Appendix A Compliance Calculations and Design Examples

A.1 General Retention Compliance Calculator

The General Retention Compliance Calculator is an Excel file located on the DDOE website at http://ddoe.dc.gov/swregs.

Each regulated project must use the General Retention Compliance Calculator to demonstrate proper BMP selection and sizing to achieve the required amount of stormwater retention and/or water quality treatment. The completed worksheets from this calculator must be submitted with the Stormwater Management Plan (SWMP). All major regulated projects are required to address the Stormwater Retention Volume (SWRv), and major regulated projects in the Anacostia Waterfront Development Zone (AWDZ) are required to address the Water Quality Treatment Volume (WQTv), as described in Chapter 2.

The General Retention Compliance Calculator can also be used, in addition to other hydrologic methods and models, to demonstrate compliance with detention obligations (see Section 2.6 and Appendix H).

A.2 Instructions for Compliance Calculations

The following guidance explains how to use each of the worksheet tabs in the General Retention Compliance Calculator.

Note: All cells highlighted in blue are user input cells. Cells highlighted in gray are calculation cells, and cells highlighted in yellow are constant values that generally should not be changed.

Site Data Sheet

1. Input the name of the proposed project on **line 9**.
2. Determine if the site is located in the AWDZ and note in **cell E13**.
3. Determine if the site is located in the MS4 and note in **cell E14**.
4. The regulatory rain event for calculation of the SWRv varies depending upon the type of development. For major land-disturbing activities, the SWRv is based upon the 90th percentile depth (1.2 inches). For major substantial improvements, the SWRv is based upon the 80th percentile depth (0.8 inches). If the site is in the AWDZ and undergoing major substantial improvement, the SWRv is based upon the 85th percentile depth (1.0 inches). Choose the type of development on **line 15**. The regulatory rain event for SWRv will be shown on **line 16**, and the regulatory rain event for the WQTv (if applicable) will be shown on **line 17**.

5. For the site, indicate the area (in square feet) of post-development Natural Cover, Compacted Cover, and best management practice (BMP) surface area in **cells D22–D25**. Guidance for various land covers is provided in Table A.1. Efforts to reduce impervious cover on the site and maximize Natural Cover will reduce the required Stormwater Retention Volume (SWRv). Portions of a project located in the public right-of-way should be considered separately from the rest of the site and surface area by cover type should be indicated in **cells E22–E25**.

   Note: This step will be iterative as BMP sizing is performed, and the area of both BMPs and other land cover types are adjusted.

6. From the land cover input, weighted site-runoff coefficients (*Rv*) will be calculated (**line 33**) for both the site and the public right-of-way based upon the land cover *Rv* values of 0.00 for Natural Cover, 0.25 for Compacted Cover, and 0.95 for Impervious Cover.

$$\%N = AN/SA \times 100$$

$$\%C = AC/SA \times 100$$

$$\%I = AI/SA \times 100$$

$$Rv = (\%N \times RvN + (\%C) \times RvC + (\%I) \times RVI$$

where:

$\%N$	=	percent of site in natural cover
AN	=	area of post-development natural cover (ft^2)
$\%C$	=	percent of site in compacted cover
AC	=	area of post-development compacted cover (ft^2)
$\%I$	=	percent of site in impervious cover
AI	=	area of post-development impervious cover (ft^2)
SA	=	total site area (ft^2)
Rv	=	weighted site runoff coefficient
Rv_N	=	runoff coefficient for natural cover (0.00)
Rv_C	=	runoff coefficient for compacted cover (0.25)
Rv_I	=	runoff coefficient for impervious cover (0.95)

7. The SWRv that must be retained on the site and in the PROW will be calculated on **line 37**.

$$SWRv = P/12 \times Rv \times SA$$

where:

SWRv	=	Stormwater Retention Volume (ft^3)
P	=	regulatory rain event (in.)
12	=	conversion from inches to feet
Rv	=	weighted site runoff coefficient
SA	=	total site area (ac)

8. If the site is in the AWDZ, the WQTv that must be treated on site and in the PROW will be calculated on **line 39**. The regulatory rain event for calculation of the WQTv is based upon the 95th percentile depth (1.7 inches).

$$WQTv = P/12 \times Rv \times SA$$

where:

WQTv	=	stormwater treatment volume (ft^3)
P	=	regulatory rain event (1.7 in.)
12	=	conversion from inches to feet
Rv	=	weighted site runoff coefficient
SA	=	total site area (ac)

Table A.1 Land Cover Guidance for General Retention Compliance Calculator, consult Appendix N for more details.

Natural Cover
Land that will remain undisturbed and exhibits hydrologic properties equal to or better than meadow in good condition OR land that will be restored to such a condition. This includes: ▪ Portions of residential yards in forest cover that will NOT be disturbed during construction. ▪ Community open space areas that will not be mowed routinely, but left in a natural vegetated state (can include areas that will be rotary mowed no more than two times per year). ▪ Utility rights-of-way that will be left in a natural vegetated state (can include areas that will be rotary mowed no more than two times per year). ▪ Other areas of existing forest and/or open space that will be protected during construction and that will remain undisturbed. Operational and Management Conditions in Natural Cover Category: ▪ Undisturbed portions of yards, community open space, and other areas that will be considered as forest/open space must be shown outside the Limits of Disturbance (LOD) on an approved Soil Erosion and Sediment Control Plan (SESCP) AND demarcated in the field (e.g., fencing) prior to commencement of construction. ▪ Portions of roadway rights-of-way that will count as natural cover are assumed to be disturbed during construction, and must follow the most recent design specifications for soil restoration and, if applicable, site reforestation, as well as other relevant specifications if the area will be used as a BMP. ▪ All areas that will be considered natural cover for stormwater purposes must have documentation that prescribes that the area will remain in a natural, vegetated state. Appropriate documentation includes: subdivision covenants and restrictions, deeded operation and maintenance agreements and plans, parcel of common ownership with maintenance plan, third-party protective easement, within public right-of-way or easement with maintenance plan, or other documentation approved by DDOE. ▪ While the goal is to have natural cover areas remain undisturbed, some activities may be prescribed in the appropriate documentation, as approved by DDOE: forest management, control of invasive species, replanting and revegetation, passive recreation (e.g., trails), limited bush hogging to maintain desired vegetative community, etc. ▪ Land that will undergo conversion from compacted cover or impervious cover to natural cover must follow the guidelines for compost amended soils in Appendix J.
Compacted Cover
Land disturbed and/or graded for eventual use as managed turf or landscaping. Managed turf comprises of areas that are graded or disturbed, and maintained as turf, including yard areas, septic fields, residential utility connections, and roadway rights of way. Landscaping includes areas that are intended to be maintained in vegetation other than turf within residential, commercial, industrial, and institutional settings.
Impervious Cover
Roadways, driveways, rooftops, parking lots, sidewalks, and other areas of impervious cover. While they are noted separately in the spreadsheet, the surface area of all BMPs, except disconnection areas are included with impervious cover in the spreadsheet's calculations.

Drainage Area Sheets 1–10

If the site has multiple discharge points, or complex treatment sequences, it must be divided into individual drainage areas (DAs). For each DA, a minimum of 50 percent of the SWRv must be retained. In the MS4, if 50 percent of the SWRv cannot be retained, that volume (or equivalent 24-hour storm) must be captured and treated with an accepted TSS treatment practice.

For each DA sheet:

1. Indicate the specific area of post-development Natural Cover, Compacted Cover, Impervious Cover, Vehicular Access, and BMP surface area in **lines 6–10**. The SWRv for the DA will be calculated in **cell G12**, and the WQTv (if in the AWDZ) will be calculated in **cell G17**.

   Note: This step will be iterative as BMP sizing is performed, and the area of both BMPs and other land cover types is adjusted. Vehicular Access Areas are a sub-category of Impervious Cover. Therefore, the Vehicular Access Areas must be included as a part of the total Impervious Cover area.

2. Apply BMPs to the drainage area to address the required SWRv and WQTv by indicating the area in square feet of compacted cover, impervious cover, and vehicular access areas (see not above) to be treated by a given BMP in **columns B, D,** and **F** (or the number of trees in the case of tree preservation or planting). This will likely be an iterative process. The available BMPs include the following:

   - Green Roofs
   - Rainwater Harvesting
   - Simple Disconnection to a Pervious Area (Compacted Cover)
   - Simple Disconnection to a Conservation Area (Natural Cover)
   - Simple Disconnection to Amended Soils
   - Permeable Pavement Systems - Enhanced
   - Permeable Pavement Systems - Standard
   - Bioretention - Enhanced
   - Bioretention - Standard
   - Stormwater Filtering Systems
   - Stormwater Infiltration
   - Grass Channels
   - Grass Channel with Amended Soils
   - Dry Swales
   - Wet Swales
   - Stormwater Ponds
   - Stormwater Wetlands
   - Storage Practices
   - Proprietary Practices
   - Tree Planting
   - Tree Preservation

3. Based upon the area input for a given BMP, the spreadsheet will calculate the Maximum Retention Volume Received by BMP in **column H**. Regardless of the Regulatory Rainfall Event that applies to the site, the volume calculated in **column F** is based on a rainfall depth of 1.7 inches. Therefore, the value in **column H** represents the greatest retention volume for which a BMP can be valued, rather than the volume that must be retained to achieve compliance. In other words, it is possible to "oversize" BMPs in one drainage area and "undersize" others to achieve compliance. However, as noted above, in the MS4, a minimum of 50 percent of the SWRv must be retained in each drainage area. Otherwise, treatment of the remaining runoff to reach 50 percent of the SWRv must be provided by an accepted TSS treatment practice.

$$V_{max} = 1.7/12 \times (Rv_N \times A_N + Rv_C \times A_C + Rv_I \times (A_I + A_{BMP}))$$

where:

V_{max}	=	volume received by the BMP from 1.7-inch rain event (ft^3)
Rv_N	=	runoff coefficient for natural cover (0.00)
A_N	=	area of post-development natural cover (ft^2)
Rv_C	=	runoff coefficient for compacted cover (0.25)
A_C	=	area of post-development compacted cover (ft^2)
Rv_I	=	runoff coefficient for impervious cover (0.95)
A_I	=	area of post-development impervious cover (ft^2)
A_{BMP}	=	area of BMP (ft^2)

4. As noted in Chapter 2, for all vehicular access areas, a minimum of 50percent of the SWRv must also be retained or treated. This volume is calculated for each BMP in **column G** as follows:

$$V = RRE/12 \times Rv_I \times Av \times 0.5$$

where:

V	=	volume received by the BMP from vehicular access areas that must be retained or treated (ft^3)
RRE	=	Regulatory Rain Event for SWRv (in.)
Rv_I	=	runoff coefficient for impervious cover (0.95)
Av	=	area of vehicular access area (ft^2)

5. If more than one BMP will be employed in series, any overflow from upstream BMPs will be accounted for in **column L**, and the total volume directed to the BMP will be summed in **column M**.

6. For most BMPs it is necessary to input the surface area of the BMP and/or the storage volume of the BMP in **columns N** and **O**. These should be calculated using the equations provided in Chapter 3.
7. The spreadsheet calculates a retention volume value in **columnP**, based on the value descriptions in **columns I–K**. Regardless of the storage volume of the BMP, the retention volume value cannot be greater than the total volume received by the BMP (**column M**).
8. The Potential Retention Volume Remaining (**column Q**) equals the total volume received by the BMP minus the retention volume value.
9. BMPs that have a less than 100 percent retention value and are accepted TSS treatment practices are assigned additional treatment volume based upon the lesser of the runoff volume received by the BMP and the actual storage volume minus the retention value. This additional treatment volume is indicated in **column R**.
10. Any potential retention volume remaining (**column Q**) can be directed to a downstream BMP in **column S** by selecting from the pull-down menu. Selecting a BMP from the menu will automatically direct the retention volume remaining to **column L** for the appropriate BMP.
11. **Column T** calculates whether or not the vehicular access area directed to each BMP is adequately addressed, via retention or treatment. To do this, the required runoff volume from the vehicular access area is compared to the retention and treatment volumes provided by the BMP, as well as from a downstream BMP, if selected. For each BMP that receives vehicular access runoff, "Yes" or "No" will be displayed. It should be noted that while this column does take downstream BMPs into account, it is not a precise enough check to ensure that all possible design variations are accounted for. Sufficient retention or treatment from vehicular access areas must be clearly shown on the design plans.
12. From the selected BMPs, the total volume retained will be summed in **cell P66**. The retention volume remaining will then be calculated as the difference between the SWRv and the total volume retained in **cell P68** (in cubic feet) and **cell P69** (in gallons). **Cell P71** indicates if at least 50 percent of the SWRv has been retained for the DA.
13. **Cell P72** indicates whether or not all of the vehicular access areas have been adequately addressed. This is accomplished with two checks. First, the cell checks that the entire vehicular access area for the drainage area indicated in **cell B9** has been included in **column F**, by comparing **cell F66** to **cell B9**. Second, the cell checks that sufficient retention or treatment volume has been provided in each BMP by searching for "No's" in **column T**. As noted above, this check is not precise enough to ensure that all possible design variations are accounted for. Sufficient retention or treatment from vehicular access areas must be clearly shown on the design plans.
14. If in the MS4, if 50 percent of the SWRv has not been retained, **cell P73** indicates that treatment is required.
15. From the selected BMPs, **cell T66** is the sum of the total volume treated. If treatment is required due to a shortage of retention, **cells T68** (cubic feet) and **T69** (gallons) indicate how much more runoff must be treated. If treatment is required because the site is located in the AWDZ, **cells T71** (cubic feet) and **T72** (gallons) indicate how much runoff must be treated to meet WQTv requirements.

16. **Cell P75** will indicate compliance for the DA with a "Yes" or "No," depending on retention and treatment volume provided in the drainage area.

    Note: Since only 50 percent of the SWRv must be retained in any individual DA, compliance in each drainage area does not automatically mean that compliance for the entire site has been achieved.

Public Right-of-Way Sheet

The Public Right-of-Way sheet is functionally identical to the Drainage Area sheet; therefore, Steps 1–16 should be followed as stated above. If SWRv or WQTv is not met, the site may still comply if it follows the Maximum Extent Practicable (MEP) process as described in Appendix B.

Compliance Worksheet Tab

The Compliance worksheet summarizes the stormwater retention and treatment results for each DA as well as the whole site. For all sites, in order to comply with the stormwater management requirements, each DA must indicate that the vehicular access areas volume has been addressed. In the MS4, each DA must either indicate that 50 percent of the SWRv has been retained, or that there are 0 inches of remaining volume to treat 50percent of the SWRv. Key values for each drainage area are described on this worksheet, with site compliance and the public right-of-way summarized at the bottom.

Cell B206 indicates the total volume retained on site. **Cell B208** (cubic feet) and **cell B209** (gallons) indicate the remaining retention volume (if any) to meet the SWRv. If the SWRv has not been fully met, **cell B215** indicates the required Off-site Retention Volume (Offv). The Offv may be addressed through the use of Stormwater Retention Credits (SRCs) and/or payment of an in-lieu fee. If the SWRv has been exceeded, **cell B214** indicates the volume that may be available to generate SRCs

This sheet also summarizes the stormwater retention results from the Public Right-of-Way (PROW) sheet. **Cell B224** indicates the Total Volume Retained on site. **Cells B225** and **B226** show the remaining retention volume (if any) in cubic feet and gallons, respectively. **Cells B232–B235** show the remaining treatment volume (if any) to meet SWRv and WQTv requirements.

Channel and Flood Protection

This sheet assists with calculation of Adjusted Curve Numbers that can be used to calculate peak flows associated with the 2-year storm, 15-year storm, or other storm events.

1. Indicate the appropriate depths for the 1-year, 2-year, and 100-year 24-hour storms (or other storms as needed) on **line 5**.
2. Each cover type is associated with a Natural Resource Conservation Service (NRCS) curve number. **Cells D54, D56, and D58** show the curve number for D.A. 1. Using these curve numbers (or other curve numbers if appropriate), a weighted curve number and the total runoff volume for D.A. 1 is calculated (**cell E58**).

3. **Line 61** calculates the runoff volume without regard to the BMPs employed in D.A. 1. **Line 62** subtracts the storage volume provided by the BMPs in D.A. 1 from these totals.
4. The spreadsheet then determines the curve number that results in the calculated runoff volume with the BMPs. This Adjusted Curve Number is reported on **line 63**.
5. These steps are repeated for Drainage Areas 2–10.

Weighted Curve Number

$$CN = [(AN \times 70) + (AC \times 74) + (AI \times 98)]/SA$$

where:

CN	=	weighted curve number
AN	=	area of post-development natural cover (ft^2)
AC	=	area of post-development compacted cover (ft^2)
AI	=	area of post-development impervious cover (ft^2)
SA	=	total site area (ft^2)

Potential Abstraction

$$S = 1000/(CN\text{-}10)$$

where:

S	=	potential abstraction (in.)
CN	=	weighted curve number

Runoff Volume with no Retention

$$Q = (P - 0.2 \times S)2/(P + 0.8 \times S)$$

where:

Q	=	runoff volume with no BMPs (in.)
P	=	precipitation depth for a given 24-hour storm (in.)
S	=	potential abstraction (in.)

Runoff Volume with BMPs

$$Q_{BMP} = Q - Cv_{DA} \times 12/DA$$

where:

Q_{BMP}	=	runoff volume with BMPs (in.)
Q	=	runoff volume with no BMPs (in.)
Cv_{DA}	=	total storage volume provided by BMPs for the drainage area (ft^3)
12	=	unit adjustment factor, feet to inches
DA	=	drainage area (ft^2)

Adjusted Curve Number

The adjusted curve number is calculated using a lookup table of curve number and runoff volumes so that:

$$CN_{adjusted}, \text{ so } (P - 0.2 \times S_{adjusted}) \times 2/(P + 0.8 \times S_{adjusted}) = Q_{BMP}$$

$$S_{adjusted} = 1000/(CN_{adjusted} - 10)$$

where:

$CN_{adjusted}$	=	adjusted curve number that will create a runoff volume equal to the drainage area runoff volume including BMPs
P	=	precipitation depth for a given 24-hour storm (in.)
$S_{adjusted}$	=	adjusted potential abstraction based upon adjusted curve number (in.)
Q_{BMP}	=	runoff volume with BMPs (in.)

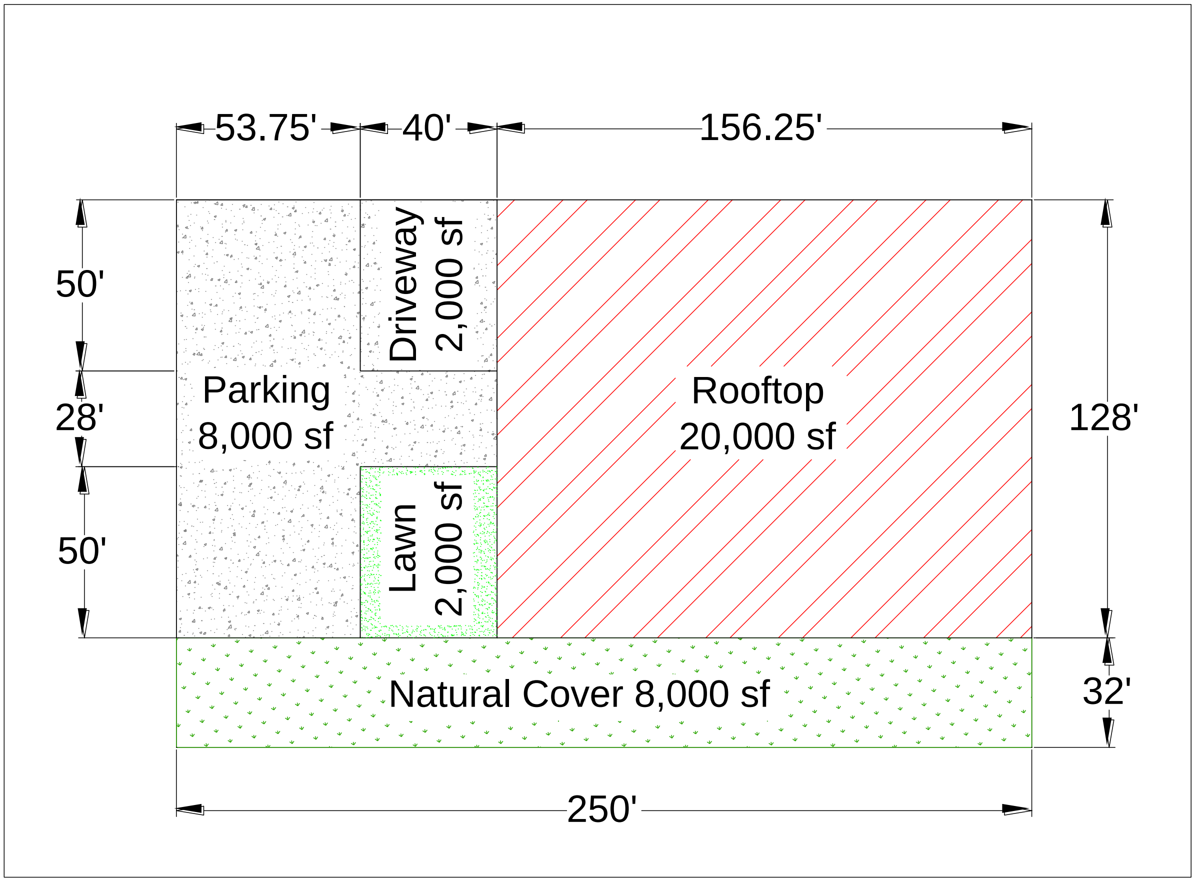
A.3 Design Examples

Design Example 1

Step 1: Determine Design Criteria.

Design Example 1 includes the following site characteristics:

Site Name	Anacostia Offices
Total Site Area	40,000 ft^2
Natural Cover Area	8,000 ft^2
Compacted Cover	2,000 ft^2
Impervious Cover	30,000 ft^2
Vehicular Access Areas	10,000 ft^2
Is site located within the AWDZ?	No
Is site located within the MS4?	No
What type of activity is site undergoing?	Major Land Disturbing



Step 2: **Input Design Criteria to Determine the Retention and Treatment Requirements.**

The General Retention Compliance Calculator will calculate a Stormwater Retention Volume (SWRv), once the natural cover, compacted cover, and impervious cover areas are put into **cells D22–D25** on the Site Data sheet.

Based on the design criteria above, Anacostia Offices has the following requirements:

SWRv = **cell D37** = 2,900 ft^3

Step 3: **Identify Site Constraints and BMP Restrictions.**

Key considerations for Anacostia Offices include the following:

- Site soils are contaminated, so infiltration is not allowed, and impermeable liners will be required for most BMPs.
- The commercial land use means that most BMPs are otherwise acceptable.

Step 4: **Select BMPs to Meet the Retention and Treatment Requirements.**

While there are numerous options for treatment of this site, two BMPs were selected: rainwater harvesting (R1) for the rooftop and bioretention (B1) for any remaining rooftop runoff and the rest of the site. Since the site is contaminated, a liner is required and the enhanced bioretention option is not available.

The site will ultimately have one outlet point, and the selected treatment train is relatively simple, so the calculations can be performed on one Drainage Area tab – D.A. 1. Therefore, all of the same values from the Site Data tab for the various cover types (plus the vehicle access area) should be put into **cells B6-B10** on the D.A.1tab.

The first BMP selected is rainwater harvesting for runoff from the rooftop. The Rainwater Harvesting Retention Calculator should be used to determine the cistern size and the associated retention value. In the Rainwater Harvesting Retention Calculator 20,000 square feet should be put in as the Contributing Drainage Area (CDA) (**cell L7**). For utilization of the rainwater, flushing toilets/urinals is selected as the use, and the appropriate values are entered. In this case, 500 people will use the building per day (**cell L21**), Monday through Friday (**cells L30** and **L32**), 8 hours per day (**cell L34)**. On the Results – Retention Value sheet, the retention values are given for various tank sizes. The tables and graphs show that a 30,000 gallon underground tank (or series of tanks) would meet much of the demand and have a very high retention value—94 percent.

The next step is to return to the D.A. 1 tab and input the 20,000-square foot CDA into **cell D25** for rainwater harvesting and input the efficiency (94%) into **cell K25**. The result is that 2,530 cubic feet of runoff are retained and 162 cubic feet remain. Since Standard Bioretention will be the next BMP in the series, it should be selected from the pull-down menu in **cell S25**. The remaining runoff volume will then be directed to this BMP.

In addition to the overflow from the rainwater harvesting BMP, the bioretention area will receive runoff from the rest of the site. Initially, these land uses can be input into **cells B39–D40**. However, the surface area of the bioretention area must be accounted for as well. Through trial and error, it was determined that a 1,000-square-foot bioretention area would be sufficient to meet the retention requirement. This area will be taken from the compacted cover area and will need to be changed on the Site Data Tab as well as at the top of DA. 1. Compacted cover will now be 1,000 square feet, and BMP will be 1,000 square feet. The 8,000 square feet of natural cover will remain. Impervious cover directed to the bioretention area (**cell D39**) will be 10,000 square feet (the remaining impervious area after 20,000 square feet was removed for rainwater harvesting). 1,000 square feet of compacted cover and 1,000 square feet of BMP surface area will also be directed to the bioretention area (**cells B40** and **D40**). Since the 10,000 square feet of impervious cover is made up of driveway and parking area, it is all classified as vehicular access area, so 10,000 should be put into **cell F39** as well.

The vehicular access retention/treatment requirement is 475 cubic feet (**cell G39**), and the total volume directed to the bioretention area, including the “overflow” from the rainwater harvesting BMP, will be 1,677 cubic feet (**cell M39**). Inputting 800 cubic feet for the storage volume in the spreadsheet (**cell O39**) is more than sufficient to address the vehicular access volume and leads to an exceedance of 300 gallons for the SWRv (**cell Q69**). This information is also summarized on the Compliance worksheet tab.

Step 5: **Size the BMPs According to the Design Equations.**

The size of the rainwater-harvesting cistern was already determined to be 30,000 gallons, although additional volume may be necessary for dead storage for a pump, and/or freeboard.

To meet the bioretention criteria, the bioretention area is sized with 1.5 feet of filter media, 0.75 feet of gravel, and a 0.5-foot ponding depth. The bioretention cell sizing goal is 800 cubic feet.

***Step 5.1*:** **Check the Filter Media Depth.**

Ensure that the filter media depth does not exceed the maximum in Table 3.21. The ratio of the surface area of the BMP (1,000 ft^2) to the contributing drainage area (32,000 ft^2) is 3.1%. The Rv for the contributing drainage area to the bioretention practice is 0.93. The maximum filter media depth allowed is 5.0 feet. As the bioretention was sized with 1.5 feet of filter media, it passes this check.

Table 3.21 Determining Maximum Filter Media Depth (feet)

SA:CDA (%)	RvCDA								
	0.25	0.3	0.40	0.50	0.60	0.70	0.80	0.90	0.95
0.5	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
1.0	5.0	5.5	6.0	6.0	6.0	6.0	6.0	6.0	6.0
1.5	3.5	4.0	5.0	6.0	6.0	6.0	6.0	6.0	6.0
2.0	2.5	3.0	4.0	5.0	5.5	6.0	6.0	6.0	6.0
2.5	2.0	2.5	3.5	4.0	4.5	5.0	5.5	6.0	6.0
3.0	1.5	2.0	3.0	3.5	4.0	4.5	5.0	5.5	5.5
3.5	1.5	1.5	2.5	3.0	3.5	4.0	4.5	5.0	5.0
4.0	1.5	1.5	2.0	2.5	3.0	3.5	4.0	4.5	4.5
4.5	1.5	1.5	2.0	2.5	3.0	3.5	3.5	4.0	4.5
5.0	1.5	1.5	1.5	2.0	2.5	3.0	3.5	4.0	4.0
5.5	1.5	1.5	1.5	2.0	2.5	2.5	3.0	3.5	3.5
6.0	1.5	1.5	1.5	1.5	2.0	2.5	3.0	3.0	3.5
6.5	1.5	1.5	1.5	1.5	2.0	2.5	2.5	3.0	3.0
7.0	1.5	1.5	1.5	1.5	1.5	2.0	2.5	3.0	3.0
7.5	1.5	1.5	1.5	1.5	1.5	2.0	2.5	2.5	2.5
8.0	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.5	2.5
8.5	1.5	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.5
9.0	1.5	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.0
9.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	2.0	2.0
10.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	2.0	2.0

***Step 5.2*: Determine Storage Volume.**

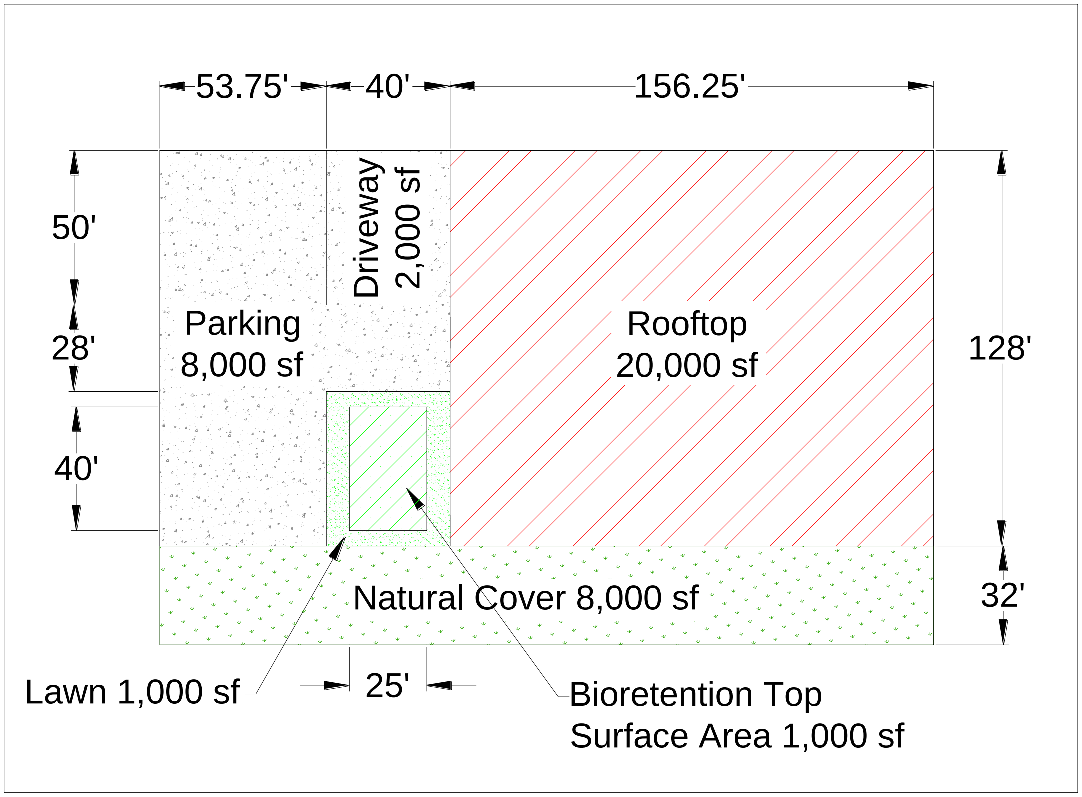
Equation 3.5

$$Sv = SA_{bottom} \times \left[\left(d_{media} \times \eta_{media} \right) + \left(d_{gravel} \times \eta_{gravel} \right) \right] + \left(SA_{average} \times d_{ponding} \right) \right]$$

where:

Sv	=	total storage volume of bioretention (ft^3)
SA_{bottom}	=	bottom surface area of bioretention (ft^2)
d_{media}	=	depth of the filter media (ft)
η_{media}	=	effective porosity of the filter media (typically 0.25)
d_{gravel}	=	depth of the underdrain and underground storage gravel layer(ft)
η_{gravel}	=	effective porosity of the gravel layer (typically 0.4)
$SA_{average}$	=	the average surface area of the bioretention (ft^2) typically, where SA_{top} is the top surface area of bioretention, $SA_{average} = \frac{SA_{bottom} + SA_{top}}{2}$
$d_{ponding}$	=	the maximum ponding depth of the bioretention (ft)

Solving Equation 3.5 often requires an iterative approach to determine the most appropriate bottom surface area and average surface area to achieve the desired *Sv*. In this case, a bioretention with a 40 foot by 25 foot top area and 3:1 side slopes will provide a SA_{top} of 1,000 square feet, a SA_{bottom} of 814 square feet, a $SA_{average}$ of 907 square feet, and achieve a *Sv* of 1,003 cubic feet. This more than meets the goal of 800 cubic feet. If desired, the surface area of the practice could be reduced accordingly, or more SRCs could be generated with the excess volume.



Step 6: **Check Design Assumptions and Requirements.**

Key assumptions and requirements for this site include:

- Based upon the above design, the rainwater harvesting cistern will be 30,000 gallons and the bioretention cell will require at least 1,000 square feet of surface area. The designer would need to ensure that space would be available for these BMPs on the site.
- The contributing drainage area for traditional bioretention must be 2.5 acres or less and this site is less than 1 acre.
- The required head for the above design will be 25 feet, including ponding depth (9 inches), mulch (3 inches), filter media (18 inches), choking layer (about 3inches) , and gravel layer (about 9 inches). (See Figure 3.18). The outlet for the underdrain must be at least this deep.
- The water table must be at least 2 feet below the underdrain, or 5.5 feet below the surface. According to the Soil Survey, Beltsville soils have a 1.5- to 2-foot depth to seasonally high groundwater table, Croom soils have greater than a 5-foot depth, and Sassafras soils have a 4-foot depth. On-site soil investigations will be needed to determine if the 5.5-foot depth to the groundwater table can be met on this site.
- Due to soil contamination and the bioretention area’s proximity to the building (less than 10 feet), an impermeable liner is required.

Since all of these assumptions and requirements can be met in this design example (pending groundwater table investigations), this step is complete.

Step 7: Use the Adjusted Curve Number to Address Peak Flow Requirements.

On the Channel and Flood Protection tab, enter values for C soils in **cells D54, D56**, and **D58** (70 for natural areas, 74 for turf, and 98 for impervious cover, respectively). The original site curve number of 92 is reduced for the 2-year, 15-year, and 100-year storms to 79, 82, and 83, respectively, by the retention provided by the cistern and bioretention cell. These values can be used to help determine detention requirements for this site.

Step 8: Determine Detention Requirements.

Detention is required to reduce the peak discharge rate from the 2-year storm event to the predevelopment (meadow conditions or better) peak discharge rate and to reduce the peak discharge rate from the 15-year storm event to the preproject peak discharge rate. Appendix H includes details on the procedure for calculating the detention volume. In this example, the proposed impervious cover and the proposed runoff curve number is less than the preproject conditions, so detention for the 15-year storm is not required. Detention for the 2-year storm will be required.

The peak inflow (q_{i2}) and the peak outflow (q_{o2}) can be calculated using the WinTR-55 Small Watershed Hydrology program, the area of the site, the time of concentration (Tc), assumed to be 10 minutes), and the curve numbers. The reduced curve of 79, determined above, generates a q_{i2} of 1.61 cubic feet per second (cfs). The curve number for meadow in good condition, 71, generates a q_{o2} of 1.07 cfs.

The ratio of 1.07 cfs to 1.61 cfs equals 0.63. Using Figure H.1, the ratio of storage volume (Vs_2) to runoff volume (Vr_2) is 0.22.

The runoff volume (Vr_2) determined from the General Retention Compliance Calculator is 1.33 inches, which equates to 4,333 cubic feet. Using the calculated ratio of Vs_2/Vr_2, the storage volume required for the site (Vs_2) is 1,020 cubic feet.

With appropriate orifice design to ensure that outflows are properly restricted, this detention volume can be incorporated below the proposed bioretention area or located elsewhere on the site as a standalone detention practice.

Design Example 2

Step 1: **Determine Design Criteria.**

Design Example 2 includes the following proposed design criteria:

Site Name	Downtown Multi-Story Renovation
Total Site Area	15,000 ft^2
Natural Cover Area	0 ft^2
Compacted Cover	0 ft^2
Impervious Cover (Rooftop)	15,000 ft^2
Vehicular Access Areas	0 ft^2
Is site located within the AWDZ?	No
Is site located within the MS4?	Yes
What type of activity is the site undergoing?	Major Substantial Improvement

Step 2: **Input Design Criteria to Determine the Retention and Treatment Requirements.**

The Compliance Calculator Spreadsheet will calculate a Stormwater Retention Volume (SWRv), once the above values are put into the Site Data sheet.

Based on the design criteria above, the Multi-Story Renovation project is required to treat 0.8 inches of rainfall for the SWRv:

SWRv = **cell D37** = 950 ft^3

Step 3: **Identify Site Constraints and BMP Restrictions.**

Key considerations for the Multi-Story Renovation project include the following:

- Since this is a rooftop-only site, very few treatment options are available.
- As a renovation, the structure of the existing roof will be a factor for any rooftop practice.

Step 4: **Select BMPs to Meet the Retention and Treatment Requirements.**

As an initial estimate 75 percent of the rooftop is proposed to be converted to a green roof, with the remaining 25 percent draining to it. Therefore, the land use values need to be changed to account for the green roof: 3,750 square feet should be entered as impervious cover in **cell D24** on the Site Data sheet, and 11,250 square feet should be entered in **cell D25** as “BMP.” As there will be only one drainage area for the site, these same values should be entered into **cells B8** and **B10** on sheet D.A. 1. and as the Green Roof drainage area (**cells D23** and **D24**).

