Module 8: Evaluating Water Quality Compliance

Module 8 Objectives

After completing this module, you should be able to:

- Identify Volume and Load Tracking in the Runoff Reduction Method
- Identify Total Removal of Clearinghouse BMP Practices
- Review Redevelopment Calculations
- Review Offline Facilities and Flow Bypass Approaches
- Calculate the water quality flow rate
- Recall Off-site Compliance materials presented in the Basic SWM course

Module 8 Content

8a: Evaluating On-site Compliance

8a1. Introduction

8a2. Complex Treatment Trains

8a3. Redevelopment

8b. BMP Variations

8b1. Introduction

8b2. Online vs. Offline Practices and Flow Bypass

8b3. Water Quality Treatment Volume (Tv) Peak Flow Rate

8c. Off-site Compliance Options

8a. Evaluating On-site Compliance

8a1. Introduction

On site water quality compliance for standard New Development activities was addressed previously in Module 4. This module is intended to provide practical information about the complexities of plan review, volume and load tracking, and redevelopment scenarios and requirements. For basic instructional material, refer to the Module 4 participant guide.

8a2. Complex Treatment Trains

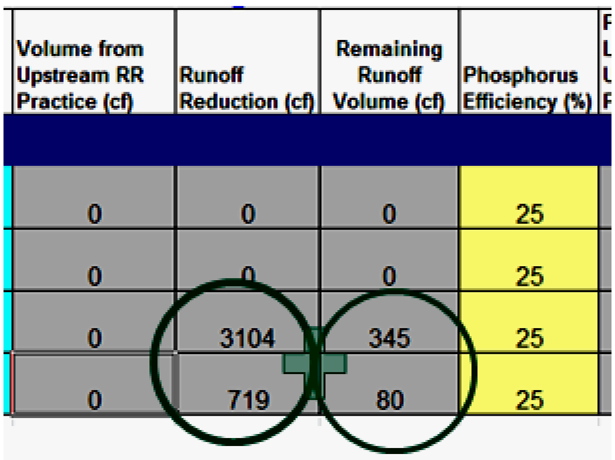
Plan reviewers are likely to encounter many instances where there are limitations on the spreadsheets capabilities. Specifically, the spreadsheet will be useful for evaluating compliance on simple sites with very linear treatment processes, but will be of more limited use when complex treatment trains and drainage networks are employed.

1. The presentation introduces some scenarios and shows the user where the individual components of the spreadsheet track volume and load.
2. For complex scenarios, one spreadsheet may not be enough, so reviewers may have to check tabulated information that is derived from multiple spreadsheets.
3. Specifically, it is important for reviewers to understand some basic things about the methodology:
    a. How is the treatment volume tracked in the spreadsheet?
    b. How is runoff reduction tracked in the spreadsheet?
    c. How is pollutant load tracked in the spreadsheet?
    d. Variables to account for:
        i. Hydrologic Parameters
            1. Land Cover: Forest/Turf/Impervious
            2. Hydrologic Soil Group: A/B/C/D
        ii. Volume and Load
            1. Tracked for **each sub-area** and for **each practice**

    2. Volume to next practice includes **residual volume** from upstream BMP **plus direct volume**
    3. Load includes **residual load** and **direct load**
    4. Remember to include **bypass loads**
4. The illustrations are intended to give the reviewer a better feel for where the numbers derive.

The Runoff Reduction Technical Memorandum and the Spreadsheet Users Instructions should serve as the primary references for reviewers to understand how the method works and track volume and load, when the spreadsheet is insufficient for a given application.

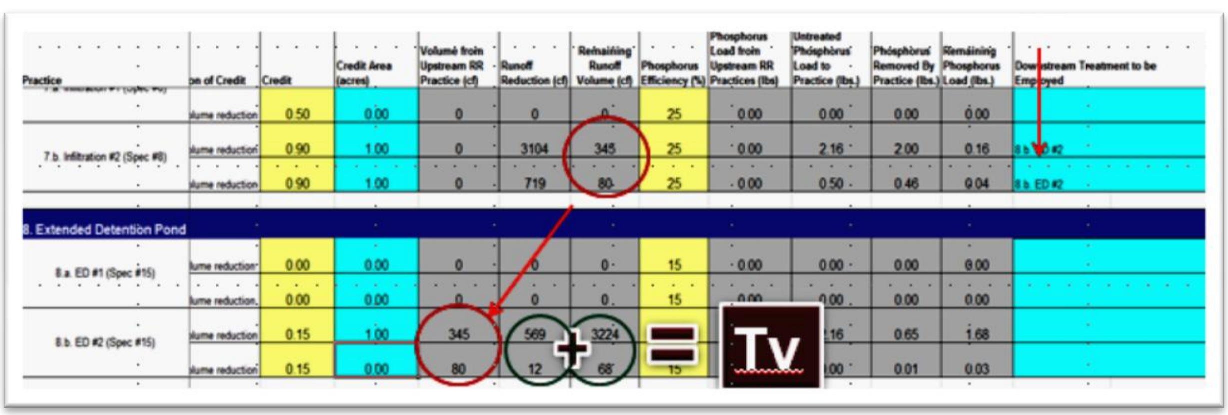
Treatment Volume Note: Reviewers should understand that for a given BMP, the spreadsheet tabulates both the ***"Runoff Reduction"***, and the ***"Remaining Runoff Volume"***:



Volume from Upstream RR Practice (cf)	Runoff Reduction (cf)	Remaining Runoff Volume (cf)	Phosphorus Efficiency (%)
0	0	0	25
0	0	0	25
0	3104	345	25
0	719	80	25

The **Treatment Volume** for a given BMP is the **sum** of these two volumes (the spreadsheet does not tabulate the total Tv for each BMP on the drainage area tabs).

