volume Worksheet.

Table 1: Total Void Space (ET) Credit Used by Spreadsheet for Vegetated Systems

Media Depth (ft)	ET Volume Reduction (% Volume)	Media Depth (ft)	ET Volume Reduction (% Volume)
0.5	34.3	2.8	25.5
0.6	33.6	2.9	25.4
0.7	32.9	3.0	25.3
0.8	32.2	3.1	25.2
0.9	31.5	3.2	25.1

[1] Hess, Amanda Jean, Ph.D., May 2017. Rain Garden Evapotranspiration Accounting. Doctorate Dissertation, Villanova University College of Engineering.

Media Depth (ft)	ET Volume Reduction (% Volume)	Media Depth (ft)	ET Volume Reduction (% Volume)
1.0	30.7	3.3	25
1.1	30	3.4	25
1.2	29.3	3.5	24.9
1.3	28.5	3.6	24.9
1.4	28.2	3.7	24.8
1.5	27.9	3.8	24.8
1.6	27.6	3.9	24.7
1.7	27.3	4.0	24.7
1.8	27	4.1	24.6
1.9	26.6	4.2	24.6
2.0	26.3	4.3	24.5
2.1	26.2	4.4	24.5
2.2	26.1	4.5	24.4
2.3	26	4.6	24.4
2.4	25.9	4.7	24.3
2.5	25.8	4.8	24.3
2.6	25.7	4.9	24.2
2.7	25.6	5.0	24.2

NOTE 36 – ET Credit is balanced with Infiltration Credit so that the sum of these Credits does not exceed the Volume Routed to BMP. Therefore, the actual volume of stormwater removed through ET is not necessarily shown. For example, if the Volume Routed to BMP is 100 CF and the Infiltration Credit is determined to be 70 CF, the ET Credit may be displayed as 30 CF, although actual ET Credit may be higher. Actual ET Credit is shown when the sum of ET and Infiltration Credits is less than the Volume Routed to BMP.

- **Infiltration & ET Credits (CF)** – The sum of all Infiltration and ET Credits for all BMPs is calculated and presented.

- **Managed Release Credit (CF)** – MRC Credits are calculated automatically when the "MRC?" column is set to "Y" and the Discharge is "Off-Site" for a BMP. Supporting documentation must be attached (e.g., MRC Design Summary Sheet). Also see NOTE 23.

- **Capture and Reuse Credit (CF)** – If any selected BMP is a "Capture and Reuse" BMP, the Volume Routed to BMP is converted to a credit and the total of all credits is displayed. All other cells to the right after the Volume Routed to BMP column within the row for a Capture and Reuse BMP should be left blank.

- **Riparian Forest Buffer Credit (CF)** – If the BMP named "Riparian Forest Buffer (Min 150 Ft)" is selected, the Volume Routed to BMP is converted to a credit and the total of all credits is displayed. All other cells to the right after the Volume Routed to BMP column within the row for the Riparian Forest Buffer (Min 150 Ft) BMP should be left blank.

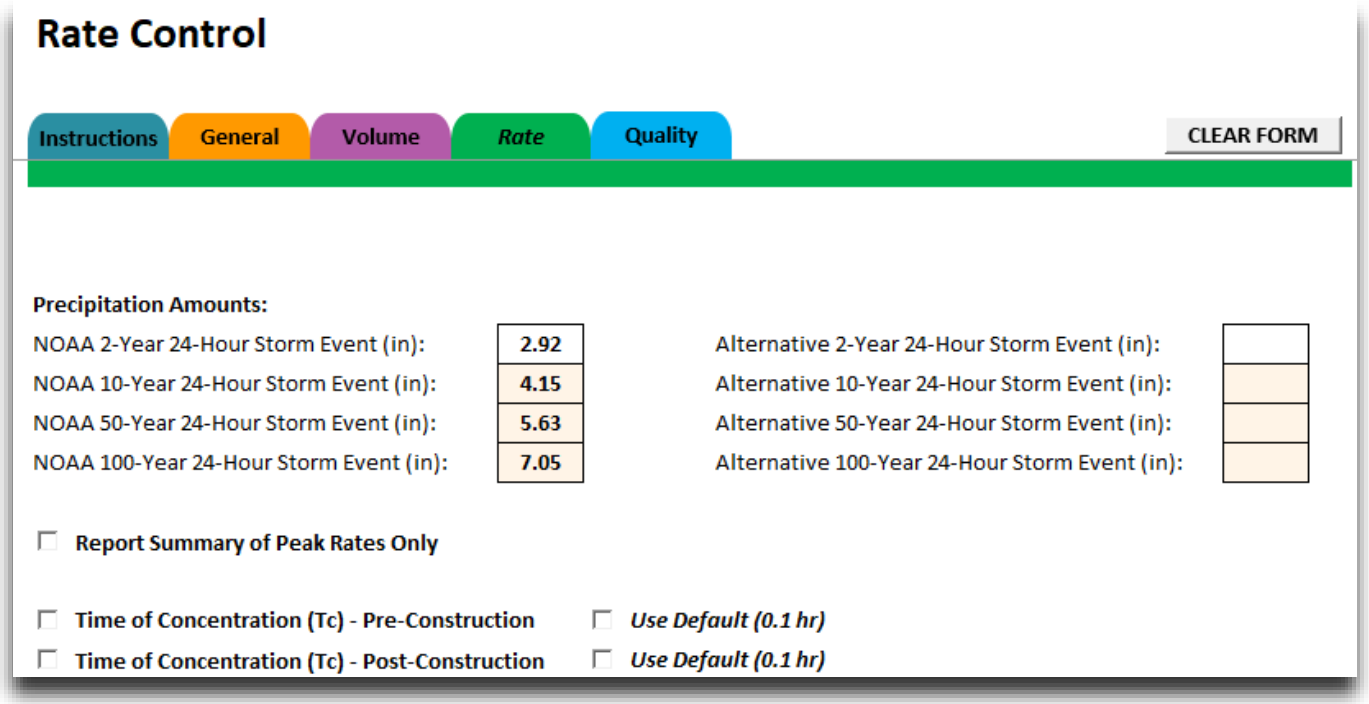
- **Total Credits** – The bottom of the worksheet displays the cumulative credits (non-structural, structural, managed release, capture and reuse, and riparian forest buffer credits) and compares it to the net change in volume to manage, calculated previously. When the number of credits meets or exceeds the net change in volume, satisfaction of the volume management requirement will be shown in green text; in the interim, red text will indicate the volume requirement is not satisfied.

INFILTRATION & ET CREDITS (CF):	22,478
MANAGED RELEASE CREDIT (CF):	13,785
CAPTURE AND REUSE CREDIT (CF):	26,000
RIPARIAN FOREST BUFFER CREDIT (CF):	1,286
NET CHANGE IN VOLUME TO MANAGE (CF):	61,222
TOTAL CREDITS (CF):	63,549

VOLUME REQUIREMENT SATISFIED

Rate Worksheet

The Rate Worksheet utilizes the design standard that applicants must manage the net change in peak rate for the 2-, 10-, 50- and 100-year/24-hour storm events. Peak rates are determined using the Graphical Peak Discharge Method in TR-55. The Rate Worksheet is intended for drainage areas less than 5 acres or for sites that contain simple land cover conditions (i.e., those projects where the limitations of the Graphical Peak Discharge Method do not apply). Any applicant with a project utilizing hydrological calculations that involve pond routings or otherwise involve multiple land covers may report a summary of peak rates in this worksheet but should not use the calculations in this worksheet to determine peak rates. In such cases the output of hydrologic modeling software should be attached to the permit application to demonstrate rate control requirements have been met.



The Rate Worksheet includes two possible advisory statements that may be displayed below the top menu:

1. If the criteria for a small site exception are satisfied as explained in the instructions for the General Worksheet, the following statement is displayed:

SMALL SITE EXCEPTION SATISFIED: RATE CONTROL NOT REQUIRED

2. If the weighted curve number for either pre-construction or post-construction conditions is less than 50, the Rate Worksheet should not be used due to the error associated with weighted curve numbers under 50 and the limitations of the Graphical Peak Discharge Method. In such cases, use hydrologic modeling software that enables the use of separate curve numbers. The user can report a summary of peak rates and attach model data or calculations. The following statement is displayed:

WEIGHTED CN FOR PRE- AND/OR POST-CONSTRUCTION CONDITIONS PRECLUDES USE OF RATE CALCULATIONS IN THIS WORKSHEET. REPORT SUMMARY OF PEAK RATES AND ATTACH MODEL DATA OR CALCULATIONS.