The goal of this design is to capture the entire retention volume (950 ft^3) in the Green Roof. This can be shown on the spreadsheet by entering 950 cubic feet in **cell O23** on sheet D.A. A. **Cell Q69** shows that the SWRv has been met for the site. This information is also summarized on the Compliance worksheet tab.

Step 5: Size the BMPs According to the Design Equations.

The green roof needs to be sized according to Equation 3.1. Since green roofs are typically manufactured systems, several of the parameters, such as the drainage layer depth and maximum water retention of all layers, need to be provided by the manufacturer. The values for the roof used in this design are provided in the variable descriptions below Equation 3.1 (with each layer illustrated in Figure 3.1).

Equation 3.1 Storage Volume for Green Roofs

$$Sv = \frac{SA \times [(d \times \eta_1) + (DL \times \eta_2)]}{12}$$

where:

Sv	=	storage volume (ft^3) (goal is 950 ft^3)
SA	=	green roof area (ft^2) (need to determine)
d	=	media depth (in.) (6 in.)
η1	=	verified media maximum water retention (0.25)
DL	=	drainage layer depth (in.) (1 in.)
η2	=	verified drainage layer maximum water retention (0.4)

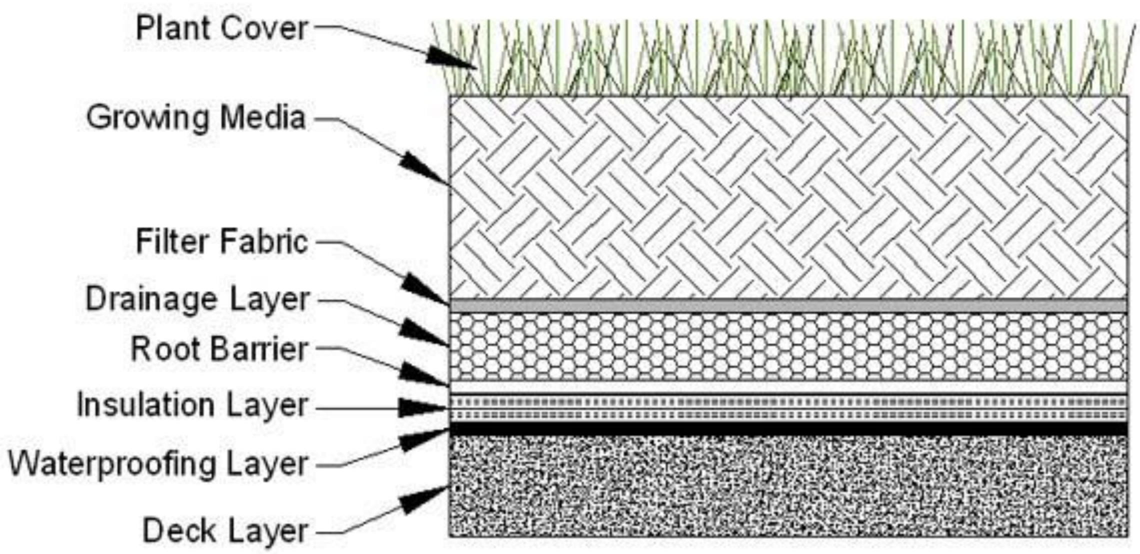


Figure 3.1 Typical layers for a green roof.

Rearranging Equation 3.1 to find the minimum required surface area:

$$SA = Sv/[(d \times \eta\ 1)+(DL \times \eta\ 2)] \times 12$$

or:

$$SA = 950/(6 \times 0.25+1\times 0.4) \times 12$$

$$SA = 6{,}000\ \text{ft}^2$$

Therefore, the green roof must be sized to be at least 6,000 square feet, given the proposed depths. The original assumption was that an 11,250-square-foot roof would be used. Since a smaller roof is feasible, the drainage areas in the spreadsheet may be revised accordingly.

Note: The drainage area to the green roof is only 25 percent larger than the green roof itself, so the maximum additional drainage area to a 6,000-square-foot roof is 1,500 square feet. Alternatively, the larger roof may be utilized, and the increased storage volume can be used to reduce peak flow volume requirements (see Step 8) or sold as Stormwater Retention Credits.

Step 6: Check Design Assumptions and Requirements.

Key assumptions and requirements for this site include:

- A structural analysis of the building is needed to determine that the green roof can be supported by the existing structure.
- Ensure that there is sufficient space on the rooftop (allowing for structures such as vents, steep areas of the roof, and other panels). In this case, the minimum roof area of 6,000 square feet is less than half of the entire roof area and most roofs can accommodate this area.
- At least 1,500 square feet of the rooftop not covered by green roof needs to be designed so that it drains to the green roof without damaging it.

Since all of these assumptions and requirements can be met in this design example, this step is complete.

Step 7: Use the Adjusted Curve Number to Address Peak Flow Requirements.

The initial curve number for this site is 98, but retention provided by the green roof changes this number. The Channel and Flood Protection tab notes the reduced curve numbers for the 2-year, 15-year, and 100-year storms: 90, 91, and 92, respectively. These curve numbers can be used to help determine detention requirements for this site.

Step 8: Determine Detention Requirements.

Detention is required to reduce the peak discharge rate from the 2-year-storm event to the predevelopment (meadow conditions or better) peak discharge rate and to reduce the peak discharge rate from the 15-year storm event to the preproject peak discharge rate. Appendix H includes details on the procedure for calculating the detention volume. In this example, since the proposed land cover is the same as the preproject conditions, detention is not required for the 15-year storm. However, detention is required for the 2-year storm.

The peak inflow, $qi_2$and the peak outflow, q_{o2} can be calculated using the WinTR-55 Small Watershed Hydrology program, the area of the site, the time of concentration (Tc, assumed to be 10 minutes), and the curve numbers. The reduced curve of 90, determined above, generates a qi_2 of 1.00 cubic foot per second (cfs). The curve number for meadow in good condition, 71, generates a q_{o2} of 0.39 cfs.

The ratio of 0.39 cfs to 1.00 cfs equals 0.39. Using Figure H.1, this equates to a ratio of storage volume (Vs_2) to runoff volume (Vr_2) of 0.33.

The runoff volume (Vr_2) determined in the Compliance Calculator spreadsheet is 2.21 inches, which equates to 2,763 cubic feet. Using the calculated ratio of Vs_2/Vr_2, the storage volume required for the site (Vs_2) is912 cubic feet.

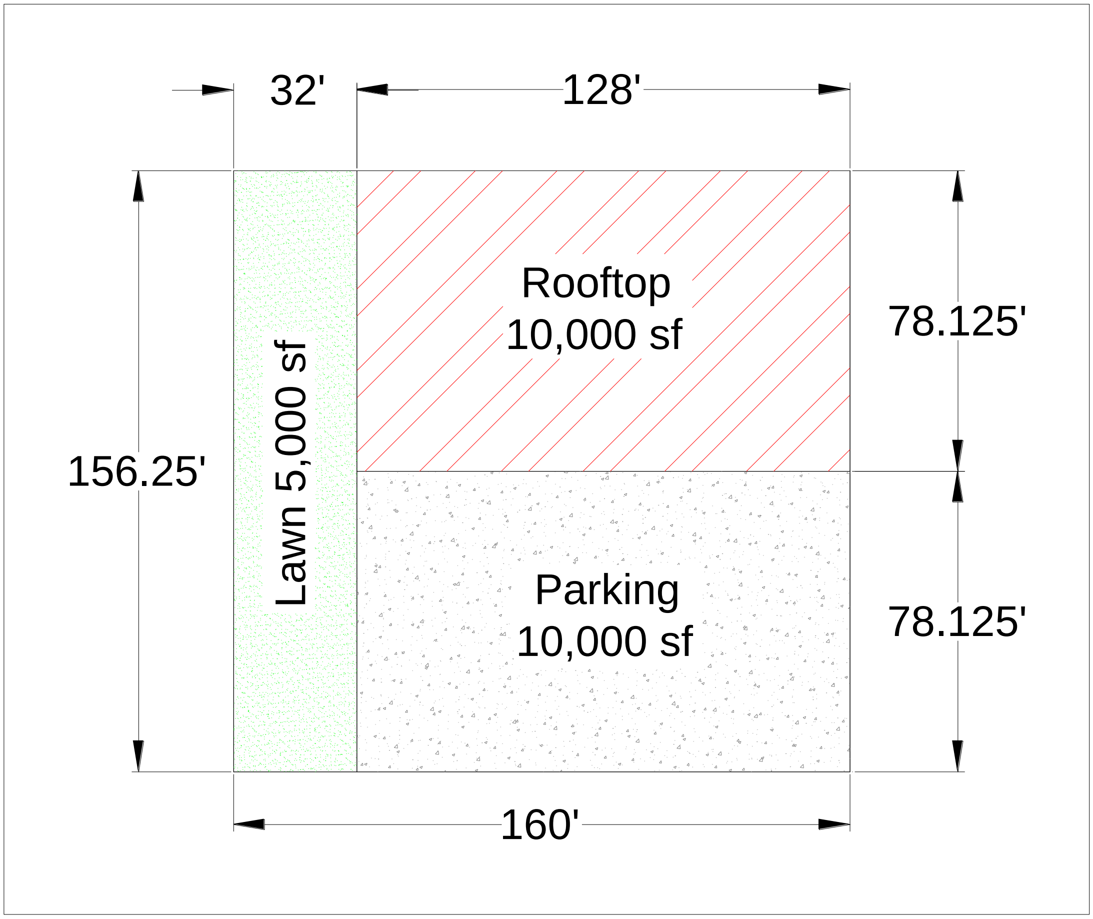
Rooftop Storage (see Appendix I) may be the most cost effective method for achieving this detention volume in this example.

Design Example 3

Step 1: **Determine Design Criteria.**

Design Example 3 includes the following proposed design criteria:

Site Name	Ward 5 Low-Rise Commercial
Total Site Area	25,000 ft^2
Natural Cover Area	0 ft^2
Compacted Cover	5,000 ft^2
Impervious Cover	20,000 ft^2
Vehicular Access Areas	10,000 ft^2
Is site located in the AWDZ?	No
Is site located within the MS4?	Yes
What type of activity is site undergoing?	Major Land Disturbing



Step 2: **Input Design Criteria to Determine the Retention and Treatment Requirements.**

The Compliance Calculator Spreadsheet will calculate a Stormwater Retention Volume (SWRv), once the natural cover, compacted cover, and impervious cover areas are put into **cells D22–D25** on the Site Data sheet.

Based on the design criteria above, the project has the following requirement:

SWRv = **cell D37** = 2,025 ft^3

Step 3: **Identify Site Constraints and BMP Restrictions.**

Key considerations for the project include the following:

- Only a small portion of the compacted cover is available for potential BMPs.
- The Multi-Family Residential site is not restrictive of BMP options.
- The relatively permeable Sunnyside-Sassafras-Muirkirk-Christiana soils on this site allow for infiltration into site soils.

Step 4: Select BMPs to Meet the Retention and Treatment Requirements.

An enhanced bioretention with no underdrain is chosen for this site, primarily to minimize cost. Several other options, such as permeable pavers, would have been acceptable at this site.

The site will ultimately have one outlet point, with only one BMP, so the calculations can be performed on one Drainage Area tab—D.A. 1. Therefore, all of the same values from the Site Data tab for the various cover types (plus the vehicle access area) should be put into **cells B6–B10** on the D.A. 1 sheet.

It is assumed that the entire site will be directed to the bioretention area, so the same values from the top of the DA1 sheet may be input into **cells B37–F38** (including the 10,000 square feet of vehicle access area in **cell F37**. However, the surface area of the bioretention area must be accounted for as well. It was determined that only 1,000 square feet of compacted cover would be available for a bioretention area. This area will be taken from the compacted cover area, and will need to be changed on the Site Data Tab as well as the top of D.A. 1. Compacted cover will now be 4,000 square feet, and “BMP” will be 1,000 square feet. The rooftop and parking areas will not change. This approach will lead to a total volume of 2,968 cubic feet directed to the BMP.

Since enhanced bioretention receives100 percent retention value, the required storage volume to meet the SWRv is 2,095 cubic feet (this is the required SWRv after changes in land use were made to account for the bioretention surface area). However, the 1,000 square feet available will not be sufficient to provide the entire required storage volume. Through trial and error (see Step 5 below) it was determined that the maximum storage volume is 1,301 cubic feet. This value can be input into **cell O37**. **Cell P68** indicates that there is still 794 cubic feet, or 5,939 gallons (**cell P69**), remaining. This volume will have to be met through the purchase or generation of Stormwater Retention Credits (SRCs) (see Chapter 7 and Step 9 below).

Step 5: Size the BMPs According to the Design Equations.

Assume a filter media depth of 2 feet, a gravel depth of 0.75 feet, and a ponding depth of 1 foot.

Step 5.1: Check the Filter Media Depth.

Ensure that the filter media depth does not exceed the maximum in Table 3.21. The ratio of the surface area of the bioretention (1,000 ft^2) to the contributing drainage area (25,000 ft^2) is 4%. The *Rv* was previously determined to be 0.84. The maximum filter media depth allowed is 4.0 feet. As the bioretention was sized with 2 feet of filter media, it passes this check.

Table 3.21 Determining Maximum Filter Media Depth (feet)

SA:CDA (%)	RvCDA								
	0.25	0.3	0.40	0.50	0.60	0.70	0.80	0.90	0.95
0.5	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
1.0	5.0	5.5	6.0	6.0	6.0	6.0	6.0	6.0	6.0
1.5	3.5	4.0	5.0	6.0	6.0	6.0	6.0	6.0	6.0
2.0	2.5	3.0	4.0	5.0	5.5	6.0	6.0	6.0	6.0
2.5	2.0	2.5	3.5	4.0	4.5	5.0	5.5	6.0	6.0
3.0	1.5	2.0	3.0	3.5	4.0	4.5	5.0	5.5	5.5
3.5	1.5	1.5	2.5	3.0	3.5	4.0	4.5	5.0	5.0
4.0	1.5	1.5	2.0	2.5	3.0	3.5	4.0	4.5	4.5
4.5	1.5	1.5	2.0	2.5	3.0	3.5	3.5	4.0	4.5
5.0	1.5	1.5	1.5	2.0	2.5	3.0	3.5	4.0	4.0
5.5	1.5	1.5	1.5	2.0	2.5	2.5	3.0	3.5	3.5
6.0	1.5	1.5	1.5	1.5	2.0	2.5	3.0	3.0	3.5
6.5	1.5	1.5	1.5	1.5	2.0	2.5	2.5	3.0	3.0
7.0	1.5	1.5	1.5	1.5	1.5	2.0	2.5	3.0	3.0
7.5	1.5	1.5	1.5	1.5	1.5	2.0	2.5	2.5	2.5
8.0	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.5	2.5
8.5	1.5	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.5
9.0	1.5	1.5	1.5	1.5	1.5	1.5	2.0	2.0	2.0
9.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	2.0	2.0
10.0	1.5	1.5	1.5	1.5	1.5	1.5	1.5	2.0	2.0

Step 5.2: Determine the Storage Volume.

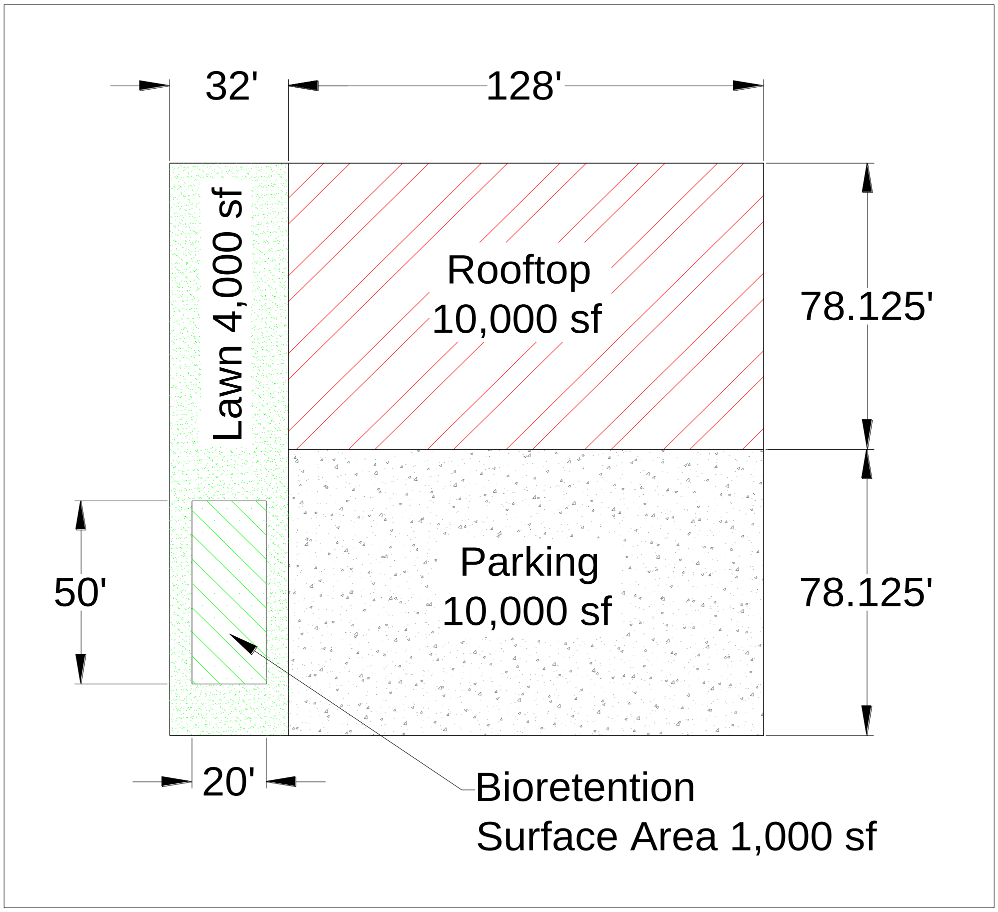
Equation 3.5

$$Sv = SA_{bottom} \times [(d_{media} \times \eta_{media}) + (d_{gravel} \times \eta_{gravel})] + (SA_{average} \times d_{ponding})$$

where:

Sv	=	total storage volume of bioretention (ft^3)
SA_{bottom}	=	bottom surface area of bioretention (ft^2)
d_{media}	=	depth of the filter media (ft)
η_{media}	=	effective porosity of the filter media (typically 0.25)
d_{gravel}	=	depth of the underdrain and underground storage gravel layer(ft)
η_{gravel}	=	effective porosity of the gravel layer (typically 0.4)
$SA_{average}$	=	the average surface area of the bioretention (ft^2) typically, where SA_{top} is the top surface area of bioretention, $SA_{average} = \frac{SA_{bottom} + SA_{top}}{2}$
$d_{ponding}$	=	the maximum ponding depth of the bioretention (ft)

Solving Equation 3.5 often requires an iterative approach to determine the most appropriate bottom surface area and average surface area to achieve the desired *Sv*. In this case, a long, narrow practice with a 50 foot by 20 foot top area and 3:1 side slopes was all that would fit on the site. This configuration will provide a SA_{top} of 1,000 square feet, a SA_{bottom} of 616 square feet, a $SA_{average}$ of 808 square feet, and will achieve an *Sv* of 1,301 cubic feet.



Step 6: **Check Design Assumptions and Requirements.**

Key assumptions and requirements for this site include:

- The design will need at least 1,000 square feet of surface area. The designer would need to ensure that this area is available.
- Contributing drainage area for traditional bioretention must be 2.5 acres are less, and this site has a total drainage area of less than 0.5 acres.
- Vehicle access areas must be addressed. The vehicle access retention/treatment requirement of 475 cubic feet is met by this design.
- Head requirements are not likely to be an issue, since this is an infiltration design.

- The water table must be at least 2 feet below the bottom of the bioretention, or 4.25 feet below the surface.
- The measured permeability of the underlying soils must be at least 0.5 inches/hour.
- Additional SRCs will need to be generated or purchased off-site.

Since all of these assumptions and requirements can be met (pending groundwater table and infiltration rate investigations) in this design example, this step is complete.

Step 7: Use the Adjusted Curve Number to Address Peak Flow Requirements.

On the Channel and Flood Protection tab, enter values for B soils in **cells D54**, **D56**, and **D58** (55 for natural areas, 61 for turf, and 98 for impervious cover, respectively). The original site curve number of 92 is reduced for the 2-year, 15-year, and 100-year storms to 87, 88, and 89, respectively by the retention provided by the bioretention cell. These curve numbers can be used to help determine detention requirements for this site.

Step 8: Determine the Detention Requirements.

Detention is required to reduce the peak discharge rate from the 2-year storm event to the predevelopment (meadow conditions or better) peak discharge rate and to reduce the peak discharge rate from the 15-year storm event to the preproject peak discharge rate. Appendix H includes details on the procedure for calculating the detention volume. In this example, the proposed impervious cover and the proposed runoff curve number is less than the preproject conditions, so detention for the 15-year storm is not required. Detention for the 2-year storm will be required.

The peak inflow (qi_2) and the peak outflow (q_{o2}) can be calculated using the WinTR-55 Small Watershed Hydrology program, the area of the site, the time of concentration (Tc, assumed to be 10 minutes), and the curve numbers. The reduced curve of 87, determined above, generates a qi_2 of 1.50 cubic feet per second (cfs). The curve number for meadow in good condition, 58, generates a q_{o2} of 0.18 cfs.

The ratio of 0.18 cfs to 1.50 cfs equals 0.12. Using Figure H.1, the ratio of storage volume (Vs_2) to runoff volume (Vr_2) is 0.53.

The runoff volume (Vr_2) determined in the Compliance Calculator spreadsheet is 1.84 inches, which equates to 3,833 cubic feet. Using the calculated ratio of Vs_2/Vr_2, the storage volume required for the site (Vs_2) is 2,032 cubic feet.

This detention volume, with appropriate orifice design to ensure that outflows are properly restricted, can be incorporated below the proposed bioretention area or located elsewhere on the site, such as underneath the parking lot as a standalone detention practice.

Step 9: Identify Stormwater Retention Credits.

Since the SWRv was short of the requirement by 7,615 gallons, 7,615 SRCs will need to be purchased or generated annually for this site to achieve compliance (see Chapter 7 for more details and example calculations).

Design Example 4

Design Example 4 includes the following proposed design criteria:

Site Name	Green St. and Gold St. Intersection
Total Site Area	13,528 ft^2
Natural Cover Area	0 ft^2
Compacted Cover	185 ft^2
Impervious Cover	13,343 ft^2

The site in this design example is a street reconstruction project. Since it is located in the public right-of-way (PROW), the maximum extent practicable (MEP) design process applies (see Appendix B).

Step 1: **Calculate SWRv.**

This intersection includes four stormwater inlets (one at each corner), so it will be divided into four drainage areas. The MEP Verification checklist requires calculation of the contributing drainage area within the limit of disturbance (LOD) as well as calculation of the contributing drainage area outside the LOD.

Drainage Area (DA 1 - N)	Contributing Area (ft^2)		SWRv (gal)	
	within LOD	outside LOD	within LOD	outside LOD
DA1	3,473	1,138	2,371	809
DA2	2,937	987	2,087	701
DA3	5,285	1,747	3,756	1,241
DA4	1,833	1,931	1,303	1,372
DATOTAL	**13,528**	**5,803**	**9,517**	**4,123**

SWRv can be calculated using the Compliance Calculator spreadsheet. In this case, all of the drainage areas were 100 percent impervious, except for DA1, which included 185 square feet of landscaped area within the LOD.

Step 2: **Consider Infiltration.**

This step requires looking at infiltration options by identifying constraints to infiltration, such as a high water table, soil contamination, or poor infiltration rates and locating areas that are well suited for infiltration.

In this example, a high water table and soil contamination were not a concern, The soil had only a moderate to low infiltration rate, making an infiltration sump a possibility as part of another BMP (such as enhanced bioretention) but not feasible as a standalone BMP.

Step 3: **Demonstrate Full Consideration of Land-Cover Conversions and Optimum BMP Placement.**

Opportunities for BMP placement within and adjacent to the PROW include traffic islands, triangle parks, median islands, cul-de-sacs, paper streets, and traffic calming measures, such as median islands, pedestrian curb extensions, bump outs, chicanes, and turning radius reductions.

As this example is a small intersection project, pedestrian curb extensions are the only feasible location for BMP placement. BMP locations in the pedestrian curb extensions will be possible at three of the four corners of the intersection.

Step 4: **Demonstrate Full Consideration of Opportunities Within Existing Infrastructure.**

This step requires the assessment and documentation of utility locations, storm sewer depths, right-of-way widths, and exiting trees to determine potential conflicts.

In this example, the difference in elevation between the storm sewer inlets and the invert of the pipes is approximately 5 feet. Other utilities will constrain the space available for the proposed BMPs but will not eliminate the pedestrian curb extension spaces entirely.

Step 5: **Locate and Choose BMPs.**

Although they may be undersized, enhanced bioretention areas will be selected for 3 of the 4 corners in the space available.

Areas for enhanced bioretention are as follows:

Drainage Area (DA 1 - N)	Contributing Area within LOD (ft^2)	SWRv within LOD (gal)	Available Area for BMP (ft^2)
DA1	3,473	2,371	72
DA2	2,937	2,087	285
DA3	5,285	3,756	190
DA4	1,833	1,303	0
DATOTAL	**13,528**	**9,517**	**N/A**

Step 6: **Size BMPs.**

Each bioretention area will be designed with a similar cross section: vertical side slopes for the ponding area, a ponding depth of 0.75 feet, a filter media depth of 2 feet, and a gravel depth (including the infiltration sump) of 1.25 feet.

The storage volume is determined with Equation 3.5

Equation 3.5

$$Sv = SA_{bottom} \times \left[\left(d_{media} \times \eta_{media} \right) + \left(d_{gravel} \times \eta_{gravel} \right) \right] + \left(SA_{average} \times d_{ponding} \right) \Big]$$

where:

Sv	=	total storage volume of bioretention (ft^3)
SA_{bottom}	=	bottom surface area of bioretention (ft^2)
d_{media}	=	depth of the filter media (ft)
η_{media}	=	effective porosity of the filter media (typically 0.25)
d_{gravel}	=	depth of the underdrain and underground storage gravel layer(ft)
η_{gravel}	=	effective porosity of the gravel layer (typically 0.4)
$SA_{average}$	=	the average surface area of the bioretention (ft^2) typically, where SA_{top} is the top surface area of bioretention, $SA_{average} = \frac{SA_{bottom} + SA_{top}}{2}$
$d_{ponding}$	=	the maximum ponding depth of the bioretention (ft)

With the cross section dimensions provided above, Equation 3.5 yields the following results:

Drainage Area (DA1–N)	Available Area for BMP (ft^2)	Sv (gal)	Sv (ft^3)
DA1	72	942	126
DA2	285	3,731	499
DA3	190	2,487	332
DA4	0	0	0

The table below indicates that there is a retention deficiency for 3 of the 4 drainage areas with the proposed BMPs.

Drainage Area (DA 1 - N)	Regulated SWRv within LOD (gal)	SWRv Achieved (gal)	Retention Deficiency (gal)	Altered Drainage Profile	
				Y	N
DA1	2,371	942	1,429		X
DA2	2,087	3,731	N/A		X
DA3	3,756	2,487	1,269		X
DA4	1,303	-	1,303		X
DATOTAL	**9,517**	**7,160**			

If there is a retention volume deficiency, the MEP design process notes that the designer should consider sizing BMPs to manage the comingled volume on-site, and/or revisit Design Steps 1 –6 to increase land conversion areas and BMP facilities.

In this case, the proposed bioretention areas in DA2 could treat additional volume, but the proposed bioretention areas in DA1 and DA3 are at capacity. At this point, the designer should review Steps 1 through 6 to ensure that all opportunities for land conversion and BMP facilities have been maximized. If so, this step is complete.

Step 7: **Identify Drainage Areas Where Zero-Retention BMPs are Installed.**

Drainage areas that do not include a retention BMP will require installation of a water-quality catch basin to treat stormwater runoff. This requirement applies only to DA4 in this example.

Design Example 5

Step 1: **Determine Design Criteria.**

Design Example 5 includes the following proposed design criteria:

Site Name	NoMa Office Tower
Total Site Area	65,340 ft^2
Natural Cover Area	0 ft^2
Compacted Cover	0 ft^2
Impervious Cover (Rooftop)	65,340 ft^2
Vehicular Access Areas	0 ft^2
Is site located within the AWDZ?	No
Is site located within the MS4?	Yes
What type of activity is the site undergoing?	Major Land Disturbing

Step 2: **Input Design Criteria to Determine the Retention and Treatment Requirements.**

The Compliance Calculator Spreadsheet will calculate a Stormwater Retention Volume (SWRv), once the impervious cover area is put into **cell D24** on the Site Data sheet.

Based on the design criteria above, the NoMa Office Tower project is required to treat 1.2 inches of rainfall for the SWRv:

SWRv (**cell D37**) = 6,207 ft^3

Identify Site Constraints and BMP Restrictions.

Limitation of space is the key considerations for the NoMa Office tower project. The lot line to lot line construction means there are limited retention and treatment options. A rooftop approach is selected.

Step 3: Select BMPs to Meet the Retention and Treatment Requirements.

As an initial estimate 60 percent of the rooftop is proposed to be converted to a green roof, with an additional 15 percent of the remaining rooftop draining to it. Therefore, the land use values need to be changed to account for the green roof: 26,136 square feet should be entered as rooftop in **cell D24** on the Site Data sheet, and 39,204 square feet should be entered in **cell D25** as "BMP." As there will be only one drainage area for the site, these same values should be entered into **cells B8** and **B10** on sheet DA A. For the Green Roof drainage area (**cells D23** and **D24**), 9801 square feet should be entered as impervious cover, and 39,204 should be entered as BMP surface area.

The goal of this design is to capture the entire retention volume (6,207 ft^3) in the Green Roof. This can be shown on the spreadsheet by entering 6,208 cubic feet (1 extra cubic foot to ensure that any rounding losses are covered) in **cell O23** on sheet DA A. **Cell P68** shows that the SWRv has been met for the site. This information is also summarized on the Compliance worksheet tab.

Step 4: Size the BMPs According to the Design Equations.

The green roof needs to be sized according to Equation 3.1. Note that, since green roofs are typically manufactured systems, several of the parameters, such as the drainage layer depth and maximum water retention of all layers, need to be provided by the manufacturer. In this example, a media depth of 6 inches with a maximum water retention of 0.40 was chosen. The drainage layer has a depth of 1 inch and a maximum water retention of 0.15. These values are indicated in the variable descriptions below Equation 3.1 (with each layer illustrated in Figure 3.1).

Equation 3.1 Storage Volume for Green Roofs

$$Sv = \frac{SA \times [(d \times \eta_1) + (DL \times \eta_2)]}{12}$$

where:

Sv	=	storage volume (ft^3)
SA	=	green roof area (ft^2)
d	=	media depth (in.) (minimum 3 in.)
η_1	=	verified media maximum water retention
DL	=	drainage layer depth (in.)
η_2	=	verified drainage layer maximum water retention

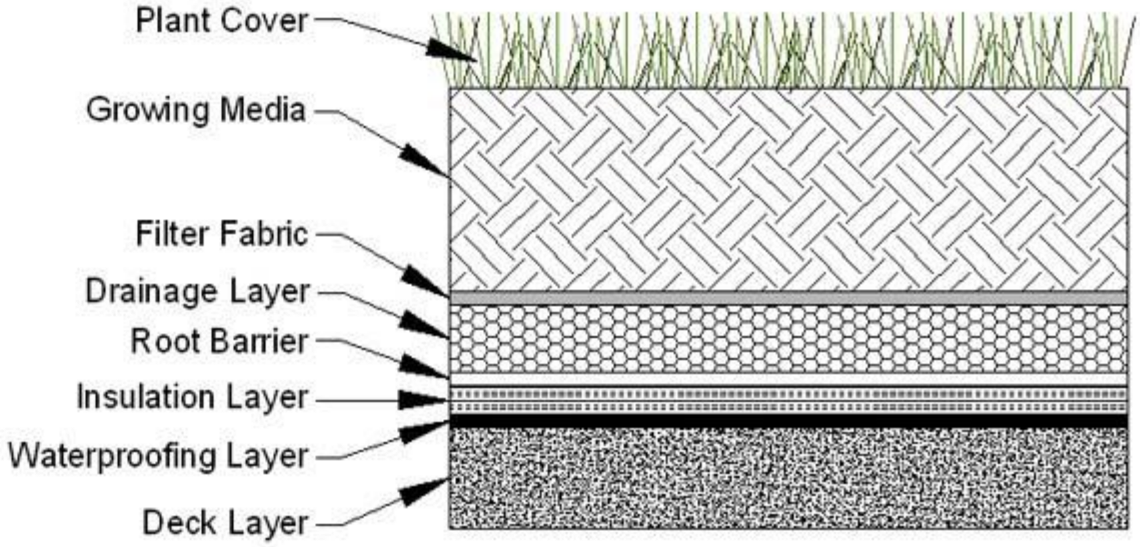


Figure 3.1 Typical layers for a green roof.

Rearranging Equation 3.1 to find the minimum required surface area:

$$SA = Sv/[(d \times \eta_1)+(DL \times \eta_2)] \times 12$$

or:

$$SA = 6{,}208/(6 \times 0.40 + 1 \times 0.15) \times 12$$

$$SA = 29{,}214 \text{ ft}^2$$

Therefore, the green roof must be sized to be at least 29,214 square feet (45% of the rooftop surface area), given the proposed depths. The original assumption was that a 39,204-square-foot roof would be used. Since a smaller roof is feasible, the drainage areas in the spreadsheet may be revised accordingly. However, the maximum drainage area to a green roof is only 25% more than the green roof itself. If a smaller roof is used, the design must indicate that the water can be conveyed onto the green roof in a non-erosive manner. If the larger green roof area is used, it could be designed with a lower media depth or the increased storage volume could be used to reduce peak flow volume requirements (see Step 8) and/or sold as Stormwater Retention Credits.

Step 5: **Check Design Assumptions and Requirements.**

Key assumptions and requirements for this site include:

- Ensure that there is sufficient space on the rooftop (allowing for structures such as vents, steep areas of the roof, and other panels). In this case, the green roof area of 29,214 square feet is less than half of the entire roof area.
- At least 19,791 square feet of the rooftop not covered by green roof needs to be designed so that it drains to the green roof without damaging it. This may require level spreaders or other devices.

Since all of these assumptions and requirements can be met in this design example, this step is complete.

Step 6: **Use the Adjusted Curve Number to Address Peak Flow Requirements.**

The initial curve number for this site is 98, but retention provided by the green roof change this number. The Channel and Flood Protection tab notes the reduced curve numbers for the 2-year, 15-year, and 100-year storms: 86, 88, and 88, respectively. These curve numbers can be used to help determine detention requirements for this site.

Step 7: **Determine Detention Requirements.**

Detention is required to reduce the peak discharge rate from the 2-year-storm event to the predevelopment (meadow conditions or better) peak discharge rate and to reduce the peak discharge rate from the 15-year storm event to the preproject peak discharge rate. Appendix H includes details on the procedure for calculating the detention volume. In this example, the proposed land cover is the same as the preproject conditions, so detention is not required for the 15-year storm. However, detention is required for the 2-year storm.

The peak inflow, qi_2 and the peak outflow, q_{o2} can be calculated using the WinTR-55 Small Watershed Hydrology program, the area of the site, the time of concentration (Tc, assumed to be 10 minutes), and the curve numbers. The reduced curve of 90, determined above, generates a $qi_2$of 3.80 cubic foot per second (cfs). The curve number for meadow in good condition, 71, generates a q_{o2} of 1.74 cfs.

The ratio of 0.39 cfs to 1.00 cfs equals 0.46. Using Figure H.1, this equates to a ratio of storage volume (Vs_2) to runoff volume (Vr_2) of approximately 0.29.

The runoff volume (Vr_2) determined in the Compliance Calculator spreadsheet is 1.83 inches, which equates to 9,964 cubic feet. Using the calculated ratio of Vs_2/Vr_2, the storage volume required for the site (Vs_2) is 2,890 cubic feet.

Rooftop Storage (see Appendix I) may be the most cost effective method for achieving this detention volume in this example, if space is available, and the design configuration can be created that routes the green roof to the rooftop storage. Alternatively, the required storage could be achieved via a tank located somewhere in the building

Design Example 6

Step 1: **Determine Design Criteria**

Design Example 6 includes the following proposed design criteria:

Site Name	Connecticut Ave. Complex
Total Site Area	65,340 ft^2
Natural Cover Area	0 ft^2
Compacted Cover	0 ft^2
Impervious Cover (Rooftop)	65,340 ft^2
Vehicular Access Areas	0 ft^2
Is site located within the AWDZ?	No
Is site located within the MS4?	Yes
What type of activity is the site undergoing?	Major Land Disturbing

Step 2: **Input Design Criteria to Determine the Retention and Treatment Requirements.**

The General Retention Compliance Calculator will calculate a stormwater retention volume (SWRv) once the impervious cover area is entered in **cell D24** on the Site Data sheet.

