Appendix E.1

Stormwater Credits for Innovative Site Planning

E.1.0 Stormwater Credits

In Maryland, there are many programs at both the State and local level that seek to minimize the impact of land development. Critical Areas, forest conservation, and local stream buffer requirements are designed to reduce nonpoint source pollution. Non-structural practices can play a significant role in reducing water quality impacts and are increasingly recognized as a critical feature of every stormwater BMP plan, particularly with respect to site design. In most cases, non-structural practices must be combined with structural practices to meet stormwater requirements. The key benefit of non-structural practices is that they can reduce the generation of stormwater from the site; thereby reducing the size and cost of stormwater storage. In addition, they can provide partial removal of many pollutants. Non-structural practices have been classified into six broad groups and are designed to mesh with existing state and local programs (e.g., forest conservation, stream buffers etc.). To promote greater use, a series of six stormwater credits are provided for designers that use these site planning techniques.

Credit 1.	Natural Area Conservation
Credit 2.	Disconnection of Rooftop Runoff
Credit 3.	Disconnection of Non Rooftop Runoff
Credit 4.	Sheet Flow to Buffers
Credit 5.	Open Channel Use
Credit 6.	Environmentally Sensitive Development

This chapter describes each of the credits for the six groups of non-structural practices, specifies minimum criteria to be eligible for the credit, and provides an example of how the credit is calculated. Designers should check with the appropriate approval authority to ensure that the credit is applicable to their jurisdiction. Clearly both of the site designs used to illustrate the credits could be more creative to provide more non-structural opportunities.

In general, the stormwater sizing criteria provide a strong incentive to reduce impervious cover at development sites (e.g., Re_v, WQ_v, Cp_v or Qp and Qf). Storage requirements for all five stormwater sizing criteria are directly related to impervious cover. Thus, significant reductions in impervious cover result in smaller required storage volumes and, consequently, lower BMP construction costs.

These and other site design techniques can help to reduce impervious cover, and consequently, the stormwater treatment volume needed at a site. The techniques presented in this chapter are considered options to be used by the designer to help reduce the need for stormwater BMP storage capacity. Due to local safety codes, soil conditions, and topography, some of these site design features will be restricted. Designers are encouraged to consult with the appropriate approval authority to determine restrictions on non-structural strategies.

NOTE: This chapter contains archived material and is presented here for historical purposes only.

These credits are an integral part of a project's overall stormwater management plan and BMP storage volume calculation. Therefore, use of these credits shall be documented at the initial (concept) design stage, documented with submission of final grading plans, and verified with "as-built" certifications. If a planned credit is not implemented, then BMP volumes shall be increased appropriately to meet Re_v, WQ_v, Cp_v, and Q_p where applicable.

Table E.1.1 Summary of Stormwater Credits

Stormwater Credit	**WQ_v**	**Re_v**	**Cp_v or Q_p**
Natural Area Conservation	Reduce Site Area	No credit. Use as receiving area w/Percent Area Method.	Forest/meadow CN for natural areas
Disconnection of Rooftop Runoff	Reduced R_v	No credit. Use with Percent Area Method.	Longer t_c (increased flow path). CN credit.
Disconnection of Non-Rooftop Runoff	Reduced R_v	No credit. Use with Percent Area Method.	Longer t_c (increased flow path) CN credit
Sheet Flow to Buffers	Subtract contributing site area to BMP	Reduced Re_v	CN credit
Open Channel Use	May meet WQ_v	Meets Re_v	Longer t_c (increased flow path) No CN credit
Environmentally Sensitive Development	Meets WQ_v	Meets Re_v	No CN credit t_c may increase

Section E.1.1 Natural Area Conservation Credit

Natural Area Conservation Credit

A stormwater credit is given when natural areas are conserved at development sites, thereby retaining pre development hydrologic and water quality characteristics. A simple WQ_v credit is granted for all conservation areas permanently protected under conservation easements or other locally acceptable means. Examples of natural area conservation include:

- forest retention areas
- non-tidal wetlands and associated buffers
- other lands in protective easement (floodplains, open space, steep slopes)
- stream systems

Under the credit, a designer can subtract conservation areas from total site area when computing the water quality volume. The volumetric runoff coefficient, R_v, is still calculated based on the percent impervious cover for the entire site.

As an additional incentive, the post development curve number (CN) used to compute the Cp_v or Qp_2, and Qp_{10} for all natural areas protected by conservation easements can be assumed to be woods in good condition when calculating the total site CN.

As an example, the required WQ_v for a ten acre site with three acres of impervious area and three acres of protected conservation area before the credit would be:

WQ_v = [(P)(R_v)(A)]/12; where P= 1”, R_v= 0.05+0.009(30%)
WQ_v = [(1”) (0.32)(10 acres)]/12 = 0.266 acre-feet.

Under the credit, three acres of conservation are subtracted from total site area, which yields a smaller storage volume:

WQ_v =[(P)(R_v)(A)]/12; where P=1”, R_v=0.05+0.009(30%)
WQ_v =[(1”)(0.32)(10-3 acres)]/12 = 0.187 acre-feet.

The recharge requirement (Re_v) is not reduced using this credit.