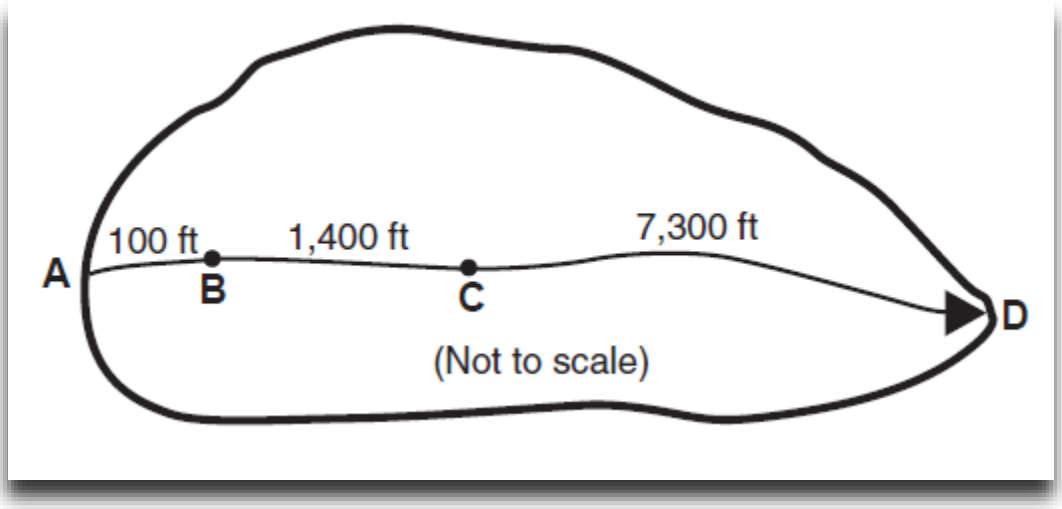
- **Precipitation Amounts** – Enter the NOAA Atlas 14 storm event totals for the 10-, 50- and 100-year/24-hour storm events (the 2-year/24-hour storm event total is reported as entered in the Volume Worksheet). If a different source of data was used for precipitation amounts, enter those values in the cells labeled for alternatives.

  NOTE 37 – If alternative precipitation amounts are utilized for the Rate Worksheet, they must be derived from the same source as the alternative precipitation amount used in the Volume Worksheet.

- **Report Summary of Peak Rates Only** – Users should select this box if modeling using software or other calculations are performed and the Rate Worksheet is not used for these calculations. Checking the box will provide a table where the user can manually enter pre- and post-construction peak rates for the storm events.

  NOTE 38 – The design of volume and rate control BMPs includes a consideration of stormwater from drainage areas that are outside of the disturbed area. BMP design calculations that are submitted as part of a PCSM Plan must include all stormwater flows routed to them, including those originating from outside the disturbed area, which is beyond the scope of the stormwater analysis that is the subject of DEP's PCSM Spreadsheet.

- **Time of Concentration (Tc) – Pre- and Post-Construction** – The time of concentration for pre- and post-construction runoff uses the methodologies contained in Chapter 3 of TR-55. The designer should be knowledgeable in determining the types of runoff and establishing hydraulic flow paths. A typical stormwater flow routing diagram is shown below ("D" is the BMP location or discharge point).



The user may check the box for "Use Default (0.1 hr)", if appropriate, to automatically set Tc values to 0.1 hour (6 minutes), which is the minimum recognized by the TR-55 method, in lieu of conducting further analysis. Note

that you should check the Time of Concentration boxes first, and then check the "Use Default (0.1 hr)" box, in order for automated calculations to occur.

Otherwise, click on the appropriate boxes for Sheet Flow, Shallow Concentrated Flow and Open Channel Flow to determine the travel time for each of these types of runoff. Each runoff type provides for two flow segments. Once the minimum necessary information is entered by the user into the highlighted cells, travel time is computed using Equations 3-3, 3-1 and 3-4 of TR-55 for Sheet Flow, Shallow Concentrated Flow and Open Channel Flow, respectively. The average velocity for Shallow Concentrated Flow is calculated by the spreadsheet using Figure 3-1 of TR-55 for paved and unpaved surfaces. Velocity for open channel and piped flow is computed using Manning's equation.

The Tc values for Pre- and Post-Construction are summed for all flow conditions and are presented for each storm event.

- **Peak Discharge Rates** – Upon completing the Time of Concentration section, the Peak Discharge Rates table will be completed to show the difference in the estimated peak rates between pre- and post-construction (without BMPs) for each storm event.

  - **Disturbed Area (mi^2)** – The Area of Earth Disturbance in Drainage Area (acres) entered on the General Worksheet is divided by 640 to present the disturbed area in terms of square miles for both pre- and post-construction conditions.

  - **Runoff Depth (inches)** – An area-weighted CN value is computed from the values entered into the Pre- and Post-Construction Volume Calculation Tables (i.e., one weighted CN for pre-construction and one for post-construction). The depth of runoff associated with the weighted CN values is then looked up using the default or user-entered peak design storm events, based on NRCS' National Engineering Handbook (Chapter 10, Estimation of Direct Runoff from Storm Rainfall, Appendix 10A).

  - **Unit Peak Discharge (csm/in)** – Unit peak discharges are calculated using the Graphical Peak Discharge Method (Chapter 4 of TR-55). The following steps are taken in the spreadsheet for this calculation:

    - Using the County selected on the General worksheet, the rainfall distribution type (A, B, C or D) is determined using a lookup chart based on the NRCS National Engineering Handbook Pennsylvania Notice 34 Supplement.

    - The initial abstraction (Ia) for the area-weighted CN is determined using Table 4-1 of TR-55.

    - Unit Peak Discharges are calculated using equation PA2-2 of the Pennsylvania Notice 34 Supplement, as shown below (**Equation 6**). Coefficients are derived using Tables A2-1 through A2-4 of the Supplement, which use the rainfall distribution type and the ratio of Ia to the various storm event totals (inches).

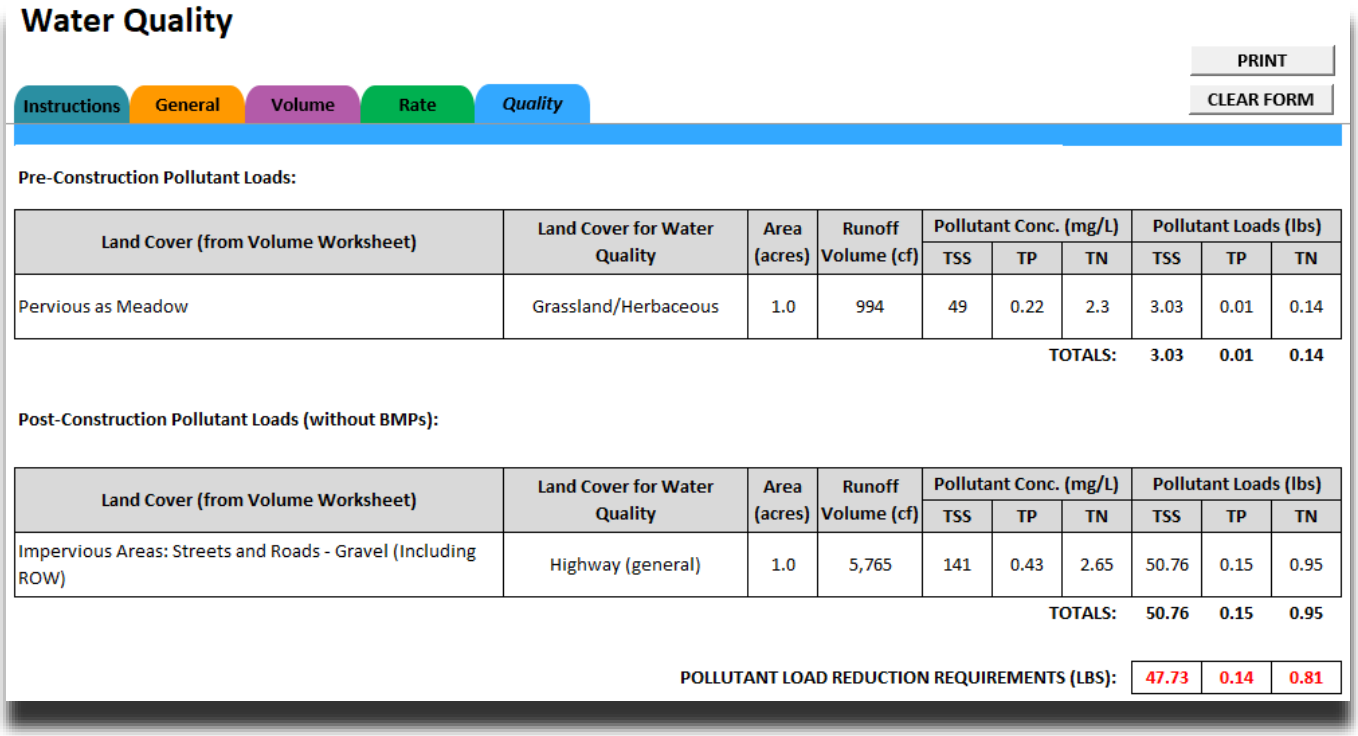
$$q = 10 \text{ ^ } (Coeff\_1 + Coeff\_2 * LOG(Tc) + Coeff\_3 * (LOG(Tc))^2)$$

  - **Peak Discharge Rates (cfs)** – The peak discharge rate for each storm event is calculated as the product of Disturbed Area (mi^2), Runoff Depth (inches) and Unit Peak Discharge (csm/in).