Based on the design criteria above, the Connecticut Ave. Complex project is required to treat 1.2 inches of rainfall for the SWRv:

$$SWRv\ (\textbf{cell D37}) = 6{,}207\ ft^3$$

Step 3: **Identify Site Constraints and BMP Restrictions.**

Key considerations for the Connecticut Ave. Complex project include the following:

- Since this is a rooftop-only site, very few treatment options are available.

Step 4: **Select BMPs to Meet the Retention and Treatment Requirements.**

Rainwater harvesting (R-1) is selected as the most appropriate BMP for this site.

The site will ultimately have one outlet point, so the calculations can be performed on one Drainage Area sheet – D.A. 1. Therefore, the impervious cover value from the Site Data tab should be put into **cell B8** on the D.A.1 sheet.

The Rainwater Harvesting Retention Calculator should be used to determine the cistern size and the associated retention value. In the Rainwater Harvesting Retention Calculator 65,340 square feet should be put in as the Contributing Drainage Area (CDA) (**cell L7**). For utilization of the rainwater, flushing toilets/urinals is selected as the use, and the appropriate values are entered. In this case, 1,600 people will use the building per day (**cell L21**), Monday through Friday (**cells**

L30 and **L32**), 8 hours per day (**cell L34)**. On the Results – Retention Value sheet, the retention values are given for various tank sizes. The tables and graphs show that an 80,000 gallon tank would have a 74% retention value. Coincidentally, it would also meet 74% of the annual demand.

The next step is to return to the D.A. 1 tab and input the 65,340-square foot CDA into **cell D25** for rainwater harvesting and input the efficiency (74%) into **cell K25**. The result is that 6,507 cubic feet of runoff are retained and 2,286 cubic feet remain. **Cell P68** shows that the SWRv has been met for the site, and **cell Q69** shows that the SWRv exceedance of 2,244 gallons may be available to generate SRCs.

Step 5: Size the BMPs According to the Design Equations.

The size of the rainwater-harvesting cistern was already determined to be 80,000 gallons, although additional volume may be necessary for detention, as described in Step 8 below, as well as for dead storage for a pump, and/or freeboard.

Step 6: Check Design Assumptions and Requirements.

Key assumptions and requirements for this site include:

- The rainwater harvesting cistern will be at least 80,000 gallons. The designer would need to ensure that space would be available for these BMPs on the site.
- Demand for the water from toilet flushing should be verified.

Since all of these assumptions and requirements can be met in this design example, this step is complete.

Step 7: Use the Adjusted Curve Number to Address Peak Flow Requirements.

The initial curve number for this site is 98, but retention provided by rainwater harvesting changes this number. The Channel and Flood Protection tab notes the reduced curve numbers for the 2-year, 15-year, and 100-year storms: 85, 87, and 88, respectively. These curve numbers can be used to help determine detention requirements for this site.

Step 8: Determine Detention Requirements.

Detention is required to reduce the peak discharge rate from the 2-year-storm event to the pre-development (meadow conditions or better) peak discharge rate and to reduce the peak discharge rate from the 15-year storm event to the pre-project peak discharge rate. Appendix H includes details on the procedure for calculating the detention volume. In this example, the proposed land cover is the same as the pre-project conditions, so detention is not required for the 15-year storm. However, detention is required for the 2-year storm.

The peak inflow, qi_2 and the peak outflow, q_{o2} can be calculated using the WinTR-55 Small Watershed Hydrology program, the area of the site, the time of concentration (Tc, assumed to be 10 minutes), and the curve numbers. The reduced curve of 85, determined above, generates a qi_2 of 3.64 cubic foot per second (cfs). The curve number for meadow in good condition, 71, generates a q_{o2} of 1.74 cfs.

The ratio of 1.74 cfs to 3.64 cfs equals 0.48. Using Appendix H this equates to a ratio of storage volume (Vs_2) to runoff volume (Vr_2) of approximately 0.29.

The runoff volume (Vr_2) determined in the Compliance Calculator spreadsheet is 1.77 inches, which equates to 9,938 cubic feet. Using the calculated ratio of Vs_2/Vr_2, the storage volume required for the site (Vs_2) is 2,795 cubic feet.

Since rainwater harvesting is the selected BMP on this project, the most appropriate means for detaining the 2,795 cubic feet (20,907 gallons) may be to increase the size of the cistern to 13,500 cubic feet (101,000 gallons). Alternatively, if stage-storage routing is performed on the tank for a 2-year storm event, beginning with the average daily volume in the tank, the detention volume may be decreased significantly.

Appendix B Maximum Extent Practicable Process for Existing Public Right-of-Way

B.1 Maximum Extent Practicable: Overview

Maximum extent practicable, or "MEP," is the language of the Clean Water Act that sets the standards to evaluate efforts pursued to achieve pollution reduction to United States waterbodies. MEP refers to management practices; control techniques; and system, design, and engineering methods for the control of pollutants. It allows for considerations of public health risks, societal concerns, and social benefits, along with the gravity of the problem and the technical feasibility of solutions.

MEP is achieved, in part, through a process of selecting and implementing different design options with various structural and non-structural stormwater best management practices (BMPs), where ineffective BMP options may be rejected, and replaced when more effective BMP options are found. MEP is an iterative standard that evolves over time as urban runoff management knowledge increases. As such, it must be assessed continually and modified to incorporate improved programs, control measures, and BMPs to attain compliance with water quality standards. As a result of this evolution, some end-of-pipe strategies that were considered to meet the MEP standard ten years ago are no longer accepted as such. Similarly, in cases where just one BMP may have gained project approval in the past, today there are many cases where multiple BMPs will be required to achieve treatment to the MEP.

Many jurisdictions have said of the MEP standard that there "must be a serious attempt to comply, and practical solutions may not be lightly rejected." If project applicants implement only a few of the least expensive BMPs, and the regulated volume has not been retained, it is likely that the MEP standard has not been met. If, on the other hand, a project applicant implements all applicable and effective BMPs except those shown to be technically infeasible, then the project applicant would have achieved retention to the MEP.

B.2 Public Right-of-Way Projects

Public right-of-way (PROW) projects within the District of Columbia are owned and operated by the District Government. They are linear in orientation and are distinct from parcel or lot development.

PROW is defined as the surface, the air space above the surface (including air space immediately adjacent to a private structure located on public space or in a PROW), and the area below the surface of any public street, bridge, tunnel, highway, railway track, lane, path, alley, sidewalk, or boulevard, where a property line is the line delineating the boundaries of public space and private property.

The Public Parking Area or "Public Parking," is important for the following discussion. It is defined as that area of public space devoted to open space, greenery, parks, or parking that lies between the property line (which may or may not coincide with the building restriction line) and the edge of the actual or planned sidewalk that is nearer to the property line, as the property line and sidewalk are shown on the records of the District. This area often includes spaces that appear to be front yards with private landscaping, which create park-like settings on residential streets.

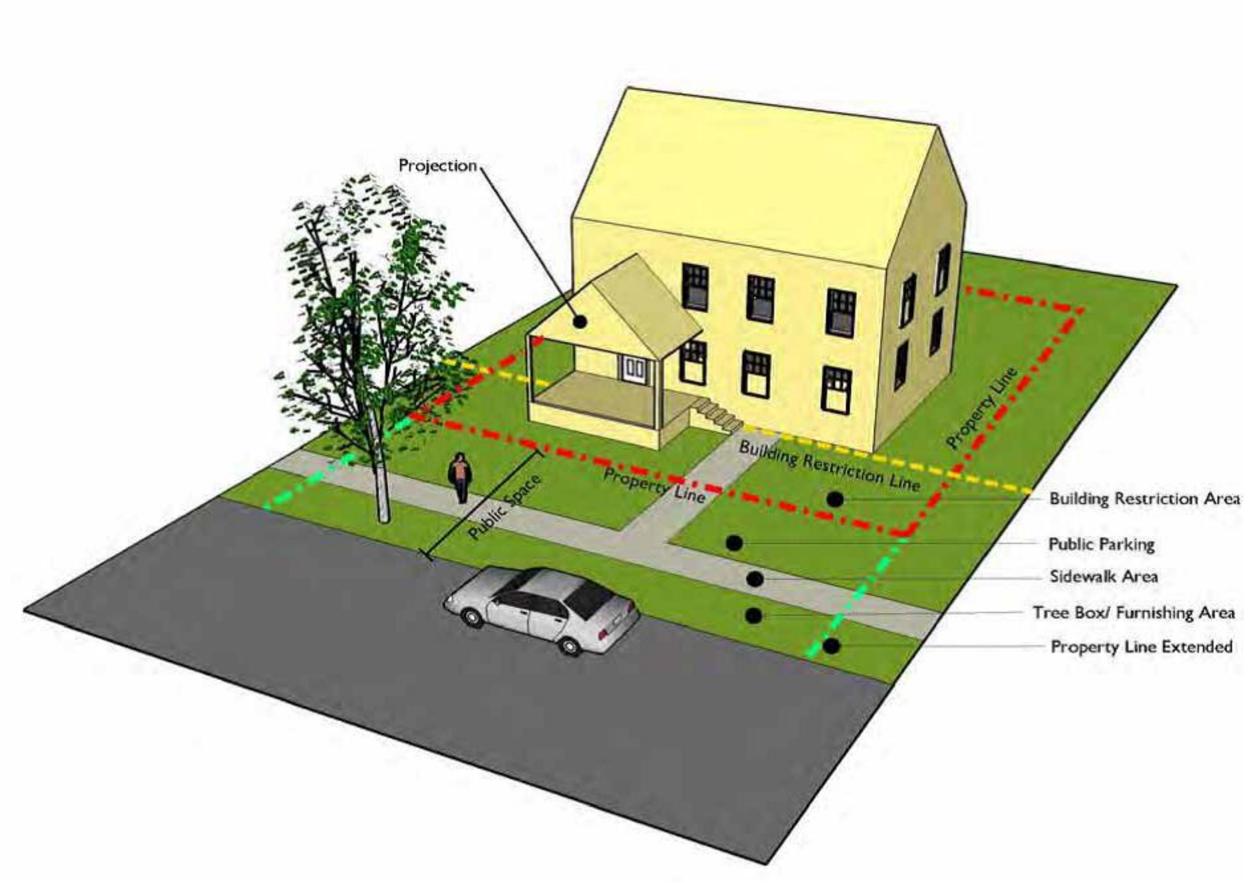


Figure B.1 Diagram of typical residential public right-of-way in the District of Columbia (DDOT Public Realm Design Manual 2011).

Public Space is defined as all the publicly owned property between the property lines on a street, park, or other public property, as such property lines are shown on the records of the District, and includes any roadway, tree space, sidewalk, or parking between such property lines.

Other important terms are the tree box area or planter area and the sidewalk area. These are defined as the area of the roadside that provides a buffer between the pedestrians and vehicles, which primarily contains landscaping such as a continuous planting strip in residential areas. The sidewalk area is sometimes known as the "pedestrian clear zone", this is the walking zone adjacent to the tree box that must remain clear, both horizontally and vertically.

In the MEP discussion that follows, a PROW project means a land-disturbing activity conducted in the existing PROW and the existing public space associated with the project. The MEP discussion applies only to those PROW projects required for the operation and maintenance of existing commercial and residential streets, existing alleyways, and other existing transportation infrastructure designed and maintained for the safe conveyance of people and commerce. Private subdivision roads or streets shall not be considered PROW projects.

Construction projects to maintain and upgrade the District's PROW are faced with a multitude of unique site constraints that vary widely. Limited space outside of the roadway restricts opportunities for infiltration and evapotranspiration, and in many cases the width of the roadway cannot be reduced to create additional space. In the roadway itself, the structural integrity of the pavement is the prime concern. The weight and volume of traffic loads may limit the use of permeable pavements.

The PROW occupy approximately 25 percent of the impervious area of the District of Columbia, making the PROW one of the most significant sources of stormwater runoff impacting District waterbodies. Stormwater runoff from roadways can present high pollutant loading. Despite the challenges to stormwater management faced by PROW projects, it is essential for the protection of District waterbodies to strive to achieve full retention of the regulated stormwater volume through the use of BMPs to the MEP on all PROW projects. This means the design process of all PROW projects shall evaluate and implement all applicable and effective BMPs except those shown to be technically infeasible.

The aim for full retention on-site of a PROW project's regulated stormwater volume is consistent with the District of Columbia Department of Transportation's (DDOT's) "Complete Streets" policy which states, "improvements to the right-of-way shall consider… environmental enhancements including, reducing right-of-way stormwater run-off, improving water quality, prioritizing and allocating sustainable tree space and planting areas (both surface and subsurface), … wherever possible". It is also an effort consistent with the District's 2012 Municipal Separated Storm Sewer System (MS4) permit which requires the retrofit for on-site stormwater retention of 1,500,000 ft^2 of PROW by 2016, which might translate to 35.5 miles of 8 foot wide pervious parking lanes or 4.7 miles of 60 foot wide full PROW cross section where the runoff is captured and managed from sidewalks, tree boxes, parking lanes, and the roadway.

The sections that follow, Design Considerations and Decision Process, are intended to provide structure for planners, designers and reviewers to evaluate whether or not a PROW project has exhausted every opportunity to achieve the full retention of the regulated stormwater volume. Achieving the regulated Stormwater Retention Volume (SWRv) in the PROW projects will be technically infeasible on many occasions, even after going through the MEP process. Given this and the compelling interest of the ongoing reconstruction of the PROW for the maintenance of public safety and well-being, PROW projects can be excluded from the requirement to use Stormwater Retention Credits (SRCs) or pay an in-lieu fee to satisfy any shortfall in attaining the SWRv if the MEP is demonstrated. These PROW projects are the only type of projects that are excluded from this requirement.

DDOE's MEP process applies to two types of projects. Type 1 projects solely involve reconstruction of the existing PROW, such as when the District of Columbia Department of

Transportation reconstructs multiple blocks of a roadway. Type 2 designates parcel-based development projects that reconstruct the adjacent, existing PROW as portion of the project. Under the MEP process for Type 2 projects, the parcel portion of the application will be reviewed under the full stormwater management performance standards defined in Chapter 2, while the PROW portion of the application will be reviewed under the MEP Type 2 approach defined in this appendix.

The General Retention Compliance Calculator has a separate PROW worksheet that allows Type 2 applicants to separate parcel drainage area obligations from PROW obligations. The compliance tab also presents these drainage areas separately to simplify the review process and make it transparent. To request an MEP Type 2 review, an applicant will follow the format used to the request "relief for extraordinarily difficult site conditions" described in Appendix E, which requires a request memo with supporting evidence in addition to the completed worksheets from the General Retention Compliance Calculator.

The memo must address the six designs steps described in Section B.5. Type 2 applicants can choose to follow the same table, plan view, and narrative approach identified for Type 1 applicants without the multiple-stage review process for the 30 percent 65 percent, and 90 percent design phases. Type 1 projects will use a stormwater report that contains information in spreadsheet, plan view, and narrative formats for the submission and review of the 30 percent, 65 percent, and 90 percent design stages, typically of DDOT projects. Table B.3 indicates the information and submission format expected at each review stage.

B.3 Codes

DDOT uses a "functional street classification" system that is defined in Chapter 30 of the Transportation Design and Engineering Manual. There are five functional categories including Freeways, Principal arterials, Minor arterials, Collector streets and Local streets. Table B.1 shows relative distribution of roadway classifications in the District. Each type has design criteria that are governed by traffic volumes, land use, and expected growth. These design criteria set the acceptable ranges for geometric design elements that will govern roadway geometry. The MEP process assumes transportation design criteria govern when conflicting demands exist.

Table B.1 Roadway Classification and Extent Relative to Total Roadway System

Type	Approximate Miles	% of District Roadway System
Freeways	46	4
Principal Arterials	92	8
Minor Arterials	178	15
Collectors	152	13
Local Roads	682	60

The MEP process assumes BMP designs will comply with the District of Columbia Department of Transportation Design and Engineering Manual Chapter 33, Chapter 47, and the Design and

Engineering Manual supplements for Low Impact Development and Green Infrastructure Standards and Specifications as well as Chapter 3 in this guidebook.

B.4 PROW Design Considerations

B.4.1 Considerations in the Planning Process (limited to Type 1).

The local capital authority for PROW projects is defined in the District of Columbia's Capital Improvement Program (CIP), a six-year-plan that is updated annually. Federally funded projects are listed in the Transportation Improvement Program (TIP), which is updated every other year according to the Metropolitan Washington Council of Government National Capital Region Transportation Planning Board's (MWCOG TPB) schedule and is also coordinated with the Constrained Long-Range Transportation Plan (CLRP). Each planning stage has an amendment process. Planners shall incorporate the MEP process into all future PROW projects and shall review and revisit, as needed, existing PROW plans for MEP analysis, revisions, and amendments. The TIP and CLRP are able to be amended and modified as allowed by the MWCOG TPB. As projects move from study to design and construction, DDOT will include necessary measures to include MEP analysis and implementation.

B.4.2 Site Assessment Considerations for the Retention Standard in PROW Projects

1. **Level of Disturbance (Type 1 and Type 2).** If a PROW project includes major land-disturbing activity required for the operation and maintenance of existing commercial and residential streets, existing alleyways, and other existing transportation infrastructure designed and maintained for the safe conveyance of people and commerce, it is captured by the stormwater regulatory obligations of Chapter 5 of Title 21, of the District of Columbia Municipal Regulations, Water Quality and Pollution (2012). Routine maintenance such as surface asphalt milling of roadways, where the roadway base is not disturbed, is not considered a level of disturbance that will require compliance with the regulation.
2. **Available Space (Type 1 and Type 2).** A PROW project must first and foremost seek to maximize landscape areas, maximize available space for stormwater retention, and minimize impervious surface, while coordinating with transportation, access, safety, and other applicable requirements, such as the American Disability Act (ADA) requirements and emergency vehicle needs. Street widths should be reduced to the appropriate minimum width while maintaining multi-modal transportation needs, parking, and public safety. A rule of thumb used in some cities (e.g. Los Angeles, Portland, Seattle, and Philadelphia) equates the expected landscape space to a minimum percentage of the imperviousness within each drainage area within the PROW project limits of disturbance. This percentage ranges from 4 percent to 10 percent.

   In the District of Columbia several hundred triangular islands, less than one acre in area, are created by diagonal street intersections. A PROW project must consider the opportunity for stormwater retention within traffic islands, or triangle parks, that fall within, or adjacent to, the project limits of disturbance. Streets that end as cul-de-sacs, are less prevalent in the District, however, when present cul-de-sacs within, or adjacent to, the limits of disturbance of a PROW project must be evaluated for stormwater retention opportunities. In the District "paper streets" exist throughout, as areas of the City dedicated as streets but not useable as transportation passageways. These areas, under the control of the DDOT, may be created by the intersection of streets with parks and streams, and are often mowed grass areas. “Paper streets” within, or adjacent to, the limits of disturbance of a PROW project must be evaluated for stormwater retention opportunities.

3. **Impervious Cover Removal (Type 1 and Type 2).** The elimination of impervious surface may be accomplished by closing diagonal roadways adjacent to triangle parks to create larger parks. Diagonal roadways that are adjacent to triangle parks and fall within, or are adjacent to, a PROW project must be evaluated for stormwater retention opportunities. PROW projects must evaluate the opportunity to integrate traffic calming measures including but not limited to, median islands, pedestrian curb extensions, bump outs and chicanes, and turning radius reductions that may double as areas for impervious surface removal and BMPs.

   Replacing impervious cover with landscape area in the contributing drainage area converts the runoff coefficient from 95 percent to 25 percent in essence decreasing that area’s contribution to stormwater runoff by 70 percent without the use of an active stormwater facility. If an area can be converted to “natural cover” through conservation and reforestation strategies that area’s contribution to stormwater runoff is reduced to zero. Consult Appendix N for minimum thresholds and other required for each land cover designation. Further opportunities to reduce stormwater runoff in these drainage areas should be explored with adjacent property both public and private as source control may be the most cost effective approach to managing stormwater runoff, see Section 3.4 Impervious Surface Disconnection.

4. **Drainage Areas (Type 1 and Type 2).** Overall conceptual drainage plans for PROW projects should identify drainage areas outside of the project’s limits of disturbance that generate runoff that may comingle with on-site runoff. The project is not required to consider off-site runoff in the calculation for the regulated Stormwater Retention Volume (SWRv); however BMPs sized for retention of comingled off-site runoff can be used to off-set the inability to capture and retain the SWRv in areas within the project for which significant constraints prevent retention.

   For example, a typical city block will have at least two distinct drainage areas created by the crown in the center of the road. While one side of the road may have significant obstacles to the implementation of retention practices the other may not. If the limits of disturbance are defined by the boundaries of the sidewalks on either side of the roadway this is the area that is used to calculate the SWRv. However, in many circumstances stormwater runoff is entering the sidewalk and roadway from adjacent properties, both public and private, creating a comingled stormwater runoff. Under these conditions the side of the street that has the greater opportunity to implement retention strategies shall be designed to manage that comingled volume up to the full SWRv.

   Type 1 and Type 2 projects must prioritize capturing roadway runoff. For Type 2 projects, where limits of disturbance do not extend into the roadway, the capture of roadway runoff from adjacent roadway drainage areas may be accomplished with curb cuts or sidewalk trenches used to direct roadway runoff from the curb line into sidewalk BMPs within the project’s limits of disturbance. This must be the first consideration to satisfy the SWRv calculated for the project’s PROW portion.

5. **Ownership of Land Adjacent to Right-of-Ways (limited to Type 1).** The opportunity to incorporate stormwater retention may depend on the ownership of land adjacent to the right-of-way. Acquisition of additional right-of-way and/or access easements may only be feasible if land bordering the project is publicly owned. PROW project must identify public lands and public rights of way adjacent to the project's limit of disturbance. PROW project planners and managers may need to consult with adjacent public property owners and managers to evaluate opportunities to direct stormwater runoff from the project drainage area to adjacent public lands.

6. **Location of Existing Utilities (Type 1 and Type 2).** The location of existing storm drainage utilities (grey infrastructure) can influence the opportunities for stormwater retention in PROW projects. Utilizing the existing grey infrastructure for the conveyance of large events with under drain connections and curb line overflows can reduce costs. Using existing grey infrastructure where possible frees funds for drainage areas within the project limits of disturbance where grey infrastructure does not exist or is more challenging to utilize. Standard peak-flow curb inlets, such as catch basins, should be located downstream of areas with potential for stormwater retention practices so that water can first flow into the BMP, and then overflow to the downstream inlet if capacity of the BMP is exceeded. It is more difficult to apply retention practices after water has entered the storm drain. The location of other utilities will influence the ability connect BMPs to storm drains, and may limit the allowable placement of BMPs to only those areas where a clear pathway to the storm drain exists.

   The following outlines an approach to take when considering the design and location of BMPs in the existing PROW relative to existing utilities: 1) avoidance; 2) mitigation; 3) relocation; and 4) acceptance.

   Avoidance. Whenever possible, locate BMPs to avoid a conflict that either jeopardizes the functionality and longevity of the utility or complicates future utility maintenance. Consult with each utility company on their recommended offsets which will allow utility maintenance work with minimal disturbance to the BMP. A consolidated presentation of the various utility offset recommendations can be found in Chapter 33.14.5 of the District of Columbia Department of Transportation Design and Engineering Manual, latest edition. Consult the District of Columbia Water and Sewer Authority (DC Water) Green Infrastructure Utility Protection Guidelines, latest edition, for water and sewer line recommendations. Avoidance of utility conflicts may mean one BMP type is selected over another. It may mean the sizing of a BMP is altered.

   Mitigation. Under the mitigation approach the BMP design is adjusted to mitigate utility concerns. A BMP design may need to be resized or otherwise altered to satisfy utility offsets. This may include moving, adding, or deleting a key design feature of the BMP such as check dams, inlets, outlets and trees.

   Relocation. Under the relocation approach an attempt is made to coordinate with utility companies to allow them to replace or relocate their aging infrastructure while BMPs are being implemented. Where the capital budget and priorities of the utility can be aligned with the larger construction in the PROW, there are potential benefits, including cost savings, for both the utility and the entity undertaking the reconstruction of the PROW. The age of the utility line is a factor in selecting this solution. While a utility relocation during a street reconstruction project may be advantageous to the utility provider, it is understood that the utility may not be able to align its capital budget or may be otherwise unable or unwilling to take advantage of the relocation opportunity.

Acceptance. When the first three approaches are inadequate to achieve the required stormwater retention, consider a fourth approach, acceptance of conflicts that do not jeopardize the functionality, longevity and vehicular access to manholes and other key points of utility maintenance. This does not preclude the typical public right-of-way PROW BMP such as street trees, bioretention, or permeable pavement which the utility would be expected to replace if maintenance in those areas was required. In this scenario, a BMP location and design that complicates utility maintenance should be considered acceptable if it does not compromise the utility function, longevity, and major access points. When accepting utility conflict into the BMP location and design, it is understood the BMP will be temporarily impacted during utility work but the utility will replace the BMP or, alternatively, install a functionally comparable BMP according to the specifications in the current version of this Stormwater Management Guidebook and the District of Columbia Department of Transportation Design and Engineering Manual with special attention to Chapter 33, Chapter 47, and the Design and Engineering Manual supplements for Low Impact Development and Green Infrastructure Standards and Specifications. To clarify whether a conflict jeopardizes the functionality, longevity and access to a utility consider the latest editions of the District of Columbia Department of Transportation Design and Engineering Manual and the District of Columbia Water and Sewer Authority (DC Water) Green Infrastructure Utility Protection Guidelines.

7. **Grade Differential Between Road Surface and Storm Drain System (Type 1 and Type 2).** Some BMPs require more head from inlet to outlet than others; therefore, allowable head drop may be an important consideration in BMP selection. Storm drain elevations may be constrained by a variety of factors in a roadway project (utility crossings, outfall elevations, etc.) that cannot be overcome and may override Stormwater Retention Volume considerations.
8. **Longitudinal Slope (limited to Type 1).** The suite of BMPs which may be installed on steeper road sections is more limited. Specifically, permeable pavement and swales are more suitable for gentle grades. Other BMPs may be more readily terraced to be used on steeper slopes. Check dams and weirs should be incorporated into BMP designs on steeper slopes.
9. **Potential Access Opportunities (limited to Type 1).** A significant concern with the installation of BMPs in high speed, high volume PROW is the ability to safely access the BMPs for maintenance considering traffic hazards. A PROW project involving high speed, high volume PROW should include a site assessment to identify vehicle travel lanes and areas of specific safety hazards for maintenance crews. Subsequent steps in the preparation of the stormwater management plan (SWMP) for the PROW project should attempt to avoid placing BMPs in these areas.
10. **Tree Canopy and Vegetation (Type 1 and Type 2).** Concern for the preservation of existing mature trees is a reasonable consideration when determining where and how to direct stormwater runoff from the curb line for retention goals in a PROW project. In general, stormwater retention practices should be installed outside the drip line of existing trees (more specific guidance is provided in Section 3.14). A guiding principal for PROW projects

should be the improvement and maintenance of the most robust tree canopy possible along the PROW. The planting of trees and the preservation of trees should look to the latest science on the soil volume requirements, spacing needs and methods to connect stormwater runoff to tree roots to support healthy vigorous tree growth. PROW projects should clearly identify existing healthy trees and detail how to prevent tree losses during construction. Additionally, diseased and dead trees should be removed. Soils in tree planting areas should be amended and volumes expanded whenever trees are replaced or new trees are planted.

11. **Infiltration (Type 1 and Type 2).** Infiltration practices have very high storage and retention capabilities when sited and designed appropriately. Designers should evaluate the range of soil properties during initial site layout and seek to configure the site to conserve and protect the soils with the greatest recharge and infiltration rates. In particular, areas of Hydrologic Soil Group A or B soils shown on NRCS soil surveys should be considered as primary locations for infiltration practices. When designing a PROW project consult Appendix O, Geotechnical, and Chapter 3.7, Infiltration, as well as chapters on specific BMPs under consideration in this Stormwater Management Guidebook (SWMG) for specific design details and constraints.

    In areas where a qualified professional engineer, soils scientist or geologist determines during an initial feasibility test the presence of soil characteristics which support the categorization as D soils, no further investigation is required. A designer of a PROW project should first consider reducing the impervious surface area draining to these poor soil areas. Other soil types may require further analysis to determine infiltration feasibility. It is important to understand that areas with poor soils may still be sites for BMPs that are designed with underdrains.

    If the seasonally high water table is determined to be less than two feet from the bottom of the proposed BMP, infiltration may not be appropriate. This may be determined through a comparison of historic and actual elevations. If the site is one of known soil contamination or receiving uncontrolled stormwater runoff from a land use hotspot, as determined by guidance in Appendix P. Stormwater Hotspots, infiltration must not be used.

12. **Street Profile (limited to Type 1).** The profile of an impervious surface such as a street or an alleyway determines how stormwater runoff flows off the surface. District streets follow a crowned design with the high point in the center draining to both sides, alleyways are typically reverse crowned, draining to the center and sidewalks side shed, draining to one side. Flat drainage is a term used to denote vertical drainage through a permeable paving profile. A PROW project should consider all variations of drainage patterns when the standard drainage design does not provide retention for the full regulated Stormwater Retention Volume (SWRv). The drainage patterns of the project should be developed so that drainage can be routed to areas with BMP opportunities before entering storm drains. For example, if a median strip is present, a reverse crown should be considered, so that stormwater can drain to a median swale.

13. **Pedestrian Circulation (Type 1 and Type 2).** The design of stormwater retention facilities should harmonize with effective pedestrian circulation in PROW projects. PROW project BMPs commonly integrate the goals of stormwater retention and pedestrian safety by reducing pedestrian crossing distances, providing more space against vehicular traffic, and improving site angles at intersections. While pedestrian circulation and stormwater retention

should not be at odds, conflicts can arise with on street parking. Considerations should be given to provide adequate egress for parking adjacent to a BMP (typically 2 feet). In addition, frequent walkways across BMPs can give pedestrians sufficient access to parking zones.

Retention facilities with vertical drops of greater than six inches in a PROW projects should provide pedestrians with visual or physical signals that denote a significant drop in grade, such as a raised curb edge, a detectable warning strip or a raised railing. Railings maybe designed to perform additional functions such as seating or bicycle racks. In areas with the potential for high pedestrian volume railings may be needed to prevent pedestrians from cutting through landscaped areas, trampling vegetation and compacting soils.

B.4.3 Fundamental Tenets of MEP for PROW

A PROW project shall demonstrate a design approach that indicates stormwater retention opportunities were evaluated to the MEP, which includes the following:

a. Selecting BMPs based on site opportunities to reduce stormwater runoff volumes.

b. Sizing BMPs opportunistically to provide the maximum stormwater retention while accounting for the many competing considerations in PROW projects.

c. Prioritizing capturing roadway runoff. By managing comingled stormwater runoff within some project drainage areas to offset minimum retention achieved in other project drainage areas.

d. Developing innovative stormwater management configurations integrating “green” with “grey” infrastructure,

e. Minimizing street width to the appropriate minimum width for maintaining traffic flow and public safety.

f. Maximizing tree canopy by planting or preserving trees/shrubs, amending soils, increasing soil volumes and connecting tree roots with stormwater runoff.

g. Using porous pavement or pavers for low traffic roadways, on-street parking, shoulders or sidewalks.

h. Integrating traffic calming measures that serve as stormwater retention BMPs.

i. Reducing stormwater runoff volume by converting impervious surfaces to land cover types that generate little or zero stormwater runoff.

j. Reducing stormwater runoff volume by employing impervious surface disconnection strategies within and adjacent to the project’s limits of disturbance.

B.5 Design Process for PROW

Step 1: Identify Drainage Areas and Calculate SWRv.

a. Define the limits of disturbance for the PROW project.

b. Delineate all drainage areas both within, and contributing to, the limits of disturbance for the PROW project. Prioritize drainage areas conveying roadway runoff.

c. Identify proposed land covers within the limits of disturbance for the PROW project, including impervious cover, compacted cover, and natural cover. Area under proposed BMPs counts as impervious cover. A continuous planter strip may be consider compacted cover, or natural cover; consult Appendix N for the minimum thresholds an area needs to qualify for each designation. Individual street trees may count as compacted cover or as a BMP. Use the General Retention Compliance Calculator PROW worksheet to determine which approach provides the greatest SWRv reduction.

d. Calculate the regulated Stormwater Retention Volume (SWRv) based on land cover and area within the limits of disturbance for the entire PROW project. Calculate the portion of the SWRv for each drainage area within the limits of disturbance of the PROW project. Calculate any "unregulated" off-site stormwater retention volume contributing to the project limits of disturbance.

   Note: When off-site stormwater runoff volumes are managed their reduction will count toward a reduction in the SWRv. Off-site stormwater runoff volumes may be managed at the source or within the project's limits of disturbance. Prioritize drainage areas conveying roadway runoff.

e. Consider land conversion and BMP designations in adjacent public lands. While these volumes are not counted in the calculation of the site's SWRv, if controlled they will count towards the reduction of the site's SWRv. Identify opportunities for land cover conversions or other source control measures that would reduce these off-site volumes.

f. Consider altering the drainage profile if that alteration would increase runoff capture opportunities. This consideration will typically be set aside until all other considerations have been exhausted (limited to Type 1).

Step 2: Evaluate Infiltration.

a. Determine historical and actual water table elevations to evaluate opportunities and restrictions for locating infiltration practices.

b. Consult a qualified professional engineer, soil scientist or geologist using initial infiltration feasibility tests, to identify the areas within the limits of disturbance with Hydrologic Soil groups that should be preserved and targeted for infiltration BMPs, and areas where infiltration BMPs will require amended soils and under drains.

c. Identify any areas within the limits of disturbance where there is a known issue of soil contamination. Infiltration BMPs in these areas are not allowed. Use the guidance in Appendix P. Stormwater Hotspots to evaluate adjacent land use hotspots that may be a source of uncontrolled contaminates in stormwater runoff.

Step 3: Demonstrate Full Consideration of Opportunities with Existing Infrastructure.

a. Review substructure maps and utility plans; delineate areas of potential conflict as well as areas without conflict.

b. Identify the location and elevation of the existing storm drainage system (grey infrastructure), including catch basins, drain inlets, and manholes in both the drainage areas within, and those drainage areas contributing stormwater runoff to, the limits of disturbance for the PROW project.

c. Identify all existing trees to be preserved. Identify and record tree species, size and preservation status.

Step 4: Demonstrate Full Consideration of Land Cover Conversions and Optimum BMP Placement.

a. Identify traffic islands, triangle parks, median islands, cul-de-sacs, and paper streets within and adjacent to the PROW project's limits of disturbance. These areas can be the focus of land cover conversions and BMP locations (unless within LOD of Type 2 this is limited Type 1).

b. Evaluate the opportunity to integrate traffic calming measures including but not limited to, median islands, pedestrian curb extensions, bump outs and chicanes, and turning radius reductions. Delineate these areas out for consideration for impervious surface removal and BMP facilities. Delineate areas available for additional tree planting. Note whether soil volume increases and amended soils are required (unless within LOD of Type 2 this is limited Type 1).

c. Evaluate right-of-way widths; identify minimum requirements for trails, alleys, roadways and sidewalks. Delineate sections where existing conditions exceed minimum requirements. These areas can be the focus of land cover conversions and BMP locations (limited to Type 1).

d. Select areas delineated as optimum opportunities for land conversion or BMP location.

   Note: Land conversions can significantly reduce the project's SWRv without the use of an active stormwater facility. Designate land conversions and recalculate SWRv at the full project scale and the scale of the individual drainage areas within the project area.

e. Select most appropriate BMP types for each area delineated as optimum opportunities for BMP locations. Consult Table B.2 for potential BMPs recommended by US EPA for "Green Streets", DDOT's AWI Chapter 5 LID, DDOT's LID Action Plan, DDOT's LID Standards and Specifications, and Chapters 3.1 through 3.12 in this Guidance Manual.

Step 5: Size BMPs.

a. The following process are used to size BMPs for PROW projects:

   1. Delineate drainage areas to BMP locations including any area outside the limits of disturbance contributing off-site stormwater runoff volume; prioritize roadway runoff; consider the land covers to compute optimum Stormwater Retention Volume. Consider designing to the over control retention volume, above the regulated requirement of 1.2 inches, up to the regulated ceiling of 1.7 inches.

   2. Look up the recommended sizing methodology for the BMP selected in each drainage area and using the appropriate BMP chapter of this guidance manual to calculate target sizing criteria.

   3. Design BMPs per the appropriate chapter of this guidance manual and the District of Columbia Department of Transportation Design and Engineering Manual.

   4. Attempt to provide the calculated sizing criteria for the selected BMPs.

5. If sizing criteria cannot be achieved, document the constraints that override the application of BMPs, and provide the largest portion of the sizing criteria that can be reasonably provided given constraints.