Criteria for Natural Area Credit

To receive the credit, the proposed conservation area:

- *Shall not be disturbed during project construction (e.g., cleared or graded) except for temporary impacts associated with incidental utility construction or mitigation and afforestation projects,*

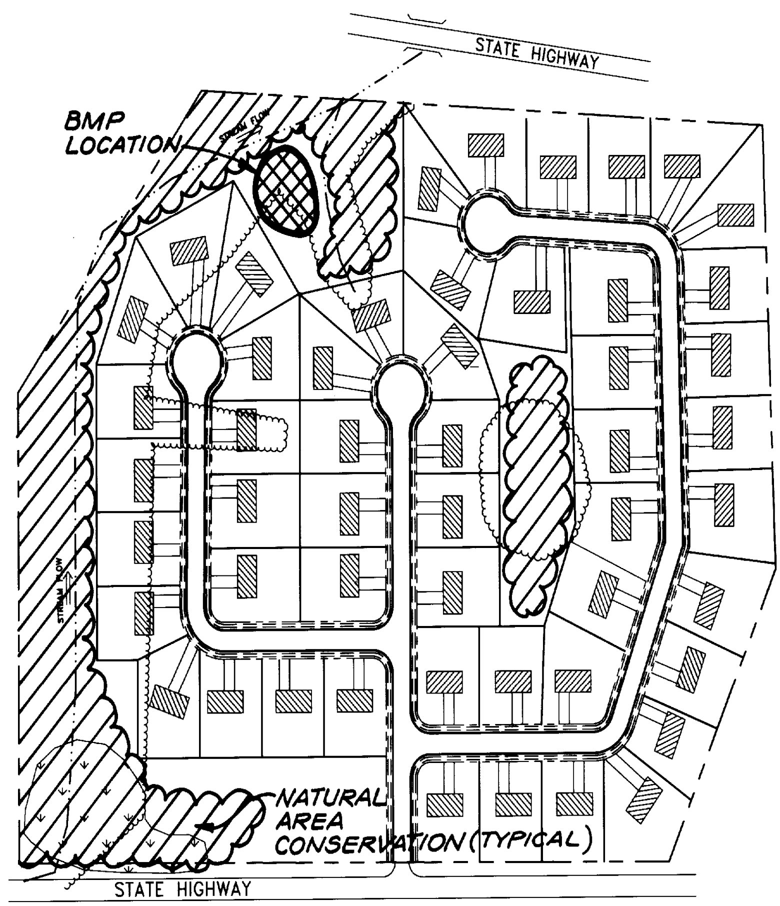
- *Shall be protected by having the limits of disturbance clearly shown on all construction drawings and delimited in the field except as provided for above,*

- *Shall be located within an acceptable conservation easement or other enforceable instrument that ensures perpetual protection of the proposed area. The easement must clearly specify how the natural area vegetation shall be managed and boundaries will be marked* [Note: managed turf (e.g., playgrounds, regularly maintained open areas) is not an acceptable form of vegetation management]*, and*

- *Shall be located on the development project*.

Example of Calculating Natural Area Credit

Site Data - 51 Single Family Lots
Area = 38 ac.
Conservation Area = 7.0 ac
Impervious Area = 13.8 ac
R_v = .38, P= 0.9”
Post dev. CN = 78
Original WQ_v = 1.08 ac-ft.
Original Re_v = .25 ac-ft.
Original Cp_v = 1.65 ac-ft.
Original Qp_{10} = 2.83 ac-ft.



Computation of Stormwater Credits

WQ_v = [(P)(R_v)(A)]/12
 = [(0.9)(.38)(38.0 - 7.0 ac.)]/12
 = 0.89 ac-ft

Re_v = Same as original
(However, area draining to Natural Area may used with the Percent Area Method)

Cp_v and Q_{p10} (total site): CN reduced from 78 to 75

Section E.1.2 Disconnection of Rooftop Runoff Credit

Disconnection of Rooftop Runoff Credit

A credit is given when rooftop runoff is disconnected and then directed to a pervious area where it can either infiltrate into the soil or filter over it. The credit is typically obtained by grading the site to promote overland filtering or by providing bioretention areas on single family residential lots.

If a rooftop is adequately disconnected, the disconnected impervious area may be deducted from total impervious cover (therefore reducing WQ_v). In addition, disconnected rooftops can be used to meet the Re_v requirement as a non-structural practice using the percent area method (see Chapter 2).

Post development CN's for disconnected rooftop areas used to compute Cp_v and Qp can be assumed to be woods in good condition.

Criteria for Disconnection of Rooftop Runoff Credit

The credit is subject to the following restrictions:

- *Rooftop cannot be within a designated hotspot,*
- *Disconnection shall cause no basement seepage,*
- *The contributing area of rooftop to each disconnected discharge shall be 500 square feet or less,*
- *The length of the "disconnection" shall be 75' or greater, or compensated using Table E.1.2,*
- *Dry wells, french drains, rain gardens, or other similar storage devices may be utilized to compensate for areas with disconnection lengths less than 75 feet. (See Table E.1.2 and Figure E.1.1, dry wells are prohibited in "D" soils),*
- *In residential development applications, disconnections will only be credited for lot sizes greater than 6000 sq. ft.,*
- *The entire vegetative "disconnection" shall be on an average slope of 5% or less,*
- *The disconnection must drain continuously through a vegetated channel, swale, or through a filter strip to the property line or BMP,*
- *Downspouts must be at least 10 feet away from the nearest impervious surface to discourage "re-connections", and*
- *For those rooftops draining directly to a buffer, only the rooftop disconnection credit or the buffer credit may be used, not both.*