Residual volume from upstream BMP contributes to next BMP in treatment train for sizing:



Practice	on of Credit	Credit	Credit Area (acres)	Volume from Upstream RR Practice (cf)	Runoff Reduction (cf)	Remaining Runoff Volume (cf)	Phosphorus Efficiency (%)	Phosphorus Load from Upstream RR Practices (lbs)	Untreated Phosphorus Load to Practice (lbs.)	Phosphorus Removed By Practice (lbs.)	Remaining Phosphorus Load (lbs.)	Downstream Treatment to be Employed
	lume reduction	0.50	0.00	0	0	0	25	0.00	0.00	0.00	0.00	
7.b. Infiltration #2 (Spec #8)	lume reduction	0.90	1.00	0	3104	345	25	0.00	2.16	2.00	0.16	8.b. ED #2
	lume reduction	0.90	1.00	0	719	80	25	0.00	0.50	0.46	0.04	8.b. ED #2
8. Extended Detention Pond												
8.a. ED #1 (Spec #15)	lume reduction	0.00	0.00	0	0	0	15	0.00	0.00	0.00	0.00	
	lume reduction	0.00	0.00	0	0	0	15	0.00	0.00	0.00	0.00	
8.b. ED #2 (Spec #15)	lume reduction	0.15	1.00	345	569	3224	[illegible]	[illegible]	[illegible]	0.65	1.68	
	lume reduction	0.15	0.00	80	12	68	15	[illegible]	[illegible]	0.01	0.03	

Total Mass Load Efficiency Note: The total removal efficiency of a practice is the sum of the Runoff Reduction efficiency and the Pollutant Removal efficiency applied to the balance of runoff:

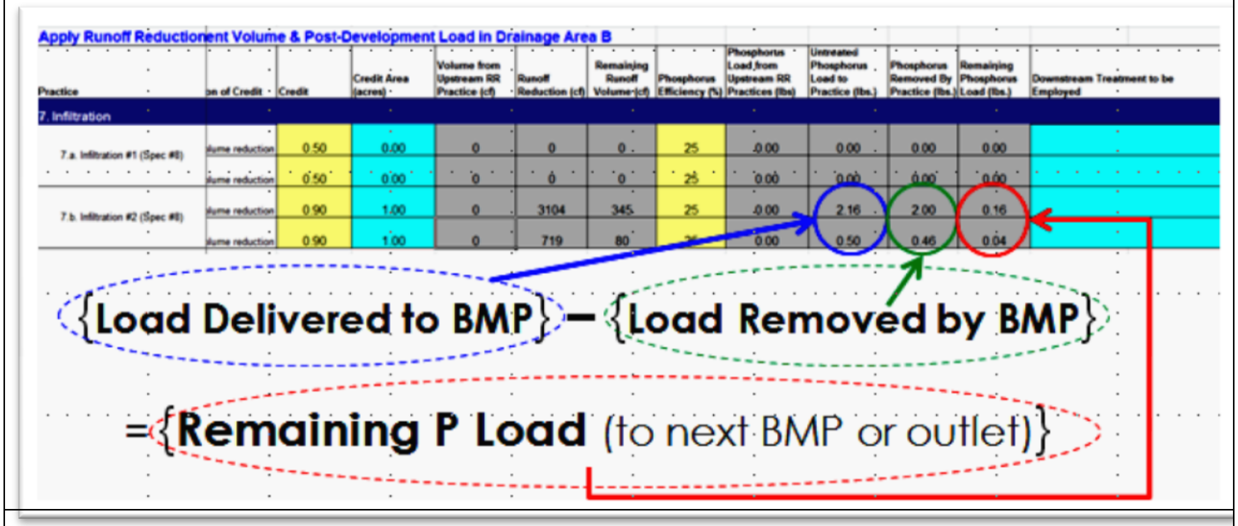
Stormwater Function	Level 1 Design	Level 2 Design
Annual Runoff Volume Reduction (RR)	50%	90%
Total Phosphorus (TP) EMC Reduction[1] by BMP Treatment Process	25%	+ 25% × Balance of Tv
Total Phosphorus (TP) Mass Load Removal	63%	= 93%
Total Nitrogen (TN) EMC Reduction[1] by BMP Treatment Process	15%	15%
Total Nitrogen (TN) Mass Load Removal	57%	92%

7.a. Infiltration #1 (Spec #8)	lume reduction	0.50	0.00	0	0	0	25	0.00	0.00	0.00	0.00	
7.b. Infiltration #2 (Spec #8)	lume reduction	0.90	1.00	0	3104	345	25	0.00	2.16	2.00	0.16	
	lume reduction	0.90	1.00	0	719	80	25	0.00	0.50	0.46	0.04	

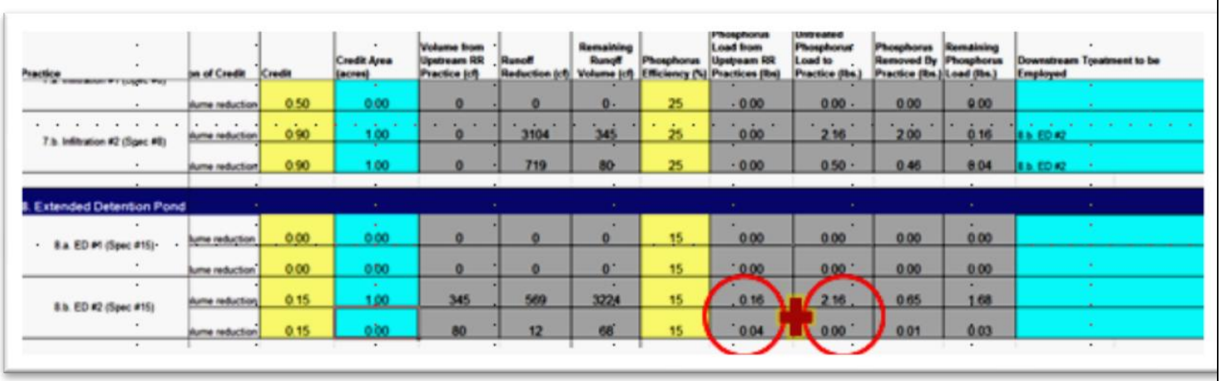
{TR: Total Mass Load Efficiency}
={RR Eff. }+ {PR Eff x (1-Rreff)}

{90%}+ {25% x (1-0.90)} = {90+(25*0.1)} = 92.5%

Load Tracking:



Loading to the next BMP will include the residual load from the upstream BMPs and the additional (direct) untreated load to that BMP:



8a3. Redevelopment

Redevelopment requirements for pollutant load reductions were addressed in the Basic SWM Course. Please refer to the Act, Regulations and the Basic SWM Participants Guide for additional information about redevelopment requirements.