- **Peak Rate Mitigation** – BMPs that were selected on the Volume Worksheet are shown. The user must then enter the peak inflow and outflow rates to and from the BMP for the various storm events (calculations must be attached). A separate table is populated to show the differences between pre-construction rates, post-construction rates without BMPs, and post-construction rates with BMPs. Peak rates will be satisfied when green text is visible to the right of each storm event row.

Quality Worksheet

The Quality worksheet utilizes a design standard that applicants must manage the net change in pollutant loads for Total Suspended Solids (TSS), Total Phosphorus (TP) and Total Nitrogen (TN) up to and including the 2-year/24-hour storm event when compared to pre-construction pollutant loads.



Water Quality

PRINT | CLEAR FORM

Instructions | General | Volume | Rate | *Quality*

Pre-Construction Pollutant Loads:

Land Cover (from Volume Worksheet)	Land Cover for Water Quality	Area (acres)	Runoff Volume (cf)	Pollutant Conc. (mg/L)			Pollutant Loads (lbs)		
				TSS	TP	TN	TSS	TP	TN
Pervious as Meadow	Grassland/Herbaceous	1.0	994	49	0.22	2.3	3.03	0.01	0.14
						TOTALS:	3.03	0.01	0.14

Post-Construction Pollutant Loads (without BMPs):

Land Cover (from Volume Worksheet)	Land Cover for Water Quality	Area (acres)	Runoff Volume (cf)	Pollutant Conc. (mg/L)			Pollutant Loads (lbs)		
				TSS	TP	TN	TSS	TP	TN
Impervious Areas: Streets and Roads - Gravel (Including ROW)	Highway (general)	1.0	5,765	141	0.43	2.65	50.76	0.15	0.95
						TOTALS:	50.76	0.15	0.95
						POLLUTANT LOAD REDUCTION REQUIREMENTS (LBS):	47.73	0.14	0.81

- **Pre- and Post-Construction Pollutant Load Tables** – If the ***Automatically Calculate CN, Ia, Runoff and Volume*** box is checked in the Volume Worksheet, the Pre- and Post-Construction Pollutant Load tables are completed automatically.

  The Land Covers selected or entered in the Volume Worksheet are shown in these tables and a crosswalk is used to show the Land Covers for Water Quality purposes. A crosswalk is necessary because available research on pollutant concentrations has not categorized concentrations by TR-55 land uses. The crosswalk, pollutant concentrations, and data sources are presented in **Attachment B**.

  If the ***Automatically Calculate CN, Ia, Runoff and Volume box*** is not checked in the Volume Worksheet, the user must enter pollutant concentrations for TSS, TP and TN. Entry of "Land Cover for Water Quality" is optional. Attach justification of the manually entered pollutant concentrations.

  Pollutant Loads are calculated by **Equation 7**:

  Event Mean Pollutant Concentration (mg/L) x (Runoff Volume (calculated in Volume Worksheet) (CF) / 43,560 CF/acre-ft) x 2.72 (conversion factor)

  Below the Pollutant Load Tables the Pollutant Load Reduction Requirements for TSS, TP and TN are presented in lbs (Post-Construction – Pre-Construction Loads). The remainder of this worksheet addresses credits to ensure Post-Construction Pollutant Loads do not exceed Pre-Construction Pollutant Loads.

- **Characterize Undetained Areas (for Untreated Stormwater)** – This optional but recommended function allows the user to define the land cover of post-construction undetained areas, within the area of disturbance,

for a more accurate estimate of the pollutant loads draining off-site through untreated stormwater. Users can check the box and complete the table by selecting Land Cover, Area (acres), and Soil Type within post-construction undetained areas, similar to how runoff volumes are estimated in the Volume Worksheet. The pollutant loads for each land cover are determined using Equation 7 and are summed. These pollutant loads are reported under "Pollutant Loads for Untreated Stormwater" (see below), unless this function is not used.

If not used, a general estimate of pollutant loads in untreated stormwater is determined as follows:

Step 1 – The volume of untreated stormwater is estimated by subtracting the Total Volume Routed to Structural BMPs and Non-Structural BMP Volume Credits from the Total Post-Construction Volume. It is noted that for BMPs in series in which downstream BMPs receive stormwater from additional drainage area (i.e., beyond the drainage area of prior BMPs in series), this additional volume is considered treated stormwater.

Step 2 – Volume-weighted Event Mean Pollutant Concentrations are calculated and used to represent the average pollutant concentrations in stormwater runoff site-wide, regardless if the runoff is collected for treatment. Pollutant loads in untreated stormwater are then calculated using Equation 7, utilizing the runoff volume from Step 1 and the Volume-weighted Event Mean Pollutant Concentrations in Step 2.

While this function is optional, in many cases its use will be beneficial as the general approach can overestimate pollutant loads from undetained areas, and is necessary to claim Pervious Undetained Area Credit (below).

- **Non-Structural BMP Water Quality Credits**

  - **Pervious Undetained Area Credit** – DEP provides this credit to promote the minimization of impervious areas and in recognition that it may not be feasible or necessary to route all post-construction stormwater flows to structural BMPs. Based on available research, DEP is applying reductions of 25%, 20%, and 15% from the Event Mean Pollutant Concentrations for TSS, TP, and TN for all post-construction land covers that are not impervious, as follows:

    - TSS Credit: 48.8 mg/L x 0.25 = 12.2 mg/L
    - TP Credit: 0.22 mg/L x 0.2 = 0.044 mg/L
    - TN Credit: 2.3 mg/L x 0.15 = 0.345 mg/L

    When the box next to ***Pervious Undetained Area Credit*** is checked, assuming the Characterization of Undetained Areas box is checked and the table has been completed, the credit, in lbs, is calculated by (**Equation 8**):

    (Runoff Volume for Pervious (non-Impervious) Undetained Area (CF) / 43,560 CF/acre-ft) x TSS, TP, and TN Credits (mg/L) x 2.72 (conversion factor)

    NOTE 39 – In prior versions of the PCSM Spreadsheet, DEP provided a volume credit for pervious undetained areas based on ET. Since ET is incorporated into the Curve Number approach, DEP no longer believes it is appropriate to provide volume credit, but believes water quality credit can be provided.

  - **Other Credit –** If the user is claiming other non-structural BMP water quality credits, the user should enter a description of the non-structural BMP(s), enter the pollutant load reductions in the appropriate cells, and attach the supporting documentation to the permit application or the Quality Worksheet.

    NOTE 40 – Street sweeping may be claimed as a water quality "Other Credit" by attaching pollutant load reduction calculations to the spreadsheet or application where the calculations are consistent with the Stormwater BMP Manual or utilize other technically sound methods.

    NOTE 41 – When water quality filters or other stormwater treatment devices are used for pretreatment of stormwater prior to other structural BMPs, pollutant removal from the filters or devices are not automatically reflected in the Structural BMP Water Quality Credits table. Water quality credit is only

calculated for those structural BMPs that discharge off-site. Upstream BMPs in series provide water quality benefit in the Structural BMP Water Quality Credits table only to the extent that volume is reduced. In the case of water quality filters and other devices, volume reduction does not take place, so the user must use a different approach to reflect water quality credit. A user can incorporate water quality credit for such filters or devices by reporting pollutant load reduction as an "Other Credit" or the user may manually adjust BMP Outflow Concentrations, as discussed below (in either case supporting calculations must be attached).