Figure E.1.1 Schematic of Dry Well

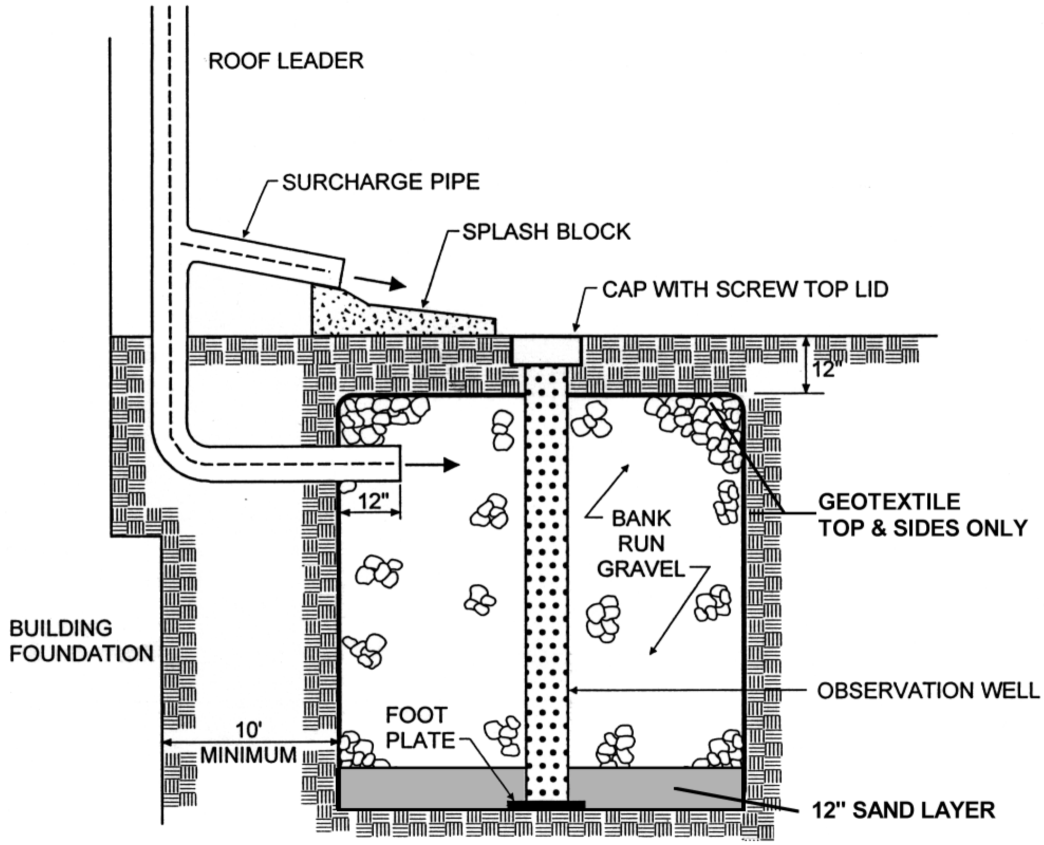


Table E.1.2 Rooftop Disconnection Compensation Storage Volume Requirements
(Per Disconnection Using Drywells, Raingardens, etc.)

Disconnection Length Provided	0 - 14 ft.	15 - 29 ft.	30 - 44 ft.	45 - 59 ft.	60 - 74 ft.	≥ 75 ft.
% WQ_v Treated by Disconnect	0%	20%	40%	60%	80%	100%
% WQ_v Treated by Storage	100%	80%	60%	40%	20%	0%
Max. Storage Volume* (Eastern Rainfall Zone)	40 cu-ft.	32 cu-ft.	24 cu-ft.	16 cu-ft.	8 cu-ft.	0 cu-ft.
Max. Storage Volume* (Western Rainfall Zone)	36 cu-ft.	28.8 cu-ft.	21.6 cu-ft.	14.4 cu-ft.	7.2 cu-ft.	0 cu-ft.

*Assuming 500 square feet roof area to each downspout.

Example of Using the Rooftop Disconnection Credit

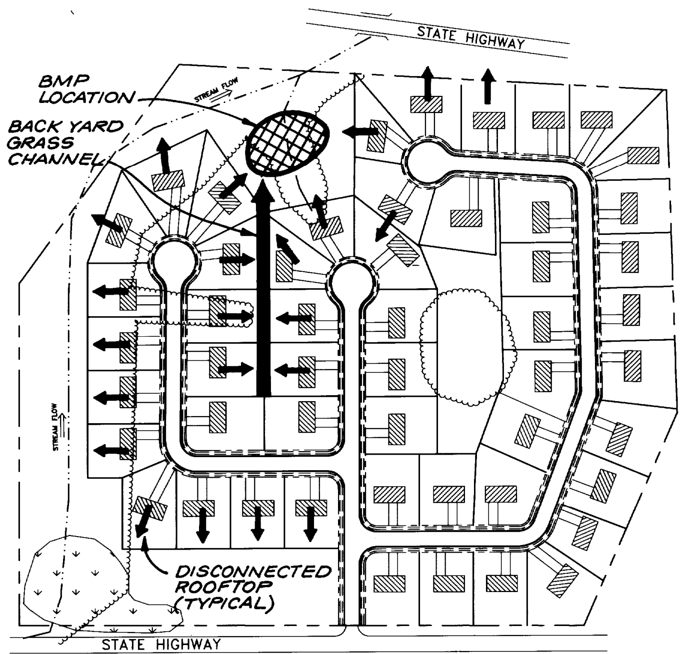
Site Data - 51 Single Family Lots
Area = 38 ac., ½ acre lots
Original Impervious Area = 13.80 ac.
Original R_v = .38
Post dev. CN = 78
# of Disconnected Rooftops = 22
Original WQ_v = 1.08 ac-ft
Original Re_v = 0.25 ac-ft
Original Cp_v = 1.65 ac-ft
Original Qp_v = 2.83 ac-ft