Note: If BMPs cannot be sized to provide the calculated volume for the drainage area, it is still essential to design the BMP inlet, energy dissipation, and overflow capacity for the full drainage area, including any area contributing off-site stormwater runoff volume, to ensure that flooding and scour is avoided. It is strongly recommended that BMPs which are designed to less than their target design volume be designed to bypass peak flows.

b. Aggregate the retention values achieved with the BMPs and compare with the regulated Stormwater Retention Volume (SWRv) for PROW project. If the aggregate retention value meets or exceeds the SWRv the project has meet its regulatory obligation.

c. If there is a retention volume deficiency, consider sizing BMPs to manage the comingled volume on-site.

d. If there is a retention volume deficiency, revisit Design Steps 1–4. Increase land conversion areas and BMP facilities. Depending on the extent and complexity of the PROW project this may require several iterations.

Step 6: **Address Drainage Areas where Zero-Retention Practices are Installed.**

It is possible, despite following the design considerations, fundamental tenants, and the iterative Steps 1–5 of the design process, that drainage areas within the proposed limits of disturbance may emerge without any retention practices. If these cases occur in the Municipal Separate Storm Sewer System (MS4), those drainage areas must incorporate water quality catch basins or other emergent technologies that provide water quality treatment for the SWRv of those drainage areas.

Table B.2 Potential BMPs for Green Streets Projects (modified US EPA)

BMP Type	Opportunity Criteria for PROW Projects
Street Trees, Canopy Interception	▪ Access roads, residential streets, local roads and minor arterials ▪ Drainage infrastructure, sea walls/break water ▪ Effective for projects with any slope ▪ Trees may be prohibited along high speed roads for safety reasons or must be setback behind the clear zone or protected with guard rails and barriers; planting setbacks may also be required for traffic and pedestrian lines of sight.
Stormwater Curb Extensions / Stormwater Planters	▪ Access roads, residential streets, and local roads with parallel or angle parking and sidewalks ▪ Can be designed to overflow back to curb line and to standard inlet ▪ Shape is not important and can be integrated wherever unused space exists ▪ Can be installed on relatively steep grades with terracing
Bioretention Areas	▪ Low density residential streets without sidewalks; along roadways adjacent to park space; well suited for the District’s triangle parks; ramp, slipways and road closings can make good conversion-sites ▪ May require more space than curb extensions/ planters, consider combing with minimized road widths to maximize bioretention area.
Permeable Pavement	▪ Parking and sidewalk areas of residential streets, and local roads If significant run-on from major roads is a possibility ensure deign and maintenance protocols to accommodate potential TSS loads ▪ Should not be subject to heavy truck/ equipment traffic ▪ Light vehicle access roads and alleyways
Permeable Friction Course Overlays	▪ High speed roadways unsuitable for full depth permeable pavement ▪ Suitable for parking lots and all roadway types
Vegetated Swales (compost amended were possible)	▪ Roadways with low to moderate slope or terraced systems ▪ Residential streets with minimal driveway access ▪ Minor to major arterials with medians or mandatory sidewalk set-backs Access roads ▪ Swales running parallel to storm drain can have intermittent discharge points to reduce required flow capacity
Filter strips (amended road shoulder)	▪ Access roads ▪ Major roadways with excess PROW ▪ Not practicable in most PROWs because of width requirements
Proprietary Biotreatment	▪ Constrained PROWs ▪ Typically have small footprint to drainage area ratio ▪ Simple install and maintenance ▪ Can be installed on roadways of any slope ▪ Can be designed to overflow back to curb line and to standard inlet
Infiltration Trench	▪ Constrained PROWs ▪ Can require small footprint where soils are suitable ▪ Low to moderate traffic roadways ▪ Infiltration trenches are not suitable for high traffic roadways ▪ Requires robust pretreatment

B.6 Summary of MEP Type 1 Submission Process

Table B.3 MEP Type 1Submission Elements and Review Points

	Stormwater Report Design Phases								
	30%			**65%**			**90%**		
Process Steps	**Table**	**Plan**	**Narrative**	**Table**	**Plan**	**Narrative**	**Table**	**Plan**	**Narrative**
Step 1: Identify Drainage Areas and Calculate SWRv									
DA count	I		I	R		R	F		F
DA list and SWRv per DA	I			R			F		
Project LOD		I			R			F	
DAs within LOD		I			R			F	
DAs outside LOD		I			R			F	
Land cover in LOD	I			R			F		
Volume calculated per DA inside LOD	I			R			F		
Volume calculated per DA outside LOD	I			R			F		
Will altered drainage profile increase SWRV?		I	I		R	R			F
Consider adjacent public lands		I			R	R			F
Step 2: Evaluate Infiltration									
Water table conflict per DA (Y/N)	I		I	R		R	F		F
Bedrock conflict per DA (Y/N)	I		I	R		R	F		F
Hydro soil group per DA (Y/N)	I		I	R		R	F		F
Hotspot concern noted (Y/N)	I		I	R		R	F		F
Water table impact (Y/N)					R	R	F	F	
Initial infiltration feasibility tests–opportunities and restrictions? (Y/N)					R	R		F	
Identify adjacent land use hotspots (Y/N)		I			R	R		F	
Step 3: Demonstrate Full Consideration of Existing Infrastructure									
Utility plans		I			R			F	
Utility conflicts		I			R			F	
Existing sewer infrastructure elevations		I			R			F	
Existing Trees	I	I			R			F	
Step 4: Demonstrate Full Consideration of Land Cover Conversions and Optimum BMP Placement									
Land conversion and BMP placement		I	I		R	R		F	F
Count of BMPs and land conversions	I			R			F		
Step 5: Size BMPs									

	Stormwater Report Design Phases								
	30%			65%			90%		
Process Steps	**Table**	**Plan**	**Narrative**	**Table**	**Plan**	**Narrative**	**Table**	**Plan**	**Narrative**
BMP drainage areas within LOD and outside LOD (Y/N)					I			R	
Consider overcontrol of SWRV (Y/N)						I			R
Achieve BMP sizing criteria (Y/N)						I			R
Design sizing achieved (under/over)				I			R		
Sizing constraints						I			R
Step 6: Address DAs with Zero-Retention Practices Installed									
SWRv achieved per DA				I		I	F		F

Notes:
I = Initial findings and presentation; this should define known facts and best opportunities.
R = Revisions based on further investigations and review comments; this will include some firm commitments.
F = Final design decisions based on initial commitments, interim reviews and final findings.
The process outlined in this table leads to a final submission of 100 percent design SWMP as required for the building permit.
DA = drainage area, LOD = limits of disturbance, SWRv = stormwater retention volume

B.7 References

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Appendix C Off-Site Retention Forms for Regulated Sites

This appendix includes the following off-site retention forms for regulated sites:

- Application to Use Stormwater Retention Credits for Off-Site Retention Volume
- Notification of In-Lieu Fee Payment to Meet Off-Site Retention Volume

GOVERNMENT OF THE DISTRICT OF COLUMBIA
District Department of the Environment
1200 First Street NE, Fifth Floor, Washington, DC 20002

Application to Use Stormwater Retention Credits for Off-Site Retention Volume

Acronyms

AWDZ Anacostia Waterfront Development Zone
CSS Combined Sewer System
DDOE District Department of the Environment
ILF In-Lieu Fee
MS4 Municipal Separate Storm Sewer System
Offv Off-Site Retention Volume
SRC Stormwater Retention Credit
SWMP Stormwater Management Plan
SWRv Stormwater Retention Volume

Application date: ___________________________

Address of regulated site for which SRC use is proposed:

____

Lot: ______Square: _____Ward: ______Storm Sewer System (CSS or MS4): ____________

Is the site an AWDZ site (Yes or No)? _________

Name of site owner: ____

Address: ____

E-Mail: ___________________________ Phone: ____________________________

Name of owner's agent (if applicable): _______________________________

Address: ____

E-Mail:___________________________ Phone: ____________________________

Information from DDOE-Approved SWMP for Regulated Site	
SWMP tracking number	
SWRv	
On-site retention volume achieved	
Offv	

1

Figure C.1 Application to Use Stormwater Retention Credits for Off-Site Retention Volume.

Offv to be met with SRCs (number of gallons): ______________________________

For an AWDZ site, how much of the Offv will be met with SRCs from outside the Anacostia River watershed? ______________________________

Offv to be met with payment of ILF (number of gallons): ______________________

SRCs proposed for use (Attach additional sheet if necessary):

Starting date for use (Indicate date or "as of final inspection." Multiple dates may be listed.)	**Serial numbers** (May indicate as range, where appropriate)

Applicant's Signature

A. Owner of regulated property: I hereby certify that I am the owner of the regulated property and of the SRCs proposed for use herein and that this application is correct to the best of my knowledge.

Signature of Owner: Date:

B. Agent: I hereby certify that I have the authority of the regulated property owner to make this application. The owner has assured me that he/she owns the SRCs proposed for use herein. I declare that this application is correct to the best of my knowledge.

Signature of Agent: Date:

<table>
<tr><th colspan="3">FOR DEPARTMENT USE ONLY</th></tr>
<tr><td>Approved:</td><td>Approved in part:</td><td>Disapproved:</td></tr>
<tr><td colspan="2">Signature:</td><td>Date:</td></tr>
<tr><td colspan="3">Notes:</td></tr>
</table>

2

Figure C.1 (continued)

GOVERNMENT OF THE DISTRICT OF COLUMBIA
District Department of the Environment
1200 First Street NE, Fifth Floor, Washington, DC 20002

Instructions for Application to Use Stormwater Retention Credits for Off-Site Retention Volume

Purpose of form: This form provides DDOE with the necessary information to track compliance with an Offv by use of SRCs.

NOTE: Buyers, sellers, or their agents must complete an Application for Transfer of Stormwater Retention Credit Ownership before SRCs may be used to satisfy an Offv requirement.

Instructions

Application date: Enter the date that the applicant completes the application.

Address of regulated site for which SRC use is proposed: Enter the street address for the regulated site that seeks to use SRCs to meet an Offv requirement. Lot, square, and ward information is available from the building permit and the approved SWMP for the site.

Is the site an AWDZ site (Yes or No)? Select "yes" or "no". AWDZ sites must purchase SRCs generated outside of the Anacostia River watershed at a 1.25:1 ratio.

Name of site owner: Enter the name of the site owner. Also provide the site owner's contact information.

Name of owner's agent: If applicable, enter the name of a representative whom the owner has charged with achieving the Offv.

Information from DDOE-approved SWMP for regulated site: Enter information from the SWMP including the Plan's tracking number, total required stormwater retention volume in gallons, on-site volume achieved, and required Offv.

Offv to be met with SRCs: Enter the number of gallons of the Offv requirement that a site owner seeks to achieve through SRCs.

For an AWDZ site, how much of the Offv will be met with SRCs from outside the Anacostia River watershed? AWDZ sites must purchase SRCs generated outside of the Anacostia River watershed at a 1.25:1 ratio. This information assists DDOE in calculating the correct number of SRCs for the regulated site to achieve its Offv requirement.

Offv to be met with payment of ILF: Enter the number of gallons of the Offv to be achieved through payment of the ILF. To use an ILF payment for compliance, sites must also submit a Notification of In-Lieu Fee Payment to Meet Off-Site Retention Volume.

SRCs proposed for use: Enter the effective date when SRCs will be used to satisfy an Offv requirement. Also list the serial numbers of purchased SRCs.

3

Figure C.1 (continued)

GOVERNMENT OF THE DISTRICT OF COLUMBIA
District Department of the Environment
1200 First Street NE, Fifth Floor, Washington, DC 20002

Notification of In-Lieu Fee Payment to Meet Off-Site Retention Volume

Acronyms

AWDZ Anacostia Waterfront Development Zone
CSS Combined Sewer System
DDOE District Department of the Environment
ILF In-Lieu Fee
MS4 Municipal Separate Storm Sewer System
Offv Off-Site Retention Volume
SRC Stormwater Retention Credit
SWMP Stormwater Management Plan
SWRv Stormwater Retention Volume

Application date: ___________________________

Address of regulated site for which ILF use is proposed:

____

Lot: ______Square: _____Ward: ______Storm Sewer System (CSS or MS4): _____________

Is the site an AWDZ site (Yes or **No)?** _________

Name of site owner: ____

Address: ____

E-Mail: ___________________________ Phone: ____________________________

Name of owner's agent (if applicable): _________________________________

Address: ____

E-Mail: ___________________________ Phone: ____________________________

Information from DDOE-Approved SWMP for Regulated Site	
SWMP tracking number	
SWRv	
On-site retention volume achieved	
Offv	

1

Figure C.2 Notification of In-Lieu Fee Payment to Meet Off-Site Retention Volume.

Offv to be met with SRCs (number of gallons): ________________

Offv to be met with payment of ILF (number of gallons): ________________

Proposed use of ILF (attach additional sheet if necessary).

Starting Date For Use (Indicate date or "as of final inspection." Multiple years may be listed.)	**Total Payment**

Applicant's Signature

A. Owner of regulated property: I hereby certify that I am the owner of the regulated property and that this application is correct to the best of my knowledge.

Signature of Owner: Date:

B. Agent: I hereby certify that I have the authority of the regulated property owner to make this application. I declare that this application is correct to the best of my knowledge.

Signature of Agent: Date:

FOR DEPARTMENT USE ONLY		
Payment Received:	Payment Received in Part:	Payment Not Received:
Signature:		Date:
Notes:		

2

Figure C.2 (continued)

GOVERNMENT OF THE DISTRICT OF COLUMBIA
District Department of the Environment
1200 First Street NE, Fifth Floor, Washington, DC 20002

Instructions for Notification of In-Lieu Fee Payment to Meet Off-Site Retention Volume

Purpose of form: This form provides DDOE with the necessary information to track compliance with an Offv by use of ILF

Instructions

Application date: Enter the date that the applicant completes the application.

Address of regulated site for which ILF is proposed: Enter the street address for the regulated site that seeks to make an ILF payment to meet an Offv. Lot, Square, Ward, and Storm Sewer System information is available from the building permit and the approved SWMP for the site.

Is the site an AWDZ site (Yes or No)? Select "yes" or "no". AWDZ sites must purchase SRCs generated outside of the Anacostia River watershed at a 1.25:1 ratio.

Name of site owner: Enter the name of the site owner. Also provide the site owner's contact information.

Name of owner's agent: If applicable, enter the name of a representative whom the owner has charged with achieving the Offv.

Information from DDOE-Approved SWMP for regulated site: Enter information from the SWMP including the Plan's tracking number, total required stormwater retention volume in gallons, on-site volume achieved, and required Offv.

Offv to be met with SRCs: Enter the number of gallons of the Offv requirement that a site owner seeks to achieve through SRCs.

Offv to be met with payment of in-lieu fee: Enter the number of gallons of the Offv that a site owner seeks to achieve through payment of the ILF. To use an ILF payment for compliance, sites must also submit a Notification of In-Lieu Fee Payment to Meet Off-Site Retention Volume.

Proposed use of in-lieu fee: Enter the effective date when in-lieu fee will be used to satisfy an Offv requirement.

3

Figure C.2 (continued)

Appendix D Stormwater Retention Credit Forms (Certification, Trading, and Retirement)

This appendix includes the following Stormwater Retention Credit forms:

- Application for Certification of Stormwater Retention Credits
- Application for Transfer of Stormwater Retention Credit Ownership
- Application to Retire Stormwater Retention Credits

GOVERNMENT OF THE DISTRICT OF COLUMBIA
District Department of the Environment
1200 First Street NE, Fifth Floor, Washington, DC 20002

Application for Certification of Stormwater Retention Credits

Acronyms

BMP	Best Management Practice	**MS4**	Municipal Separate Storm Sewer System
CSS	Combined Sewer System	**SRC**	Stormwater Retention Credit
DDOE	District Department of the Environment	**SWMP**	Stormwater Management Plan

Application date: ______________________________

Address of site with eligible retention capacity:

____

Lot: ______Square: _____Ward: ______Storm Sewer System (CSS or MS4): ______________

Name of owner of proposed SRCs: ______________________________________

Address: ____

E-Mail:__________________________ Phone: ______________________________

Name of site owner (if different from proposed SRC owner):

____

Address: ____

E-Mail:__________________________ Phone: ______________________________

Name of owner of retention capacity (if different from site owner):

____

Address: ____

E-Mail:__________________________ Phone: ______________________________

1

Figure D.1 Application for Certification of Stormwater Retention Credits.

Name of agent for owner of proposed SRCs (if applicable): ___________________________

Address: ____

E-Mail:___________________________ Phone: ______________________________

Should the agent be listed as the contact person for interested SRC buyers in DDOE's SRC registry (Yes or No)? _______________________

DDOE tracking number for SWMP: ___________________________

Identification number(s) for each BMP for which SRCs are requested:

____

SRC-eligible retention capacity for each BMP or land cover for which SRCs are requested:

____

Has DDOE previously certified SRCs for the retention capacity (Yes or No) _____________

If no, attach the following:

- ☐ As-built SWMP, including site plan showing pre-project site conditions and retention.
- ☐ Signed maintenance contract or documentation of capacity and expertise to conduct maintenance for the time period for which SRCs are requested.
- ☐ Documentation of the legal right to the SRCs applied for, if the proposed SRC owner is not the property owner.
- ☐ Completed DDOE SRC calculator spreadsheet.

If yes, attach the following:

- ☐ Signed maintenance contract or documentation of capacity and expertise to conduct maintenance for the time period for which SRCs are requested.
- ☐ Documentation of the legal right to the SRCs applied for, if the proposed SRC owner is not the property owner.

Is this application for SRCs for the maximum three-year period (Yes or No)? ___________

If no, what is the period for which SRCs are requested? ______________________________

What is the listing price for each SRC (optional)? ___________________________________

Should DDOE list these SRCs and corresponding name and contact information in DDOE's SRC registry (Indicate Yes or No and, if yes, who should be listed):

____

2

Figure D.1 (continued)

GOVERNMENT OF THE DISTRICT OF COLUMBIA
District Department of the Environment
1200 First Street NE, Fifth Floor, Washington, DC 20002

Applicant's Signature

A. Proposed SRC Owner: I hereby certify that I have the legal right to the SRCs proposed for certification above; that the application, including supporting documentation, is complete and correct to the best of my knowledge; that access will be provided for DDOE inspections; that the retention capacity will be maintained in accordance with the maintenance plan for the period for which SRCs are requested; that, if the retention capacity is not maintained, I will, for the volume from the period of failed maintenance, forfeit the SRCs, purchase replacement SRCs, or pay in-lieu fee to DDOE. ; and that, if during the period of time for which an SRC is certified, the property is sold or otherwise transferred to another person, the owner of the property on which the BMP or land cover is located will notify DDOE.

Signature of Proposed SRC Owner: Date:

B. Agent: I hereby certify that I have the authority of the proposed SRC owner to make this application and that the application and plans are complete and correct to the best of my knowledge. The owner has assured me that access will be provided for DDOE inspections and that the retention capacity will be maintained in accordance with the maintenance plan for the period for which SRCs are requested. If the retention capacity is not maintained in good working order, the proposed SRC owner has assured me that, for the volume from the period of failed maintenance, he will forfeit the SRCs, purchase replacement SRCs, or pay in-lieu fee to DDOE. Finally, the proposed SRC owner has assured me that, if during the period of time for which an SRC is certified, the property is sold or otherwise transferred to another person, the owner of the property on which the BMP or land cover is located will notify the Department.

Signature of Agent: Date:

FOR DEPARTMENT USE ONLY		
Approved:	Approved in part:	Disapproved:
Signature:		Date:
Total SRCs certified:	Total time period for which SRCs are certified:	
SRCs certified year 1:	Serial numbers:	
SRCs certified year 2:	Serial numbers:	
SRCs certified year 3	Serial numbers:	
Notes:		

3

Figure D.1 (continued)

Instructions for Application for Certification of Stormwater Retention Credits

Purpose of form: This form provides DDOE with the necessary information to certify SRCs.

NOTE: Buyers, sellers, or their agents must complete an Application for Transfer of Stormwater Retention Credit Ownership before an SRC transaction may occur.

Instructions

Application date: Enter the date that the applicant completes the application.

Address of site with eligible retention capacity: Enter the street address for the site with retention capacity that complies with the eligibility requirements for SRC certification. Lot, square, and ward information is available from the building permit and the approved SWMP for the site.

Name of owner of proposed SRCs: Enter the name and contact information for the person proposed as the owner of the SRCs. Once DDOE certifies the SRCs, this person will become the original SRC owner, with associated maintenance obligation. This person or their agent signs the application form. Once SRCs are certified or the agent signs the application, DDOE will notify the proposed SRC owner of its determination for the application. DDOE will list the original SRC owner (or the owner's agent) and contact information in a public registry posted to the DDOE website.

Name of site owner: If different from the proposed SRC owner, enter the name and contact information for the person who owns the site where practices are installed to generate SRCs. DDOE recognizes that a site owner could assign the right to the SRCs to an SRC aggregator or other person. In such a case, the SRC aggregator or other person would presumably be the proposed SRC owner.

Name of owner of retention capacity: If different from site owner, enter the name and contact information for the owner of the retention capacity generating SRCs on a site. DDOE expects that typically the site owner would also be the owner of the retention capacity, but this may not always be the case.

Name of agent for owner of proposed SRCs (if applicable): Enter the name and contact information for a person who is authorized to represent the proposed SRC owner in applying for certification of SRCs. If the agent is also authorized to represent (and take the place of) the proposed SRC owner in DDOE's SRC registry as the contact for interested SRC buyers, that should be indicated.

4

Figure D.1 (continued)

GOVERNMENT OF THE DISTRICT OF COLUMBIA
District Department of the Environment
1200 First Street NE, Fifth Floor, Washington, DC 20002

DDOE tracking number for SWMP: Enter the tracking number assigned to the SWMP by DDOE.

Identification number(s) for each BMP for which SRCs are requested: Enter the tracking number for the BMP, as identified in the SWMP. This will allow DDOE to identify the specific BMP on a site for which SRCs are being requested and for which maintenance will be required. Some sites may have multiple BMPs.

SRC-eligible retention capacity for each BMP or land cover for which SRCs are requested: Enter the SRC-eligible volume, as identified in the as-built SWMP for a site. For a site with one SRC-eligible BMP or land cover, this will typically correspond to cell B:50 of the SRC calculator.

Has DDOE previously certified SRCs for the retention capacity? Select "yes" or "no". DDOE certifies SRCs for three-year periods. If the retention capacity continues to be maintained and function properly, applicants may apply for an additional three years of SRCs.

Is this application for SRCs for the maximum three-year period? Select "yes" or "no". DDOE certifies SRCs for three year periods, but applicants should apply for fewer years if they do not intend to maintain the retention capacity for the entire three-year time period.

If no, what is the period for which SRCs are requested? Enter the period of time for which the applicant requests SRCs.

What is the listing price for for each SRC (optional)? If the applicant would like DDOE to include an SRC price in the SRC registry, indicate that here. This is not binding, and the final price will be determined by the SRC seller and buyer.

Should DDOE list these SRCs and corresponding name and contact information in DDOE's SRC registry? Indicate whether the proposed SRC owner or the owner's agent would like the SRCs to be listed in DDOE's SRC registry. Also indicate whether contact information for the owner or agent should be listed.

5

Figure D.1 (continued)

GOVERNMENT OF THE DISTRICT OF COLUMBIA
District Department of the Environment
1200 First Street NE, Fifth Floor, Washington, DC 20002

Application for Transfer of Stormwater Retention Credit Ownership

Acronyms

DDOE District Department of the Environment

SRC Stormwater Retention Credit

Application date: ___________________________

Number of SRCs to transfer: ___________________________

Serial numbers of SRCs (may be listed as a range):

Purchase price for SRCs: ___________________________

Name of current owner of SRCs: ___________________________

Address___________________________

E-Mail:___________________________ Phone: ___________________________

Name of new owner of SRCs: ___________________________

Address: ___________________________

E-Mail: ___________________________ Phone: ___________________________

Name of agent for new owner of SRCs (if applicable):

____

Address: ___________________________

E-Mail: ___________________________ Phone: ___________________________

1

Figure D.2 Application for Transfer of Stormwater Retention Credit Ownership.

Should DDOE list these SRCs and the name and contact information for the owner or owner's agent in DDOE's SRC registry? (Indicate Yes or No and, if yes, who should be listed)

Signature of Current Owner

I hereby certify that I am the owner of the above SRCs; that I request the ownership of these SRCs to be transferred as stated above; and that this application is complete and correct to the best of my knowledge.

Signature: Date:

Signature of New Owner (or Owner's Agent)

I hereby certify that this application is complete and correct to the best of my knowledge.

Signature: Date:

FOR DEPARTMENT USE ONLY		
Approved:	Approved in part:	Disapproved:
Signature:		Date:
Notes:		

2

Figure D.2 (continued)

GOVERNMENT OF THE DISTRICT OF COLUMBIA
District Department of the Environment
1200 First Street NE, Fifth Floor, Washington, DC 20002

Instructions for Application for Transfer of Stormwater Retention Credit Ownership

Purpose of form: This form provides DDOE with the necessary information to verify and track ownership of SRCs and the price at which SRCs are traded.

Instructions

Application date: Enter the date that the applicant completes the application.

Number of SRCs to transfer: Enter the number of SRCs that are proposed for transfer from a seller to buyer.

Serial numbers of SRCs (may be listed as a range): Enter the serial numbers for SRCs to be transferred. Individually list serial numbers for SRCs that are not in sequential order. Use a range for sequential SRCs.

Purchase price for SRCs: Enter the price for each SRC to be transferred. If prices vary for different SRCs being transferred, enter each of the prices and the corresponding SRCs. DDOE will share price information on its website.

Name of current owner of SRCs: Enter the name and contact information for the current owner of SRCs to be transferred to the new owner.

Name of new owner of SRCs: Enter the name and contact information for the person to whom the SRCs will be transferred. DDOE will list the new owner on its SRC registry, unless the new owner requests not to be listed.

Name of agent for new owner: If applicable, enter the name and contact information for the agent of the new owner.

Should DDOE list these SRCs and the new owner's name and contact information in DDOE's SRC registry? Indicate whether the new SRC owner or the owner's agent would like the SRCs to be listed in DDOE's SRC registry. Also indicate whether the listed contact information should be for the new owner or the agent.

3

Figure D.2 (continued)

GOVERNMENT OF THE DISTRICT OF COLUMBIA
District Department of the Environment
1200 First Street NE, Fifth Floor, Washington, DC 20002

Application to Retire Stormwater Retention Credits

Acronyms

DDOE District Department of the Environment **SRC** Stormwater Retention Credit

Application date: ____________________

Number of SRCs to retire: ______________________

Serial numbers of SRCs (may be listed as a range):

Name of current owner of SRCs: ________________________________

Address: ____

E-Mail: ____________________ Phone: ______________________

Signature of SRC Owner

I hereby certify that I am the owner of the above SRCs; that I request these SRCs to be retired; and that this application is complete and correct to the best of my knowledge.

Signature: Date:

FOR DEPARTMENT USE ONLY		
Approved:	Approved in part:	Disapproved:
Signature:		Date:
Notes:		

1

Figure D.3 Application to Retire Stormwater Retention Credits.

GOVERNMENT OF THE DISTRICT OF COLUMBIA
District Department of the Environment
1200 First Street NE, Fifth Floor, Washington, DC 20002

Instructions for Application to Retire Stormwater Retention Credits

Purpose of form: This form provides DDOE with the necessary information to retire SRCs and track accordingly.

Instructions

Application date: Enter the date that the applicant completes the application.

Number of SRCs to retire: Enter the number of SRCs that are proposed for retirement.

Serial numbers of SRCs (may be listed as a range): Enter the serial numbers for SRCs to be retired. Individually list serial numbers for SRCs that are not in sequential order. Use a range for sequential SRCs.

Name of current owner of SRCs: Enter the name and contact information for the owner of the SRCs.

2

Figure D.3 (continued)

Appendix E Relief for Extraordinarily Difficult Site Conditions

E.1 Relief from Extraordinarily Difficult Site Conditions

Note that major land-disturbing activity in the existing public right-of-way (PROW) uses the maximum extent practicable process detailed in Appendix B to determine sizing criteria used to achieve the stormwater management performance requirements for regulated activity. These projects are not required to apply for relief from extraordinarily difficult site conditions. Regulated activity located in the Anacostia Waterfront Development Zone (AWDZ) that are governed by the Anacostia Waterfront Environmental Standards Amendment Act of 2012 (see D.C. Official Code §§ 2-1226.36(c)(1)) must have all off-site retention and all off-site water quality treatment volume approved by DDOE through the process defined in this appendix, even if the District-wide minimum 50 percent on-site retention requirement is met. All development sites are required to address the Stormwater Retention Volume (SWRv), as described in Chapter 2. All development sites in the Anacostia Waterfront Development Zone (AWDZ), governed by the Anacostia Waterfront Environmental Standards Amendment Act of 2012, are required to address the Water Quality Treatment Volume (WQTv), as described in Chapter 2. If compliance with the minimum on-site retention requirement or on-site water quality treatment requirement is technically infeasible or environmentally harmful, the applicant may apply for relief from extraordinarily difficult site conditions. Additionally, if the regulated activity is in the Anacostia Waterfront Development Zone (AWDZ), governed by the Anacostia Waterfront Environmental Standards Amendment Act of 2012, consideration for a request for relief will include the limited appropriateness of on-site compliance in terms of impact on surrounding landowners or overall benefit to District waterbodies. In cases where an applicant claims extraordinarily difficult site conditions, it is the responsibility of the applicant to provide sufficient evidence to support the claim.

Once granted relief from extraordinarily difficult site conditions, an applicant is allowed to provide less than the minimum compliance requirements on site by managing a greater retention volume or water quality treatment volume through off-site mitigation. This process does not relieve the applicant from the obligation to manage the full SWRv or the WQTv determined through compliance calculations. Additionally, stormwater runoff not receiving the minimum on-site retention must receive treatment to remove 80 percent of total suspended solids based on the treatment practices, as defined in Chapter 3 of this guidance manual. When DDOE finds the evidence presented is sufficient and compelling to grant relief, the Stormwater Management Plan (SWMP) for the project must the two conditions for relief have been satisfied: (1) removing 80 percent of total suspended solids from 50 percent of the SWRv and (2) identifying the requirement for the use of off-site retention to offset the entire on-site retention deficit.

E.2 Submission requirements for Relief from Extraordinarily Difficult Site Conditions

A request for relief is made through a "relief request memo." The memo is submitted in advance of a final SWMP, but not before the 65 percent design stage of the SWMP, of the SWMP with supporting evidence to demonstrate the claim of technical infeasibility or environmental harm. The memo shall provide a detailed explanation of each opportunity for on-site installation of retention BMPs that was considered and rejected, and the reasons for each rejection. The applicant shall address each retention practice specified in this guidance manual in BMP groups 1 through 13, specifically,

BMP Group 1	Green Roofs
BMP Group 2	Rainwater Harvesting
BMP Group 3	Impermeable Surface Disconnection
BMP Group 4	Permeable Pavement Systems
BMP Group 5	Bioretention
BMP Group 7	Infiltration
BMP Group 8	Open Channel Systems
BMP Group 13	Tree Planting

Evidence of site conditions limiting each opportunity for a retention BMP include the following:

1. Data on soil and groundwater contamination;
2. Data from soils testing consistent with the geotechnical requirements in Appendix O;
3. Documentation of the presence of utilities requiring impermeable protection or a setback;
4. Evidence of the applicability of a statute, regulation, court order, preexisting covenant, or other restriction having the force of law;
5. Evidence that the installation of a retention BMP would conflict with the terms of a non-expired approval, applied for prior to the end of Transition Period Two A for a major land-disturbing activity or before the end of Transition Period Two B for a major substantial improvement activity, of a:
   (a) Concept review by the Historic Preservation Review Board;
   (b) Concept review by the Commission on Fine Arts;
   (c) Preliminary or final design submission by the National Capital Planning Commission;
   (d) Variance or special exception from the Board of Zoning Adjustment; or
   (e) Large Tract Review by the District Office of Planning; and
6. For a utility, evidence that a property owner on or under whose land the utility is conducting work objects to the installation of a BMP; and

7. For a major substantial improvement activity, evidence that the structure cannot accommodate a BMP without significant alteration, because of a lack of available interior or exterior space or limited load-bearing capacity.

Projects in the AWDZ, governed by the Anacostia Waterfront Environmental Standards Amendment Act of 2012, may also discuss the limited appropriateness of on-site compliance verses a combination of off-site and on-site retention and or water quality treatment in terms of the impact on surrounding landowners or the overall benefit to District waterbodies.

E.3 Review of Requests for Relief from Extraordinarily Difficult Site Conditions

In an application for Relief from Extraordinarily Difficult Site Conditions, a completed application and proof of payment of the applicable fee are required to begin the review of the request. DDOE cannot render a final decision until an application for relief is considered complete. However, if an application is substantially complete, DDOE may begin consideration of the request for relief. Upon accepting an application, DDOE will review and determine whether the application meets the requirements of this section, including the following:

a. Require additional information;
b. Grant relief;
c. Grant relief, with conditions;
d. Deny relief; or
e. Deny relief in part.

In determining whether to grant relief, DDOE may consider the following:

a. The applicant’s submittal;
b. Other site-related information;
c. An alternative design;
d. DDOE’s Stormwater Management Guidebook (SWMG);
e. Another BMP that meets the SWMG’s approval requirements; and
f. Relevant scientific and technical literature, reports, guidance, and standards.

Appendix F Stormwater Conveyance System Design

F.1 Introduction

The focus of this SWMG is to define standards and specifications for design, construction and maintenance of BMPs required to meet stormwater performance objectives. The components and considerations of the accompanying stormwater conveyance system are outlined in this appendix.

F.2 Clearance with Other Utilities

- All proposed and existing utilities crossing or parallel to designed storm sewer systems must be shown on the plan and profile.
- Storm drain and utility crossings must not have be less than a 45-degree angle between them.
- Minimum vertical and horizontal clearances, wall to wall, must be provided between storm drainage lines and other utilities as defined by the District of Columbia Water and Sewer Authority (DC Water). Consult DC Water's Project Design Manual and Green Infrastructure Utility Protection Guidelines, latest additions, for details. Exceptions may be granted by the DC Water on a case-by-case basis when justified.

F.3 Design of Stormwater Conveyance Systems

The Chezy-Manning formula is to be used to compute the system's transport capacities:

$$Q = \frac{1.486}{n} \times A \times R^{2/3} \times S^{1/2}$$

where:

Q	=	channel flow (cfs)
n	=	Manning's roughness coefficient (Table F.1)
A	=	cross-sectional area of flow (ft^2)
R	=	hydraulic radius (ft)
S	=	channel slope (ft/ft)
Wp	=	wetland perimeter
R	=	A/W_P

Table F.1 Manning's Roughness Coefficient (*n*) Values for Various Channel Materials

Channel Materials	Roughness Coefficient
Concrete pipe and precast culverts	
24 inches and smaller	0.015
27 inches and larger	0.013
Monolithic concrete in boxes, channels	0.015
Corrugated metal	0.022
PVC pipes	0.011
Sodded channel with water depth < 1.5 feet	0.050
Sodded channel with water depth >1.5 feet	0.035
Smooth earth channel or bottom of wide channels with sodded slopes	0.025
Rip-rap channels	0.035

Note: Where drainage systems are composed of more than one of the above channel materials, a composite roughness coefficient must be computed in proportion to the wetted perimeter of the different materials.

Also, the computation for the flow velocity of the channel must use the continuity equation as follows:

$$Q = A \times V$$

where:

V = velocity (ft/s)
A = cross-sectional area of the flow (ft^2)

F.4 Gutters

With uniform cross slope and composite gutter section use the following equation:

$$Q = \frac{0.50}{n} \times S_x^{1.67} \times S^{0.5} \times T^{2.67}$$

where:

Q = flow rate (cfs)
n = Manning's roughness coefficient (Table F.1)
S_x = cross slope (ft/ft)
S = longitudinal slope (ft/ft)
T = width of flow (spread) (ft)

F.5 Inlets

In accordance with the current requirements of the District of Columbia Plumbing Code, all inlets on private or public parcels, but outside the public right-of-way (PROW), must be sized to ensure safe conveyance of stormwater flows exceeding the capacity of the approved on-site stormwater management practices and the designated pervious land cover areas. These stormwater flows must not flow over property lines onto adjacent lots unless these flows run into an existing natural water course. Stormwater inlets in the PROW must be designed in accordance with the current requirements in Chapter 33 of the District of Columbia Department of Transportation Design and Engineering Manual and be approved for use by the District of Columbia Water and Sewer Authority.

F.6 Street Capacity (Spread)

Design of the conveyance of stormwater runoff within the public right-of-way must follow the current requirements in the Design and Engineering Manual of the District of Columbia Department of Transportation. The roadway drainage design criteria for existing streets is a 15-year storm, 5-minute duration, and a maximum spread of 6 feet from the face of the curb (32.3.13 DDOT Design and Engineering Manual 2009). Proposed streets must use AASHTO Chapter VI for their design criteria.

F.7 Manhole and Inlet Energy Losses

The following formulas must be used to calculate headloss:

$$HL = \frac{V_{outlet}^2 - V_r^2}{2g} + SL$$

$$V_r = \frac{Q(V\cos\frac{a}{2})(inlet\,1) + Q(V\cos\frac{a}{2}(inlet\,2) + ...}{Q(outlet)}$$

where:

HL	=	headloss in the structure
V_r	=	resultant velocity
g	=	gravitational acceleration (32.2 ft/s^2)
SL	=	minimum structure loss
a	=	angle between the inlet and outlet pipes (180°)

Table F.2 provides the minimum structure loss for inlets, manholes, and other inlet structures for use in the headloss calculation.