- **Structural BMP Water Quality Credits** – The BMPs that were selected in the Volume Worksheet will be displayed on the Quality Worksheet. As noted above, if there are BMPs that function only to improve water quality, such as inlet filters, such BMPs should be recorded on the Volume Worksheet, so that those BMPs are shown on the Quality Worksheet (although manual credit calculations will need to be provided).

☑ **Structural BMP Water Quality Credits:**

☑ *Use default BMP Outflows and Median BMP Outflow Concentrations*

DP No.	BMP No.	BMP Name	Series	BMP DA (acres)	Vol. Routed to BMP (CF)	Inf. & ET Credits (CF)	Capture Credits (CF)	Outflow (CF)	Outflow Conc. (mg/L)			Pollutant Loads (lbs)		
									TSS	TP	TN	TSS	TP	TN
001	1	Infiltration Basin	-	5.00	23,000	5,679		17,321	10	0.24	1.04	10.82	0.26	1.12

The box for ***Use default BMP Outflows and Median BMP Outflow Concentrations*** is checked by default. When checked, Structural BMP Water Quality Credits will be calculated automatically for each BMP.

NOTE 42 – If the name of a BMP is entered by the user (rather than selected from the drop-down list) in the Volume Worksheet, the user must de-select the ***Use default BMP Outflows and Median BMP Outflow Concentrations*** box so that outflow concentrations (as described below) can be manually entered. The user may also wish to de-select this box to reflect alternative BMP Outflow Concentrations when water quality filters or devices are used as pretreatment.

The following describes the calculations in this table:

- **Outflow (CF)** – The Volume Routed to BMP, Infiltration (Inf.) & Evapotranspiration (ET) Credits, and (Reuse and) Capture & (Riparian Forest) Buffer Credits are displayed as entered or calculated on the Volume Worksheet. Outflow is calculated as the difference between Volume Routed to BMP and Inf. & ET Credits and Capture & Buffer Credits. This volume, which represents the volume not permanently removed by a BMP, is then used to calculate pollutant loads as the outflow volume.

  If the user wishes to use a BMP-specific outflow volume, uncheck the box for ***Use default BMP Outflows and Median BMP Outflow Concentrations*** (and attach calculations).

- **Outflow Concentrations (Conc.) (mg/L)** – Median BMP outflow concentrations are utilized from the International Stormwater BMP Database, 2016 Summary Statistics, Final Report (The Water Environment & Reuse Foundation). As additional research is completed and new data are available, DEP will update BMP Outflow Concentrations accordingly. The following table presents the outflow concentrations used in the Quality Worksheet for the standard BMPs:

BMP	Median Outflow TSS	Median Outflow TP	Median Outflow TN
Porous Pavement w/Infiltration Bed	26	0.11	1.19
Infiltration Basin	10	0.24	1.04
Infiltration Bed	24.3	0.19	1.19
Infiltration Trench	24.3	0.19	1.19

BMP	Median Outflow TSS	Median Outflow TP	Median Outflow TN
Rain Garden / Bioretention	10	0.24	1.04
Dry Well / Seepage Pit	24.3	0.19	1.19
Constructed Filter	9	0.09	1.05
Vegetated Swale	24	0.2	0.85
Vegetated Filter Strip	19	0.17	1.13
Infiltration Berm & Retentive Grading	24	0.2	0.85
Vegetated Roof	19	0.17	1.13
Capture and Reuse	N/A	N/A	N/A
Constructed Wetland	12	0.1	1.31
Wet Pond / Retention Basin	11.7	0.09	1.2
Dry Extended Detention Basin	24.3	0.19	1.19
Water Quality Filters & Hydrodynamic Devices	9	0.09	1.05
Floodplain Restoration	10	0.24	1.04
Soil Amendment	19	0.17	1.13
Riparian Buffer	10	0.24	1.04

NOTE 43 – A crosswalk is used to align BMP descriptions in the International Stormwater BMP Database with BMPs identified in the Stormwater BMP Manual.

If the user wishes to use alternative BMP outflow concentrations for TSS, TP and TN, uncheck the box for ***Use default BMP Outflows and Median BMP Outflow Concentrations***.

NOTE 44 – Pollutant concentrations are not assigned to the outflows of MRC BMPs that discharge off-site, and therefore pollutant loads are not calculated, as pollutants in such outflows are considered to be managed. See NOTE 23.

- **Pollutant Loads (lbs)** – Pollutant Loads in BMP Outflows are calculated by the equation:

  Median BMP Outflow Concentration (mg/L) x (Outflow (CF) / 43,560 CF/acre-ft) x 2.72 (conversion factor)

- **Pollutant Load Summary Table** – Below the table for Structural BMP Water Quality Credits is a summary of pollutant loading data:

	TSS	TP	TN
POLLUTANT LOADS FROM STRUCTURAL BMP (TREATED) OUTFLOWS (LBS):	0.71	0.01	0.08
POLLUTANT LOADS FROM UNTREATED STORMWATER (LBS):	0.00	0.00	0.00
NON-STRUCTURAL BMP WATER QUALITY CREDITS (LBS):	0.00	0.00	0.00
NET POLLUTANT LOADS FROM SITE, POST-CONSTRUCTION (LBS):	0.71	0.01	0.08
POLLUTANT LOADS FROM SITE, PRE-CONSTRUCTION (LBS):	3.03	0.01	0.14

WATER QUALITY REQUIREMENT SATISFIED

- **Pollutant Loads from Structural BMP (Treated) Outflows (lbs)** – The total pollutant loads flowing out of structural BMPs is calculated and displayed.

- **Pollutant Loads from Untreated Stormwater (lbs)** – The pollutant loads associated with untreated stormwater are calculated as explained in the section for Characterization of Undetained Areas, above.

- **Non-Structural BMP Water Quality Credits (lbs)** – Credits entered in the worksheet for non-structural BMPs, if applicable.

- **Net Pollutant Loads from Site, Post-Construction (lbs)** – The Net Pollutant Loads from the project site following construction is calculated by (**Equation 9**):

  Pollutant Loads from Structural BMP (Treated Outflows) (lbs) + Pollutant Loads from Untreated Stormwater (lbs) – Non-Structural BMP Water Quality Credits (lbs)

  If the Net Pollutant Loads from Site, Post-Construction, are less than or equal to the Pollutant Loads from Site, Pre-Construction, the calculated values will be shown in green text and a statement will be displayed, "Water Quality Requirements Satisfied." Otherwise, pollutants that have post-construction loads greater than pre-construction loads will be shown in red.

Certification – Enter the name of the person who utilized the spreadsheet, which serves as an electronic signature, and the date the spreadsheet is signed, after reading the Certification statement. The spreadsheet should not be modified; if this recommendation is not followed, the user should attach an explanation of what modifications to the spreadsheet were made. DEP/CCD reviewers may request an electronic copy of the spreadsheet to aid in their review when deemed appropriate.

ATTACHMENT A
BMPs IN SERIES EXAMPLE

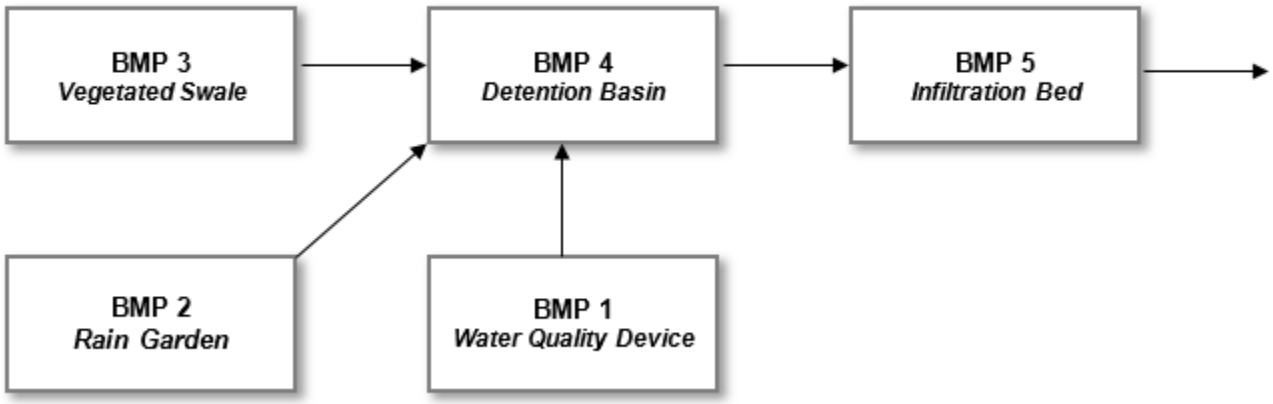
DEP provides this example of how BMPs in series may be entered into the DEP PCSM Spreadsheet to assist applicants.