Spreadsheet Demonstration

It is important for reviewers to understand several things about how the redevelopment requirements are implemented in the Runoff Reduction Method. Specifically:

1. Redevelopment reductions may vary dependent on the total disturbed area for the site
   a. 10% net reduction required for <1 Acre of disturbance
   b. 20% net reduction required for 1 Acre or more of disturbance
2. For sites which results in increases in impervious cover, the requirements for redevelopment and the requirements for the new development portion of the site are tabulated separately.
3. It is important for reviewers to understand to which area the redevelopment requirements will apply.
   a. The redevelopment requirements of the Virginia Stormwater Management Regulations apply only to the land disturbing activity, but some authorities may implement more stringent requirements for redevelopment which apply to undisturbed portions of the redevelopment site.

Predevelopment refers to conditions that exist:

- at time plans are submitted for land development of a tract of land
- For multi-phase projects:
  - at time of original submission for first phase of project

Redevelopment Examples:

Post-ReDevelopment Project & Land Cover Information	3		**Total Disturbed Acreage**		0.00
Constants					
Annual Rainfall (inches)	43				
Target Rainfall Event (inches)	1.00				
Phosphorus EMC (mg/L)	0.26			Nitrogen EMC (mg/L)	1.86
Target Phosphorus Target Load (lb/acre/yr)	0.41				
Pj	0.90				

Pre-ReDevelopment Land Cover (acres)	**A soils**	**B Soils**	**C Soils**	**D Soils**	**Totals**
Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land	0.00	0.00	0.00	0.00	0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	0.00	0.00	0.00
Impervious Cover (acres)	0.00	0.00	0.00	0.00	0.00
				Total	0.00

Post-ReDevelopment Land Cover (acres)	**A soils**	**B Soils**	**C Soils**	**D Soils**	**Totals**
Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land	0.00	0.00	0.00	0.00	0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	0.00	0.00	0.00
Impervious Cover (acres)	0.00	0.00	0.00	0.00	0.00
				Total	0.00
Area Check	Okay	Okay	Okay	Okay	

Example 1 (Project disturbs 1 acre or greater but has no increase in impervious cover):

Site Data: Managed Turf = 2 acres; Impervious Cover = 2 acres

Post-ReDevelopment Project & Land Cover Information		**Total Disturbed Acreage**	1.00
Constants			
Annual Rainfall (inches)	43		
Target Rainfall Event (inches)	1.00		
Phosphorus EMC (mg/L)	0.26	Nitrogen EMC (mg/L)	1.86
Target Phosphorus Target Load (lb/acre/yr)	0.41		
Pj	0.90		

Total Site Area (acres)	4.00	4.00	Total ReDev. Site Area (acres)	4.00	Total New Dev. Site Area (acres)	0.00
Site Rv	0.59	0.59	ReDev. Site Rv	0.59	New Dev. Site Rv	0.95
Pre-Development Treatment Volume (acre-ft)	0.1950	0.1950	Post-ReDevelopment Treatment Volume (acre-ft)	0.1950	Post-Development Treatment Volume (acre-ft)	0.0000
Pre-Development Treatment Volume (cubic feet)	8,494	8,494	Post-ReDevelopment Treatment Volume (cubic feet)	8,494	Post-Development Treatment Volume (cubic feet)	0
Pre-Development Load (TP) (lb/yr)	5.34	5.34	Post-ReDevelopment Load (TP) (lb/yr)	5.34	Post-Development Load (TP) (lb/yr)	0.00
			Maximum % Reduction Required Below Pre-ReDevelopment Load	20%		
			TP Load Reduction Required for Redeveloped Area (lb/yr)	1.07	TP Load Reduction Required for New Impervious Area (lb/yr)	0.00
			Total Load Reduction Required (lb/yr)	1.07		
Pre-Development Load (TN) (lb/yr)	36.18		Post-Development Load (TN) (lb/yr)	36.18		

[1]*Adjusted* **Land Cover Summary** reflects the pre redevelopment land cover minus the pervious land cover (forest/open space or managed turf) acreage proposed for new impervious cover. The adjusted total acreage is consistent with the Post Redevelopment acreage (minus the acreage of new impervious cover). The load reduction requriement for the new impervious cover to meet the new development load limit is computed in **Column I**.

Example 2 (Project disturbs less than 1 acre but has no increase in impervious cover):