Table F.2 Minimum Structure Loss to Use in Hydraulic Grade Line Calculation

Velocity, V_{outlet} (ft/s)*	**Structure Loss, *SL***
2	0.00
3	0.05
4	0.10
5	0.15
6	0.20
6	0.25

* Velocities leaving the structure.

Headloss at the field connection is to be calculated like those structures, eliminating the structure loss. For the angular loss coefficient, cos a/2 is assumed to be 1.

F.8 Open Channels

- Calculations must be provided for all channels, streams, ditches, swales and etc., including a typical section of each reach and a plan view with reach locations. In the case of existing natural streams/swales, a field survey of the stream (swale) cross sections may be required prior to the final approval.
- The final designed channel must provide a 6-inch minimum freeboard above the designated water surface profile of the channel.
- If the base flow exists for a long period of time or velocities are more than five feet per second in earth and sodded channel linings, gabion or rip-rap protection must be provided at the intersection of the inverts and side slopes of the channels unless it can be demonstrated that the final bank and vegetation are sufficiently erosion-resistant to withstand the designed flows, and the channel will stay within the floodplain easement throughout the project life.
- Channel inverts and tops of bank are to be shown in plan and profile views.
- For a designed channel, a cross section view of each configuration must be shown.
- For proposed channels, a final grading plan must be provided.
- The limits of a recorded 100-year floodplain easement or surface water easement sufficient to convey the 100 year flow must be shown.
- The minimum 25-foot horizontal clearance between a residential structure and 100 year floodplain must be indicated in the plan.
- For designed channels, transition at the entrance and outfall is to be clearly shown on the site plan and profile views.

F.9 Pipe Systems

- Individual stormwater traps must be installed on the storm drain branch serving each structural best management practice, or a single trap must be installed in the main storm drain after it leaves the structural best management practice and before it connects with the city's combined sewer. Such traps must be provided with an accessible cleanout. The traps must not be required for storm drains which are connected to a separate storm sewer system.
- The pipe sizes used for any part of the storm drainage system within the public right-of-way must follow District of Columbia Water and Sewer Authority Standard and Specifications. The minimum pipe size to be used for any part of a private storm drainage system must follow the current requirements of the District of Columbia Plumbing Code.
- The material and installation of the storm drain for any part of public storm sewer must follow District of Columbia Water and Sewer Authority Standard and Specifications.
- An alternative overflow path for the 100-year storm is to be shown on the plan view if the path is not directly over the pipe. Where applicable, proposed grading must ensure that overflow will be into attenuation facilities designed to control the 100-year storm.
- A pipe schedule tabulating pipe lengths by diameter and class is to be included on the drawings. Public and private systems must be shown separately.
- Profiles of the proposed storm drains must indicate size, type, and class of pipe, percent grade, existing ground and proposed ground over the proposed system, and invert elevations at both ends of each pipe run. Pipe elevations and grades must be set to avoid hydrostatic surcharge during design conditions. Where hydrostatic surcharge greater than one foot of head cannot be avoided, a rubber gasket pipe is to be specified.

F.10 Culverts

Culverts must be built at the lowest point to pass the water across embankment of pond or highway. Inlet structure must be designed to resist long term erosion and increased hydraulic capacities of culverts. Outlet structures must be designed to protect outlets from future scouring. The following formulas are to be used in computing the culvert:

If the outlet is submerged then the culvert discharge is controlled by the tail water elevation:

$$h = h_e + h_f + h_v$$

where:

h = head required to pass given quantity of water through culvert flowing in outlet control with barrel flowing full throughout its length
h_e = entrance loss
h_f = friction loss
h_v = velocity head

and

$$h = k_e\left(\frac{V^2}{2g}\right) + \frac{n^2V^2L}{2.21R^{4/3}} + \frac{V^2}{2g}$$

$$h = \left[k_e + \frac{n^2L}{2.21R^{4/3}} \times 2g + 1\right] \times \left(\frac{V^2}{2g}\right)$$

$$h = \left[k_e + \frac{n^2L}{2.21R^{4/3}} \times 2g + 1\right] \times \left(\frac{8Q^2}{9.87gD^4}\right)$$

where:

k_e	=	entrance loss coefficient = 0.5 for a square-edged entrance
		entrance loss coefficient = 0.1 for a well-rounded entrance
V	=	mean or average velocity in the culvert barrel (ft/s)
g	=	32.2ft/s^2 (gravitational acceleration)
n	=	Manning's roughness coefficient = 0.012 for concrete pipe
L	=	length of culvert barrel (ft)
R	=	0.25D = hydraulic radius (ft)
Q	=	flow (cfs)
D	=	diameter (ft)

If the normal depth of the culvert is larger than the barrel height, the culvert will flow into a full or partially full pipe. The culvert discharge is controlled by the entrance conditions or entrance control.

$$Q = C_d A(2gh)^{0.5}$$

where:

Q	=	discharge (cfs)
Cd	=	discharge coefficient = 0.62 for square-edged entrance
		discharge coefficient = 0.1 for well-rounded entrance
A	=	cross sectional area (ft^2)
g	=	32.2ft/s^2 (gravitational acceleration)
h	=	hydrostatic head above the center of the orifice (ft)

If the hydrostatic head is less than 1.2D, the culvert will flow under no pressure as an open channel system.

If the flows are submerged at both ends of the culvert, use Figure F.1.

F.11 Hydraulic Grade Line

A hydraulic grade line (HGL) must be clearly indicated on the system profiles and identified with the initials HGL on the line and identified in the legend key. This grade line must take into consideration pipe and channel friction losses, computing structures losses, tail water conditions and entrance losses. All pipe systems must be designed so that they will operate without building up a surcharged hydrostatic head under design flow conditions. It is recommended that the HGL be no more than 1 foot above the pipe crown. If pipes have a HGL more than 1 foot above the pipe crown, rubber gaskets are required.

If the structural best management practice discharges into a storm sewer or a combined sewer system, a detailed HGL analysis of the system including the receiving system must be submitted with the final stormwater management plans for the 15- and 100-year flow frequencies. If the time characteristics of the HGL are unknown, the designed structural best management practice must be functional under expected minimum and maximum grade lines.

F.12 Manholes and Inlets

- District of Columbia Water and Sewer Authority Standards and Specifications must be used. All structures are to be numbered and listed in the structure schedule and must include type, standard detail number, size, top elevation, slot elevation and locations, and modification notes.
- Access structures must be spaced according to the District of Columbia Water and Sewer Authority Standards and Specifications and the Design and Engineering Manual of the District of Columbia Department of Transportation.
- Where two or more pipes enter a structure maintain a minimum of 9 inches of undisturbed concrete between holes in precast concrete is required to ensure sufficient steel. Consult the District of Columbia Water and Sewer Authority (DC Water) for more specifics.
- A minimum drop of 0.1 foot must be provided through the structure invert.
- Drainage boundary and contours must be shown around each inlet to ensure that positive drainage to the proposed inlet is provided.
- Invert elevations of the pipes entering and leaving the structures must be shown in the profile view.
- Yard or grate inlets must show the 15-year and 100-year ponding limits (if applicable). A depth of not more than two feet is allowed from the throat or grate to the 100-year storm elevation.
- Public street inlets must follow District of Columbia Water and Sewer Authority and District of Columbia Department of Transportation criteria.
- Additional structures are recommended and may be required on steep slopes to reduce excessive pipe depths and/or to provide deliberate drops in the main line to facilitate safe conveyance to a proper outfall discharge point. In order to provide an outfall at a suitable slope (i.e., less than 5 percent slope), drop structures may need to be used to reduce the velocity before discharging on a rip-rap area.
- Curb inlets located on private cul-de-sacs must have a maximum 10 linear feet opening.
- For commercial/industrial areas, inlets must be kept at least five feet away from the driveway aprons.

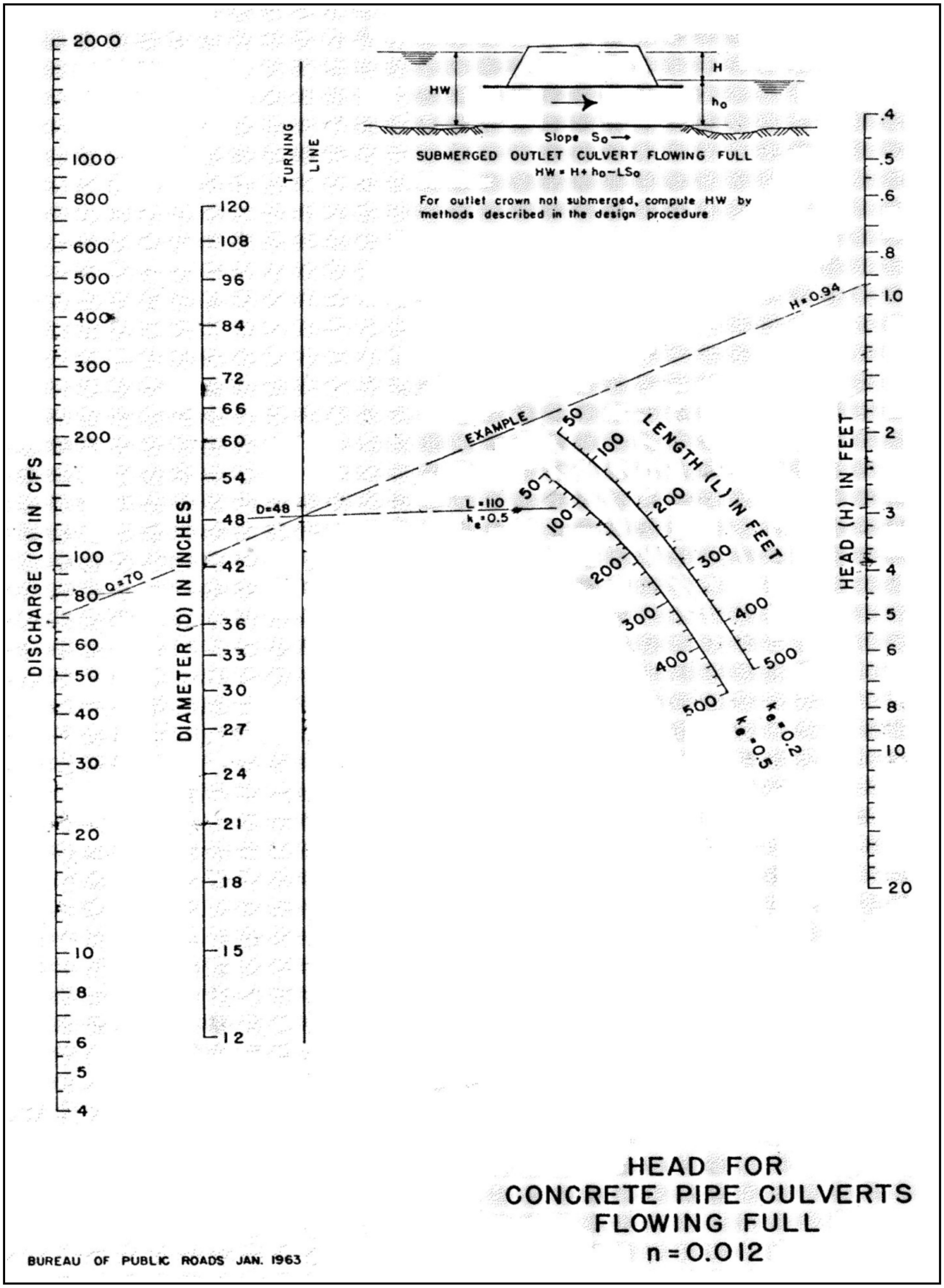

Figure F.1 Typical nomograph for culverts under outlet control.

The determination of the minimum width of a structure based on incoming pipes is based on the following formula:

$$W = \frac{D}{\sin\theta} + \frac{T}{\tan\theta}$$

where:

D	=	pipe diameter (outside)
T	=	inlet wall thickness
W	=	minimum structure width (inside)
θ	=	angle of pipe entering structure

Appendix G Design of Flow Control Structures

G.1 Design of Flow Control Structures

Flow control devices are orifices and weirs. The following formulas shall be used in computing maximum release rates from the designed structural BMP.

G.1.1 Circular Orifices

$$Q = CA(2gh)^{0.5}$$

where:

Q	=	orifice discharge (cfs)
C	=	discharge coefficient = 0.6
A	=	orifice cross-sectional area (ft^2) = 3.1416(D2/4)
g	=	gravitational acceleration (ft/s^2) = 32.2
h	=	hydraulic head above the center of the orifice (ft)

When h < D, the orifice shall be treated as a weir:

$$Q = CLH^{3/2}$$

where:

Q	=	flow through the weir (cfs)
C	=	3
L	=	diameter of orifice (ft)
H	=	hydraulic head above bottom of weir opening (ft)

G.1.2 Flow Under Gates

Flow under a vertical gate can be treated as a square orifice. For submerged conditions:

When outflow is not influenced by downstream water level:

$$Q = b \times a \times C \times \left[2g \times \left(\frac{H_0}{H_0 + H_i} \right) \right]^{0.5}$$

where:

Q	=	flow through the gate (cfs)
b	=	width of gate (ft)
a	=	gate opening height (ft)

C = discharge coefficient
G = 32.2 ft/s^2 (gravitational acceleration)

When outflow is influenced by downstream water level:

$$Q' = KQ$$

where:

Q = flow through the gate (cfs)
K = coefficient found in Figure G.1

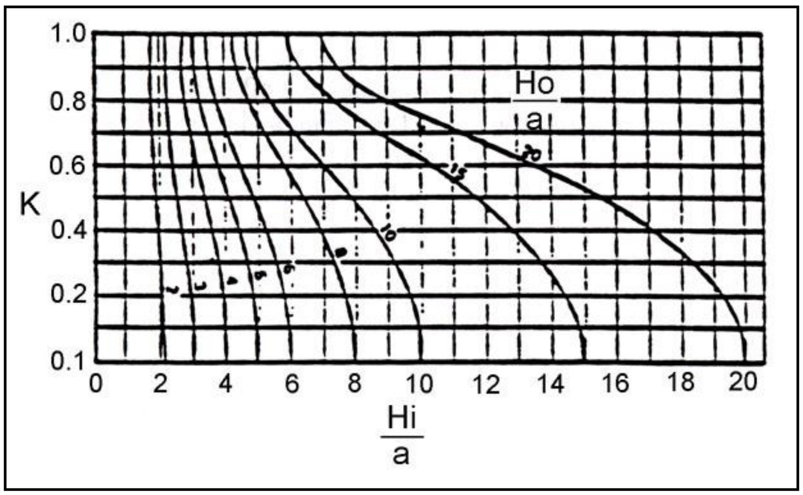

Figure G.1 Absolute downstream control of flow under gate.

G.1.3 Weirs

Rectangular:

$$Q = 3.33H^{1.5}(L - 0.2H)$$

60o V-notch:

$$Q = 1.43H^{2.5}$$

90o V-notch:

$$Q = 2.49H^{2.48}$$

where:

Q	=	low through the weir (cfs)
H	=	hydraulic head above the bottom of the weir (ft)
L	=	length of the weir crest (ft)

Appendix H Acceptable Hydrological Methods and Models

H.1 Acceptable Hydrologic Methods and Models

The following are the acceptable methodologies and computer models for estimating runoff hydrographs before and after development. These methods are used to predict the runoff response from given rainfall information and site surface characteristic conditions. The design storm frequencies used in all of the hydrologic engineering calculations will be based on design storms required in this guidebook unless circumstances make consideration of another storm intensity criterion appropriate:

- Urban Hydrology for Small Watersheds TR-55 (TR-55)
- Storage-Indication Routing
- HEC-1, WinTR-55, TR-20, and SWMM Computer Models
- Rational Method (limited to sites under five acres)

These methods are given as valid in principle, and are applicable to most stormwater management design situations in the District. Other methods may be used when the District reviewing authority approves their application.

Note: Of the above methods, TR-55 and SWMM allow for the easiest correlation of the benefits of retention BMPs used to meet the SWRv with peak flow detention requirements, and are therefore strongly recommended. Appendix A includes more information on using the General Retention Compliance Calculator to account for retention BMPs in calculating peak flow detention requirements.

The following conditions should be assumed when developing predevelopment, preproject, and post-development hydrology, as applicable:

- Predevelopment runoff conditions (used for the 2-year storm) shall be computed independent of existing developed land uses and conditions and shall be based on “Meadow in good condition” or better, assuming good hydrologic conditions and land with grass cover.
- Preproject runoff conditions (used for the 15-year storm) shall be based on the existing condition of the site
- Post-development shall be computed for future land use assuming good hydrologic and appropriate land use conditions. If a NRCS CN Method-based approach, such as TR-55, is used, this curve number may be reduced based upon the application of retention BMPs, as indicated in the General Retention Compliance Calculator (see Appendix A). This curve number reduction will reduce the required detention volume for a site, but it should not be used to reduce the size of conveyance infrastructure.

- The rainfall intensity - duration - frequency curve should be determined from the most recent version of the Hydrometeorological Design Studies Center's Precipitation Frequency Data Server (NOAA Atlas 14, Volume 2).
- Predevelopment time of concentration shall be based on the sum total of computed or estimated overland flow time and travel in natural swales, streams, creeks and rivers, but never less than six minutes.
- Post-development time of concentration shall be based on the sum total of the inlet time and travel time in improved channels or storm drains, but shall not be less than six minutes.
- Drainage areas exceeding 25 acres that are heterogeneous with respect to land use, soils, RCN or Time of Concentration (Tc) shall require a separate hydrological analysis for each sub-area.
- Hydrologic Soil Groups approved for use in the District are contained in the Soil Survey of the District of Columbia Handbook. Where the Hydrologic Soil Group is not available through the Soil Survey due to the listed soil type being "Urban Soils" or similar, a Hydrologic Soil Group of C shall be used.

H.2 Urban Hydrology for Small Watersheds TR-55

Chapter 6 of Urban Hydrology for Small Watersheds TR-55, Storage Volume for Detention Basins, or TR-55 shortcut procedure, is based on average storage and routing effects for many structures, and can be used for multistage outflow devices. Refer to TR-55 for more detailed discussions and limitations.

Information Needed

To calculate the required storage volume using TR-55, the predevelopment hydrology for the 2-year storm, and the preproject hydrology for the 15-year storm are needed, along with post-development hydrology for both the 2-year and 15-year storms. The predevelopment hydrology for the 2-year storm is based on natural conditions (meadow), and will determine the site's predevelopment peak rate of discharge, or allowable release rate, qo_2, for the 2-year storm, whereas the preproject hydrology for the 15-year storm is based on existing conditions, and will determine the site's preproject peak rate of discharge, or allowable release rate, qo_{15}, for the 15-year storm.

The post-development hydrology may be determined using the reduced curve numbers calculated in the General Retention Compliance Calculator (See Appendix A) or more detailed routing calculations. This will determine the site's post-development peak rate of discharge, or inflow for both the 2-year and 15-year storms, qi_2 and qi_{15}, respectively, and the site's post-developed runoff, Q_2 and Q_{15}, in inches. (Note that this method does not require a hydrograph.) Once the above parameters are known, the TR-55 Manual can be used to approximate the storage volume required for each design storm. The following procedure summarizes the TR-55 shortcut method.

Procedure

1. Determine the peak development inflows, q_{i2} and q_{i15}, and the allowable release rates, $q_{o2}$and q_{o15}, from the hydrology for the appropriate design storm.

   Using the ratio of the allowable release rate, q_o , to the peak developed inflow, q_i , or q_o/q_i , for both the 2-year and 15-year design storms, use Figure H.1 (or Figure 6.1 in TR-55) to obtain the ratio of storage volume, Vs , to runoff volume, Vr , or Vs_2/Vr_2 and Vs_{15}/Vr_{15} for Type II storms.

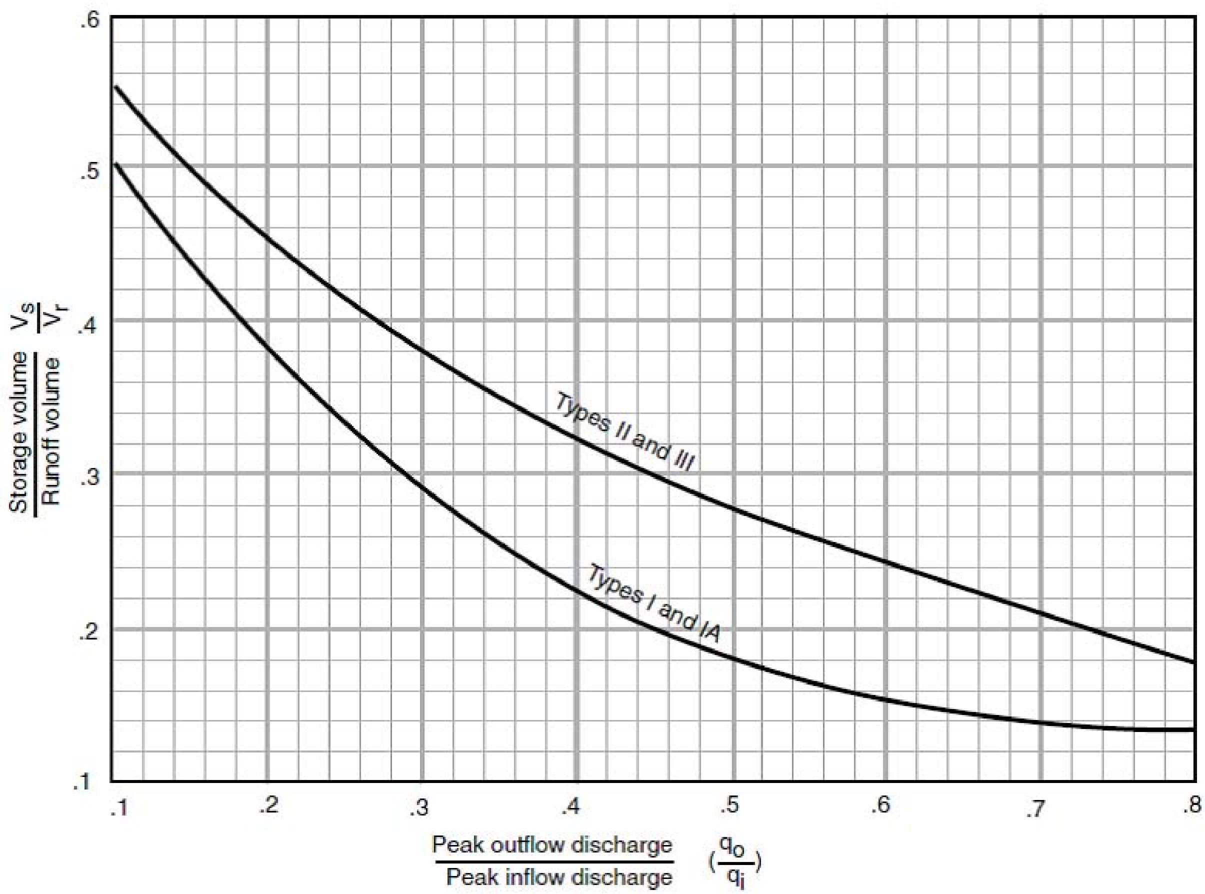

Figure H.1 Approximate detention basin routing for rainfall types I, IA, II and III.

2. Determine the runoff volumes, Vr_2 and Vr_{15}.

$$Vr_2 = 53.33 \text{ x } Q_2 \times Am$$

where:

53.33	=	conversion factor from in-mi^2 to acre-feet
Q_2	=	post-development runoff, in inches for the 2-year storm
Am	=	drainage area, in square miles

$$Vr15 = 53.33 \text{ x } Q_{15} \times Am$$

where:

53.33	=	conversion factor from in-mi^2 to acre-feet
Q_{15}	=	post-development runoff for the 15-year storm (in.)
Am	=	drainage area (mi^2)

3. Multiply the Vs /Vr ratios from Step 1 by the runoff volumes, Vr_2 and Vr_{15}, from Step 2, to determine the required storage volumes, Vs_2 and Vs_{15}, in acre-feet.

$$(\frac{Vs_2}{Vr_2})Vr_2 = Vs_2$$

$$(\frac{Vs_{15}}{Vr_{15}})Vr_{15} = Vs_{15}$$

Note: In most cases, Vs_{15} represents the total storage required for the 2-year storm and the 15-year storm, and the outflow, qo_{15}, includes the outflow q_{o2}. In some cases, Vs_{15} may be less than Vs_2. In these cases, the storage volume provided for the 2-year storm (Vs_2) may or may not be sufficient to meet the 15-year requirements, and must be checked via stage-storage curve analysis.

The design procedure presented above may be used with Urban Hydrology for Small Watersheds TR-55 Worksheet 6a. The worksheet includes an area to plot the stage-storage curve, from which actual elevations corresponding to the required storage volumes can be derived. The characteristics of the stage-storage curve are dependent upon the topography of the proposed storage practice and the outlet structure design (see Appendix G), and may be best developed using a spreadsheet or appropriate hydraulics software.

Limitations

This routing method is less accurate as the qo/qi ratio approaches the limits shown in Figure H.1. The curves in Figure H.1 depend on the relationship between available storage, outflow device, inflow volume, and shape of the inflow hydrograph. When storage volume (Vs) required is small, the shape of the outflow hydrograph is sensitive to the rate of the inflow hydrograph. Conversely, when Vs is large, the inflow hydrograph shape has little effect on the outflow hydrograph. In such instances, the outflow hydrograph is controlled by the hydraulics of the outflow device and the procedure therefore yields consistent results. When the peak outflow discharge (qo) approaches the peak inflow discharge (qi) parameters that affect the rate of rise of a hydrograph, such as rainfall volume, curve number, and time of concentration, become especially significant.

The procedure should not be used to perform final design if an error in storage of 25 percent cannot be tolerated. Figure H.1 is biased to prevent undersizing of outflow devices, but it may significantly overestimate the required storage capacity. More detailed hydrograph development and storage indication routing will often pay for itself through reduced construction costs.

H.3 Storage-Indication Routing

Storage-Indication Routing may be used to analyze storage detention practices. This approach requires that the inflow hydrograph be developed through one of the methods listed in this appendix (TR-55, WinTR-55, SWMM, etc.), as well as the required maximum outflows, q_{o2} and qo_{15}. Using the stage-discharge relationship for a given combination outlet devices, the detention volume necessary to achieve the maximum outflows can be determined.

H.4 HEC-1, WinTR-55, TR-20, and SWMM Computer Models

If the application of the above computer models is needed, the complete input data file and printout will be submitted with the stormwater management plans at the 85 percent submittal stage. Submission of stormwater management plans shall include the following computer model documentation:

- For all computer models, supporting computations prepared for the data input file shall be submitted with the stormwater management plans.
- Inflow-outflow hydrographs shall be computed for each design storm presented graphically, and submitted for all plans.
- Schematic (node) diagrams must be provided for all routings.

H.5 Rational Method

While this method is not recommended, as it cannot account for the retention/detention benefits of the BMPs applied on a site, this method will be permitted for use in a development of five acres or less. When applying this method, the following steps must be taken in the design consideration:

- In the case of more than one sub-drainage area, the longest time of concentration shall be selected.
- Individual sub-drainage flows shall not be summed to get the total flow for the watershed.
- The runoff coefficient, C, shall be a composite of the future site development conditions for all contributing areas to the discharge point. Runoff coefficient factors for typical District land uses are provided in Table H.1.
- The flow time in storm sewers shall be taken into account in computing the watershed time of concentration.
- The storm duration shall be dependent upon the watershed time of concentration.
- The storm intensity can be selected from the selected storm duration.

Table H.1 Runoff Coefficient Factors for Typical District of Columbia Land Uses

Zone	Predominant Use	Minimum Lot Dimensions		Runoff Coefficient C
		Width (ft)	Area (ft^2)	
R-1-A	One-family detached dwelling	75	7,500	0.60
R-1-B	One-family detached dwelling	50	5,000	0.65
R-2	One-family semi-detached dwelling	30	3,000	0.65
R-3	Row dwelling	20	2,000	0.70
R-4	Row dwelling	18	1,800	0.75
R-5-A	Low density apartment	–	–	0.70
R-5-B	Medium density apartment house	–	–	0.75
R-5-C	Medium high density apartment house	–	–	0.80
R-5-D	High density building	–	–	0.80
C	Commercial	–	–	0.85–0.95
M	General Industry	–	–	0.80–0.90
Park	Open green space	–	–	0.35

H.6 Stormwater Retention Volume Peak Discharge

The peak rate of discharge for individual design storms may be required for several different components of water quality BMP design. While the primary design and sizing factor for most stormwater retention BMPs is the design Stormwater Retention Volume (SWRv), several design elements will require a peak rate of discharge for specified design storms. 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.

The peak rate of discharge from a drainage area can be calculated from any one of several calculation methods discussed in this appendix. The two most commonly used methods of computing peak discharges for peak runoff calculations and drainage system design are NRCS TR-55 Curve Number (CN) methods (NRCS TR-55, 1986) and the Rational Formula. 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 tables for the rainfall depth and region of interest (Claytor and Schueler, 1996). Unfortunately, there are no IDF curves available at this time for the 1.2-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 two inches), but can significantly under estimate the discharge from small storm events (Claytor and Schueler, 1996). Since the Tv is based on a one-inch rainfall, this underestimation of peak discharge can lead to undersized diversion and overflow structures, potentially bypassing a significant volume of the design SWRv around the retention 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 and accuracy, the following Modified CN Method is recommended to calculate the peak discharge for the SWRv 1.2-inch rain event. The method utilizes 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, and the time of concentration is computed using the method outlined in TR-55.

The following provides a step-by-step procedure for calculating the Stormwater Retention Volume peak rate of discharge (q_{pSWRv}):

Step 1: Calculate the adjusted curve number for the site or contributing drainage area.

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

$$CN = \left[\frac{100_0}{10 + 5P + 1_0 Q_a - 1_0\left(Q_a^2 + 1.2_5 Q_a P\right)^{0.5}}\right]$$

where:

C	=	adjusted curve number
P	=	rainfall (in.), (1.2 in.)
Q_a	=	runoff volume (watershed inches), equal to SWRv divided by drainage area

Note: When using hydraulic/hydrologic model for sizing a retention BMP or calculating the SWRv peak discharge (), designers must use this modified CN for the drainage area to generate runoff equal to the SWRv for the 1.2-inch rainfall event.

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

TR-55 Chapter 3: Time of Concentration and Travel Time provides a detailed procedure for computing the Tc.

Step 3: Calculate the Stormwater Retention Volume peak discharge ($qp_{\mathrm{SWR}v}$)

Step 4: The $qp_{\mathrm{SWR}v}$ is computed using the following equation and the procedures outlined in TR-55, Chapter 4: Graphical Peak Discharge Method. Designers can also use WinTR-55 or an equivalent TR-55 spreadsheet to compute qp_{SWRv}:

- Read initial abstraction (I_a) from TR-55 Table 4.1 or calculate 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 $qp_{\mathrm{SWR}v}$ peak discharge:

$$qp_{\mathrm{SWR}v} = q_u \times A \times Qa$$

where:

$qp_{\mathrm{SWR}v}$ = Stormwater Retention Volume peak discharge (cfs)
q_u = unit peak discharge (cfs/mi^2/in.)
A = drainage area (mi^2)
Q_a = runoff volume (watershed inches = SWRv/A)

This procedure is for computing the peak flow rate for the 1.2-inch rainfall event. All other calculations of peak discharge from larger storm events for the design of drainage systems, culverts, etc., should use published curve numbers and computational procedures.

H.7 References

Claytor, R. and T. Schueler. 1996. Design of Stormwater Filtering Systems. Chesapeake Research Consortium and the Center for Watershed Protection. Ellicott City, MD. http://www.cwp.org/online-watershed-library?view=docman

Pitt, R., 1994, Small Storm Hydrology. University of Alabama - Birmingham. Unpublished manuscript. Presented at design of stormwater quality management practices. Madison, WI, May 17-19 1994.

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Appendix I Rooftop Storage Design Guidance and Criteria

I.1 Rooftop Storage Design Guidance and Criteria

Rooftop storage, as described in this Appendix, is intended as a detention practice only. The rules and guidelines presented in this Appendix do not apply to green roofs (Section 3.2).

1. Rooftop storage may be used to provide detention for the 2-year and 15-year storms, as applicable. Detention calculations must follow the procedures identified in Chapter 2 and Appendix H.
2. Rainfall from the 2-year, 24-hour storm results in an accumulated rainfall of approximately 3.2 inches, and rainfall from the 15-year, 24-hour storm results in an accumulated rainfall of approximately 5.2 inches. Peak flow detention calculations for either of these storms will require less than these depths (assuming there is no run-on from other rooftop areas.
   (a) Based on a snow load of 30 pounds per square foot or 5.8 inches of water, properly designed roofs must be structurally capable of holding the required detention volume with a reasonable factor of safety.
   (b) Roofs calculated to store depths greater than three inches shall be required to show structural adequacy of the roof design.
3. No less than two roof drains shall be installed in roof areas of 10,000 square feet or less, and at least four drains shall be installed in roof areas over 10,000 square feet in area. Roof areas exceeding 40,000 square feet shall have one drain for each 10,000 square foot area.
4. Emergency overflow measures adequate to discharge the 100-year, 45-minute storm must be provided.
   (a) If parapet walls exceed 5 inches in height, the designer shall provide openings (scuppers) in the parapet wall sufficient to discharge the design storm flow at a water level not exceeding 5 inches.
   (b) One scupper shall be provided for every 20,000 square feet of roof area, and the invert of the scupper shall not be more than 5 inches above the roof level. (If such openings are not practical, then detention rings shall be sized accordingly).
5. Detention rings shall be placed around all roof drains that do not have controlled flow.
   (a) The number of holes or size of openings in the rings shall be computed based on the area of roof drained and run-off criteria.
   (b) The minimum spacing of sets of holes is 2 inches center-to-center.
   (c) The height of the ring is determined by the roof slope and detention requirements, and shall be 5 inches maximum.

   (d) The diameter of the rings shall be sized to accommodate the required openings and, if scuppers are not provided, to allow the 100-year design storm to overtop the ring (overflow design is based on weir computations with the weir length equal to the circumference of the detention ring).

   (e) Conductors and leaders shall also be sized to pass the expected flow from the 100-year design storm.

6. The maximum time of drawdown on the roof shall not exceed 17 hours.

7. Josam Manufacturing Company and Zurn Industries, Inc. market "controlled-flow" roof drains. These products, or their equivalent, are acceptable.

8. Computations required on plans:

   (a) Roof area in square feet.

   (b) Storage provided at design depth.

   (c) Maximum allowable discharge rate.

   (d) Inflow-outflow hydrograph analysis or acceptable charts (for Josam Manufacturing Company and Zurn Industries, Inc. standard drains, the peak discharge rates as given in their charts are acceptable for drainage calculation purposes without requiring full inflow-outflow hydrograph analysis).

   (e) Number of drains required.

   (f) Sizing of openings required in detention rings.

   (g) Sizing of ring to accept openings and to pass 100-year design storm.

HYDRAULIC CHARACTERISTICS OF ROOF DRAIN RINGS

WATER DEPTH AT INLET (INCHES)	CAPACITY THROUGH HOLES — DISCHARGE (GPM)			
	1 SET HOLES	8 SETS	10 SETS	18 SETS
1.5	1	8	10	18
2.0	2	16	20	36
2.5	5	40	50	90
3.0	6	48	60	108

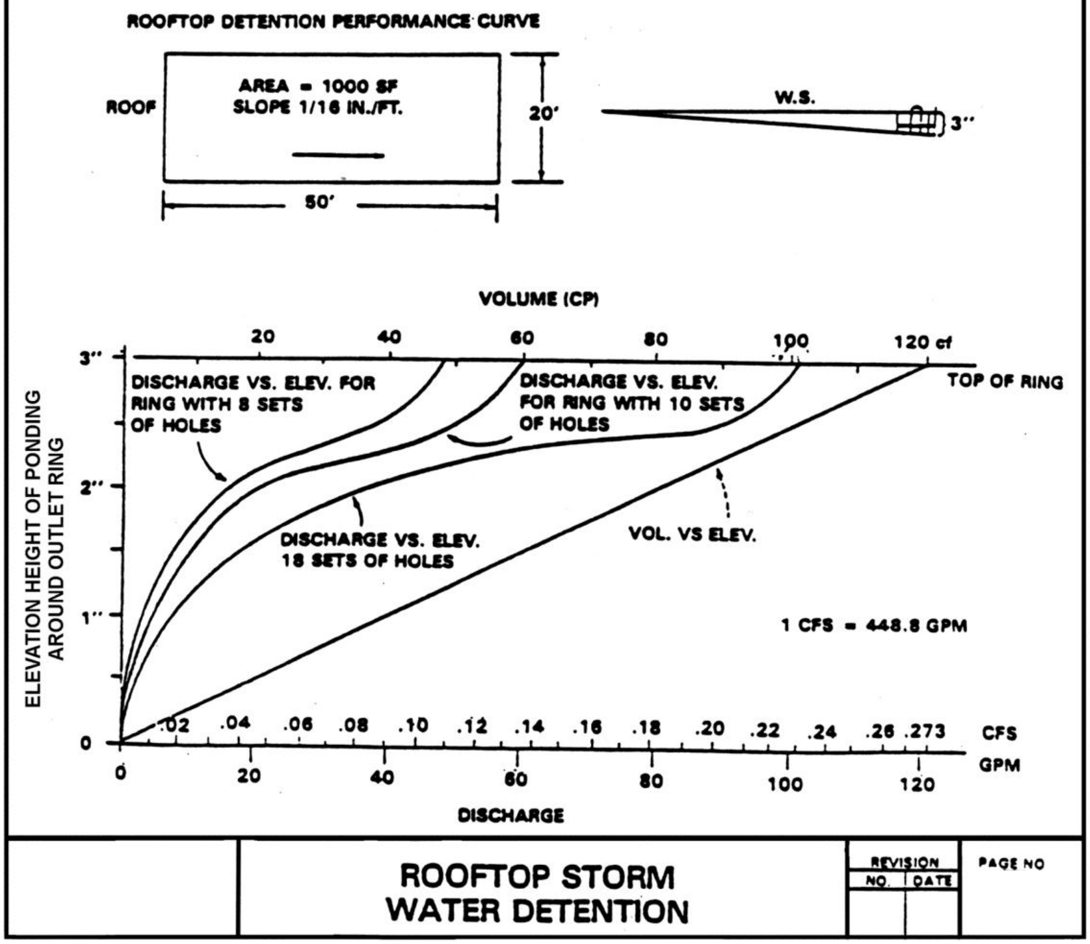

Figure I.1 Rooftop stormwater detention.