The example site is located in Ferguson Township, Centre County. The project site is comprised of 6.90 acres of existing meadow in good condition, which slopes from the north to the south. Original drainage patterns will be maintained to the extent possible. The proposed improvements will consist of impervious and grass in good condition covers distributed across the site. The soil's Hydrological Soil Group is C across the entire project site. The proposed development includes 3.13 acres of impervious area, and 0.04 acres of undetained area (i.e., area that is not treated or managed by a BMP).

The stormwater runoff from the northern portion of the site will be collected, conveyed, and managed by 1) a vegetated swale (BMP 3) at the western portion of the site, 2) a rain garden (BMP 2) at the central portion, and 3) a storm sewer system with a water quality device (BMP 1) at the eastern portion of the site. The vegetated swale, rain garden, and water quality device discharge to a detention basin (BMP 4) that is located at the southern portion of the site. The detention basin discharges to an infiltration bed (BMP 5) that is adjacent to the southern property boundary. See Figure A-1 below.

The vegetated swale, rain garden and detention basin each contain 6 inches of filter soil mixture to promote water quality. The rain garden (BMP 2) will also be built with a 6-inch berm to provide surface stormwater volume storage. Overflow from the rain garden (BMP 2) will sheet flow to the detention basin (BMP 4). A water quality device (BMP 1) will be installed in the storm sewer system for initial treatment of that discharge before it enters the detention basin (BMP 4). The detention basin (BMP 4) is equipped with a typical outlet structure with a pipe that discharges into the subsurface infiltration bed (BMP 5). The infiltration bed (BMP 5) will be constructed with a 0.4-foot depression and 0.5 foot of topsoil over 0.6 foot of stone.

Figure A-1: Example BMP Diagram



Infiltration tests have been conducted uniformly across the entire site and suitable results were only found at the locations of the proposed rain garden (BMP 2) and infiltration bed (BMP 5). A geometric mean result of 1.5 inches per hour was determined. Shallow bedrock was encountered elsewhere throughout the site. Since there will be less than 2 feet of separation distance between the bottom of the other proposed BMPs and top of bedrock, infiltration will not be utilized. No groundwater was encountered during the geotechnical testing.

Design Considerations

The drainage areas to each of the 5 BMPs will be delineated and labeled as Drainage Area A for the storm sewer system with the Water Quality Device (BMP 1), Drainage Area B to the Rain Garden (BMP 2), Drainage Area 1 to

the Vegetated Swale (BMP 3), Drainage Area 2 to the Detention Basin (BMP 4) and Drainage Area 3 to the Infiltration Bed (BMP 5). A marginal area below the Infiltration Bed will bypass the BMPs and has been labeled as Undetained Area. The areas are shown in Figure A-2 below and are tabulated in the calculations.

It is important to label the BMPs and corresponding drainage areas in a logical order and remain consistent in entering the data onto the PCSM Spreadsheet. The final, and critical, BMP in the series should be placed last on the Structural BMP Volume Credits table. Consideration needs to be taken to list all of the BMPs that either perform volume removal and/or water quality functions. Improper data entry into the worksheets will cause incorrect results.

Infiltration, subsurface and above grade stormwater volume storage is demonstrated in this example. Understanding how each BMP functions is vital to successfully completing the Volume and Quality Worksheets.

Modeling the Series

The Vegetated Swale (BMP 3), Rain Garden (BMP 2) and Water Quality Device (BMP 1) all contribute to the downstream Detention Basin (BMP 4) so we will need to determine how to set up the series. Based upon the labeling of the drainage areas and numbering of the BMPs, the proceeding calculations will be presented to demonstrate how to account for the routed volume inflow and resultant outflow.

Figure A-2: Example Drainage Area Plan (not to scale)

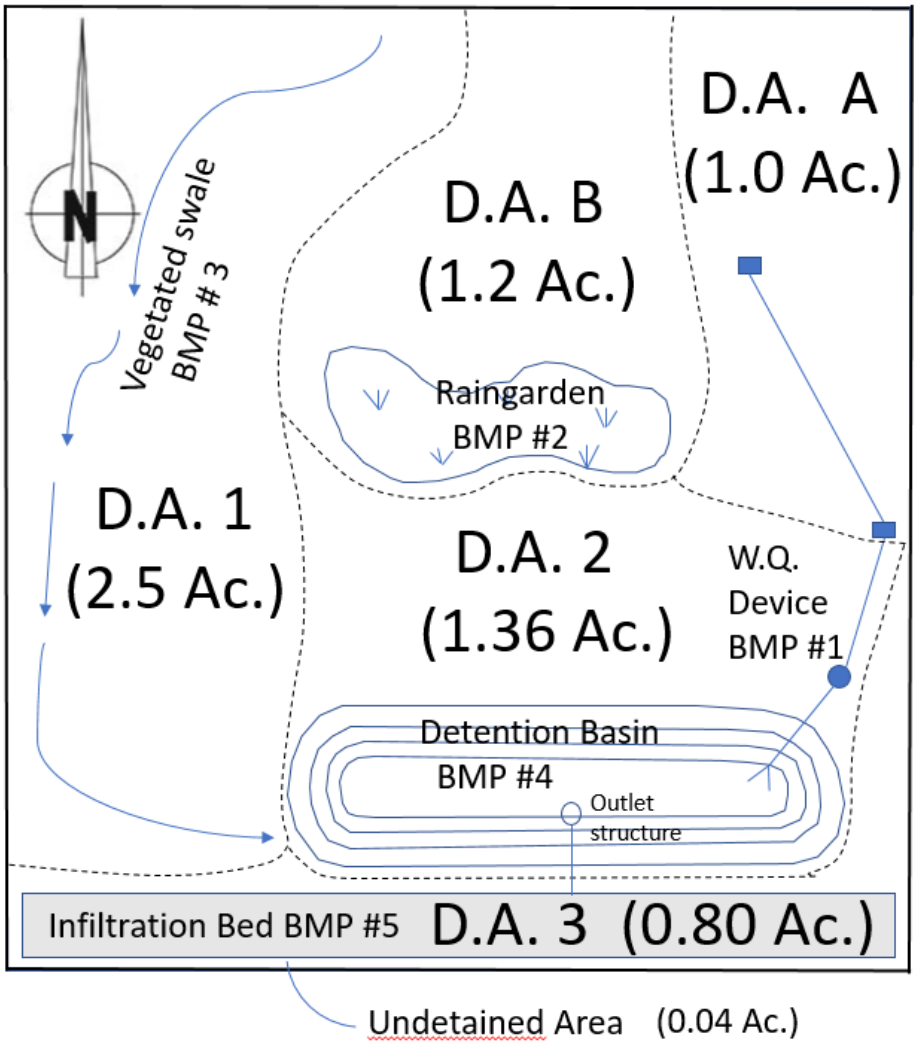


Table A-1 provides the distribution of drainage areas for the project site. In this example the entire project site of 6.90 acres will be disturbed, with 6.86 acres draining to BMPs and 0.04 acre bypassing the infiltration bed (BMP 5).

Table A-1: Example Drainage Area Distribution

Drainage Area	BMP	Total Drainage Area (Acres)*	Impervious Cover (Acres)	Vegetated Cover (Acres)
A	Water Quality Device (BMP 1)	1.00	0.67	0.33
B	Rain Garden (BMP 2)	1.20	0.95	0.25
1	Vegetated Swale (BMP 3)	2.50	0.60	1.90
2	Detention Basin (BMP 4)	1.36	0.91	0.45
3	Infiltration Bed (BMP 5)	0.80	0.00	0.80
---	Undetained	0.04	0.00	0.04

*To be input into the "Incremental BMP DA (acres)" column in the Volume Worksheet. Note that if a downstream BMP receives only the discharge from an upstream BMP, the incremental BMP DA would be entered as 0.

Surface areas of the vegetated BMPs are shown in Table A-2 below:

Table A-2: Example Surface Areas for Vegetated BMPs

Drainage Area	BMP	Bottom Surface Area (SF)*
B	Rain Garden (BMP 2)	4,300
1	Vegetated Swale (BMP 3)	767
2	Detention Basin (BMP 4)	6,500
3	Infiltration Bed (BMP 5)	11,000

*To be input into the "Infiltration/Vegetated Area (SF)" column in the Volume Worksheet.