60% B Soils
40% C Soils
Composite S=0.208 (20.8%)

22 Lots Disconnected w/5 Downspouts each.
∴ 2500 sq. ft. each lot

Net impervious area reduction = (22)(2500)/43560 = 1.3 ac

Net Impervious Area =
13.8 - 1.3 = 12.5 acres



Computation of Stormwater Credit:

New R_v= 0.05+.009 (12.5 ac/38 ac) = .35
∴ WQ_v= [(0.9)(.35)(38 ac)]!12 = 1.00 ac-ft.

Required Re_v (Percent Area Method)
Re_v = 20.8%× 13.8 ac. =2.87 acres
Re_v treated by disconnection =1.3 acres
Re_v remaining for treatment = 1.57 acres non structurally or 0.14 acre-feet structurally

Cp_v and Q_p (total site): CN reduced from 78 to 76

Section E.1.3 Disconnection of Non Rooftop Runoff Credit

Disconnection of Non Rooftop Runoff Credit

Credit is given for practices that disconnect surface impervious cover runoff by directing it to pervious areas where it is either infiltrated into the soil or filtered (by overland flow). This credit can be obtained by grading the site to promote overland vegetative filtering or providing bioretention areas on single family residential lots.

These "disconnected" areas can be subtracted from the impervious area when computing WQ_v. In addition, disconnected surface impervious cover can be used to meet the Re_v requirement as a non-structural practice using the percent area method (See Chapter 2).

Criteria for Disconnection of Non Rooftop Runoff Credit

The credit is subject to the following restrictions:

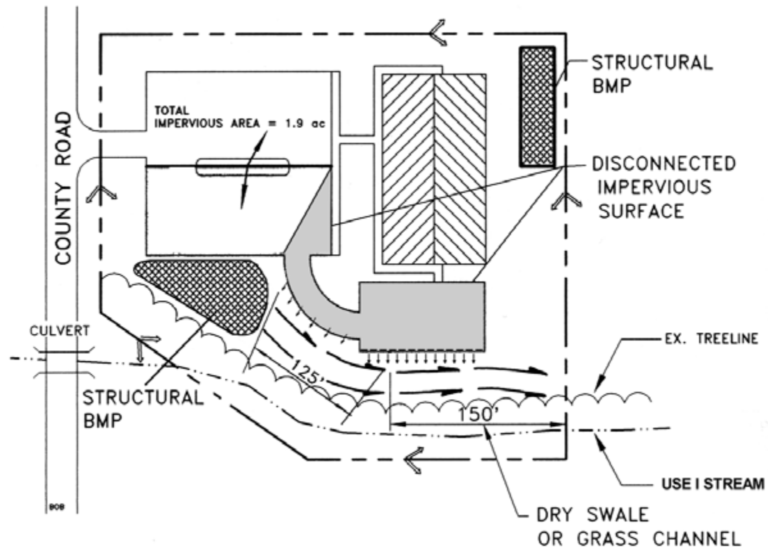
- *Runoff cannot come from a designated hotspot,*
- *The maximum contributing impervious flow path length shall be 75 feet,*
- *The disconnection shall drain continuously through a vegetated channel, swale, or filter strip to the property line or BMP,*
- *The length of the "disconnection" must be equal to or greater than the contributing length,*
- *The entire vegetative "disconnection" shall be on an average slope of 5% or less,*
- *The surface impervious area to any one discharge location cannot exceed 1,000* ft^2.
- *Disconnections are encouraged on relatively permeable soils (HSG's A and B),*
- *If the site cannot meet the required disconnect length, a spreading device, such as a french drain, rain garden, gravel trench or other storage device may be needed for compensation, and*
- *For those areas draining directly to a buffer, only the non rooftop disconnection credit or the stream buffer credit can be used, not both.*

Example of Calculating the Non Rooftop Disconnection Credit

Site Data -Community Center
Area = 3.0 ac
Original Impervious Area = 1.9 ac. = 63.3%
Original R_v = .62
Post dev. CN = 83
B Soils, S = 0.26
Original WQ_v = 6752 ft^3
Original Re_v = 1688 ft^3
Original Cp_v = N/A
Original Qp_2 = 10,630 ft^3

0.33 ac of surface imperviousness disconnected

Net impervious area reduction
1.9 - 0.33 = 1.57 ac.



Computation of Stormwater Credit:

New R_v = 0.05+.009 (1.57 ac/3.0 ac)= .52
$\therefore WQ_v$ = [(1.0)(0.52)(3.0 ac)]/12 = 0.13 ac-ft (5662.8 cf)

Required Re_v (Percent area method)
$Re_v = (S)(A_i)$ = (0.26)(1.9 ac.) = 0.49 acres
Re_v treated by disconnection = 0.33 acres
Re_v remaining for treatment = 0.16 acres non structurally or 551.2 cf structurally

Cp_v and Q_p Post developed CN may be reduced

Section E.1.4 Sheetflow to Buffer Credit

Sheetflow to Buffer Credit

This credit is given when stormwater runoff is effectively treated by a natural buffer to a stream or forested area. Effective treatment is achieved when pervious and impervious area runoff is discharged to a grass or forested buffer through overland flow. The use of a filter strip is also recommended to treat overland flow in the green space of a development site. The credits include:

1. The area draining by sheet flow to a buffer is subtracted from the total site area in the WQ_v calculation.
2. The area draining to the buffer contributes to the recharge requirement, Re_v.
3. A *wooded* CN can be used for the contributing area if it drains to a forested buffer.