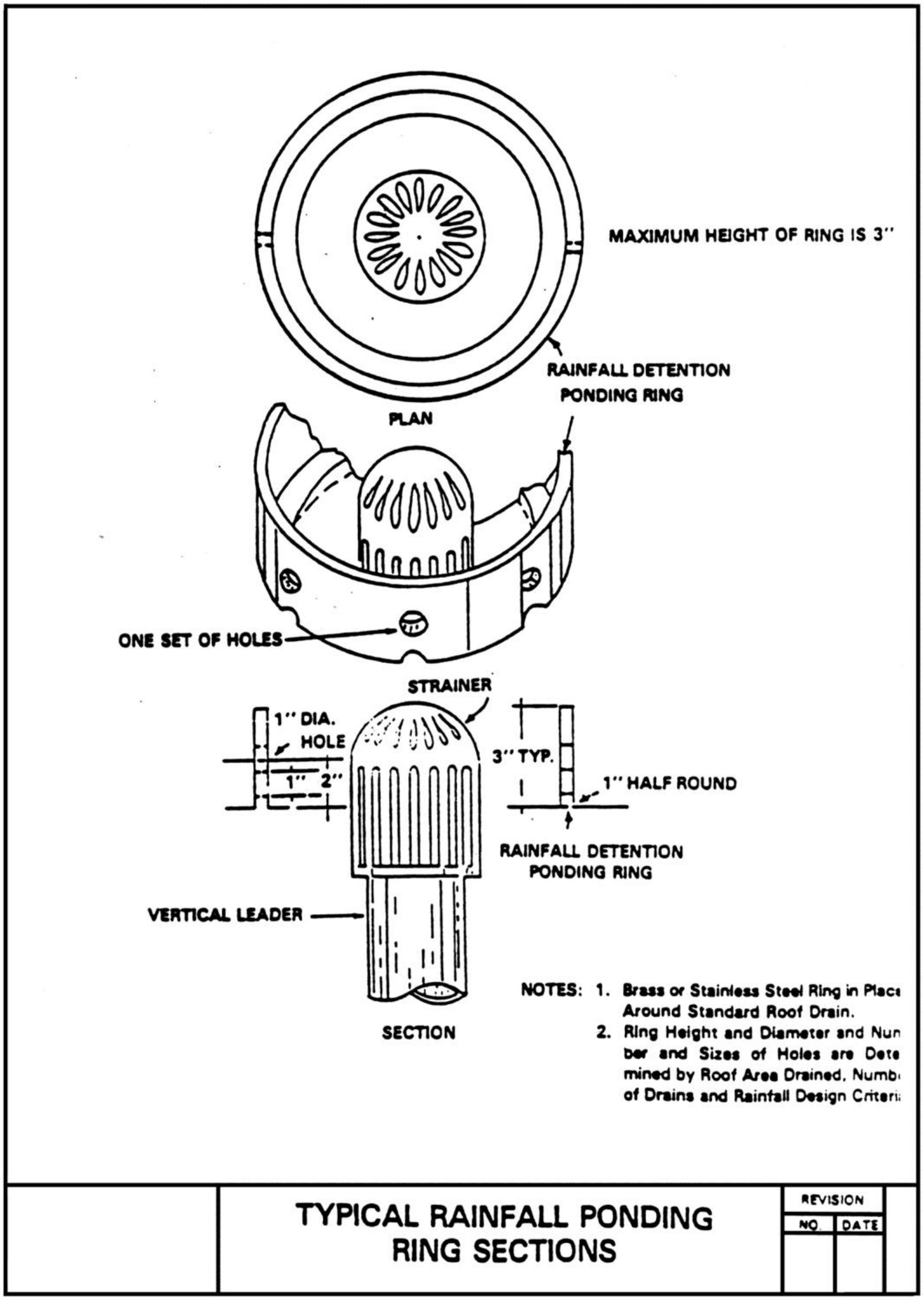

Figure I.2 Typical rainfall ponding ring sections.

Appendix J Soil Compost Amendment Requirements

J.1 Introduction

Soil amendment (also called soil restoration) is a technique applied after construction to deeply till compacted soils and restore their porosity by amending them with compost. These soil amendments can be used to enhance the performance of impervious cover disconnections and grass channels.

J.2 Physical Feasibility and Design Applications

Amended soils are suitable for any pervious area where soils have been or will be compacted by the grading and construction process. They are particularly well suited when existing soils have low infiltration rates (HSG C and D) and when the pervious area will be used to filter runoff (downspout disconnections and grass channels). The area or strip of amended soils should be hydraulically connected to the stormwater conveyance system. Soil restoration is recommended for sites that will experience mass grading of more than a foot of cut and fill across the site.

Compost amendments are not recommended where:

- Existing soils have high infiltration rates (e.g., HSG A and B), although compost amendments may be needed at mass-graded B soils in order to maintain infiltration rates.
- The water table or bedrock is located within 1.5 feet of the soil surface.
- Slopes exceed 10 percent (compost can be used on slopes exceeding 10 percent as long as proper soil erosion and sediment control measures are included in the plan).
- Existing soils are saturated or seasonally wet.
- They would harm roots of existing trees (keep amendments outside the tree drip line).
- The downhill slope runs toward an existing or proposed building foundation.
- Areas that will be used for snow storage.

J.3 Design Criteria

Performance. When Used in Conjunction with Other Practices. As referenced in several of the Chapter 3 specifications, soil compost amendments can be used to enhance the performance of allied practices by improving runoff infiltration. The specifications for each of these practices contain design criteria for how compost amendments can be incorporated into those designs:

- Impermeable Surface Disconnection – See Section 3.4 Impervious Surface Disconnection.
- Grass Channels –See Section 3.9 Open Channel Systems.

Soil Testing. Soil tests are required during two stages of the compost amendment process. The first testing is done to ascertain preconstruction soil properties at proposed amendment areas. The initial testing is used to determine soil properties to a depth 1 foot below the proposed amendment area, with respect to bulk density, pH, salts, and soil nutrients. These tests should be conducted every 5000 square feet, and are used to characterize potential drainage problems and determine what, if any, further soil amendments are needed.

The second soil test is taken at least one week after the compost has been incorporated into the soils. This soil analysis should be conducted by a reputable laboratory to determine whether any further nutritional requirements, pH adjustment, and organic matter adjustments are necessary for plant growth. This soil analysis must be done in conjunction with the final construction inspection to ensure tilling or subsoiling has achieved design depths.

Determining Depth of Compost Incorporation. The depth of compost amendment is based on the relationship of the surface area of the soil amendment to the contributing area of impervious cover that it receives. Table J.1 presents some general guidance derived from soil modeling by Holman-Dodds (2004) that evaluates the required depth to which compost must be incorporated. Some adjustments to the recommended incorporation depth were made to reflect alternative recommendations of Roa Espinosa (2006), Balousek (2003), Chollak and Rosenfeld (1998) and others.

Table J.1 Method to Determine Compost and Incorporation Depths

Ratio of Area of Contributing Impervious Cover to Soil Amendment[a] (IC/SA)	Compost Depth[b] (in.)	Incorporation Depth (in.)	Incorporation Method
0.5	3–6[c]	8–12[c]	Tiller
0.75	4–8[c]	15–18[c]	Subsoiler
1.0[d]	6–10[c]	18–24[c]	Subsoiler

[a] IC = contrib. impervious cover (ft^2) and SA = surface area of compost amendment (ft^2)
[b] Average depth of compost added
[c] Lower end for B soils, higher end for C/D soils
[d] In general, IC/SA ratios greater than 1 should be avoided

Once the area and depth of the compost amendments are known, the designer can estimate the total amount of compost needed, using an estimator developed by TCC, (1997):

$$C = A \times D \times 0.0031$$

where:

C = compost needed (yd^3)
A = area of soil amended (ft^2)
D = depth of compost added (in.)

Compost Specifications. The basic material specifications for compost amendments are outlined below:

- Compost shall be derived from plant material and provided by a member of the U.S. Composting Seal of Testing Assurance (STA) program. See www.compostingcouncil.org for a list of local providers.
- Alternative specifications and/or certifications, such as those administered by the Maryland Department of Agriculture or other agencies, may be substituted, as authorized by DDOE. In all cases, compost material must meet standards for chemical contamination and pathogen limits pertaining to source materials, as well as reasonable limits on phosphorus and nitrogen content to avoid excessive leaching of nutrients.
- The compost shall be the result of the biological degradation and transformation of plant-derived materials under conditions that promote anaerobic decomposition. The material shall be well composted, free of viable weed seeds, and stable with regard to oxygen consumption and carbon dioxide generation. The compost shall have a moisture content that has no visible free water or dust produced when handling the material. It shall meet the following criteria, as reported by the U.S. Composting Council STA Compost Technical Data Sheet provided by the vendor:

  (a) 100 percent of the material must pass through a half-inch screen

  (b) The pH of the material shall be between 6 and 8

  (c) Manufactured inert material (plastic, concrete, ceramics, metal, etc.) shall be less than 1.0 percent by weight

  (d) The organic matter content shall be between 35 and 65 percent

  (e) Soluble salt content shall be less than 6.0 mmhos/cm

  (f) Maturity must be greater than 80 percent

  (g) Stability shall be 7 or less

  (h) Carbon/nitrogen ratio shall be less than 25:1

  (i) Trace metal test result = “pass”

  (j) The compost must have a dry bulk density ranging from 40 to 50 lb/ft^3

J.4 Construction Sequence

The construction sequence for compost amendments differs depending whether the practice will be applied to a large area or a narrow filter strip, such as in a rooftop disconnection or grass channel. For larger areas, a typical construction sequence is as follows:

Step 1: **Soil Erosion and Sediment Control.** When areas of compost amendments exceed 2500 square feet install soil erosion and sediment control measures, such as silt fences, are required to secure the area until the surface is stabilized by vegetation.

Step 2: **Deep Till.** Deep till to a depth of 12 to 18 inches after the final building lots have been graded prior to the addition of compost.

Step 3: **Dry Conditions.** Wait for dry conditions at the site prior to incorporating compost.

Step 4: **Compost.** Incorporate the required compost depth (as indicated in Table J.1) into the tilled soil using the appropriate equipment.

Level the site. Seeds or sod are required to establish a vigorous grass cover. To help the grass grow quickly lime or irrigation is recommended..

Step 5: **Vegetation.** Ensure surface area is stabilized with vegetation.

Construction Inspection. Construction inspection by a qualified professional involves digging a test pit to verify the depth of amended soil and scarification. A rod penetrometer should be used to establish the depth of uncompacted soil at a minimum of one location per 10,000 square feet.

J.5 Maintenance

First-Year Maintenance Operations. In order to ensure the success of soil compost amendments, the following tasks must be undertaken in the first year following soil restoration:

- **Initial inspections.** For the first six months following the incorporation of soil amendments, the site should be inspected by a qualified professional at least once after each storm event that exceeds 1/2-inch of rainfall.
- **Spot Reseeding.** Inspectors should look for bare or eroding areas in the contributing drainage area or around the soil restoration area and make sure they are immediately stabilized with grass cover.
- **Fertilization.** Depending on the amended soils test, a one-time, spot fertilization may be needed in the fall after the first growing season to increase plant vigor.
- **Watering.** Water once every three days for the first month, and then weekly during the first year (April-October), depending on rainfall.

Ongoing Maintenance. There are no major ongoing maintenance needs associated with soil compost amendments, although the owners may want to de-thatch the turf every few years to increase permeability. The owner should also be aware that there are maintenance tasks needed for filter strips, grass channels, and reforestation areas. DDOE's maintenance inspection checklist for an area of Soil Compost Amendments can be accessed in Appendix L.

Declaration of Covenants. A maintenance covenant is required for all stormwater management practices. The covenant specifies the property owner's primary maintenance responsibilities, and authorizes DDOE staff to access the property for inspection or corrective action in the event the proper maintenance is not performed. The covenant is attached to the deed of the property (see standard form, variations exist for scenarios where stormwater crosses property lines). The covenant is between the property and the Government of the District of Columbia. It is submitted through the Office of the Attorney General. All SWMPs have a maintenance agreement stamp that must be signed for a building permit to proceed. There may be a maintenance schedule on the drawings themselves or the plans may refer to the maintenance schedule (Exhibit C in the covenant).

Covenants are not required on government properties, but maintenance responsibilities must be defined through a partnership agreement or a memorandum of understanding.

J.6 References

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Holman-Dodds, L. 2004. Chapter 6. Assessing Infiltration-Based Stormwater Practices. PhD Dissertation. Department of Hydroscience and Engineering. University of Iowa. Iowa City, IA.

Low Impact Development Center. 2003. Guideline for Soil Amendments. Available online at: http://www.lowimpactdevelopment.org/epa03/soilamend.htm

Roa-Espinosa. 2006. An Introduction to Soil Compaction and the Subsoiling Practice. Technical Note. Dane County Land Conservation Department. Madison, Wisconsin

Appendix K Construction Inspection Checklists

Inspections before, during and after construction are required to ensure that SWMPs are built in accordance with the approved plan specifications. Inspectors will use detailed inspection checklists that require sign-offs by qualified individuals at critical stages of construction to ensure the contractor's interpretation of the plan is consistent with the designer's intent.

This appendix includes the following construction phase inspection checklists:

- Green Roof Construction Inspection
- Rainwater Harvesting Construction Inspection
- Impervious Surface Disconnection Construction Inspection
- Permeable Pavement Construction Inspection
- Bioretention Construction Inspection
- Filtering System Construction Inspection
- Infiltration Practice Construction Inspection
- Open Channel System Construction Inspection
- Ponds, Wetland, and Storage Practice Construction Inspection
- Generic Structural BMP Construction Inspection
- Tree Planting and Preservation Construction Inspection
- Stormwater Facility Leak Test

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Green Roof Construction Inspection Report

Building Permit #: ____________________ Plan #: ______________ Lot:__________ Square: ______________

Project Name and Address: ____Ward________________

Contractor:____ Telephone: __________________

Engineer:____ Telephone: __________________

Date Started:________________________ Final Inspection Date: ____________________________________

Green Roof Type: Extensive ________ Intensive ________ New Construction ______ Retrofit of Existing Roof_______

If this is a retrofit green roof, attach a copy of the Roof Structural Certification ________

As-Built Plan Due Date: _______________________

Inspection Item	No	Yes	Remarks	Date
Deck Preparation:				
Is the deck free of all trash, debris, grease, oil, water and moisture?				
Are all concrete surfaces properly cured, dry and free of voids, cracks, or holes?				
For **retrofitted** roofs, are all existing membranes and flashing removed to the bare concrete or deck?				
Are all expansion joints free of broken edges or loose aggregate and sealed to a depth at least twice as wide as the joint?				
Is a leak detection device installed? (*Include manufacturer and testing information.*)				
Water Proofing:				
Certification: identify type: Hot or Cold applied?				
Does the waterproofing system require an applicator "certified" by the manufacturer? (*Attach certifications.*)				
Are site conditions appropriate for application of water proofing materials? (*Note temperature and moisture conditions.*)				
Have the correct number of water proofing layers been installed as per the approved green roof plan?				
Does the membrane reinforcement and flashing meet plan specifications? (*Attach invoice and/or manufacturer's certifications.*)				
Is protection provided for water proofing membrane? (*Specify membrane type and indicate the duration between installation of membrane and media.*)				

Figure K.1 Green Roof Construction Inspection Report.

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Green Roof Construction Inspection Report—Continued

Project Name and Address: ______________________ File and WPD No: __________

Inspection Item	No	Yes	Remarks	Date
Water Test:				
Has a water test been conducted? Verify the water test is conducted according to test standards demonstrating two inches of water ponding for a 24- 48 hour period. *(Attach water test report.)*				
Green Roof Components:				
Do the over flow drains meet plan specifications? Verify dimensions, materials and locations.				
Do drain boxes, vent pipes and other penetrations meet plan specifications? Verify locations, water proofing details, flashing details and finish details. Verify materials selection and construction.				
Identify if this is a tray system or a built in place system.				
Do the root barrier, insulation, moisture retention layer, filter fabric, and drainage layers meet plan specifications? (*Attach invoice and manufactures' certifications*)				
Does the growing media meet plan specifications? Verify depth of growing material. (*Attach invoice and manufacturer's certifications.*)				
Does the vegetation layer meet plan specifications? Verify vegetation source—plugs, seeds, pre grown mat, species mixture, coverage. (*Attach invoice and laboratory certification.*)				
Does the metal curbing and flashing meet plan specifications? (*Attach invoice and manufacturer's certifications.*)				
Are all seems, joints and edges caulked and sealed with approved grade of caulk or sealant? (*Attach invoice.)*				
Do pedestals and pavers and non-vegetated areas meet plan specifications (type and location)?				
Irrigation:				
Is there an irrigation system?				
Is the system installed to plan specifications? Verify water source, location, service access, and pressure.				
Plantings and Housekeeping:				
Modular System ___ Vegetated Mats ___ Plugs___ Other___				
Do plants meet size and variety specifications?				
Are all plants installed as per plan specifications? Note the planting distribution, the depth of media, and whether or not adequate watering was provided.				
Is temporary netting or wind uplift protection required?				
Have all planting waste materials, and construction trash and debris been pickup and removed from the roof?				

Contractor/Engineer ______________________ Inspector ______________ Date ________

Figure K.1 (continued)

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Rainwater Harvesting Construction Inspection Report

Building Permit #: ____________ Plan #: ____________ Lot: ________ Square: ____________

Project Name and Address: ______________________________ Ward ____________

Contractor: ______________________________ Telephone: ____________

Engineer: ______________________________ Telephone: ____________

Responsible for Maintenance: ______________________________ Telephone: ____________

Secondary Practice (discharging to): pervious area ____ bioretention ____ infiltration practice ____ channel or swale: ____

Date Started: ____________ Final Inspection Date: ____________ As-Built Plan Due Date: ____________

Inspection Items	Yes	No	Remarks	Date
Subgrade Preparation: Has the subgrade been properly prepared and tank foundation installed as shown on plans?				
Contributing Drainage Area: Does the rooftop area draining to the tank match the plans?				
Conveyance and First Flush Diversion: Do the gutters meet specifications with the correct sizing, elevation, and slope?				
Is the first flush diversion system properly sized and installed?				
Are mosquito screens properly installed on all tank openings?				
Pump System (where applicable): The pump and piping to end-uses (indoor, outdoor irrigation, or tank dewatering release) has been properly installed				
Overflow System: Overflow device is directed as shown on plans?				
Catchment area and overflow area are stabilized?				
Secondary stormwater treatment practice(s) (if applicable) is installed as shown on plans?				
Final Inspection: Is water conveyed into tank and to end-uses appropriately?				

Owner/Agent ______________________ Inspector ______________________ Date ________

Figure K.2 Rainwater Harvesting Construction Inspection Report.

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Impervious Surface Disconnection Construction Inspection Report

Building Permit #: ____________ Plan #: ____________ Lot: ________ Square: ____________

Project Name and Address: ______________________________ Ward ____________

Contractor: ______________________________ Telephone: ____________

Engineer: ______________________________ Telephone: ____________

Responsible for Maintenance: ______________________________ Telephone: ____________

Disconnection Type: Simple ________ Dry Well ________ Rain Garden ________ Other ________

Date Started: ____________ Final Inspection Date: ____________ As-Built Plan Due Date: ____________

Inspection Items	Yes	No	Remarks	Date
Site Preparation:				
Have erosion and sediment controls been properly installed and maintained according to approved plans?				
Do site excavation and grading conform to the site plans?				
Has the pervious receiving area avoided compaction during excavation?				
Contributing Drainage Area:				
Does the impervious area draining to the receiving pervious area match the plans?				
Practice Geometry:				
Does the receiving pervious area match the dimensions and slopes shown on the plan?				
Has a secondary practice been installed according to plan (if required)?				
Vegetation:				
Does the pervious area vegetation comply with the approved planting plan and specification?				
Topsoil mixture, soil amendments, and soil compaction comply with plan (if required)				
Final Inspection:				
Have the contributing impervious area and the receiving pervious area been stabilized?				
Can water flow properly into the receiving pervious area?				

Owner/Agent ______________________ Inspector ______________________ Date ________

Figure K.3 Impervious Surface Disconnection Construction Inspection Report.

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Permeable Pavement System Construction Inspection Report

Building Permit #: ______________ Plan and File#: ______________ Lot: __________ Square: ______________

Project Name and Address: ____ Ward ______________

Contractor: ____ Telephone: ______________

Engineer: ____ Telephone: ______________

Responsible for Maintenance: ____ Telephone: ______________

Permeable Pavement Type: Porous Asphalt ______ Pervious Concrete ______________ Permeable Pavers ______________

Date Started: ______________ Final Inspection Date: ______________ As-Built Plan Due Date: ______________

Inspection Items	Yes	No	Remarks	Date
Site Preparation:				
Have erosion and sediment controls been properly installed and maintained according to approved plans?				
Is stormwater runoff being diverted around the practice?				
Has the contributing drainage area been fully stabilized?				
Subgrade Preparation:				
Is subgrade suitable free of debris, standing water, proper grading?				
If design is for infiltration, verify soils have not been compacted.				
Excavated soil stockpile is located away from practice with erosion and sediment controls in place?				
Filter Layer or Geotextile Fabric (where applicable):				
The filter layer and/or geotextile fabric have been installed according to the specifications?				
Underdrain and Reservoir Layer:				
Does the underdrain meet specifications with correct perforation pattern, elevation, and slope?				
Caps are placed on the upstream (but not the downstream) ends of the underdrains?				
Does the stone reservoir meet specifications (clean, washed, free of fines) and is it installed to design depth?				
Is at least 2 inches of aggregate provided above and below the underdrains?				

Figure K.4 Permeable Pavement Construction Inspection Report.

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Permeable Pavement System Construction Inspection Report—Continued

Project Name and Address: ______________________________ File and WPD No: __________

Inspection Items	Yes	No	Remarks	Date
Surface Material:				
Does the surface material meet the specification and has it been properly installed?				
Is the surface even and can runoff spread evenly across it?				
Has the surface material had adequate curing time (for porous asphalt and pervious concrete)				
Is the surface free of fines and areas of clogging?				
Over Flow Drain (where applicable):				
Is overflow invert at correct elevation?				
Final Inspection:				
Can water infiltrate properly into the practice?				
Does the reservoir storage layer drain within 48 hours?				

Owner/Agent ______________________ Inspector ____________________ Date ________

Figure K.4 (continued)

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Bioretention Construction Inspection Report

Building Permit #: ______________ Plan and File#: ________________ Lot:__________ Square: ______________

Project Name and Address: ____Ward________________

Contractor:____ Telephone: __________________

Engineer:____ Telephone: __________________

Responsible for Maintenance:_____________________________________ Telephone: __________________

Bioretention Type: Traditional _____ Streetscape _______Tree Pits ____ Planters: _____ Residential:________________

Date Started: _______________ Final Inspection Date: _______________ As-Built Plan Due Date: ________________

Inspection Items	Yes	No	Remarks	Date
Inflow/Overflow:				
Is overflow invert at correct elevation?				
Is inflow pipe to filter plugged with watertight seal (prior to stabilization)?				
Basin and Impermeable Liner (where applicable):				
Basin graded as per approved plan?				
Basin liner material and installation meets specification of approved plan? (*Attach labeled sample.*)				
Underdrains:				
Do collector pipes meet specifications with correct hole pattern? (*Attach materials invoice.*)				
Do collector stone and stone beneath sand meet specifications and is installed to design depth?				
Filter Media:				
Does the filter media meet specifications? (*Attach lab report and material certification.*)				
Filter media installed to design depth and compacted on __________ (date) and refilled to designed depth?				

Figure K.5 Bioretention Construction Inspection Report.

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Bioretention Construction Inspection Report—Continued

Project Name and Address: ______________________________ File and WPD No: __________

Inspection Item	No	Yes	Remarks	Date
Bioretention Plant Materials:				
Do plants meet size and variety specifications?				
Are all plants installed as per landscape plan?				
Is mulch and cover crop installed as per plan specifications?				
Are plant/ trees staked as per specifications?				
Has watering of plant material been provided once a week during first two months for fourteen consecutive days after planting has been completed , then as needed during first growing season.?				
Observation Well Inlets:				
Is observation well free of construction debris and soil?				
Is outflow pipe invert at the design elevation?				
Notes:				
1. A qualified professional must treat disease plants.				
2. Deficient stakes and wires must be replaced.				
3. Dead plants or plants diseased beyond treatment must be replaced by plant meeting original specifications.				
4. New plants must be watered every day for the first 14 days after planting.				

Owner/Agent ______________________ Inspector ______________________ Date __________

Figure K.5 (continued)

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Filtering System Construction Inspection Report

Building Permit #: ____________________ Plan #: ______________ Lot:__________ Square: ______________

Project Name and Address: ____Ward________________

Contractor:____ Telephone: __________________

Engineer:____ Telephone: __________________

Structure Type: Cast in Place __________ Prefabricated ________ Name of Plant ___________________________

Date Started: ______________ Final Inspection Date: ______________ As-Built Plan Due Date: ________________

Inspection Item	No	Yes	Remarks	Date
Subgrade:				
Is subgrade suitable (free of debris, standing water) ?				
Is a subgrade Suitability Certification provided?				
Prefabricated Structure:				
Are shop drawings provided?				
Do type and location of openings meet specifications?				
Cast-In-Place Structure:				
Are structural drawings provided?				
Is a certification provided on steel placement?				
Provide load ticket showing concrete plant mix, strength certification, and load time.				
Is a certification provided for concrete placement?				
Do the 28 day break results meet design specifications?				
Access:				
Is access for each chamber provided (manholes, doors, steps, and ladder)?				
Leak Test:				
Does the leak test meet specifications? (attach form)				
Inflow Chamber:				
Does the orifice/ submerged weir opening meet specifications of the approved plan? (dimensions)				
Is overflow/bypass installed per approved plan?				
(size, support, sealed)				

Figure K.6 Filtering System Construction Inspection Report.

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Filtering System Construction Inspection Report—Continued

Project Name and Address: ______________________________ File and WPD No: ____________

Inspection Item	No	Yes	Remarks	Date
Inflow Chamber:				
Does the orifice/ submerged weir opening meet specifications of the approved plan? (dimensions)				
Is overflow/bypass installed per approved plan?				
(size, support, sealed)				
Filter Chamber:				
Is under drain installed per approved plan?				
(specifications, number size and spacing of holes)				
Is filter bed installed per approved plan?				
(specifications of sand, gravel and filter cloth)				
(attach materials invoice)				
Outflow Chamber:				
Dewatering valve installed per approved plan?				
Are perforated pipe openings installed?				
Sump pit required?				
Back Fill:				
Does backfill soil conform to specifications?				
Is a certification for lift, thickness and density test provided?				

Owner/Agent ______________________ Inspector ______________________ Date ________

Figure K.6 (continued)

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Infiltration Practice Construction Inspection Report

Building Permit #: ______________ Plan and File#: ______________ Lot:__________ Square: ______________

Project Name and Address: ____Ward______________

Contractor:____ Telephone: ______________

Engineer:____ Telephone: ______________

Responsible for Maintenance:________________________________ Telephone: ______________

Infiltration Practice Type: Dry Well _______ Infiltration Trench _______ Infiltration Basin _______ Other _______

Date Started: ______________ Final Inspection Date: ______________ As-Built Plan Due Date: ______________

Inspection Items	Yes	No	Remarks	Date
Site Preparation: Have erosion and sediment controls been properly installed and maintained according to approved plans?				
Is stormwater runoff being diverted around the practice?				
Has the contributing drainage area been fully stabilized?				
Subgrade Preparation: Is subgrade suitable? (free of debris, standing water, properly graded)				
Has compaction of the soils been avoided?				
Excavated soil stockpile is located away from practice with erosion and sediment controls in place?				
Practice Bottom: Has a 6 to 8 inch sand layer been installed beneath the practice according to the approved plans?				
Geotextile Fabric: Have the filter layer and/or geotextile fabric been installed on the sides of the practice only according to the specifications?				
Stone Reservoir Layer: Does the stone reservoir meet specifications (clean, washed, free of fines) and is it installed to design depth?				

Figure K.7 Infiltration Practice Construction Inspection Report.

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Infiltration Practice Construction Inspection Report—Continued

Project Name and Address: ______________________________ File and WPD No: __________

Inspection Item	No	Yes	Remarks	Dat e
Surface Material: Does the surface material meet the specification and has it been properly installed?				
Is the surface free of fines and areas of clogging?				
Pretreatment: Are the pretreatment facilities installed according to the approved plans?				
Over Flow (where Applicable): Is overflow invert at correct elevation? Has the outfall been constructed with adequate protection as specified on the plans?				
Final Inspection: Can water infiltrate properly into the practice? Does the practice include an observation well? Does the reservoir storage layer drains within 72 hours?				

Owner/Agent ______________________ Inspector ______________________ Date __________

Figure K.7 (continued)

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Open Channel System Construction Inspection Report

Building Permit #: ______________ Plan and File#: ________________ Lot:__________ Square: ______________

Project Name and Address: ____Ward________________

Contractor:____ Telephone: __________________

Engineer:____ Telephone: __________________

Responsible for Maintenance:_____________________________________ Telephone: __________________

Open Channel System Type: Grass Channel _________ Dry Swale ________ Wet Swale ________ Other ____________

Date Started: _______________ Final Inspection Date: _______________ As-Built Plan Due Date: ________________

Inspection Items	Yes	No	Remarks	Date
Site Preparation:				
Have erosion and sediment controls been properly installed and maintained according to approved plans?				
Is stormwater runoff being diverted around the practice?				
Has the contributing drainage area been fully stabilized?				
Practice Geometry:				
Are the practice dimensions and longitudinal slope correct as shown on the plans?				
Are the channel side slopes no steeper than 3:1?				
Have the check dams been properly installed and to the correct elevations (where applicable)?				
Pretreatment:				
Are the pretreatment facilities installed according to the approved plans?				
Vegetation:				
Does the channel surface vegetation comply with the approved planting plan and specification?				
Topsoil mixture, soil amendments, and soil compaction comply with plan (if required)				
Over Flow (where Applicable):				
Is overflow invert at correct elevation?				
Has the outfall been constructed with adequate protection as specified on the plans?				

Figure K.8 Open Channel System Construction Inspection Report.

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Open Channel System Construction Inspection Report—Continued

Project Name and Address: ______________________________ File and WPD No: ____________

Inspection Items	Yes	No	Remarks	Date
Dry Swale Designs (where Applicable): Does planting soil meet design specifications?				
Does the underdrain meet specifications with correct hole pattern, elevation, and slope?				
Are at least 2 inches of aggregate provided above and below the underdrains?				
Does the reservoir storage layer drains within 72 hours?				

Owner/Agent ______________________ Inspector ____________________ Date ________

Figure K.8 (continued)

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Pond, Wetland, and Storage Practice Construction Inspection Report

Building Permit #: ______________ Plan and File#: ________________ Lot:__________ Square: ______________

Project Name and Address: ____Ward________________

Contractor:____ Telephone: ________________

Engineer:____ Telephone: ________________

Responsible for Maintenance:_____________________________________ Telephone: ________________

Practice Type: Wet Pond ________ Dry Pond ________ Underground Detention ________ Other ______________

Date Started: _______________ Final Inspection Date: _______________ As-Built Plan Due Date: ________________

Inspection Items	Yes	No	Remarks	Date
Contributing Drainage Area: Does the area draining to the practice match the plans?				
Practice Geometry: Are the practice dimensions correct as shown on the plans?				
Are the pond side slopes no steeper than 3:1?				
Is a geotextitle or clay lining provided (where appropriate)?				
Is the practice installed to the proper depth as shown on the plans?				
Pretreatment: Has the forebay been properly sized and designed as according to the plans?				
Outfall: Has the outfall been constructed with adequate protection as specified on the plans? Is the outfall channel lined with filter cloth and is large rip-rap provided? Is an emergency spillway provided?				

Figure K.9 Pond, Wetland, and Storage Practice Construction Inspection Report.

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Pond, Wetland, and Storage Practice Construction Inspection Report—Continued

Project Name and Address: ______________________ File and WPD No: ____________

Inspection Item	No	Yes	Remarks	Date
Overflow and Trash Rack: Has the riser or outflow structure been properly installed and to the correct elevations?				
Has a trash rank been properly installed according to the approved SWM plan?				
Pond Buffer/Vegetation (where applicable): Do the buffer dimensions match the plans?				
Is an aquatic bench properly installed?				
Does the vegetation comply with the approved planting plan and specification?				
Final Inspection: Has the contributing drainage area been properly stabilized?				
Does the site have proper maintenance and inspection access?				

Owner/Agent ______________________ Inspector ______________________ Date __________

Figure K.9 (continued)

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Generic Construction Inspection Report

Building Permit #: ______________ Plan and File#: ______________ Lot: __________ Square: ______________

Project Name and Address: ____ Ward ______________

Contractor: ____ Telephone: ______________

Engineer: ____ Telephone: ______________

Responsible for Maintenance: ____ Telephone: ______________

Device Type: Hydrodynamic treatment ____________ Filtering treatment ____________ Retention ____________

Date Started: ______________ Final Inspection Date: ______________ As-Built Plan Due Date: ______________

Inspection Items	Yes	No	Remarks	Date
Site Preparation: Have erosion and sediment controls been properly installed and maintained according to approved plans? Is stormwater runoff being diverted around the practice? Has the contributing drainage area been fully stabilized?				
Structure: Do type and location of openings meet plan specifications? Are all components installed as per plan specifications? (media cartridges, weirs, inverted pipes, tees and ports)				
Access: Access for each chamber, including inlets where applicable provided? (manholes, doors, steps, ladders)				
Backfill : Does back fill meet specifications? Is a certification for lift, thickness and density test provided?				
System Cleaned:				

Owner/Agent ________________________ Inspector ________________________ Date __________

Figure K.10 Generic Construction Inspection Report.

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Tree Planting and Preservation Construction Inspection Report

Building Permit #: ______________ Plan and File#: ______________ Lot: __________ Square: ______________

Project Name and Address: ____ Ward ______________

Contractor: ____ Telephone: ______________

Engineer: ____ Telephone: ______________

Responsible for Maintenance: ______________________________________ Telephone: ______________

Tree Type(s): New _______ Preserved : _______

Date Started: ______________ Final Inspection Date: ______________ As-Built Plan Due Date: ______________

Inspection Item	No	Yes	Remarks	Date
Inventory of Trees:				
Did a licensed forester or arborist inventory existing trees?				
Were the size, species, condition, ecological value, and location of the trees recorded?				
Identification of Trees to Preserve:				
Average mature spread of at least 35 feet?				
Were the trees selected to be conserved selected based on species, size, condition, and location?				
Protection of Trees and Soil During Construction:				
Did a licensed forester or arborist identify the Critical Root Zone (CRZ) around the trees?				
Were physical barriers properly installed and maintained around the CRZ?				
If excavating next to CRZ, were roots properly pruned to depth of 18 inches?				
Protection of Trees and Soil After Construction:				
Is there a Maintenance Covenant in place to protect the preserved trees?				
Selection of Tree Species:				
Does the tree species have an average mature spread of at least 35 feet?				
Are the trees container grown or ball and burlap?				
Do the trees have a minimum caliper size of 1.5 inches?				

Figure K.11 Tree Planting and Preservation Construction Inspection Report.