The design infiltration rates listed in Table A-3 have used a safety factor of 3, resulting in 0.5 in/hr for the Rain Garden (BMP 2) and Infiltration Bed (BMP 5). The other results were not suitable so 0.0 is listed.

Table A-3: Example Infiltration Rates for BMPs

Drainage Area	BMP	Design infiltration rate (in/hr)
B	Rain Garden (BMP 2)	0.50
1	Vegetated Swale (BMP 3)	0.00
2	Detention Basin (BMP 4)	0.00
3	Infiltration Bed (BMP 5)	0.50

Next calculations are completed to determine volumes routed to BMPs. Before the final routed volume to the Infiltration Bed (BMP 5) can be determined, calculations for the Water Quality Device (BMP 1) and the Rain Garden (BMP 2) must be completed to apply the results to the downstream BMPs in the series. The calculations for the total volume of runoff for each individual drainage area used the TR-55 standard equations, as contained in the PCSM Spreadsheet. The 2-year/24-hour rainfall is 3.0 inches (i.e., P = 3.0 inches) for this example.

First, calculate the runoff volumes for the Water Quality Device (BMP 1) and the Rain Garden (BMP 2).

Post-Development DA = A (Water Quality Device)

Land Cover	Area (acres)	Soil Group	CN	Ia (in)	Q Runoff (in)	Runoff Volume (cf)
Impervious Areas: Paved Parking Lots, Roofs, Driveways, Etc. (Excluding ROW)	0.67	C	98	0.041	2.77	6,733
Open Space (Lawns, Parks, Golf Courses, Cemeteries, Etc.) - Good Condition (Grass Cover > 75%)	0.33	C	74	0.703	0.91	1,088
TOTAL (ACRES):	**1.00**				**TOTAL (CF):**	**7,821**

Post-Development DA = B (Rain Garden)

Land Cover	Area (acres)	Soil Group	CN	Ia (in)	Q Runoff (in)	Runoff Volume (cf)
Impervious Areas: Paved Parking Lots, Roofs, Driveways, Etc. (Excluding ROW)	0.95	C	98	0.041	2.77	9,546
Open Space (Lawns, Parks, Golf Courses, Cemeteries, Etc.) - Good Condition (Grass Cover > 75%)	0.25	C	74	0.703	0.91	824
TOTAL (ACRES):	**1.20**				**TOTAL (CF):**	**10,371**

The computed runoff volumes are entered into the "Volume Routed to BMP (CF)" column on the Volume Worksheet on each respective row as shown below.

DP No.	BMP No.	BMP Name	MRC?	Discharge	Incremental BMP DA (acres)	Volume Routed to BMP (CF)	Infiltration / Vegetated Area (SF)	Infiltration Rate (in/hr)	Infiltration Period (hrs)	Vegeta-ted?	Media Depth (ft)	Storage Volume (CF)	Infiltration Credit (CF)	ET Credit (CF)
001	1	Water Quality Filters & Hydrodynamic Devices	-	to BMP No. 4	1.00	7,821								
001	2	Rain Garden / Bioretention	-	to BMP No. 4	1.20	10,371	4,300	0.50	58	Yes	0.5	2,795	**4,730**	**737**
												Totals:	**4,730**	**737**

The infiltration, vegetated, media and storage information are not applicable for the Water Quality Device (BMP 1), so those inputs are left blank. This particular type of BMP does not retain or infiltrate any inflow but only treats the stormwater runoff and discharges the entire volume. Any BMP that contributes to water quality, whether or not it has a volume removal function, should be included on the Structural BMP Volume Credit table of the Volume Worksheet.

Next, the infiltration period for the Rain Garden (BMP 2) must be determined. The Rain Garden's infiltration surface area is 4,300 SF (as identified previously). The 0.50 in/hr infiltration rate can be converted to feet per hour by dividing 0.50 in/hr by 12 inches per foot (which equates to 0.0417 ft/hr). The infiltration capacity is 4,300 SF x 0.0417 ft/hr = 179.31 CF/hr. The dewatering time can then be calculated by taking the inflow volume divided by this rate, or 10,371 CF / 179.31 CF/hr = 57.8 hours. The Rain Garden's (BMP 2) infiltration period will be the dewatering time, rounded up to 58 hours.

> **NOTE 43** – The BMP's bottom surface must be vegetated in order to qualify for ET credit. Also, if the "Vegetated" column is left blank or designated as "No", then ET credit will not be calculated.

Finally, for the Rain Garden (BMP 2), the Storage Volume must be determined. Given 6 inches (0.5 ft) of filter soil mixture (assuming 30% void space), and the 6-inch (0.5 ft) berm, the storage volume is calculated as follows: 4,300 SF x [(0.5 ft soil x 0.30) + 0.5 ft berm] = 2,795 CF. Entry of this Storage Volume into the worksheet will result in the calculation of infiltration and ET credits.

The next BMP contributing to the Detention Basin (BMP 4) is the Vegetated Swale (BMP 3). The runoff volume that is calculated to BMP 3 is as follows:

Post-Development DA = 1 (Vegetated Swale)

Land Cover	Area (acres)	Soil Group	CN	Ia (in)	Q Runoff (in)	Runoff Volume (cf)
Open Space (Lawns, Parks, Golf Courses, Cemeteries, Etc.) - Good Condition (Grass Cover > 75%)	1.90	C	74	0.703	0.91	6,264
Impervious Areas: Paved Parking Lots, Roofs, Driveways, Etc. (Excluding ROW)	0.60	C	98	0.041	2.77	6,029
TOTAL (ACRES):	**2.50**				**TOTAL (CF):**	**12,293**

The Vegetated Swale (BMP 3) has been designed to primarily convey runoff so it was designed without berms to retain stormwater runoff (i.e., no surface storage volume). Credit can still be taken for the 6 inches of subsurface filter soil, and the Storage Volume is calculated as 767 SF x 0.5 ft soil x 0.30 (30% voids) = 115 cubic feet. BMP 3 is then added to the Structural BMP Volume Credits table, where the 12,293 CF of runoff calculated previously is entered as the Volume Routed to BMP:

DP No.	BMP No.	BMP Name	MRC?	Discharge	Incremental BMP DA (acres)	Volume Routed to BMP (CF)	Infiltration / Vegetated Area (SF)	Infiltration Rate (in/hr)	Infiltration Period (hrs)	Vegeta-ted?	Media Depth (ft)	Storage Volume (CF)	Infiltration Credit (CF)	ET Credit (CF)
001	1	Water Quality Filters & Hydrodynamic Devices	-	to BMP No. 4	1.00	7,821								
001	2	Rain Garden / Bioretention	-	to BMP No. 4	1.20	10,371	4,300	0.50	58	Yes	0.5	2,795	**4,730**	**737**
001	3	Vegetated Swale	-	to BMP No. 4	2.50	12,293	767	0.00		Yes	0.5	115		**132**
												Totals:	**4,730**	**869**

All three of these BMPs (Water Quality Device (BMP 1), Rain Garden (BMP 2) and Vegetated Swale (BMP 3)) contribute runoff to the Detention Basin (BMP 4). The resultant inflow into the Detention Basin (BMP 4) is the sum of the individual contributions of the upstream BMPs minus their volume removal credits.

The sum of all of the inflow volumes for BMPs 1 through 3 are 7,821 CF + 10,371 CF + 12,293 CF = 30,485 CF.

The sum of all of the infiltration and ET credits for BMPs 1 through 3 are 4,730 CF + 737 CF + 132 CF = 5,599 CF.

The resultant inflow, from the upstream BMPs 1 through 3, into the Detention Basin (BMP 4) is 30,485 CF – 5,599 CF = 24,886 CF.

The drainage area tributary to the Detention Basin (BMP 4) adds an additional volume of 10,628 CF as shown in the calculation below:

Post-Development DA = 2 (Detention Basin)

Land Cover	Area (acres)	Soil Group	CN	Ia (in)	Q Runoff (in)	Runoff Volume (cf)
Open Space (Lawns, Parks, Golf Courses, Cemeteries, Etc.) - Good Condition (Grass Cover > 75%)	0.45	C	74	0.703	0.91	1,484
Impervious Areas: Paved Parking Lots, Roofs, Driveways, Etc. (Excluding ROW)	0.91	C	98	0.041	2.77	9,144
TOTAL (ACRES):	**1.36**				**TOTAL (CF):**	**10,628**

A total of 35,514 CF therefore flows to the Detention Basin (BMP 4) (i.e, 24,886 CF from BMPs 1 – 3 + 10,628 CF from BMP 4 Drainage Area).