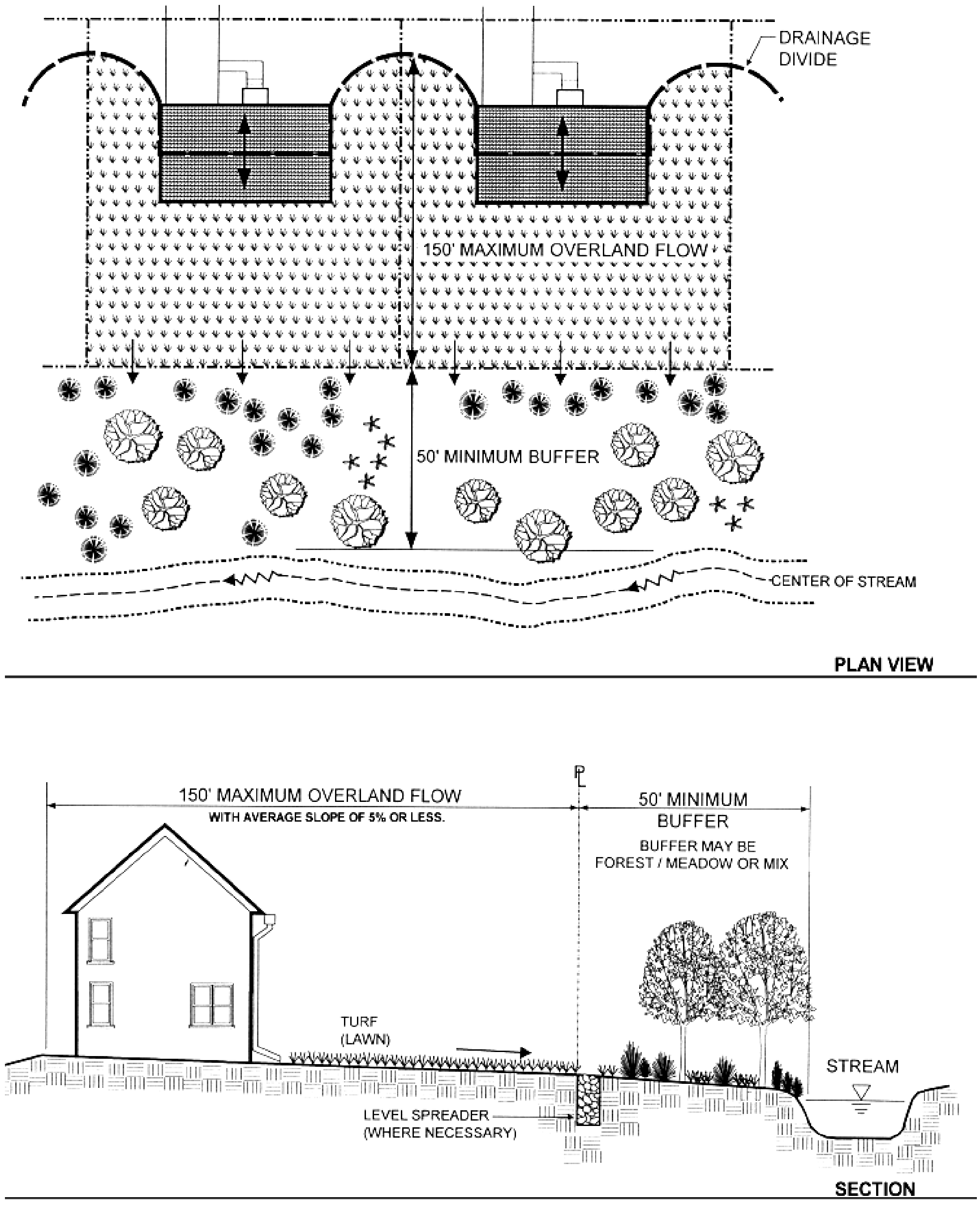
Criteria for Sheetflow to Buffer Credit

The credit is subject to the following conditions:

- *The minimum buffer width shall be 50 feet as measured from bankfull elevation or centerline of the buffer,*
- *The maximum contributing length shall be 150 feet for pervious surfaces and 75 feet for impervious surfaces,*
- *Runoff shall enter the buffer as sheet flow. Either the average contributing overland slope shall be 5.0% or less, or a level spreading device shall be used where sheet flow can no longer be maintained (see Detail No. 9 in Appendix D.8),*
- *Not applicable if rooftop or non rooftop disconnection is already provided (see Credits 2 & 3),*
- *Buffers shall remain unmanaged other than routine debris removal, and*
- *Shall be protected by an acceptable conservation easement or other enforceable instrument that ensures perpetual protection of the proposed area. The easement must clearly specify how the natural area vegetation shall be managed and boundaries will be marked* [Note: managed turf (e.g., playgrounds, regularly maintained open areas) is not an acceptable form of vegetation management].