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Tree Planting and Preservation Construction Inspection Report—Continued

Project Name and Address: ______________________ File and WPD No: __________

Inspection Item	No	Yes	Remarks	Date
Planting Sites:				
Was the appropriate tree planted in the best location based on urban planting constraints?				
Are clear sight lines provided along street and in parking lots?				
Is there enough overhead clearance for pedestrians and vehicles?				
Is there at least 2 cubic feet of useable soil per square foot of average mature tree canopy?				
Planting Techniques:				
Is the root collar exposed?				
Are erosion control blankets or other appropriate practices in place on steep slopes?				
With slopes steeper than 3:1, are trees planted on a level space on the slope?				
Post-Planting Tree Protection:				
Has 2–4 inches of organic mulch been spread over the soil surface out to the drip line of the tree?				
Are trees staked only if there is a concern of vandalism or windy exposure?				

Owner/Agent ______________________ Inspector ______________________ Date __________

Figure K.11 (continued)

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Stormwater Facility Leak Test

PLAN #_____________ WPD/ FILE # __________ BUILDING PERMIT # _______________

SQUARE____________ LOT ________________ PARCEL___________________________

NAME AND LOCATION:____

____

TYPE OF STRUCTURE: ____

BUILT: ☐ Cast-in place ☐ Precast ☐ Other _______________

METHOD OF TESTING: ☐ H2O ☐ Visual ☐ Other _______________

READINGS: Start_______________________________

Difference___________________________

Allowable ___________________________

Results _____________________________

DURATION: (24 Hour Reading) __________ Time: _________ Date: __________

(48 Hour Reading)___________Time: _________ Date: __________

(72 Hour Reading) __________ Time: _________ Date: __________

READINGS TAKEN BY:________________________ DATE:________________________

WITNESS: ___________________________________ DATE: ________________________

TITLE: ____

FOR: ____

Inspector _______________________ Owner/Agent ____________________ Date _______

Figure K.12 Stormwater Facility Leak Test form.

Appendix L Maintenance Inspection Checklists

It is recommended that an annual maintenance inspection and cleanup be conducted at each BMP site, particularly at large-scale applications.

This appendix includes the following maintenance inspection checklists:

- Green Roof Maintenance Inspection
- Rainwater Harvesting Maintenance Inspection
- Impervious Surface Disconnection Maintenance Inspection
- Permeable Pavement System Maintenance Inspection
- Bioretention Maintenance Inspection
- Filtering System Maintenance Inspection
- Infiltration Practice Maintenance Inspection
- Open Channel System Maintenance Inspection
- Wet Ponds and Wetlands Maintenance Inspection
- Storage and Underground Detention Practices Maintenance Inspection
- Generic Structural BMP Maintenance Inspection
- Tree Planting and Preservation Maintenance Inspection
- Maintenance Service Completion Inspection

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Green Roof Maintenance Inspection Report

Name/Address: ______________________________ WPD No. __________

Mailing Address: ______________________________ Ward: ________

Owner / Agent: ________________ Telephone: __________ Lot: __________ Square: ________

As-Built Plan Available (Y/N) Last Inspection Date: ______ Last Service Date: ______ Service Contract (Y/N), Type: __________

Accessibility: Public ______ Private ______ Maintenance Personal Only ______ (Number of Stories) ______ Roof Type: Flat / Slope

List all other stormwater management facilities on site: ______________________________

Review of on-site maintenance logs: ______________________________

1. Roof Condition:

Overflow Drains, Drain Boxes, Eves, and Scuppers Condition: ______________ Total Number ________

Membrane Condition __________ Flashing and Caulked Areas Condition __________ Roof Repair Needed ________

Debris/Sediment Accumulation _____ Root Penetration _____ Peeling or Physical Damage ____ Standing Water or Seepage ______

Amount of plant coverage ______________________________

Observations ______________________________

____

2. Vegetated Areas:

Roof Type:Intensive Extensive ___ Semi-intensive ___ Vegetative System: Plant-in-Place ___ Modular Tray ___ Vegetated Mat ___

Dead/diseased plants __ Weeds, Unwanted Moss, Invasive Plants, or Pests __ Thatch accumulation __ Erosion or loss of media _ Other _

Approximate Number of Growing Seasons __________ Date of last Fertilizer, Pesticide or Top Dressing Application: __

Observations (include media depth, fertility, scour): ______________________________

____

3. Watering, Irrigation, and Leak Detection:

Method of Watering : Soaker or Drip Hose_____ Sprinkler _____ Misting System_____

Hose Condition _______ Mechanical Systems Components (timers, valves, sensors and filters) ______ Last Service Date ____

Leak Detection Provided Y/N Last Service Date __________________

Observations ______________________________

____

Inspector ____________________ Received By ____________________ Date ____________________

Figure L.1 Green Roof Maintenance Inspection Report.

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Rainwater Harvesting Maintenance Inspection Report

Name/Address: ______ WPD No. ______

Mailing Address: ______ Ward: ______

Owner / Agent: ______ Telephone: ______ Lot: ______ Square: ______

As-Built Plan Available (Y/N) Last Inspection Date: ____ Last Service Date: ____ Service Contract (Y/N), Type: ______

Secondary Practice (discharging to): pervious area ____ bioretention __ infiltration practice ____ channel or swale: ______

List all other stormwater management facilities on site: ______

Review of on-site maintenance logs: ______

1. Tank and System Condition:

Tank Condition ______ Gutter and Pipe Condition ______ Pump and Electrical System Functioning Properly ______

Replacement Parts Needed ______ (specify components): ______

Observations ______

2. Inflow and Storage:

Debris in Gutters/ Downspouts ____ Debris in Prescreening Devices ____ Debris in First Flush Diverters ___

Mosquito Screens Inadequate __ Sediment Accumulation in Tank ___ Inadequate Tank Drawdown ___ Inconsistent Reuse ___

Observations ______

3. Overflow:

Over flow Device Y/N , Type: ______ Outlet Erosion ____ Debris/ Sediment in Overflow ____ Repair Needed ____

Observations ______

Inspector ______ Received By ______ Date ______

Figure L.2 Rainwater Harvesting Maintenance Inspection Report.

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Impervious Cover Disconnection Maintenance Inspection Report

Name/Address: ______________________________ WPD No. __________

Mailing Address: ______________________________ Ward: ________

Owner / Agent: ______________________ Telephone: __________ Lot: ________ Square: ________

As-Built Plan Available (Y/N) Last Inspection Date: _____ Last Service Date: _____ Service Contract (Y/N), Type: __________

Type: Disconnection: Simple________ Dry Well______ Rain Garden ______ Other ______________________

List all other stormwater management facilities on site: ______________________________

Review of on-site maintenance logs: ______________________________

1. Contributing Drainage Area:

Type of Drainage Area: Rooftop __________ Parking Lot _________ Other ___________

Observations ______________________________

____

2. Receiving Area:

Improper Conveyance to Receiving Pervious Area _______ Receiving Area Encroachment ______

Compaction in Receiving Area ______ Erosion at Inflow Points ______ Erosion in Flow Path _____ Dead Vegetation _____

Exposed Soil _____ Sediment Accumulation _______ Evidence of Standing Water ______

Observations ______________________________

____

Inspector ____________________ Received By ____________________ Date____________________

Figure L.3 Impervious Cover Maintenance Inspection Report.

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Permeable Pavement Maintenance Inspection Report

Name/Address: ____________________ WPD No. ________

Mailing Address: ____________________ Ward: ________

Owner / Agent: ____________ Telephone: ________ Lot: ________ Square: ________

As-Built Plan Available (Y/N) Last Inspection Date: _____ Last Service Date: _____ Service Contract (Y/N), Type: ________

Permeable Pavement Type: Porous Asphalt ________ Pervious Concrete ________ Permeable Pavers______

List all other stormwater management facilities on site: ____________________

Review of on-site maintenance logs: ____________________

1. Surface Condition:

Debris/ Sediment Accumulation ___Weed Accumulation______Evidence of Surface Clogging ___Sweeping Needed_____

Surface Deformation or Spalling ________ Structural Repair Needed ________

Observations ____________________

____

2. Underdrains and Cleanouts:

Underdrains Y/N , Number: ________ Observation Wells Y/N , Number: ________

Evidence of Subsurface Clogging ___ Inadequate Drawdown____ Standing Water ___ Last Rain Event >1" +/- ___ Days/Hours ___

Observations ____________________

____

3. Overflow:

Over flow Device Y/N , Type: ____________ Debris/ Sediment in Overflow______ Repair Needed _____

Observations ____________________

____

Inspector ____________ Received By ____________ Date ____________

Figure L.4 Permeable Pavement Maintenance Inspection Report.

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Bioretention Practice Maintenance Inspection Report

Name/Address: ______________________________ WPD No. ________

Mailing Address: ______________________________ Ward: ________

Owner / Agent: ____________________ Telephone: __________ Lot: ________ Square: ________

As-Built Plan Available (Y/N) Last Inspection Date: _____ Last Service Date: _____ Service Contract (Y/N), Type: __________

Bioretention Type: Traditional ___ Streetscape _____ Tree Pits _____ Planters: __________ Residential: ________

List all other stormwater management facilities on site: ______________________________

Review of on-site maintenance logs: ______________________________

1. Inlets and Drainage Area Stabilization:

Inlet Type (s) ____________ Total Number ______ Repair Needed _____ Debris/ Sediment Accumulation _____

Evidence of Erosion in Drainage Area ___ Area Needs Mowing or Clipping Removal ___ Drainage Area Debris Accumulation _____

Observations ______________________________

____

2. Bioretention Practice:

Sediments/Trash Accumulation ___ Filter Surface Clogging ___ Erosion in Practice ____ Inadequate Mulch Thickness or Cover _

Outlet: __________ Condition of Outlet _______ Debris/ Sediment in Overflow ______ Repair Needed ______

Underdrains and Cleanouts: Underdrains Y/N, Number: __________ Observation Wells Y/N, Number: ____

Evidence of subsurface clogging ___ Inadequate drawdown ____ Standing Water ____ Last Rain Event >1" +/- ___ Days/Hours ______

Observations ______________________________

____

3. Plants:

Specific Number and Types of Plants in Place ___ Dead or Diseased plants ___ Stakes and Wires ___ Inadequate Watering ___

Observations ______________________________

____

Note: A qualified professional must treat disease plants. Deficient stakes or wires must be replaced. Dead plants or plants beyond treatment must be replaced by plants meeting original specifications. New plants must be watered every day for the first 14 days after planting.

Inspector ____________________ Received By ____________________ Date ____________________

Figure L.5 Bioretention Maintenance Inspection Report.

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Filtering System Maintenance Inspection Report

Name/Address: ______________________________ WPD No. __________

Mailing Address: ______________________________ Ward: ________

Owner / Agent: ______________ Telephone: __________ Lot: ________ Square: ________

As-Built Plan Available (Y/N) Last Inspection Date: _____ Last Service Date: _____ Service Contract (Y/N), Type: __________

Structure Type: Cast in Place ____ Prefabricated ________ Name of Plant ______________

List all other stormwater management facilities on site: ______________________________

Review of on-site maintenance logs: ______________________________

1. Structural Components and Filter Bed:

Pretreatment (Y/N), Type: ________ Condition: ________ Chambers Y/N, Number: ____ Condition: ________

Filter Bed Condition: __________ Oil/Grease Accumulation ____ Debris Accumulation ____ Evidence of Bypass _____

Observation Wells (Y/N), Condition: ______ Maintenance Doors (Y/N), Condition: ______ Manholes (Y/N), Condition: ____

Valves/Drains (Y/N), Condition: ________ Water Seal (Y/N), Condition: ______ Other ______________

Inadequate drawdown_____ Standing Water ______ Last Rain Event > 1" +/-_______ Hours/ Days

Observations ______________________________

____

2. Inlets:

Type ______________ Total Number _____ Repair Needed_____ Debris/Sediment Accumulation ____

Observations ______________________________

____

3. Outlets:

Over flow Device (Y/N), Type: ______________ Debris/ Sediment in Overflow____ Repair Needed _____

Observations ______________________________

____

Inspector ______________ Received By ______________ Date ______________

Figure L.6 Filtering system Maintenance Inspection Report.

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Infiltration Practice Maintenance Inspection Report

Name/Address: ______________________________ WPD No. __________

Mailing Address: ______________________________ Ward: ________

Owner / Agent: ____________________ Telephone: __________ Lot: __________ Square: ________

As-Built Plan Available (Y/N) Last Inspection Date: _____ Last Service Date: _____ Service Contract (Y/N), Type: __________

Infiltration Device Type: Dry Well ________ Infiltration Trench ________ Infiltration Basin Other ____________

List all other stormwater management facilities on site: ______________________________

Review of on-site maintenance logs: ______________________________

1. Inlets and Drainage Area Stabilization:

Inlet Type(s) __________ Total Number ________ Repair Needed ______ Debris/ Sediment Accumulation _____

Erosion in Drainage Area _ Area Needs Mowing/Clipping Removal _ Drainage Area Debris Accumulation _ Pretreatment Bypass

Observations ______________________________

____

2. Structural Components and Function:

Vegetation and Ground Cover Type: ____________________ Surface Erosion Present? (Y/N)

Condition of Infiltration Area __________ Observation Wells (Y/N), Number: ________ Condition: __________

Inadequate Drawdown _____ Standing Water _____ Debris/Sediment Accumulation _____

Last Rain Event >1" +/- ______ Days/Hours _______

Observations ______________________________

____

3. Overflow:

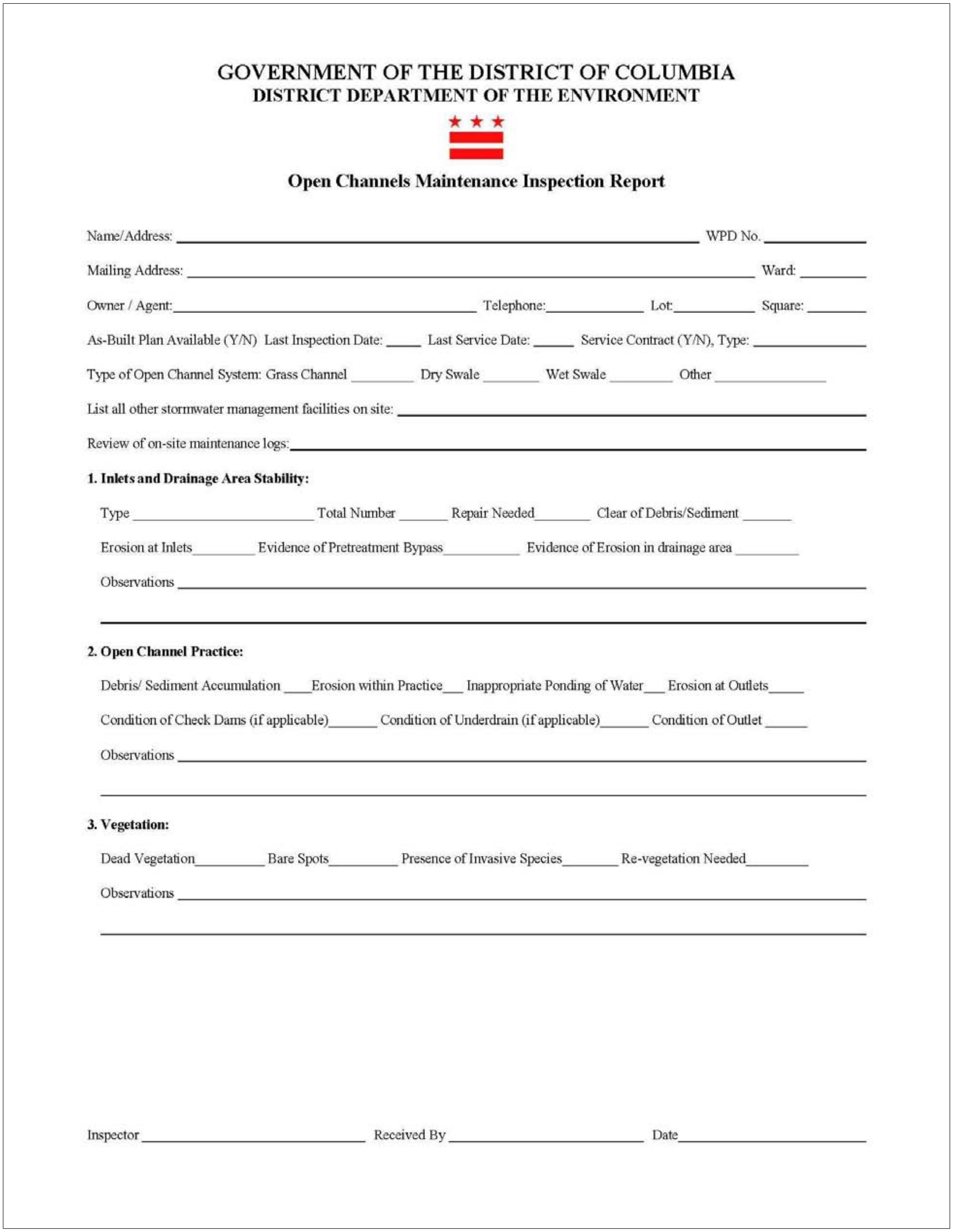
Over flow Device (Y/N), Type: ____________________ Debris/ Sediment in Overflow ______ Repair Needed _____

Observations ______________________________

____

Inspector ____________________ Received By ____________________ Date ____________________

Figure L.7 Infiltration Practice Maintenance Inspection Report.



GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Open Channels Maintenance Inspection Report

Name/Address: ______________________________ WPD No. __________

Mailing Address: ______________________________ Ward: ________

Owner / Agent: ____________________ Telephone: ___________ Lot: _________ Square: ________

As-Built Plan Available (Y/N) Last Inspection Date: _____ Last Service Date: _____ Service Contract (Y/N), Type: ___________

Type of Open Channel System: Grass Channel ________ Dry Swale _______ Wet Swale ________ Other ___________

List all other stormwater management facilities on site: ______________________________

Review of on-site maintenance logs: ______________________________

1. Inlets and Drainage Area Stability:

Type ________________ Total Number ______ Repair Needed_______ Clear of Debris/Sediment ______

Erosion at Inlets________ Evidence of Pretreatment Bypass_________ Evidence of Erosion in drainage area ________

Observations ______________________________

____

2. Open Channel Practice:

Debris/ Sediment Accumulation ____Erosion within Practice___ Inappropriate Ponding of Water___ Erosion at Outlets_____

Condition of Check Dams (if applicable)______ Condition of Underdrain (if applicable)______ Condition of Outlet ______

Observations ______________________________

____

3. Vegetation:

Dead Vegetation_________ Bare Spots_________ Presence of Invasive Species_______ Re-vegetation Needed________

Observations ______________________________

____

Inspector ____________________ Received By ____________________ Date____________________

Figure L.8 Open Channel System Maintenance Inspection Report.

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Wet Ponds and Wetlands Maintenance Inspection Report

Name/Address: ______________________________ WPD No. __________

Mailing Address: ______________________________ Ward: ________

Owner / Agent: ____________________ Telephone: __________ Lot: ________ Square: ________

As-Built Plan Available (Y/N) Last Inspection Date: _____ Last Service Date: _____ Service Contract (Y/N), Type: __________

Type of Practice: Wet Pond ________ Wetland ________ Underground Detention ____Other __________

List all other stormwater management facilities on site: ______________________________

Review of on-site maintenance logs: ______________________________

1. Inlets and Drainage Area Stabilization:

Inlet Type(s) __________ Total Number ________ Repair Needed ______ Debris/ Sediment Accumulation_____

Erosion in Drainage Area __________ Drainage Area Debris Accumulation __________ Pretreatment Bypass __________

Observations ______________________________

____

2. Practice Function and Structural Components:

Erosion within Practice_____ Debris/Sediment Accumulation _____ Inadequate Water Level _____ Excessive Algal Growth______

Over flow Device (Y/N), Type: __________ Debris/ Sediment in Overflow______ Repair Needed ______

Observations ______________________________

____

3. Vegetation:

Dead or Diseased plants _______ Inadequate Vegetation ________ Lack of Aquatic Bench _______ Lack of Plant Diversity________

Observations ______________________________

____

Inspector ____________________ Received By ____________________ Date ____________________

Figure L.9 Wet Ponds and Wetlands Maintenance Inspection Report.

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Storage and Underground Detention Facilities Maintenance Inspection Report

Name/Address: ______________________________ WPD No. __________

Mailing Address: ______________________________ Ward: ________

Owner / Agent: ____________________ Telephone: __________ Lot: ________ Square: ________

As-Built Plan Available (Y/N) Last Inspection Date: _____ Last Service Date: _____ Service Contract (Y/N), Type: __________

Type of Storage Practice: Dry Pond ________ Underground Detention ________ Other ____________________

List all other stormwater management facilities on site: ______________________________

Review of on-site maintenance logs: ______________________________

1. Inlets and Drainage Area Stabilization:

Inlet Type (s)__________ Total Number_______ Repair Needed ______ Debris/ Sediment Accumulation_____

Erosion in Drainage Area________ Drainage Area Debris Accumulation _________ Pretreatment Bypass__________

Observations ______________________________

____

2. Practice Function:

Inadequate Vegetation and/or Ground Cover (if applicable)_____ Surface Erosion in Practice_____ Debris/Sediment Accumulation ______

Inadequate Drawdown_______ Standing Water ________ Last Rain Event >1" +/- ________ Days/Hours

Observations ______________________________

____

3. Structural Components:

Over flow Device (Y/N), Type: ________________ Debris/ Sediment in Overflow______ Repair Needed ______

Vaults/Chambers (Y/N), Type: ________________ Debris/ Sediment in Chambers______ Repair Needed ______

Observations ______________________________

____

Inspector ____________________ Received By ____________________ Date____________________

Figure L.10 Storage and Underground Detention Facilities Maintenance Inspection Report.

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Generic Stormwater Management Facilities Maintenance Inspection Report

Name/Address: ______________________________ WPD No. __________

Mailing Address: ______________________________ Ward: ________

Owner / Agent: ______________________ Telephone: __________ Lot: __________ Square: ________

As-Built Plan Available (Y/N) Last Inspection Date: _____ Last Service Date: _____ Service Contract (Y/N), Type: __________

Device Type: Hydrodynamic treatment __________ Filtering treatment ________ Retention ________

List all other stormwater management facilities on site: ______________________________

Review of on-site maintenance logs: ______________________________

1. Inlets and Above Ground Condition:

Type ______________ Total Number _____ Repair _____ Clear of debris _____ Graded Areas ______

Observations ______________________________

____

2. Structure:

Access ________ Outlets ________ Elbows and Connections ______ Vaults and Chambers ______ Trash Racks ________

Observations ______________________________

____

3. Overall Function:

Oil and Grease Accumulation ______ Sediment ______ Debris Accumulation ______ Last Rain > 1" +/- ______ Hours/Days

Observations ______________________________

____

Inspector ______________ Received By ______________ Date ______________

Figure L.11 Generic Maintenance Inspection Report.

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Tree Planting and Preservation Maintenance Inspection Report

Name/Address: ________________________________ WPD No. __________

Mailing Address: ________________________________ Ward: ________

Owner / Agent: ____________________ Telephone: __________ Lot: __________ Square: ________

As-Built Plan Available (Y/N) Last Inspection Date: _____ Last Service Date: _____ Service Contract (Y/N), Type: __________

Tree Type(s): New _______ Preserved : _____

List all other stormwater management facilities on site: ________________________________

Review of on-site maintenance logs: ________________________________

1. Tree Condition:

Adequately watered_____ Dead/broken/diseased branches pruned_____ Trunk protected_____ Root collar exposed_____

Mower/weed whip damage, vandal damage, animal damage_____ Insect or disease problems_____

Observations ________________________________

____

2. Mulching:

2–4 inch deep mulch _____ Mulch not against trunk_____

Observations ________________________________

____

3. Staking (if needed):

Tree age < 1 year: Stakes in place ______ Webbing or ties hampering growth of tree_____

Tree age > 1 year: Stakes removed_____

Observations ________________________________

____

Inspector ____________________ Received By ____________________ Date ____________________

Figure L.12 Tree Planting and Preservation Maintenance Inspection Report.

GOVERNMENT OF THE DISTRICT OF COLUMBIA
DISTRICT DEPARTMENT OF THE ENVIRONMENT

Maintenance Service Completion Inspection Report

Name/Address: ______________________________

Owner/Agent: ______________________________ WPD No: ______________

Mailing Address: ______________________________

Service Providers: ______________________________

Maintenance Service Start Date: ______________________________

Maintenance Service Completion Date: ______________

Type of Stormwater Practice Serviced: ______________________________

Description of Work: ______________________________

____

____

Is the maintenance service satisfactory? Yes/No If no, list items to be completed: ______________

____

____

____

Inspector ______________ Received By ______________ Date______________

Figure L.13 Maintenance Service Completion Report.

Appendix M Tiered Risk Assessment Management: Water Quality End Use Standards

M.1 Tiered Risk Assessment Management (TRAM): Water Quality End Use Standards for Harvested Stormwater for Non-Potable Uses

This work was commissioned by the District of Columbia Department of the Environment (DDOE) to provide a frame work for applicants to follow when proposing a non-potable use of harvested stormwater runoff to comply with site stormwater retention regulations. Suggested water quality standards are drawn from a literature review of the field and rely largely on international guidance developed in Australia and the United Kingdom, guidance has also been drawn from the State of Texas and from the California County of Los Angeles. The proposed application process presented here requires the assessment of contaminates of concerns based on the collection surface(s), along with an assessment of the public health threat for categories of microbial and chemical contaminants. Under this scheme, an applicant is required to consider the potential risk of exposure and related magnitude of human health impacts with exposure. A tiered risk assessment-management (TRAM) approach is provided to evaluate site conditions and determine treatment level if needed. If treatment is required this guidance provides a procedure for evaluating any remaining public health risk (residual risk) at the time of the commissioning of treatment practices, as well an ongoing procedure to ensure those practices meet public health standards throughout their maintenance and operation.

M.2 Health Risks

Rainwater collection systems have a long history going back as far as 3000 BC in India. It was used widely for agriculture throughout South East Asia over 2,000 years ago and in early Rome rainwater harvesting systems provided central air conditioning. Although rainwater harvesting has a significant and successful history, its popularity has declined as the large urban central water distribution system has grown. The return to rainwater harvesting in current times is driven largely by two factors, water scarcity and pollution of receiving waters. However, as we reconsider the collection of stormwater for non-potable uses, we must also recognize this can pose health risks. Health risks are due to two principal categories of contaminants—pathogenic microorganisms and toxic chemicals. Although both categories of contaminants need to be evaluated to ensure public health will be protected, microorganisms will typically pose the greatest health risk at most sites where stormwater is harvested for non-potable uses. Microbial hazards include bacteria, viruses, protozoa, and—to a lesser extent—helminthes. Chemical hazards can include inorganic and organic chemicals, pesticides, potential endocrine disruptors, pharmaceuticals, and disinfection byproducts. Proposals for stormwater harvested for non-potable uses submitted to DDOE will require an assessment of the public health threat for both categories of contaminants. This assessment starts with an analysis of the likelihood of exposure and can proceed through risk-based screening to determine if stormwater harvested for non-potable uses will pose a threat to public health.

DDOE cannot anticipate all site conditions within the wide spectrum of projects that may be proposed to harvest stormwater for non-potable uses to comply with District of Columbia stormwater regulations. For this reason, DDOE has developed a tiered risk assessment-management (TRAM) approach that applicants shall follow. Formal risk assessments can be costly, time consuming, and—for many stormwater projects—unnecessary. DDOE developed the TRAM approach to reduce the cost and level of effort associated with preparing the submission of a Stormwater Management Plan (SWMP) that incorporates stormwater harvesting for non-potable uses. The TRAM approach is based on the concept that increasing levels of sophistication, level of effort, and cost of a risk assessment only need to be considered as site conditions warrant. From a risk management perspective, the overarching goal in any project proposing to harvest stormwater for non-potable uses is to demonstrate that public health will be protected when the stormwater project is fully operational.

In addition to providing a cost-effective approach for making risk management decisions, the TRAM approach can be used to identify the most cost-effective risk mitigation strategy (should it be necessary). The two types of health risks planners must consider are maximum risk (posed by untreated stormwater) and residual risk (posed by treated stormwater).

Maximum risk is defined as the risk associated with maximum exposure to untreated stormwater. It is the risk posed by stormwater under the intended non-potable use prior to any preventive measure to disinfect or otherwise decontaminate stormwater. Estimating the maximum risk is necessary for DDOE to issue a permit, and it must be based on the specific exposures that are reasonably anticipated for the untreated stormwater. High-priority contaminants significantly contributing to the maximum risk should be the primary focus if a treatment plan is required. If the maximum risk is acceptable, no treatment of collected stormwater is necessary. However, if the maximum risk exceeds acceptable levels, stormwater must be treated to reduce health risks to acceptable levels.

DDOE will not be prescriptive with regard to the technology selected to protect public health. However, the threshold criterion for approving a SWMP with harvest for non-potable uses system is ensuring public health will be protected.

DDOE will make a determination on the effectiveness of the risk reduction strategy based on the magnitude of the second type of risk—namely, residual risk. Residual risk is defined as the risk remaining after stormwater has been treated based on the specific types of human exposure associated with the intended stormwater reuse.

For permitting purposes, DDOE will require proof that the residual risk from both microbial and chemical contaminants will be reduced to acceptable levels. The magnitude of residual risk is dependent on the magnitude of the maximum risk (the pretreatment risk) and the efficiency of the risk mitigation technology selected for the project.

M.3 Evaluating the Threat to Public Health

The threat to public health is a function of two site-specific criteria—namely, the likelihood of exposure and the magnitude of health risks associated with site-specific exposure conditions. Table M.1 through Table M.3 presents a useful matrix that planners can use to evaluate these two primary criteria during project planning. Proposed plans submitted to DDOE should be based on the classification scheme presented in these tables because it will streamline both the process of planning a stormwater project and DDOE's review of the submitted plans.

Table M.1 presents three categories for determining the likelihood of exposure. For some stormwater programs, human exposures will only occur under unusual site conditions. For example, in closed systems where contact with collected stormwater is not anticipated (unless there is a breach in the system), the likelihood of exposure would be classified as unlikely. Under these conditions, stormwater use would not pose a health threat and a treatment system would be unnecessary.

Where exposures are classified as possible or likely, a more detailed analysis of potential maximum health risks for the untreated stormwater will be required. An applicant will identify all proposed collection surfaces to determine potential contaminates of concern (COC). If collection surfaces include any existing surfaces, i.e., contributing drainage areas that exist preproject will remain as part of the final development and will contribute to the proposed rainwater harvest system, sampling of those site conditions may be required to identify COC.

When sampling existing surfaces that are proposed to contribute to the rainwater harvesting system in the proposed development contaminant levels in these samples will be compared with risk-based levels that DDOE has derived for a select group of chemicals. Samples will also be screened for microbial threats. Table M.2 presents three categories of risks that roughly characterize maximum risk. Whether stormwater treatment is necessary will depend on the magnitude of maximum risk, which will be quantified with a risk-based screening approach. When contaminant levels are equal to or less than the risk-based levels, the maximum risk is classified as low or acceptable, and stormwater can be used without any treatment. When contaminant concentrations in stormwater are less than ten-times the risk-based concentration, the maximum risk is characterized as minor and DDOE will use its discretion to decide whether treatment is necessary.

Table M.3 shows the matrix of all possible outcomes for the combined evaluation of the likelihood of exposure and magnitude of health risks. These represent the classification of the health threat. Treatment technologies will not be required for stormwater harvesting projects posing a low threat. DDOE will use professional judgment to determine if moderate threats require a treatment system. Treatment systems will be required for high threats to public health.

Finally, all proposals shall present an analysis of both intended and unintended uses and exposures. While these situations may be rare and unique, they could pose a high risk to a small number of individuals. This could include inadvertent cross connections with drinking water systems and maintenance personnel or children being unintentionally exposed to untreated stormwater. Rainwater harvest proposals must identify how those unintended uses and exposures will be avoided. Some examples of protective measures include backflow protectors, use of purple pipes and identification stamps, water coloring and signage.

Table M.1 Likelihood Exposure will Occur

Descriptor	Description of Likelihood
Unlikely	Exposure could occur only in unusual circumstances
Possible	Exposure might occur
Likely	Exposure will probably occur

Table M.2 Magnitude of Health Risk

Descriptor	Risk
Insignificant	Low or Acceptable Levels
Minor	Minor
Severe	Major

Table M.3 Characterizing Threat to Public Health

Likelihood of Exposure	Magnitude of Public Health Threat		
	Insignificant	Minor	Severe
Unlikely	Low	Low	Low
Possible	Low	Moderate	High
Likely	Low	Moderate	High

M.4 Applying the Tiered Risk Assessment-Management Approach

DDOE’s intent in developing the TRAM approach is to expedite the permitting process and keep investigative costs to a minimum. It is based on the concept that the complexity of investigations should match the complexity of the site and conditions of exposure. DDOE will only require that sufficient information be presented to satisfy the requirement that public health is protected. The level of effort necessary to verify this threshold will depend on site-specific characteristics, which will vary from site to site.

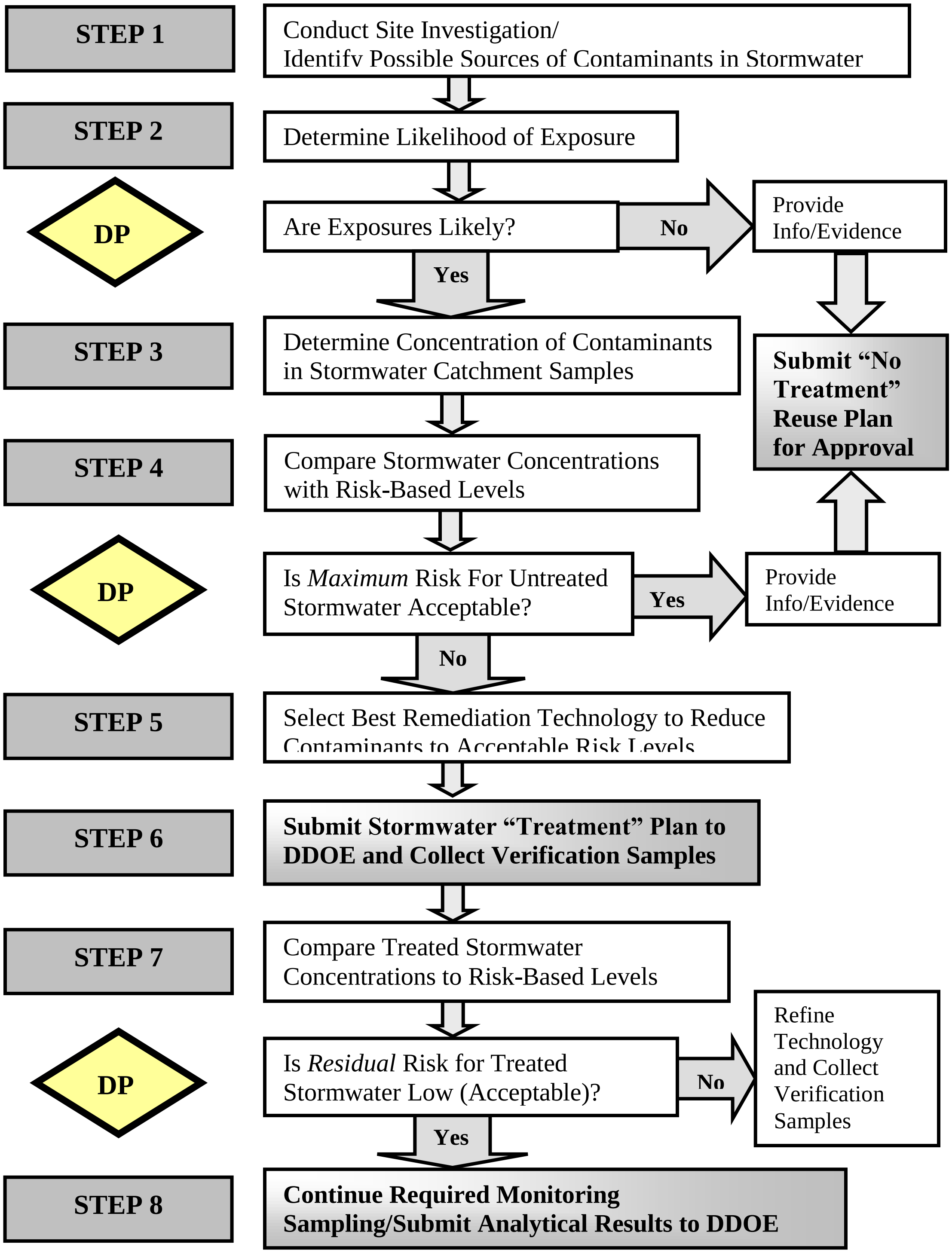
The TRAM approach is presented in a risk assessment-management decision-making framework. Although there are a total of nine steps in this process, proposed plans need only present sufficient analyses to demonstrate public health will be protected. For many sites, the entire nine-step process will not be needed to demonstrate exposure to treated or untreated stormwater will pose low risks. A determination regarding the appropriate course of action can often be made in the first four steps. DDOE believes that the most cost-effective approach for project teams is to follow the TRAM, so the complexity, level of effort, and costs of investigation will be a direct function of the site-specific conditions instead of a one-size-fits-all prescribed approach.