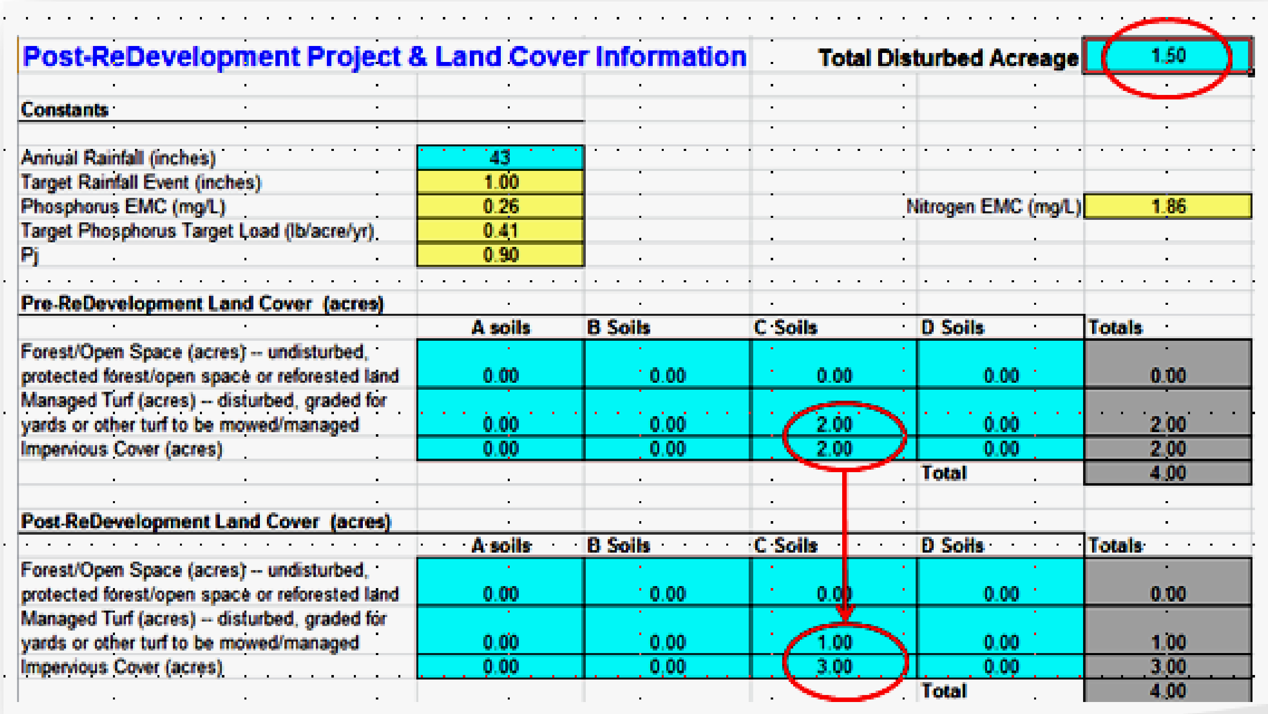
Post-ReDevelopment Project & Land Cover Information				Total Disturbed Acreage	0.50
Constants					
Annual Rainfall (inches)	43				
Target Rainfall Event (inches)	1.00				
Phosphorus EMC (mg/L)	0.26			Nitrogen EMC (mg/L)	1.86
Target Phosphorus Target Load (lb/acre/yr)	0.41				
Pj	0.90				

<u>Site Data:</u> Managed Turf = 2 acres; Impervious Cover = 2 acres

Pre-Development Treatment Volume (acre-ft)	0.1950	0.1950		Post-ReDevelopment Treatment Volume (acre-ft)	0.1950		Post-Development Treatment Volume (acre-ft)	0.0000
Pre-Development Treatment Volume (cubic feet)	8,494	8,494		Post-ReDevelopment Treatment Volume (cubic feet)	8,494		Post-Development Treatment Volume (cubic feet)	0
Pre-Development Load (TP) (lb/yr)	5.34	5.34		Post-ReDevelopment Load (TP) (lb/yr)	5.34		Post-Development Load (TP) (lb/yr)	0.00
[1]*Adjusted* **Land Cover Summary** reflects the pre redevelopment land cover minus the pervious land cover (forest/open space or managed turf) acreage proposed for new impervious cover. The adjusted total acreage is consistent with the Post Redevelopment acreage (minus the acreage of new impervious cover). The load reduction requriement for the new impervious cover to meet the new development load limit is computed in **Column I**.				Maximum % Reduction Required Below Pre-ReDevelopment Load	10%			
				TP Load Reduction Required for Redeveloped Area (lb/yr)	0.53		**TP Load Reduction Required for New Impervious Area (lb/yr)**	0.00
				Total Load Reduction Required (lb/yr)	0.53			
Pre-Development Load (TN) (lb/yr)	38.18			Post-Development Load (TN) (lb/yr)	38.18			

Example 3 (Project disturbs more than 1 acre and has an increase in impervious cover):

Site Data		
	Managed Turf	Impervious Cover
Pre-Development:	2 acres	2 acres
Post-Development:	1 acres	3 acres



Post-ReDevelopment Project & Land Cover Information — Total Disturbed Acreage: 1.50

Constants

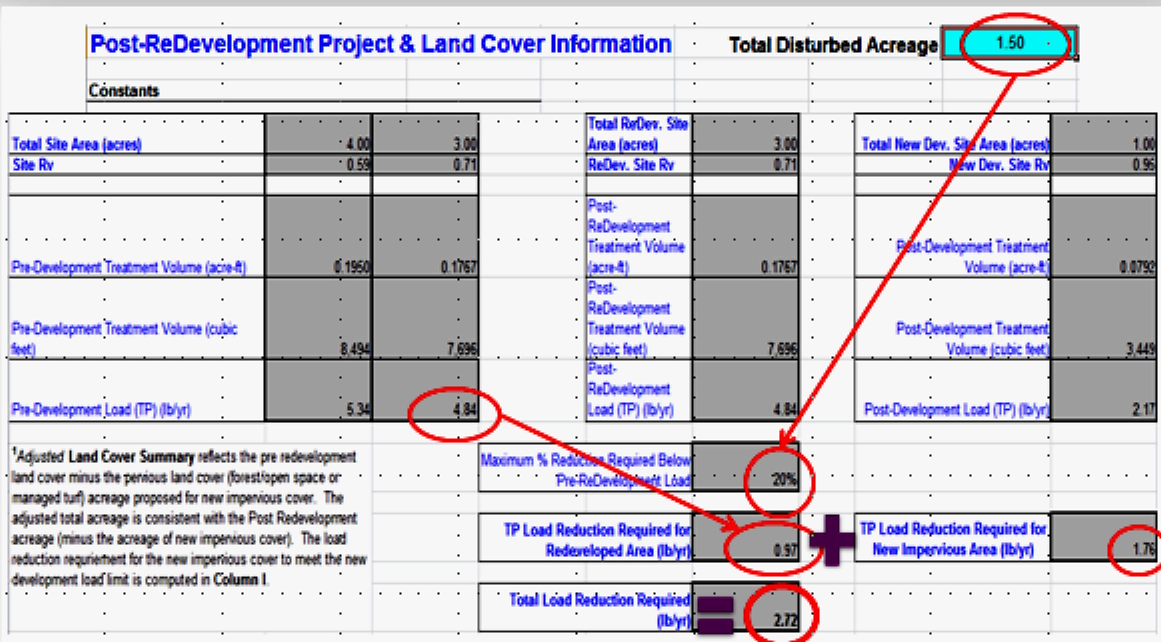
Annual Rainfall (inches)	43
Target Rainfall Event (inches)	1.00
Phosphorus EMC (mg/L)	0.26
Target Phosphorus Target Load (lb/acre/yr)	0.41
Pj	0.90
Nitrogen EMC (mg/L)	1.86