Figure E.1.2 illustrates how a buffer or filter strip can be used to treat stormwater from adjacent pervious and impervious areas.

Figure E.1.2 Example of Sheetflow to Buffer Credit

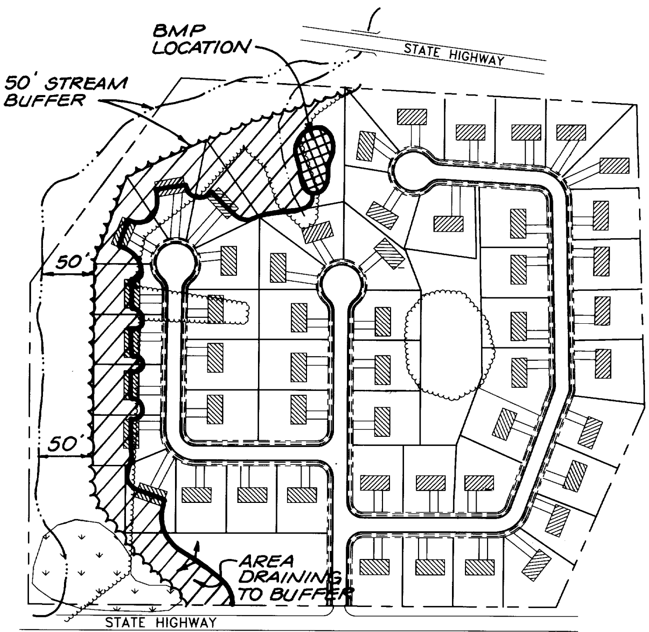


Example of Using the Sheetflow to Buffer Credit

Site Data - 51 Single Family
Area = 38.0 ac
Original Impervious Area = 13.8 ac = 36.3%
Original R_v = .38
Post-dev. CN = 78

Original WQ_v = 1.08 ac-ft
Original Re_v = 0.24 ac-ft
Original Cp_v = 1.65 ac-ft
Original Qp_v = 2.83 ac-ft

Credit
5.0 ac draining to buffer/filter strip
Rooftops represent 3% of site imperviousness = 0.41 acres



Computation of Stormwater Credits

New drainage area = 38 ac.– 5 ac.= 33.0 acres
R_v remains unchanged to BMP; R_v=0.05+0.009(36.3)=0.38

WQ_v =[(P)(R_v)(A)/!12
=[(0.9)(0.38)(33.0 ac.)]/12
= 0.94 ac-ft

Required Re_v (Percent Area Method)
Re_v = 20.8%×13.8 ac. = 2.87 acres
Re_v treated by disconnection = 0.41 acres
Re_v remaining for treatment = 2.46 acres non structurally or 0.214 ac-ft structurally

Cp_v and Q_p (total site): CN is reduced slightly.

Section E.1.5 Grass Channel Credit

Grass Channel Credit (in lieu of Curb and Gutter):

Credit may be given when open grass channels are used to reduce the volume of runoff and pollutants during smaller storms (e.g., $<$ 1 inch). The schematic of the grass channel is provided in Figure 5.3.

Use of a grass channel will automatically meet the Re_v for impervious areas draining into the channel. However, Re_v for impervious areas not draining to grass channels must still be addressed. If designed according to the following criteria, the grass channel will meet the WQ_v as well.

CNs for channel protection or peak flow control (Cp_v or Q_p) will not change.