DP No.	BMP No.	BMP Name	MRC?	Discharge	Incremental BMP DA (acres)	Volume Routed to BMP (CF)	Infiltration / Vegetated Area (SF)	Infiltration Rate (in/hr)	Infiltration Period (hrs)	Vegeta-ted?	Media Depth (ft)	Storage Volume (CF)	Infiltration Credit (CF)	ET Credit (CF)
001	1	Water Quality Filters & Hydrodynamic Devices	-	to BMP No. 4	1.00	7,821								
001	2	Rain Garden / Bioretention	-	to BMP No. 4	1.20	10,371	4,300	0.50	58	Yes	0.5	2,795	**4,730**	**737**
001	3	Vegetated Swale	-	to BMP No. 4	2.50	12,293	767	0.00		Yes	0.5	115		**132**
001	4	Dry Extended Detention Basin	-	to BMP No. 5	1.36	35,514	6,500	0.00		Yes	0.5	975		**1,115**
												Totals:	**4,730**	**1,984**

The Detention Basin (BMP 4) was not designed for infiltration due to the encountered limiting zone for bedrock; therefore, it will completely dewater through the outlet structure. However, there will be Storage Volume associated with the 6 inches of filter soil mixture, calculated as follows: 6,500 SF x 0.5 ft x 0.30 (30% voids) = 975 CF. The 1,115 CF of ET credit will be subtracted from the Volume Routed to BMP 4 of 35,514 CF to produce a discharge of 35,514 CF – 1,115 CF = 34,399 CF, which is routed to the Infiltration Bed (BMP 5).

The total routed flow into the Infiltration Bed (BMP 5) will be the 34,399 CF plus the runoff from the Infiltration Bed's drainage area, which is 2,638 CF, as shown below.

Post-Development DA = 3 (Infiltration Bed)

Land Cover	Area (acres)	Soil Group	CN	Ia (in)	Q Runoff (in)	Runoff Volume (cf)
Open Space (Lawns, Parks, Golf Courses, Cemeteries, Etc.) - Good Condition (Grass Cover > 75%)	0.80	C	74	0.703	0.91	2,638
Impervious Areas: Paved Parking Lots, Roofs, Driveways, Etc. (Excluding ROW)	0.00	C	98	0.041	2.77	0
TOTAL (ACRES):	**0.80**				**TOTAL (CF):**	**2,638**

Therefore, the total volume routed to the Infiltration Bed is 34,399 CF + 2,638 CF = 37,037 CF.

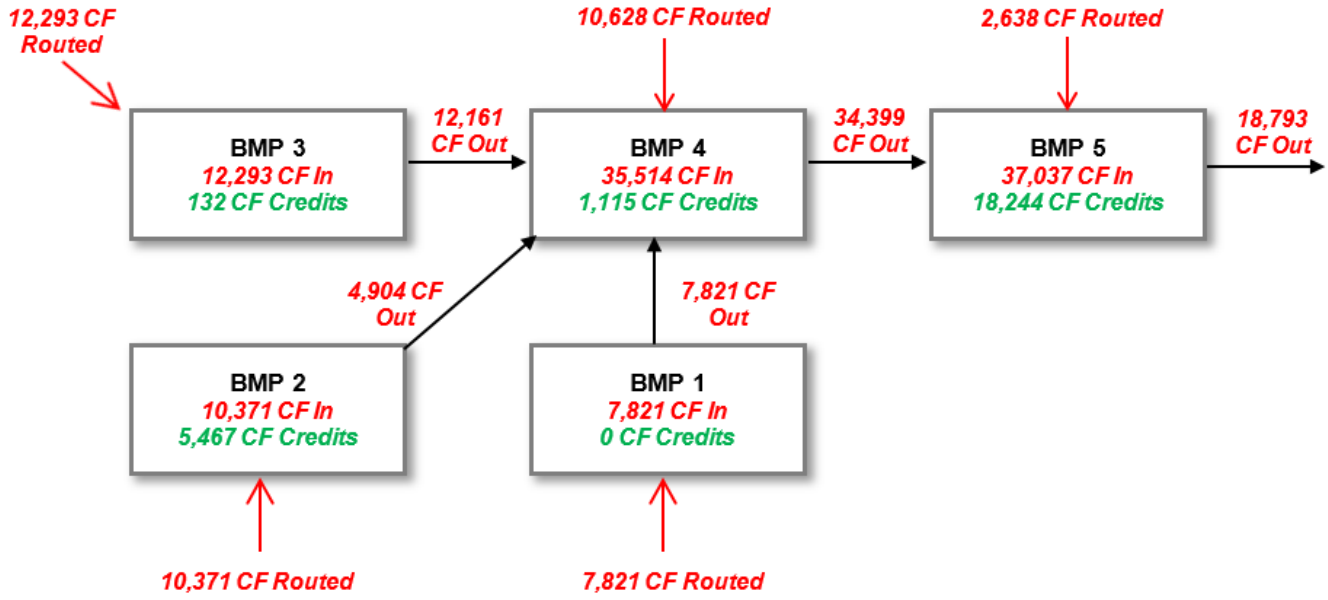
DP No.	BMP No.	BMP Name	MRC?	Discharge	Incremental BMP DA (acres)	Volume Routed to BMP (CF)	Infiltration / Vegetated Area (SF)	Infiltration Rate (in/hr)	Infiltration Period (hrs)	Vegeta-ted?	Media Depth (ft)	Storage Volume (CF)	Infiltration Credit (CF)	ET Credit (CF)
001	1	Water Quality Filters & Hydrodynamic Devices	-	to BMP No. 4	1.00	7,821								
001	2	Rain Garden / Bioretention	-	to BMP No. 4	1.20	10,371	4,300	0.50	58	Yes	0.5	2,795	**4,730**	**737**
001	3	Vegetated Swale	-	to BMP No. 4	2.50	12,293	767	0.00		Yes	0.5	115		**132**
001	4	Dry Extended Detention Basin	-	to BMP No. 5	1.36	35,514	6,500	0.00		Yes	0.5	975		**1,115**
001	5	Infiltration Bed	-	Off-Site	0.80	37,037	11,000	0.50	81	Yes	1.5	8,690	**13,640**	**4,604**
												Totals:	**18,370**	**6,587**

The infiltration period for the Infiltration Bed (BMP 5) is determined by calculating the dewatering time: 11,000 SF x 0.0417 ft/hr = 458.7 CF/hr. The inflow volume of 37,037 CF is divided by 458.7 CF/hr, resulting in 80.74 hours, which is rounded up to 81 hours.

The media depth includes 0.6 ft stone (40% voids), 0.5 ft topsoil (30% voids) and 0.4 ft of depressed area above grade or 11,000 SF x [(0.6 ft)(0.40) + (0.5 ft)(0.30) + 0.4 ft] = 8,690 CF.

A water balance for this example project is shown in Figure A-3 below.

Figure A-3: Example Water Balance for BMPs in Series



Careful organization and data entry must be taken to accurately calculate the volume removal for any BMPs in series. If multiple BMPs contribute to a singular BMP in another series, then a flow chart and supporting calculations should be provided and the final result input into the BMP in series provided on the worksheet. It is good to remember that all shaded cells (except those previously noted above) need to be completed for the calculations to run properly. Therefore, this will become a row-by-row iterative procedure to obtain all of the proper routed volumes and credits to apply to downstream BMPs in a series.

ATTACHMENT B
LAND COVER CROSSWALK AND POLLUTANT CONCENTRATIONS

Pre-Construction Land Covers

Land Cover for Volume (Based on TR-55)	Land Cover for Water Quality	Event Mean Pollutant Concentrations			Source
		TSS (mg/L)	TP (mg/L)	TN (mg/L)	
Impervious	Impervious (Mixed Use)*	116	0.35	2.57	3
Impervious as Meadow	Grassland/Herbaceous	48.8	0.22	2.3	1
Pervious as Meadow	Grassland/Herbaceous	48.8	0.22	2.3	1
Forested (Good Condition)	Deciduous Forest/Evergreen Forest/Mixed Forest	45	0.13	1.05	1

* Average event mean pollutant concentrations are used for residential, urban highway, and highway (general).