Pre-ReDevelopment Land Cover (acres)

	A soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land	0.00	0.00	0.00	0.00	0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	2.00	0.00	2.00
Impervious Cover (acres)	0.00	0.00	2.00	0.00	2.00
				Total	4.00

Post-ReDevelopment Land Cover (acres)

	A soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land	0.00	0.00	0.00	0.00	0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	1.00	0.00	1.00
Impervious Cover (acres)	0.00	0.00	3.00	0.00	3.00
				Total	4.00



Post-ReDevelopment Project & Land Cover Information — Total Disturbed Acreage: 1.50

Constants

Total Site Area (acres)	4.00	3.00
Site Rv	0.59	0.71
Pre-Development Treatment Volume (acre-ft)	0.1960	0.1767
Pre-Development Treatment Volume (cubic feet)	8,494	7,696
Pre-Development Load (TP) (lb/yr)	5.34	4.84

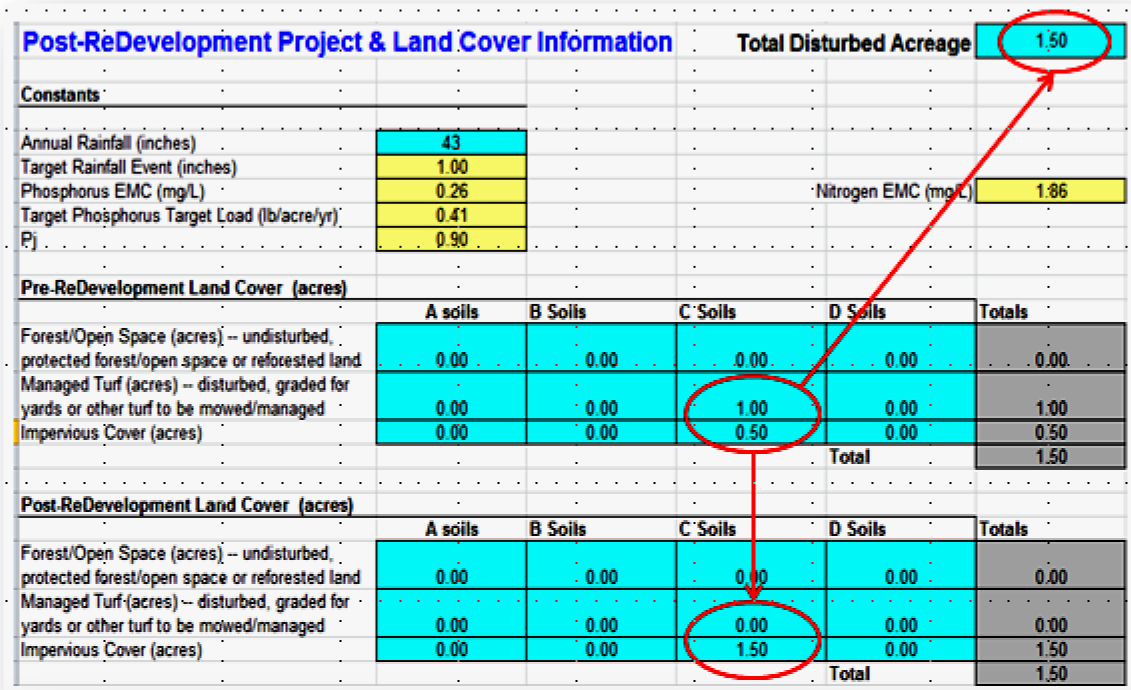
Total ReDev. Site Area (acres)	3.00
ReDev. Site Rv	0.71
Post-ReDevelopment Treatment Volume (acre-ft)	0.1767
Post-ReDevelopment Treatment Volume (cubic feet)	7,696
Post-ReDevelopment Load (TP) (lb/yr)	4.84
Maximum % Reduction Required Below Pre-ReDevelopment Load	20%
TP Load Reduction Required for Redeveloped Area (lb/yr)	0.97
Total Load Reduction Required (lb/yr)	2.72

Total New Dev. Site Area (acres)	1.00
New Dev. Site Rv	0.96
Post-Development Treatment Volume (acre-ft)	0.0792
Post-Development Treatment Volume (cubic feet)	3,449
Post-Development Load (TP) (lb/yr)	2.17
TP Load Reduction Required for New Impervious Area (lb/yr)	1.76

[1]Adjusted **Land Cover Summary** reflects the pre redevelopment land cover minus the pervious land cover (forest/open space or managed turf) acreage proposed for new impervious cover. The adjusted total acreage is consistent with the Post Redevelopment acreage (minus the acreage of new impervious cover). The load reduction requirement for the new impervious cover to meet the new development load limit is computed in **Column I**.

Example 4 (Redevelopment project equals the land disturbance area):

Site Data		
	Managed Turf	Impervious Cover
Pre-Development:	1 acres	0.5 acres
Post-Development:	0 acres	1.5 acres



Post-ReDevelopment Project & Land Cover Information — Total Disturbed Acreage: 1.50