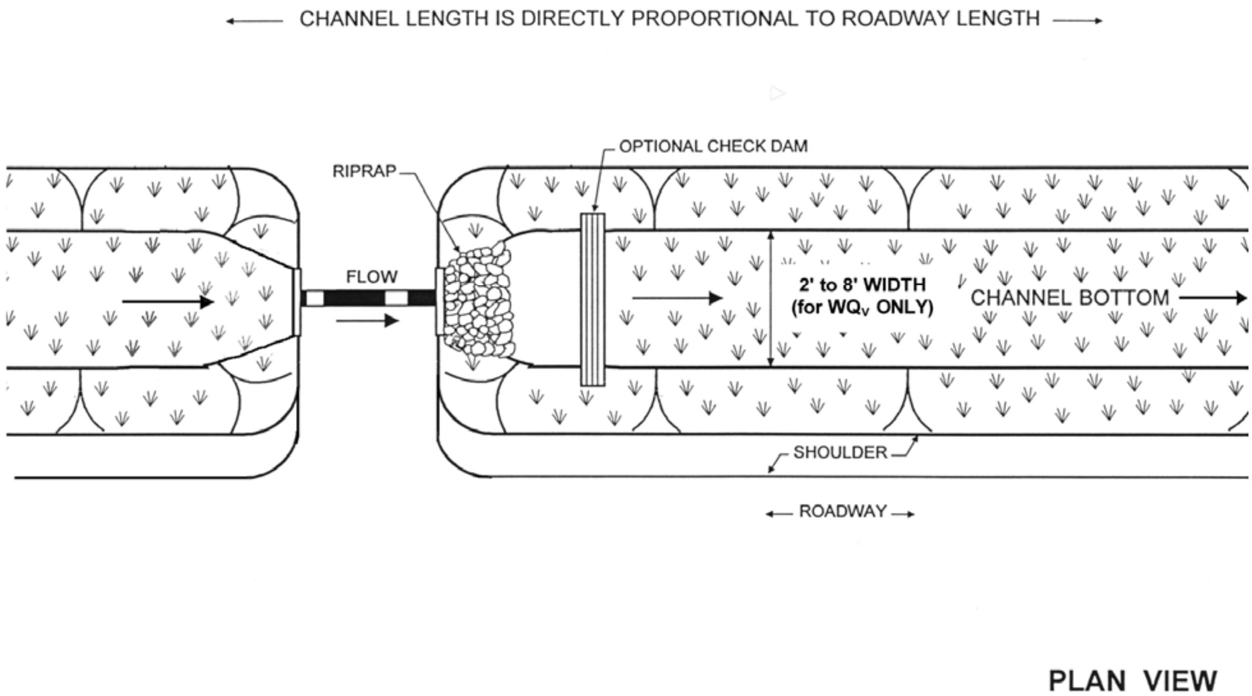
Criteria for the Grass Channel Credit

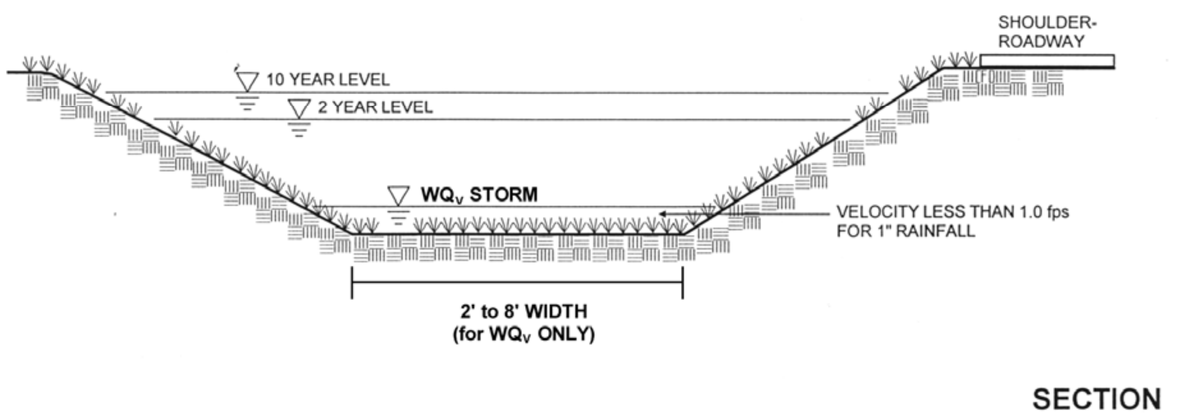
The WQ_v credit is obtained if a grass channel meets the following criteria:

- *The maximum flow velocity for runoff from the one-inch rainfall shall be less than or equal to 1.0 fps (see Appendix D.10 for methodology to compute flowrate),*
- *The maximum flow velocity for runoff from the ten-year design event shall be non erosive,*
- *The bottom width shall be 2 feet minimum and 8 feet maximum,*
- *The side slopes shall be 3:1 or flatter,*
- *The channel slope shall be less than or equal to 4.0%, and*
- *Not applicable if rooftop disconnection is already provided (see Credit 2).*

An example of a grass channel is provided in Figure E.1.3.

Figure E.1.3 Example of Grass Channel



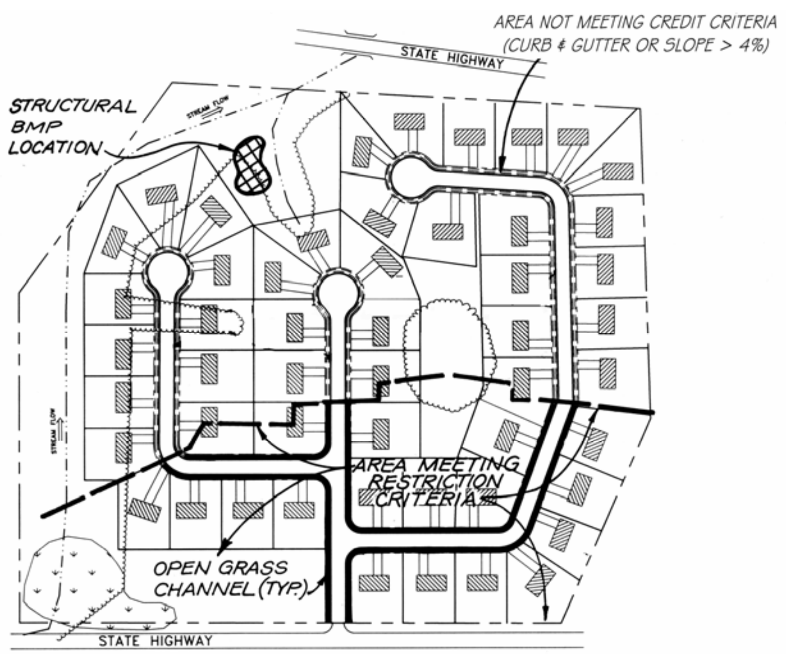


Example of Grass Channel Credit

Site Data - 51 Single Family Residences
Area = 38.0 ac
Original Impervious Area = 13.8 = 36.3%
R_v = .38
CN = 78

Original WQ_v = 1.08 ac-ft
Original Re_v = 0.25 ac-ft
Original Cp_v = 1.65 ac-ft
Original Qp_v = 2.83 ac-ft

Credit
12.5 acres meet grass channel criteria



Computation of Stormwater Credits

New WQ_v Area = 38 ac - 12.5 ac = 25.5 ac
WQ_v = [(0.9)(0.38)(25.5 ac.)]/12
= 0.74 ac-ft

Required Re_v (Percent Area Method)
$Re_v = 20.8\% \times 13.8 \text{ ac.} = 2.87 \text{ acres}$
4.5 acres of imperviousness lie within area drained by grass channels, and
4.5 acres $>$ 2.87 acres
$\therefore$ Re_v requirement is met.