Post-Construction Land Covers

Land Cover for Volume (TR-55)	Land Cover for Water Quality	Event Mean Pollutant Concentrations			Source
		TSS (mg/L)	TP (mg/L)	TN (mg/L)	
Fallow - Bare Soil	Cultivated Crops	216	1.07	7.7	1
Fallow - Crop Residue Cover (Poor Condition)	Cultivated Crops	216	1.07	7.7	1
Fallow - Crop Residue Cover (Good Condition)	Cultivated Crops	216	1.07	7.7	1
Row Crops - Straight Row (Poor Condition)	Pasture/Hay	145	0.55	5.71	1
Row Crops - Straight Row (Good Condition)	Pasture/Hay	145	0.55	5.71	1
Row Crops - Straight Row & Crop Residue (Poor Condition)	Cultivated Crops	216	1.07	7.7	1
Row Crops - Straight Row & Crop Residue (Good Condition)	Cultivated Crops	216	1.07	7.7	1
Row Crops - Contoured (Poor Condition)	Pasture/Hay	145	0.55	5.71	1
Row Crops - Contoured (Good Condition)	Pasture/Hay	145	0.55	5.71	1
Row Crops - Contoured & Crop Residue (Poor Condition)	Cultivated Crops	216	1.07	7.7	1
Row Crops - Contoured & Crop Residue (Good Condition)	Cultivated Crops	216	1.07	7.7	1

Land Cover for Volume (TR-55)	Land Cover for Water Quality	Event Mean Pollutant Concentrations			Source
		TSS (mg/L)	TP (mg/L)	TN (mg/L)	
Row Crops - Contoured & Terraced (Poor Condition)	Pasture/Hay	145	0.55	5.71	1
Row Crops - Contoured & Terraced (Good Condition)	Pasture/Hay	145	0.55	5.71	1
Row Crops - Contoured, Terraced & Crop Residue (Poor Condition)	Cultivated Crops	216	1.07	7.7	1
Row Crops - Contoured, Terraced & Crop Residue (Good Condition)	Cultivated Crops	216	1.07	7.7	1
Small Grain - Straight Row (Poor Condition)	Pasture/Hay	145	0.55	5.71	1
Small Grain - Straight Row (Good Condition)	Pasture/Hay	145	0.55	5.71	1
Small Grain - Straight Row & Crop Residue (Poor Condition)	Cultivated Crops	216	1.07	7.7	1
Small Grain - Straight Row & Crop Residue (Good Condition)	Cultivated Crops	216	1.07	7.7	1
Small Grain - Contoured (Poor Condition)	Pasture/Hay	145	0.55	5.71	1
Small Grain - Contoured (Good Condition)	Pasture/Hay	145	0.55	5.71	1
Small Grain - Contoured & Crop Residue (Poor Condition)	Cultivated Crops	216	1.07	7.7	1
Small Grain - Contoured & Crop Residue (Good Condition)	Cultivated Crops	216	1.07	7.7	1
Small Grain - Contoured & Terraced (Poor Condition)	Pasture/Hay	145	0.55	5.71	1
Small Grain - Contoured & Terraced (Good Condition)	Pasture/Hay	145	0.55	5.71	1
Small Grain - Contoured, Terraced & Crop Residue (Poor Condition)	Cultivated Crops	216	1.07	7.7	1
Small Grain - Contoured, Terraced & Crop Residue (Good Condition)	Cultivated Crops	216	1.07	7.7	1
Close-Seeded or Broadcast Legumes or Rotation Meadow - Straight Row (Poor Condition)	Pasture/Hay	145	0.55	5.71	1
Close-Seeded or Broadcast Legumes or Rotation Meadow - Straight Row (Good Condition)	Pasture/Hay	145	0.55	5.71	1

Land Cover for Volume (TR-55)	Land Cover for Water Quality	Event Mean Pollutant Concentrations			Source
		TSS (mg/L)	TP (mg/L)	TN (mg/L)	
Close-Seeded or Broadcast Legumes or Rotation Meadow - Contoured (Poor Condition)	Pasture/Hay	145	0.55	5.71	1
Close-Seeded or Broadcast Legumes or Rotation Meadow - Contoured (Good Condition)	Pasture/Hay	145	0.55	5.71	1
Close-Seeded or Broadcast Legumes or Rotation Meadow - Contoured & Terraced (Poor Condition)	Pasture/Hay	145	0.55	5.71	1
Close-Seeded or Broadcast Legumes or Rotation Meadow - Contoured & Terraced (Good Condition)	Pasture/Hay	145	0.55	5.71	1
Pasture, Grassland, or Range-Continuous Forage for Grazing (Poor Condition)	Grassland/Herbaceous	48.8	0.22	2.3	1
Pasture, Grassland, or Range-Continuous Forage for Grazing (Fair Condition)	Grassland/Herbaceous	48.8	0.22	2.3	1
Pasture, Grassland, or Range-Continuous Forage for Grazing (Good Condition)	Grassland/Herbaceous	48.8	0.22	2.3	1
Meadow-Continuous Grass, Protected from Grazing and Generally Mowed for Hay	Grassland/Herbaceous	48.8	0.22	2.3	1
Brush-Forbs-Grass Mixture with Brush the Major Element (Poor Condition)	Shrub/Scrub	39	0.15	0.19	1
Brush-Forbs-Grass Mixture with Brush the Major Element (Fair Condition)	Shrub/Scrub	39	0.15	0.19	1
Brush-Forbs-Grass Mixture with Brush the Major Element (Good Condition)	Shrub/Scrub	39	0.15	0.19	1
Woods-Grass Combination (Orchard or Tree Farm) (Poor Condition)	Deciduous Forest/Evergreen Forest/Mixed Forest	45	0.13	1.05	1
Woods-Grass Combination (Orchard or Tree Farm) (Fair Condition)	Deciduous Forest/Evergreen Forest/Mixed Forest	45	0.13	1.05	1
Woods-Grass Combination (Orchard or Tree Farm) (Good Condition)	Deciduous Forest/Evergreen Forest/Mixed Forest	45	0.13	1.05	1
Woods (Poor Condition)	Deciduous Forest/Evergreen Forest/Mixed Forest	45	0.13	1.05	1

Land Cover for Volume (TR-55)	Land Cover for Water Quality	Event Mean Pollutant Concentrations			Source
		TSS (mg/L)	TP (mg/L)	TN (mg/L)	
Woods (Fair Condition)	Deciduous Forest/Evergreen Forest/Mixed Forest	45	0.13	1.05	1
Woods (Good Condition)	Deciduous Forest/Evergreen Forest/Mixed Forest	45	0.13	1.05	1
Farmstead-Buildings, Lanes, Driveways and Surrounding Lots	Residential	65	0.29	2.05	2
Roads (Including ROW) - Dirt	Highway (general)	141	0.43	2.65	3
Roads (Including ROW) - Gravel	Highway (general)	141	0.43	2.65	3
Open Space (Lawns, Parks, Golf Courses, Cemeteries, Etc.) - Poor Condition (Grass Cover < 50%)	Open Space	78	0.25	1.25	2
Open Space (Lawns, Parks, Golf Courses, Cemeteries, Etc.) - Fair Condition (Grass Cover 50% to 75%)	Open Space	78	0.25	1.25	2
Open Space (Lawns, Parks, Golf Courses, Cemeteries, Etc.) - Good Condition (Grass Cover > 75%)	Open Space	78	0.25	1.25	2
Impervious Areas: Paved Parking Lots, Roofs, Driveways, Etc. (Excluding ROW)	Residential	65	0.29	2.05	2
Impervious Areas: Streets and Roads - Paved; Curbs and Storm Sewers (Excluding ROW)	Urban Highway	142	0.32	3	3
Impervious Areas: Streets and Roads - Paved; Open Ditches (Including ROW)	Highway (general)	141	0.43	2.65	3
Impervious Areas: Streets and Roads - Gravel (Including ROW)	Highway (general)	141	0.43	2.65	3
Impervious Areas: Streets and Roads - Dirt (Including ROW)	Highway (general)	141	0.43	2.65	3
Impervious Areas: Commercial	Commercial	61.72	0.22	2.02	3
Impervious Areas: Industrial	Industrial	81	0.24	2.01	3
Impervious Areas: Institutional	Institutional	67.49	0.14	1.21	3

Sources:

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Dept. of Environmental Services, 2010. Guidance for Estimating Pre- and Post-Development Stormwater Loads; (5) Washington State Dept. of Ecology, 2007. Efficiency of Urban Stormwater Best Management Practices: A Literature Review. Publication No. 07-03-009, 12 pp.; (6) Keiser & Associates, 2003. Empirical Sediment and Phosphorus Nonpoint Source Model for the St. Joseph River Watershed. 48 pp.

2. International Stormwater BMP Database – Median values of TSS, TP, and TN (TKN + (NO2+NO3).

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