Constants

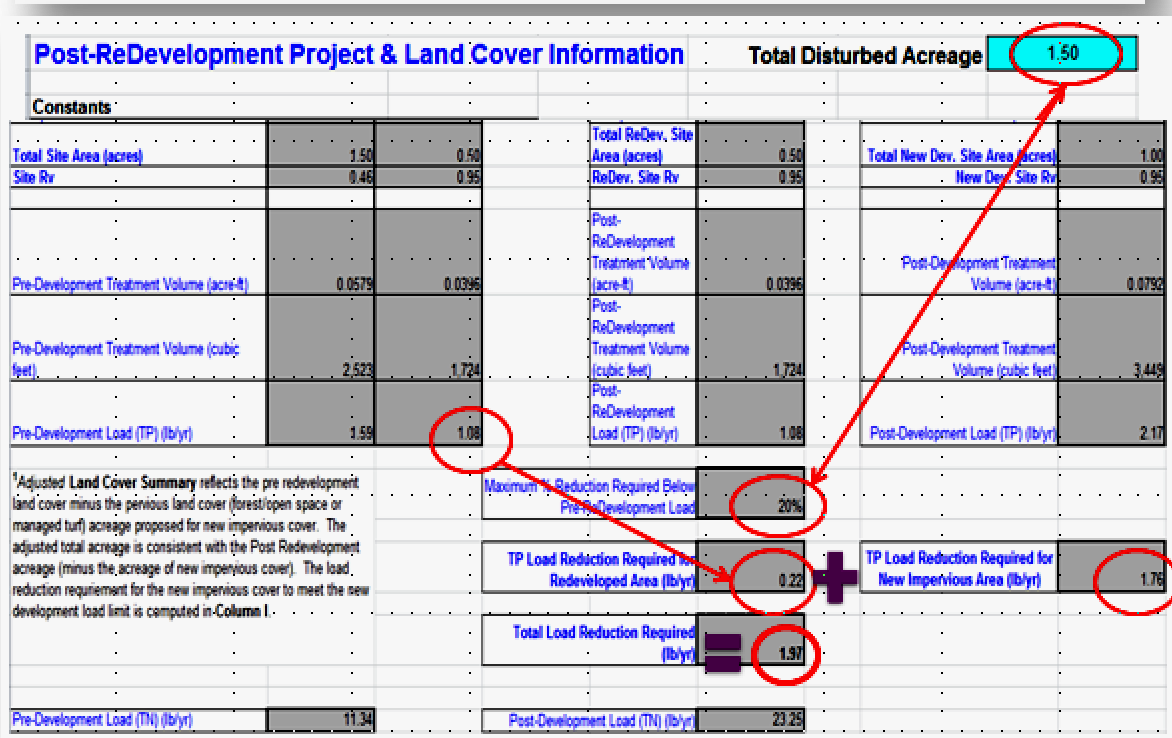
Annual Rainfall (inches)	43		
Target Rainfall Event (inches)	1.00		
Phosphorus EMC (mg/L)	0.26	Nitrogen EMC (mg/L)	1.86
Target Phosphorus Target Load (lb/acre/yr)	0.41		
Pj	0.90		

Pre-ReDevelopment Land Cover (acres)

	A soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land	0.00	0.00	0.00	0.00	0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	1.00	0.00	1.00
Impervious Cover (acres)	0.00	0.00	0.50	0.00	0.50
				Total	1.50

Post-ReDevelopment Land Cover (acres)

	A soils	B Soils	C Soils	D Soils	Totals
Forest/Open Space (acres) -- undisturbed, protected forest/open space or reforested land	0.00	0.00	0.00	0.00	0.00
Managed Turf (acres) -- disturbed, graded for yards or other turf to be mowed/managed	0.00	0.00	0.00	0.00	0.00
Impervious Cover (acres)	0.00	0.00	1.50	0.00	1.50
				Total	1.50



Post-ReDevelopment Project & Land Cover Information — Total Disturbed Acreage: 1.50

Constants

Total Site Area (acres)	1.50	0.50
Site Rv	0.46	0.95
Pre-Development Treatment Volume (acre-ft)	0.0579	0.0396
Pre-Development Treatment Volume (cubic feet)	2,523	1,724
Pre-Development Load (TP) (lb/yr)	1.59	1.08
Pre-Development Load (TN) (lb/yr)	11.34	

Total ReDev. Site Area (acres)	0.50
ReDev. Site Rv	0.95
Post-ReDevelopment Treatment Volume (acre-ft)	0.0396
Post-ReDevelopment Treatment Volume (cubic feet)	1,724
Post-ReDevelopment Load (TP) (lb/yr)	1.08
Maximum % Reduction Required Below Pre-ReDevelopment Load	20%
TP Load Reduction Required for Redeveloped Area (lb/yr)	0.22
Total Load Reduction Required (lb/yr)	1.97
Post-Development Load (TN) (lb/yr)	23.25

Total New Dev. Site Area (acres)	1.00
New Dev. Site Rv	0.95
Post-Development Treatment Volume (acre-ft)	0.0792
Post-Development Treatment Volume (cubic feet)	3,449
Post-Development Load (TP) (lb/yr)	2.17
TP Load Reduction Required for New Impervious Area (lb/yr)	1.76

[1]Adjusted Land Cover Summary reflects the pre redevelopment land cover minus the pervious land cover (forest/open space or managed turf) acreage proposed for new impervious cover. The adjusted total acreage is consistent with the Post Redevelopment acreage (minus the acreage of new impervious cover). The load reduction requirement for the new impervious cover to meet the new development load limit is computed in Column I.

8b1. Introduction

We covered the BMP standards and specifications in Module 7. Some of the practices will require placement in an offline manner in order to reduce potential for hydraulic overloading, or due to site constraints. Additionally, some of the practices (including offline practices) will require verification that the "water quality flows" representing the treatment volume area directed to the practice satisfy certain hydraulic criteria required by the Specifications. This module briefly discusses those two issues and goes on to discuss the future pathway for updates and improvements to the BMP technology specifications on the Virginia BMP Clearinghouse web site.

8b2. Online vs. Offline Practices and Flow Bypass

Runoff Reduction BMPs are typically sized and designed to manage the design treatment volume from the 1-inch rainfall event. In some cases designers may choose to manage or detain a larger storm event in order to partially or fully meet the quantity control requirements. In all cases, the designer must account for the conveyance of these larger storms *through* the BMP (the BMP is said to be ***On-Line***) or *around* the BMP (making the BMP ***Off-Line***).

Using the water quality design *Tv* peak flow rate (described later in this Module), the designer can size a bypass control for an ***On-Line*** BMP, such that flows that exceed the design capacity exit via an internal riser structure or weir overflow. This means that the BMP accepts all the runoff from the contributing drainage area and the overflow is within the BMP (or main treatment area). On-line BMPs must be carefully designed to accommodate the large storm design peak flow rate in terms of inflow velocity and energy, as well as an adequately sized overflow to allow the runoff to safely exit the BMP.