Cp_v and Q_p: No change

Section E.1.6 Environmentally Sensitive Development Credit

Environmentally Sensitive Development

Credit is given when a group of environmental site design techniques are applied to low density or residential development. The credit eliminates the need for structural practices to treat both the Re_v and WQ_v and is intended for use on large lots.

Criteria for Environmentally Sensitive Development Credit

These criteria can be met without the use of structural practices in certain low density residential developments when the following conditions are met:

For Single Lot Development:

- *total site impervious cover is less than 15%,*
- *lot size shall be at least two acres,*
- *rooftop runoff is disconnected in accordance with the criteria outlined in Section E.1.2, and*
- *grass channels are used to convey runoff versus curb and gutter.*

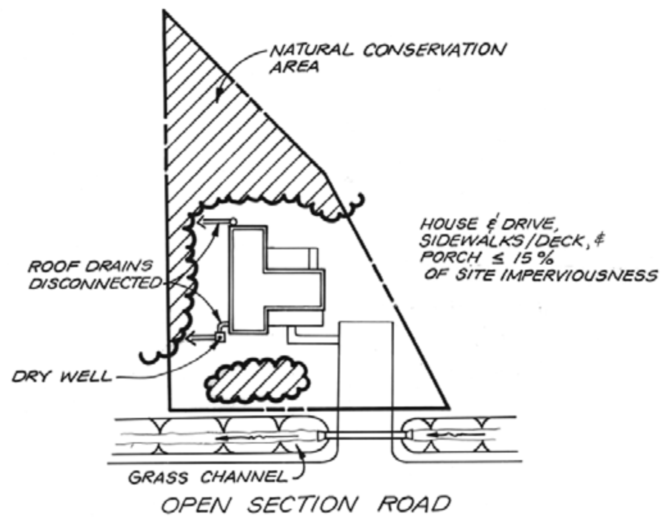
For Multiple Lot Development:

- *total site impervious cover is less than 15%,*
- *lot size shall be at least two acres if clustering techniques are not used,*
- *if clustering techniques are used, the average lot size shall not be greater than 50% of the minimum lot size as identified in the appropriate local zoning ordinance and shall be at least one half acre,*
- *rooftop runoff is disconnected in accordance with the criteria outlined in Section E.1.2,*
- *grass channels are used to convey runoff versus curb and gutter,*
- *a minimum of 25% of the site is protected in natural conservation areas (by permanent easement or other similar measure), and*
- *the design shall address stormwater (Re_v, WQ_v, Cp_v, and/or Qp_{10}) for all roadway and connected impervious surfaces.*

Example of Environmentally Sensitive Development

Site Data - 1 Single Family Lot
Area = 2.5 ac
Conservation Area = 0.6 ac
Impervious Area = .35 ac (includes adjacent road surface) = 14%
B soils
Eastern Rainfall Zone for WQ_v
$R_v = 0.05+0.009(14) = .18$
CN = 65

WQ_v : Use P=0.2 as I<15%
$WQ_v = [(0.2)(A)]/12$
$= [(0.2)(2.5)]/12 \times (43560\ ^{ft}/_{ac}.)$
$= 1{,}815\ ft^3$
$Re_v = [(S)(R_v)(A)]/12$
$= [(0.26)(0.18)(2.5)]/12 \times (43{,}560^{ft}/_{ac.})$
$= 424.7\ ft^3$



Computation of Stormwater Credits:

WQ_v is met by site design
Re_v is met by site design
Cp_v and Q_p: No change in CN, t_c may be longer which would reduce Q_p requirements

Section E.1.7 Dealing with Multiple Credits

Site designers are encouraged to utilize as many credits as they can on a site. Greater reductions in stormwater storage volumes can be achieved when many credits are combined (e.g., disconnecting rooftops and protecting natural conservation areas). However, credits cannot be claimed twice for an identical area of the site (e.g. claiming credit for stream buffers and disconnecting rooftops over the same site area).

Section E.1. 8 Other Strategies to Reduce Impervious Cover

Definition: Site planning practices that reduce the creation of impervious area in new residential and commercial development and therefore reduce the WQ_v for the site.

Examples of progressive site design practices that minimize the creation of impervious cover include:

- Narrower residential road sections
- Shorter road lengths
- Smaller turnarounds and cul-de-sac radii
- Permeable spill-over parking areas
- Smaller parking demand ratios
- Smaller parking stalls
- Angled one way parking
- Subdivisions with open space
- Smaller front yard setbacks
- Shared parking and driveways
- Narrower sidewalks

It should be noted that most site designers may have little ability to control these requirements, which are typically enshrined in local subdivision, parking and/or street codes.

Where these techniques are employed, it may be possible to reduce stormwater storage volumes. For example, because the WQ_v is directly based on impervious cover, a reduction in impervious cover reduces WQ_v. For Cp_v and Qp, the designer can compute curve numbers (CN) based on the actual measured impervious area at a site using:

$$CN = \frac{(98)I + \sum (CN)(P)}{A}$$

where:

CN = curve number for the appropriate pervious cover
I = impervious area at the site
P = pervious area at the site
A = total site area