On-line systems in these cases will require careful design and construction to ensure adequate conveyance of the large storm inflow.

On-line systems should include the following:

- Inflow points should be protected from erosive velocity
- An overflow structure must be provided within the practice to pass storms greater than the design storm storage to a stabilized conveyance or storm sewer system

- Discharge from the overflow structure should be controlled so that velocities are non-erosive at the outlet point

The overflow structure type and design should be scaled to the application – this may be a landscape grate or yard inlet for small practices or a commercial-type structure for larger installations.

Alternately, an ***Off-Line*** BMP design uses an external diversion structure to manage the large storm flow so the runoff in excess of the 1-inch rain event will not damage the BMP (excessive velocity or ponding depth) or re-suspend and export previously trapped pollutants. This can be accomplished through a low-flow diversion structure that channels the smaller storm flow volume into the BMP, while forcing the larger flows to bypass the BMP. These types of low-flow diversion or large storm bypass structures are external – thereby diverting the flow before it gets to the BMP – or they can be part of the BMP inlet structure, such as a forebay or level spreader. In some cases, off-line BMPs with a storage volume can be located so that once the storage volume is full, additional runoff simply diverts past or around the BMP. **Figure 8-1** below illustrates a simple off-line BMP.

Off-line designs require that the designer determine the runoff peak flow rates for the range of design storms: 1-inch rainfall depth, and 1-year, 2-year, and 10-year 24-hour storms, as needed.

Off-line designs are usually the preferred option for volume reduction BMPs, especially where larger drainage areas (e.g., greater than 0.5 to 1 acre) are conveyed by a pipe or armored drainage system.

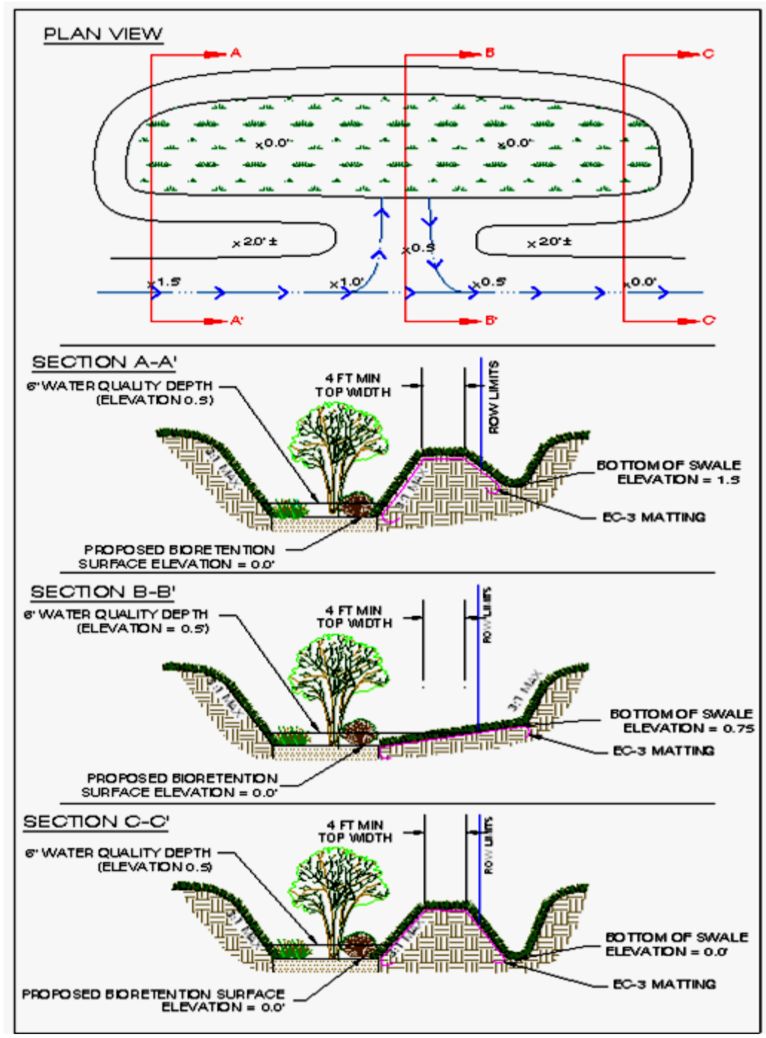
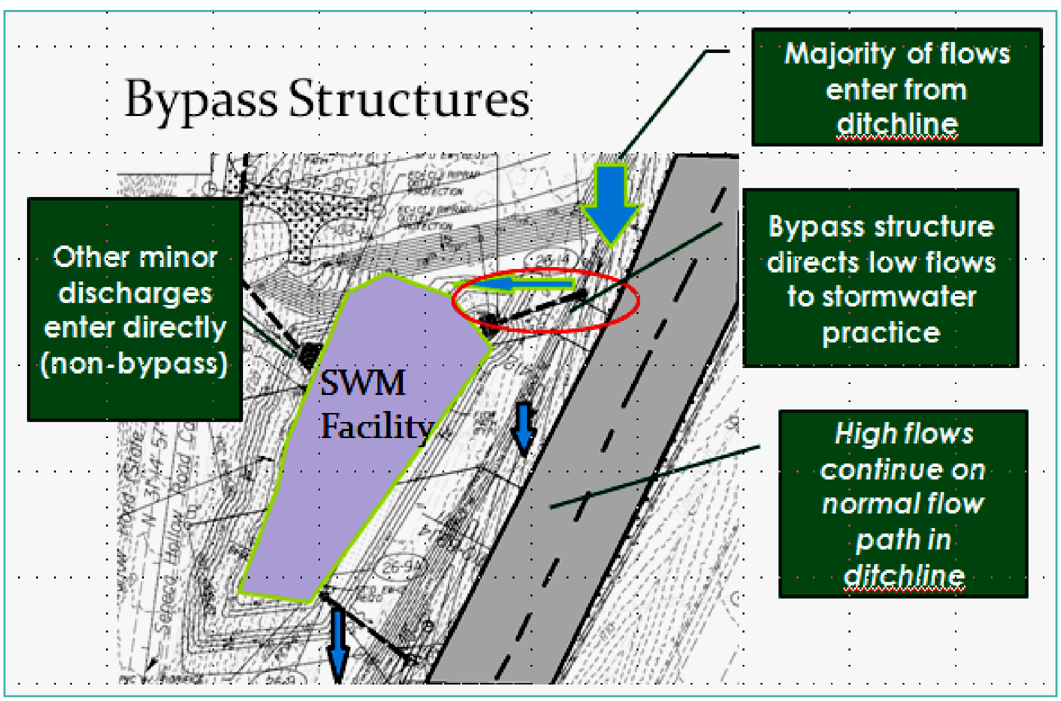


Figure 8-1: 1 Simple Off-Line BMP Plan and Cross-section



8b3. Water Quality Treatment Volume (Tv) Peak Flow Rate

The peak flow rates for the 1-year 24-hour storm and larger are readily computed using accepted hydrologic methods. However, there has not been a standard method for computing the water quality or Treatment Volume (*Tv*) design peak flow rate. The *Tv* design peak flow rate is needed for the design and sizing of pretreatment cells, level spreaders, by-pass diversion structures, overflow riser structures, grass swales and water quality swale geometry, etc. All require a peak rate of discharge in order to ensure non-erosive conditions and flow capacity.

Of the hydrologic methods available, the Rational Formula is highly sensitive to the time of concentration and rainfall intensity, and therefore should only be used with reliable Intensity-Duration-Frequency (IDF) curves (or B, D, & E factors) for the rainfall depth and region of interest (Claytor and Schueler, 1996). Unfortunately, there are no IDF curves or B, D, & E factors available for the 1-inch rainfall depth. The NRCS *CN* methods are very useful for characterizing complex sub-watersheds and drainage areas and estimating the peak discharge from large storms (greater than 2 inches), but can significantly underestimate the discharge from small storm events (Claytor and Schueler, 1996). Since the *Tv* is based on a 1-inch rainfall, this underestimation of peak discharge can lead to undersized diversion and overflow structures, resulting in a significant volume of the design *Tv* potentially bypassing the runoff reduction practice. Undersized overflow structures and outlet channels can cause erosion of the BMP conveyance features which can lead to costly and frequent maintenance.

In order to maintain consistency in design and plan review, the following Modified *CN* Method is one method recommended for calculating the peak discharge for the 1-inch rain event. The method uses the Small Storm Hydrology Method (Pitt, 1994) and NRCS Graphical Peak Discharge Method (USDA 1986) to provide an adjusted Curve Number that is more reflective of the runoff volume from impervious areas within the drainage area. The design rainfall is a NRCS Type II distribution, so the method incorporates the peak rainfall intensities common in the eastern United States. The time of concentration is computed using the method outlined in TR-55.

(The designer and reviewer should also note the methodology for determining the appropriate Tc flow path for a small catchment to a BMP: the directly contributing drainage area homogeneity is likely that of an impervious or developed area, and therefore should be represented by a representative impervious Tc path.)

The following provides a step by step procedure for calculating the Water Quality Treatment Volume's peak rate of discharge, $\boldsymbol{q_{pTv}}$:

Step 1: Calculate the adjusted *CN* for the site or contributing drainage area.

The following equation is derived from the NRCS *CN* Method and is described in detail in the **Chapter 4** (Hydrology) of the National Engineering Handbook (NEH-4), and **Chapter 2** (Estimating Runoff) of NRCS TR-55:

Equation 1 (equation 11.11 of the VSMH): Derivation of NRCS Curve Number and Runoff Equation

$$CN = \frac{1000}{[10 + 5P + 10Q_a - 10(Q_a^2 + 1.25Q_aP)^{0.5}]}$$

Where:

CN = Adjusted curve number

P = Rainfall (inches), (1.0" in Virginia)

Q_a = Runoff volume (watershed inches), equal to $Tv \div drainage\ area$

Note: When using a hydraulic/hydrologic model for sizing a runoff reduction BMP or calculating the q_{pTv}, designers should use this modified *CN* for the drainage area to generate runoff peak flow from the *Tv* for the 1-inch rainfall event.

Step 2: Compute the site or drainage area Time of Concentration (*Tc*).

Chapter 4 of the *Blue Book*, and Chapter 3 of TR-55 (Time of Concentration and Travel Time) provide detailed procedures for computing the *Tc.* The designer should select the

Tc flow path that is representative of the homogeneous drainage area, assumed to be primarily impervious cover.

Step 3: Calculate the Water Quality Treatment Volume's peak discharge (q_{pTv})

The (q_{pTv}) is computed using the following equation and the procedures outlined in Chapter 4 (Graphical Peak Discharge Method) of TR-55, Designers can also use WinTR-55 or an equivalent TR-55 spreadsheet to compute (q_{pTv}):

Read the initial abstraction (I_a) from TR-55 Table 4.1 or calculate it using $I_a = 200/CN - 2$

Compute I_a/P (P = 1.0);

Read the Unit Peak Discharge (q_u) from exhibit 4-II using *Tc* and I_a/P;

Compute the (q_{pTv}) peak discharge:

Equation 2 (equation 11.12. of the VSMH): Modified NRCS TR-55 Eq. 4-1

$$q_{pTv} = q_u \times A \times Q_a$$

Where:

q_{pTv} = Treatment Volume peak discharge (cfs)

q_u = unit peak discharge (cfs/mi^2/in)

A = drainage area (mi^2)

Q_a = runoff volume (watershed inches = Tv/A)

This procedure is for computing the peak flow rate for the 1-inch rainfall event. All other calculations of peak discharge from larger storm events for the design of drainage systems, culverts, etc., should use published *CN*s and computational procedures.

8c. Off-site Compliance Options

This is a review of material previously presented in the Basic SWM Course. Please refer to the participant guide from the basic course for additional information.