Figure 1 presents the TRAM decision-making framework. There are two important features of this framework that make it cost effective. First, investigative costs (including sampling and analysis) can be minimal for sites where there will be no human exposures to stormwater. Second, there are several exit points in the nine-step process at which investigations can be terminated and the proposed plan submitted to DDOE. The overall goal of the TRAM approach is to identify priorities as early as possible in the process to ensure public health will be protected. This requires the following:

- Identifying and documenting contaminant hazards and hazardous events;
- Estimating the likelihood that a hazardous event will occur;
- Estimating the consequences of the hazardous event occurring; and
- Characterizing the overall risk by combining the hazards and hazardous events with their likelihood and consequence.

Depending on the complexity of the site, these requirements may necessitate the following assessments:

- Initial screening-level risk assessment;
- An assessment of the maximum risk (in the absence of preventive measures); and
- An assessment of the residual risk (in the presence of preventive measures).


STEP 1
Conduct Site Investigation/ Identifv Possible Sources of Contaminants in Stormwater
STEP 2
Determine Likelihood of Exposure
DP
Are Exposures Likely?
No
Provide Info/Evidence
Yes
STEP 3
Determine Concentration of Contaminants in Stormwater Catchment Samples
Submit "No Treatment" Reuse Plan for Approval
STEP 4
Compare Stormwater Concentrations with Risk-Based Levels
DP
Is Maximum Risk For Untreated Stormwater Acceptable?
Yes
Provide Info/Evidence
No
STEP 5
Select Best Remediation Technology to Reduce Contaminants to Acceptable Risk Levels
STEP 6
Submit Stormwater "Treatment" Plan to DDOE and Collect Verification Samples
STEP 7
Compare Treated Stormwater Concentrations to Risk-Based Levels
DP
Is Residual Risk for Treated Stormwater Low (Acceptable)?
No
Refine Technology and Collect Verification Samples
Yes
STEP 8
Continue Required Monitoring Sampling/Submit Analytical Results to DDOE

Step 1: **Conduct Site Investigation.**

The goal of the initial site investigation is to identify potential contaminants that could enter the stormwater catchment and to characterize potential human exposures. This information will be used as the baseline investigation for subsequent steps in the TRAM approach. At minimum, the proposed plan must provide a general description of the site and any potential chemical or microbial contamination that may be present. Information should include:

- Site location and map showing all the properties within the proposed stormwater catchment system, in the simplest scenario this identification is the proposed roof area
- Zoning classification of all properties contributing to the stormwater catchment
- Total acreage of the stormwater catchment for the stormwater project
- Description of site property and surrounding areas based on available data and information. In the simplest scenario this is limited to an identification of the proposed roof materials and roof characteristics
- Description of any portion of the site regulated under the Resource Conservation and Recovery Act (RCRA), Superfund Program, or any other environmental investigation by the District of Columbia or the Environmental Protection Agency
- The current status of any ongoing or unresolved Consent Orders, Compliance Agreements, Notices of Violation (NOV), or other activities
- Schematic showing the location of sewer manholes
- Location of any obvious chemical spill residue (e.g., discolored soil, die-back of vegetation, etc.)
- Location of all aboveground or underground storage tanks
- Planned future uses of the site

If the site is zoned industrial, and the proposed catchment area contains surfaces other than the a proposed roof area, it will be necessary to conduct a more robust baseline investigation than for other types of properties to determine if chemical or microbial contamination is present. For sites zoned industrial, all potential chemical contaminants that were used, stored, or released on the property must be identified.

On sites where the catchment area includes surfaces beyond a proposed roof the receiving environment for all stormwater in the catchment must be characterized. All sources of variation due to seasonal and diurnal effects, as well as major rain events, must be characterized. This baseline information is very important because it provides a point of reference for evaluating untreated stormwater. It will also be important to determine whether validation and/or verification sampling or monitoring is warranted.
Stormwater contaminants detected in catchment can be due to both roof water runoff and contamination of soil within the area stormwater will be collected. Therefore, when existing roof areas and other existing surfaces will contribute to the proposed rainwater harvest system the existing roof systems must be inspected, and land use must be characterized as part of the proposal process.

Some of the important roof characteristics include the following:

- Whether vehicular traffic is allowed (i.e., parking structures)
- Whether there are overflow or bleed-off pipes from roof-mounted appliances, such as air conditioning units, hot water services, and solar heaters that will contribute to the collection area
- Whether any flues or smoke stacks from heaters, boilers, or furnaces could have contaminated roof surfaces
- Whether the roof is covered with lead flashing or exposed areas painted with lead-based paints
- Whether the roof is covered with a vegetated roof system

A short narrative of how the property has historically been used must also be provided if the proposed collection areas include existing land surfaces and information is available. This land use description is very important because some land uses have been shown to be associated with high contaminant levels. Land uses of particular interest include the following:

- Industrial land uses can result in either widespread or point sources of contamination due to organic compounds and/or inorganic metals
- Runoff from major roads and freeways with high traffic volumes can contain relatively high levels of hydrocarbons and metals (particularly, lead)
- Residential areas that experience frequent sewer overflows

Plans must describe how the stormwater will be collected, stored, and used. This will provide important exposure information necessary to estimate potential threats to public health. At minimum, the plan must provide:

- How stormwater will be collected
- The total amount of stormwater that will be collected from each source (roof water, parking lots, etc.)
- How stormwater will be stored (aboveground cistern, belowground storage tank, etc.)
- Description of the end use(s) of stormwater (municipal irrigation, spray fountain, pool, etc.)
- List of all types of individuals who could potentially be exposed to stormwater under the intended use(s) (e.g., landscapers, maintenance workers, children, joggers, etc.)
- Age groups for all types of exposed individuals (e.g., children, adults, elderly)
- Estimated time (e.g., hours, days, years) each type of individual could be exposed to stormwater under its intended use
- List of activities the exposed individuals will be engage in on site (recreational, sports, gardening, etc.)

- Type and routes of exposures for all exposed individuals (ingestion of sprays during irrigation, ingestion during car wash, ingestion of fruit and vegetables irrigated with stormwater, etc.)
- List of potential exposures associated with unintended stormwater uses (system malfunction, cross plumbing, etc.)
- List of sensitive populations that may be exposed (children, infirm, invalid, etc.)

The above information will form the basis for determining the likelihood of exposure in the next step and will also be used to characterize specific exposure conditions and routes of exposure in subsequent steps.

Step 2: Determine Likelihood of Exposure.

One of the basic tenets of risk assessment states that, "Where there is no exposure, there is no risk." This truism is applicable even for sites where chemical or microbial contamination is elevated. Accordingly, the first step in the investigation for all stormwater projects is to determine the likelihood of exposure. As was indicated in Table M.1, exposures can be characterized as unlikely, possible, or likely based on reasonable assumption. That is, DDOE's threshold will not be based on the possibility that exposures could occur, but rather on whether it is plausible exposures will occur. Information presented in Step 1 should form the basis for this determination. Making a determination that exposures are unlikely in this step is very important because no stormwater decontamination or disinfection will be required for those projects where exposure is unlikely. Untreated stormwater can be used as it was collected in these cases.

To make a determination that exposures are "unlikely" requires an evaluation of both intended and unintended exposures. An example of unlikely exposure conditions would be a closed system with no intended exposures and less than approximately 50 unintended exposure events per year involving less than 1 milliliter exposure per isolated event. System malfunctions (breaches in the system, pipe bursts per year, tank leakage, cross connections, etc.) are the most likely types of unintended exposures. Likelihood of exposure should be based on the specific end use and the types of individuals who will visit the site.

DECISION POINT 1: Are Exposures Likely?

If the information submitted to DDOE is sufficient to support a determination that exposures are "unlikely," no further study or analysis is required. This is the first exit point in the TRAM process (as was indicated in Figure 1). On the other hand, if exposure is "likely" or "possible," the investigation must proceed to the next step.

Step 3: Determine Concentration of Contaminants in Stormwater.

When human exposures are likely or possible, the maximum risk must be evaluated based on the concentration of both chemicals and pathogenic organisms. The maximum risk represents the threat to public health associated with potential exposures to untreated stormwater.

All chemicals identified and qualitatively evaluated in Step 1 should be targets in the sampling plan. If the catchment area in which stormwater will be collected is zoned industrial, it is possible that those chemicals identified in the baseline investigation may have contaminated roof water, surface soil, or pavement. For areas considered open space or recreational properties, sampling for chemical contamination can be limited to pesticides.

Table M.4 lists chemicals typically associated with industrial operations, as well as common pesticides. Pathogenic microbes may also be present in collected stormwater, and Table 4 lists the three primary categories of microbial threats to human health, which are bacteria, viruses, and protozoa. Stormwater samples collected in this step should represent the conditions that will occur during a major rain event. Note, however, that the concentrations of chemicals and microbes will be lower after a major rain event compared with a minor rain event due to the dilution effect. Planning for the stormwater sampling event should take into account roof, soil, and solid surface contributions to the stormwater catchment system. All samples submitted for laboratory testing should represent, as closely as possible, the conditions in which untreated stormwater will be stored and used at the site. For example, if collected stormwater will be stored in a cistern shielded from light for several days before it is used, the samples sent for laboratory analysis must be stored under the same conditions (i.e., same temperature under dark conditions to assess growth of microbial pathogens). After replicating site storage conditions, all samples must be sent to an EPA-approved laboratory for analysis of all chemicals of interest identified in the baseline investigation.

The sampling locations and number of samples collected at this stage should be based on the size of the catchment area and sources of potential contamination. For example, a non-industrial site totaling 2 to 3 acres with only one storage cistern could be adequately represented by taking a minimum of three samples at timed intervals over a holding time of 4 to 5 days. At the other end of the spectrum, a 10-acre site located in an industrial area with several storage cisterns spread out over the site may require sampling from each cistern after moderate and major storm events. Regardless of the type of site, DDOE encourages implementation of the most cost-effect approach as the goal is not to fully characterize the site for potential contamination, but rather to determine if the contaminants in collected stormwater pose a health threat.

Sampling results generated in this step should be evaluated in the risk-based screening comparison described in the next step.

Table M.4 Chemicals of Interest for Baseline Investigations

Inorganic Metals		
Aluminum	Chromium	Selenium
Arsenic	Iron	Silver
Barium	Manganese	Tin
Beryllium	Mercury	Zinc
Bromate	Molybdenum	
Cadmium	Nickel	
Organic Compounds		
Acrylamide	Hexachlorobutadiene	Trichloroethylene
Benzene	Polyaromatic hydrocarbons	Trichloroethane
Carbon tetrachloride	Polybrominated biphenyls	Trichloroethene
Chlorobenzene	Polychlorinated biphenyls	Vinyl chloride monomer
Benzo[a]pyrene	Tetrachloroethene	Xylene
Epichlorohydrin	Toluene	
Ethylbenzene	Trichlorobenzenes	
Pesticides		
Aldicarb	Chlordane	
Aldrin	Diazinon	
Atrazine	Heptachlor	
Pathogenic Microbes		
Bacterium: *E. coli*		
Protozoan: *Cryptosporidium parvum*		

Step 4: Compare Stormwater Concentrations with Risk-Based Levels.

To determine whether exposure to untreated stormwater is a public health threat, maximum risk must be assessed. Determining whether stormwater exposures will pose a threat does not require that a formal risk assessment be conducted. Risk assessments can be costly and time consuming to prepare. Instead, it will only be necessary to apply risk-based screening, and DDOE has even simplified this step. Screening involves a simple comparison of the chemical and/or microbial concentrations detected in untreated stormwater (in the previous step) with acceptable risk-based screening levels. Risk-based concentrations represent safe exposure levels for chemical or microbial contaminants. They are derived based on the frequency of exposure, amount ingested, and the inherent toxicity of each contaminant.

Table M.5 lists different types of stormwater use that DDOE anticipates in the District. For each stormwater use, there could be several types of exposure conditions that vary in exposure intensity and duration. For example, individuals engaged in high-intensity sports (e.g., baseball, football, soccer, etc.) would have greater exposures to contaminants in stormwater used for irrigation at a municipal park than would someone walking a pet.

Table M.5 Types of Stormwater Use and Routes of Exposure

Stormwater Use	Route of Exposure	General Description of Exposure Conditions
Home lawn or garden spray irrigation	Ingestion of aerosol spray	Typical watering every other day during half year
	Ingestion after contact with plants/grass	Routine indirect ingestion via contact with plants, lawns, etc.
	Accidental ingestion of stormwater	Infrequent inadvertent ingestion.
Open space or municipal park drip or spray irrigation	Ingestion via casual contact (picnic, walking pet)	Infrequent contact with wet grass, picnic tables
	Ingestion via low-intensity sports (golf, Frisbee)	Typical contact with irrigated plants/grasses
	Ingestion via high-intensity sports (baseball, soccer)	Frequent contact with irrigated sports field
	Ingestion by child on playground	Frequent contact with wet surfaces and frequent hand-to-mouth activity
	Public fountain with spray element	Indirect and infrequent ingestion of spray
	Public fountain with standing pool	Infrequent ingestion of pool water during hot days
Home garden drip or spray irrigation	Ingestion of irrigated vegetables and fruit	Typical ingestion of small home garden seasonal produce
Commercial farm produce drip or spray irrigation	Ingestion of irrigated vegetables and fruit	Typical ingestion of regional commercial produce
Home car wash spray application	Ingestion of water and spray	Once a week car wash for 6 months
Commercial car wash spray	Ingestion of water and spray	Car wash operator exposed 5 days per week
Toilet	Ingestion of aerosol spray	Flushing 3 times per day
Washing machine use	Ingestion of sprays	Ingestion from 1 load per day
Fire fighting	Ingestion of water and spray	Firefighter assumed exposed 50 events per year

Table M.6 lists the exposure assumptions that represent different types of stormwater use and the corresponding typical exposure conditions for each use. Project planners should identify the appropriate exposure conditions in this table that most closely match site-specific conditions. Stormwater use and the site-specific exposure conditions correspond to specific assumptions regarding how individuals will come in contact with untreated stormwater. The two most important criteria are the number of days contact is expected to occur and the volume of stormwater that will be ingested on each of those days.

For example, the first row indicates that an individual watering a lawn or garden is assumed to do so every other day for 6 months and will ingest 0.1 mL of stormwater each time the lawn is watered. While DDOE anticipates that these exposure assumptions will represent the majority of sites, a small number of reuse projects may be unique, and DDOE should be contacted to discuss unique sites. For these projects, planners should either contact DDOE directly to discuss alternative exposure assumptions or select an exposure scenario that is intentionally conservative. Although this may be an overly protective approach, such a comparison would be sufficient proof for DDOE that public health will be protected if the site passed the risk-based screen test.

Table M.6 Exposure Assumptions Based on Stormwater Use and Exposure Conditions

Stormwater Use	Route of Exposure	Exposure Assumptions	
		Volume Ingested (mL)	Days (per year)
Home lawn or garden spray irrigation	Ingestion of aerosol spray	0.1	90
	Ingestion after contact with plants/grass	1	90
	Accidental ingestion of stormwater	100	1
Open space, municipal park drip, or spray irrigation	Ingestion with casual contact-picnic, walking pet	0.1	32
	Ingestion with low intensity sports-golf, Frisbee	1	32
	Ingestion high intensity sports-baseball, soccer	2.5	16
	Ingestion child playground	4	130
	Public fountain with spray element	0.1	130
	Public fountain with standing pool	4	130
Home garden drip or spray irrigation	Ingestion of irrigated vegetables and fruit	7	50
Commercial farm produce drip or spray irrigation	Ingestion of irrigated vegetables and fruit	10	140
Home car wash spray application	Ingestion of water and spray	5	24
Commercial car wash spray	Ingestion of water and spray	3	250
Toilet	Ingestion of aerosol spray	0.01	1100
Washing machine use	Ingestion of sprays	0.01	365
Fire fighting	Ingestion of water and spray	20	50
Swimming pool	Ingestion of water	200	90

It should be stressed that although EPA and several state regulatory agencies have developed RSLs (EPA RSLs available at http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/equations.htm), these should not be used for stormwater projects. These RSLs apply only to potable drinking water and, because they are overly conservative, many stormwater projects would fail the screen. Stormwater collected in the District must never intentionally or unintentionally be used as a potable drinking water source. Therefore, EPA's RSLs for drinking water, which are based on the assumption that a child and an adult will drink 1 and 2 liters of water per day, respectively, are not applicable to stormwater reuse projects.

Furthermore, the drinking water RSL assumes an individual will drink the water 350 days per year for 30 years. This corresponds to 350 to 700 liters of water consumed per year, which is 500 to 1,000 times the amount of stormwater that will be ingested for most projects (as shown in Table M.6). Clearly, drinking water exposure assumptions do not represent typical stormwater reuse exposures and should not be used to screen for the maximum risk.

DDOE has made the risk-based screening step easy to use by evaluating the exposure conditions presented in Table M.6, ranking the intensity of each type of exposure and grouping exposures with similar intensity into one of four categories: severe, high, medium, or low. The exposure scenarios (listed in Table M.6) for each of these categories are presented in Table M.7.

Table M.7 Categorizing Exposures Based on Stormwater Use: Severe, High, Medium, and Low

Exposure Classification	Exposure Classification	Route of Exposure
Severe	Swimming pools	Ingestion of water
High	Commercial farm produce drip or spray irrigation	Ingestion of irrigated vegetables and fruit
	Fire fighting	Ingestion of water and spray
	Commercial car wash	Ingestion of water and spray
Medium	Open space or municipal park drip or spray irrigation	Ingestion by child on playground
	Open space or municipal park drip or spray irrigation	Public fountain with standing pool
	Home garden drip or spray irrigation	Ingestion of irrigated vegetables and fruit
	Home car wash spray application	Ingestion of water and spray
	Home lawn or garden spray irrigation	Accidental ingestion of stormwater
	Home lawn or garden spray irrigation	Ingestion after contact with plants/grass
Low	Open space or municipal park drip or spray irrigation	Ingestion via high-intensity sports—baseball, soccer
	Open space or municipal park drip or spray irrigation	Ingestion via low-intensity sports—golf, Frisbee
	Open space or municipal park drip or spray irrigation	Public fountain with spray element
	Toilet	Ingestion of aerosol spray
	Home lawn or garden spray irrigation	Ingestion of aerosol spray
	Washing machine use	Ingestion of sprays
	Open space or municipal park drip or spray irrigation	Ingestion with casual contact—picnic, walking pet

Project planners should select one of these four categories that best represent site-specific conditions. The selection should be based on how stormwater will be used, who will contact the stormwater, and by what route of exposure. For example, stormwater used to fill a swimming pool is ranked “severe” because the frequency of exposure combined with the high rate of ingestion of pool water while swimming is considerably greater than all other exposures. It should be noted that exposure assumptions for formal risk assessments are typically established with worst possible exposure assumptions. While the worst exposure may be hypothetically possible, DDOE expects projects to rely on realistic and common sense expectations. For this reason, detailed and complex “future exposure analyses” are unnecessary. Proposals need only submit sufficient information to allow DDOE to convey to the public that a thorough analysis has been performed and that public health is being protected.

Although exposure assumptions are typically based on broad “what if” hypothetical scenarios in formal risk assessments, DDOE encourages proposals that are based on realistic expectations to determine the most likely threats to public health. DDOE recognizes that, in many cases, the anticipated exposure conditions will be based on subjective judgment rather than on a detailed complex “future hypothetical exposure” analysis. Accordingly, proposals need only submit sufficient information to show that all potential exposures have at least been considered. This will allow DDOE to convey to the public that a thorough analysis has been performed and that public health is being protected.

In addition to the obvious and planned stormwater use, proposals must also consider inadvertent or unauthorized use of stormwater. That is, while the major focus should be on the intended uses, it is important to consider exposures that could result from inadvertent use of untreated stormwater as it may result in higher-than-intended exposure to humans and the receiving environment. For example, even though the intended use of stormwater is for purposes other than drinking, such as irrigation of parks and gardens, people may occasionally drink from a recycled-water tap by accident. Obviously, a failsafe system must be put in place to prevent this from occurring. However, preventive measures can sometimes be circumvented, and the plan should evaluate the exposure as a low-probability event to determine the magnitude of the potential threat to public health in the event of occurrence.

DDOE has derived RSLs for all the chemicals that are routinely detected in environmental media, particularly at industrial sites, which were presented in Table M.4. It is impractical to derive RSLs for all possible combinations of chemicals and for all stormwater uses and exposure conditions, but this list should be the starting point for sampling efforts. However, if the baseline investigation provides sufficient evidence that chemical contamination at the site is unlikely, sampling may be unnecessary. DDOE recognizes that sampling and laboratory analyses can be expensive and time consuming and may not be warranted. For example, if the property is currently and has always been zoned for residential use, there may be no reason to suspect a chemical release has occurred. In this situation, the planner could submit the baseline investigation and justification for a waiver to sample, which DDOE would review and consider.

The RSLs that should be used for risk-based screening are presented in Table M.8. These levels represent the acceptable concentrations corresponding to either a cancer risk of 1E-6 or non-cancer hazard index of 1.0. They correspond to the site-specific end use of the stormwater and exposure conditions as discussed previously. EPA’s risk management framework states that a risk level between 1E-6 and 1E-4 is a discretionary range. The reason DDOE selected a risk-based screening level for cancer risk of 1E-6 is that it is likely that multiple chemicals will be detected for some projects. DDOE will use discretion in setting the acceptable "cumulative" risk level for projects where the individual contaminant levels slightly exceed the concentrations presented in Table M.8.

To use the table, planners only need to identify the column that matches the site-specific exposure category and identify the row corresponding to the chemical of interest. That sample concentration is then compared with the RSL. If the sample concentration is below the RSL, it can be concluded stormwater does not pose a threat to human health, and no further action is necessary. If the sample concentration exceeds the RSL, the analysis must continue on to the next step in the TRAM process as described in the next section.

Table M.8 Risk-based Chemical Concentrations for Sites Categorized as Severe, High, Medium, and Low Exposures

Chemical (µg/L)	Drinking Water	Exposure Category			
		Severe	High	Medium	Low
Acrylamide	4.3E-02	1.6E+00	2.2E+01	5.8E+01	6.3E+02
Aldicarb	3.7E+01	1.3E+03	1.8E+04	4.9E+04	5.3E+05
Aldrin	4.0E-03	1.5E-01	2.0E+00	5.4E+00	5.8E+01
Aluminum	3.7E+04	1.3E+06	1.8E+07	4.9E+07	5.3E+08
Arsenic, Inorganic	4.5E-02	1.6E+00	2.3E+01	6.1E+01	6.6E+02
Atrazine	2.9E-01	1.1E+01	1.5E+02	3.9E+02	4.2E+03
Barium	7.3E+03	2.7E+05	3.7E+06	9.8E+06	1.1E+08
Benzene	4.1E-01	1.5E+01	2.1E+02	5.5E+02	6.0E+03
Benzo[a]pyrene	2.0E-01	7.3E+00	1.0E+02	2.7E+02	2.9E+03
Beryllium	7.3E+01	2.7E+03	3.7E+04	9.8E+04	1.1E+06
Bromate	9.6E-02	3.5E+00	4.8E+01	1.3E+02	1.4E+03
Cadmium	1.8E+01	6.7E+02	9.1E+03	2.5E+04	2.7E+05
Carbon Tetrachloride	4.4E-01	1.6E+01	2.2E+02	5.9E+02	6.4E+03
Chlordane	1.9E-01	6.9E+00	9.5E+01	2.6E+02	2.8E+03
Chlorobenzene	9.1E+01	2.7E+04	3.7E+05	9.8E+05	1.1E+07
Chromium	4.3E-02	4.0E+03	5.5E+04	1.5E+05	1.6E+06
Diazinon	2.6E+01	9.3E+02	1.3E+04	3.4E+04	3.7E+05
Epichlorohydrin	2.1E+00	8.0E+03	1.1E+05	2.9E+05	3.2E+06
Ethylbenzene	1.5E+00	5.5E+01	7.5E+02	2.0E+03	2.2E+04
Heptachlor	1.5E-02	5.5E-01	7.5E+00	2.0E+01	2.2E+02
Hexachlorobutadiene	8.6E-01	3.1E+01	4.3E+02	1.2E+03	1.3E+04
Iron	2.6E+04	9.3E+05	1.3E+07	3.4E+07	3.7E+08
Manganese	8.8E+02	3.2E+04	4.4E+05	1.2E+06	1.3E+07
Mercury	1.1E+01	4.0E+02	5.5E+03	1.5E+04	1.6E+05
Molybdenum	1.8E+02	6.7E+03	9.1E+04	2.5E+05	2.7E+06

Chemical (µg/L)	Drinking Water	Exposure Category			
		Severe	High	Medium	Low
Nickel	1.8E+03	6.7E+04	9.1E+05	2.5E+06	2.7E+07
Polybrominated Biphenyls	2.2E-03	8.0E-02	1.1E+00	3.0E+00	3.2E+01
Polychlorinated Biphenyls	5.0E-01	1.8E+01	2.5E+02	6.7E+02	7.3E+03
Selenium	1.8E+02	6.7E+03	9.1E+04	2.5E+05	2.7E+06
Silver	1.8E+02	6.7E+03	9.1E+04	2.5E+05	2.7E+06
Tetrachloroethylene	1.1E-01	4.0E+00	5.5E+01	1.5E+02	1.6E+03
Tin	2.2E+04	8.0E+05	1.1E+07	2.9E+07	3.2E+08
Toluene	2.3E+03	1.1E+05	1.5E+06	3.9E+06	4.3E+07
Trichlorobenzene	2.3	8.4E+01	1.2E+03	3.1E+03	3.4E+04
Trichloroethane	2.4E-01	8.8E+00	1.2E+02	3.2E+02	3.5E+03
Trichloroethane	9.1E+03	2.7E+06	3.7E+07	9.8E+07	1.1E+09
Trichloroethylene	2.0	7.3E+01	1.0E+03	2.7E+03	2.9E+04
Vinyl Chloride	1.6E-02	5.8E-01	8.0E+00	2.2E+01	2.3E+02
Xylene	2.0E+02	2.7E+05	3.7E+06	9.8E+06	1.1E+08
Zinc	1.1E+01	4.0E+02	5.5E+03	1.5E+04	1.6E+05

Stormwater projects must also include an evaluation of threats from microbial pathogens. Although this can be a complex investigation (there are many hundreds of different microbial pathogens), DDOE has developed a tiered approach to reduce time and costs based on the indicator pathogens *Escherichia coli* (*E. coli*) and *Cryptosporidium parvum* (*C. parvum*). With this approach, planners should first monitor for *E. coli* because it is less expensive to analyze than Cryptosporidium. *E. coli* is termed a reference or indicator microbe because it is associated with human and wildlife fecal waste (it should be noted, however, that no simple statistical correlation exists between *E. coli* and human pathogen concentrations in stormwater). *C. parvum*, however, causes gastrointestinal illness that may be severe and sometimes fatal for people with weakened immune systems (which may include infants, the elderly, and individuals who have AIDs). It will only be necessary to monitor for *C. parvum* if the *E. coli* results exceed the RSLs presented in Table M.9, if the stormwater storage system is large and at ground level, or stormwater is stored in a reservoir.

Table M.9 presents RSLs for *E. coli* that are based on EPA guidance for swimming and wading (Ambient Water Quality Criteria for Bacteria (EPA440/5-84-002 January 1986). The current level that is acceptable for swimming and wading is 160 CFU/100 mL, which corresponds to a risk of developing gastroenteritis of 8 in 1000 and is generally accepted as a safe level by regulatory agencies. This formed the basis for the "severe" category and was also used to derive the RSL for the three other categories using the attenuated exposure assumptions presented in Table M.6. For sites classified as severe exposures, the RSL should be interpreted to mean that when the site sample concentration for *E. coli* < 160 CFU/100 mL, the stormwater is safe for swimming or wading, and no further action is necessary for microbial contaminants. If this RSL is exceeded, however, samples must be collected for the next tier, which involves analyzing for *C. parvum*.

Unlike *E. coli*, no regulatory agency has yet to develop a safe level for *C. parvum* exposure. Although the EPA's recently revised new Long Term 2 Enhanced Surface Water Treatment Rule (LT2 rule; EPA 815-R06-006 February 2006) stresses the importance of monitoring for *C. parvum* to protect drinking water sources, no exposure-specific RSL is available. It should be noted, however, that DDOE's approach for monitoring microbial contaminants is similar to the strategy in the LT2 rule, because DDOE concurs with EPA that a tiered monitoring approach based on *E. coli* and *C. parvum* is the most cost-effective strategy for protecting the public from gastrointestinal illness.

Table M.9 presents RSLs for each exposure category for *C. parvum*. These levels were developed based on the WHO approach using Disability Adjusted Life Years (DALYs); they are also consistent with the tolerable levels developed in Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2) Stormwater Harvesting And Reuse (July 2009) and are set at 1E-6 risk level.

Table M.9 Risk-Based Microbial Levels for Sites Categorized As Severe, High, Medium, and Low Exposures

Microbial Pathogen	Swimming	Exposure Category			
		Severe	**High**	**Medium**	**Low**
Escherichia coli (CFU/100 mL)	126[1]	126	1714	4615	50000
Cryptosporidium [2] (oocysts/L)	NA	0.001	0.016	0.033	0.320

[1] Ambient Water Quality Criteria for Bacteria (EPA440/5-84-002 January 1986). RSLs correspond to a risk level of 8 in 1,000 of developing a gastrointestinal disease.
[2] Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2) Stormwater Harvesting and Reuse. July 2009. RSLs correspond to a 1E-6 risk level of developing a gastrointestinal disease.

The risk-based screening results for both chemicals and microbes are considered in the next step.

DECISION POINT 2: Is Maximum Risk for Untreated Stormwater Acceptable?

This step represents the important risk management decision point in the TRAM approach and it is dependent on the previous risk-screening comparison. The comparison of chemical and microbiological contaminant levels with RSLs is the only criteria needed to make this determination. This is a pivotal decision, since if the maximum risk is acceptable, no further investigation is necessary, stormwater treatment will not be required, and the proposed plan for no treatment can be submitted to DDOE for review. This represents the second exit point from the TRAM process.

On the other hand, if one or more contaminants fail the risk-based screen, action will generally be necessary to lower risks to an acceptable level. The magnitude of the exceedance will be the primary determinant for making risk management decisions. If the exceedance is less than one or two orders of magnitude, DDOE can exercise its discretion about the best path forward and whether a treatment system is necessary. DDOE will rely on factors such as availability of treatment systems, severity of the toxic effect, probability of exposures, and whether measures can be implemented to prevent exposures. DDOE's determination will ultimately be based on a cost-benefit evaluation, and the most effective remedy with the lowest cost will be selected.

If the appropriate remedy is treatment, planning should proceed to the next step.

Step 5: Select Appropriate Treatment Technology to Reduce Contaminants to Acceptable Risk Levels.

Selecting the appropriate remedy will depend on the type(s) of contaminant(s) posing the health threat. For microbial pathogens in small-to-medium sized stormwater projects, ultraviolet (UV) disinfection is the most practical and cost effect approach. Although chlorination may also be suitable, protozoa such as *C. parvum* will require a higher Ct value (disinfectant concentration × contact time) because inactivation is more difficult to achieve compared with that for bacteria and viruses.

If chemical contaminants pose an unacceptable risk, it must be determined whether they are soluble or are bound to particles. If they are particulate-bound, it may be necessary to reduce their concentration with filtration, flocculation, or other treatments that reduce suspended solids.

Proposed plans must present the type of treatment selected that will target specific chemical and/or microbial risks. Planning should proceed to the next step.

Step 6: Submit Stormwater "Treatment" Plan to DDOE and Collect Verification Samples.

Proposed plans must provide a full description of the treatment system that is selected to reduce contaminant levels. The operating efficiency and specifications are necessary because verification samples will be used to validate the system is operating as designed.

The design of a monitoring program will be specific to each project, but it must take into account both peak and average rainfall. The point of compliance will be the stormwater in the catchment rather than separate points across the property because the catchment water represents the average of all contributions because it is likely that one or more individual samples will fail risk-based screening. The extent of sampling required to verify the system is functioning properly will be project-specific with more extensive sampling required for projects where a greater number of individuals are exposed to chemicals that are considered more toxic. As a rule of thumb, projects classified as "severe" and "high" will require a slightly more complex sampling design. Also, projects that require a higher log reduction of contaminant levels will receive a greater degree of scrutiny.

Step 7: Compare Treated Stormwater Concentrations with Risk-Based Levels

The log reduction necessary to achieve acceptable risk levels represents the difference between the maximum (untreated stormwater) and residual (treated stormwater) risk. Sample concentrations should be < the target concentrations corresponding to the intended use and exposures, and those target goals are the same RSLs that were presented in Tables N.8 and N.9.

DECISION POINT 3: **Residual Risk for Treated Stormwater Acceptable?**

This point requires that a decision be made as to whether the treatment system efficiently reduced contaminant levels to acceptable concentrations. If the verification samples indicate the treatment system is performing as designed, the proposal must include the results and conclusions and proceed to the next step. As noted previously, DDOE will use discretion in determining whether the project meets the acceptable "cumulative" risk level for projects where the individual contaminant levels slightly exceed the concentrations presented in Table M.8. For example, DDOE may determine that exceedances do not rise to a level requiring action if the number of potentially exposed individuals is very small. Additionally, DDOE may use its discretion to waive action when an exceedance is less than an order of magnitude above risk-based screening levels.

If the treatment system fails to meet the design specifications and cannot achieve the required risk-based acceptable concentrations, the investigation must go back to Step 7 and repeat the subsequent steps of the TRAM process. This requires that either the selected treatment system be modified or an alternate technology selected.

Step 8: **Continue Required Monitoring Sampling/Submit Analytical Results to DDOE.**

The purpose of a monitoring program is to confirm continued compliance with the required end use water standards. The applicant will submit a post-construction monitoring program that will access the ongoing lifecycle compliance including annual verification of performance as well as performance verification after significant maintenance or modifications to the treatment system. Monitoring assesses:

- Overall performance of the systems harvesting stormwater for non-potable uses;
- Quality of the harvested stormwater being supplied or discharged;
- Changes in the receiving environment or exposed populations.

Ultimately, the goal of monitoring is to provide continued assurance that the treatment system is operating at levels specified in the permit and public health is being protected. For example, systems relying on UV radiation for disinfection would need to replace the UV source at manufacturer specified intervals, and monitoring should be conducted soon after the unit is replaced. The original proposal must present a detailed monitoring plan that anticipates routine maintenance or major modification to treatment systems. As a rule of thumb, greater emphasis on monitoring will be necessary for those projects where the exposed population is significant and/or the maximum risks associated with untreated stormwater are significantly above risk-based levels. This monitoring program will be part of the approved SWMP and detailed in the deed of covenants as part of the BMP's long term maintenance obligations.

Appendix N Land Cover Designations

N.1 General Notes

The retention standard approach taken in this guidance manual for on-site stormwater management recognizes the ability of pervious land covers to manage some, or all, of the rainwater that falls on it. This is termed "land abstraction” in this appendix. The concept is discussed as “existing retention” in chapters and appendices related to the off-site retention program. To facilitate the design, review, construction, and enforcement of site-designated land cover, land abstraction has been divided into two types of land covers: natural cover and compacted cover. The preservation and the creation of land covers with either of these designations are treated equally in this guidance manual. The designation of natural cover assumes these lands will generate zero stormwater runoff for a design rain event. The designation of compacted cover assumes these lands will generate 25 percent stormwater runoff for a design rain event. The minimum area threshold for the natural cover designation is 1,500 square feet, with a minimum length of 30 feet. All land cover designations must be recorded in the declaration of covenants.

N.2 Existing Natural Cover Requirements

A site claiming natural cover based on the preservation of existing conditions must ensure conditions remain undisturbed to preserve hydrologic properties equal to or better than meadow in good condition. Preservation areas for natural cover may include the following:

- Portions of residential yards in forest cover that will not be disturbed during construction
- Community open space areas that will not be mowed routinely, but left in a natural vegetated state (can include areas that will be rotary mowed no more than two times per year)
- Utility rights-of-way that will be left in a natural vegetated state (can include areas that will be rotary mowed no more than two times per year)
- Other areas of existing forest and/or open space that will be protected during construction and that will remain undisturbed

N.3 Planting Requirements for the Creation of Natural Cover

- Every 1,500 square feet of created natural area shall be vegetated according to the following options of plant material quantity:
  - 1 native shade tree: 1.5 inch caliper (minimum), or
  - 2 native ornamental trees: 6 foot height (minimum), or
  - 6 native shrubs: 5 gallon container size (minimum), or
  - 50 native perennial herbaceous plants: 1 gallon container size (minimum), or

  - 1 native ornamental tree: 6- to 10-foot height (minimum), and 25 native perennial herbaceous plants: 1 gallon container size (minimum), or
  - 3 native shrubs: 5 gallon container size (minimum), and 25 native perennial herbaceous plants: 1 gallon container size (minimum), or
  - Steep slope greater than 6 percent grade will require additional plantings, soil stabilization, or a terracing system.
- Whip and seedling stock may be used (when approved by DDOE) as a site's natural cover creation if a stream bank stabilization opportunity falls within the site's footprint. In this instance, whips or seedlings must be planted at a minimum density of 700 plants per acre, and at least 55 percent of these plants must remain at the end of the 2-year management period.
- Natural regeneration (i.e., allowing volunteer plants to propagate from surrounding natural cover as a cover creation technique) may be allowed by DDOE, when 75 percent of the proposed planting area is located within 25 feet of adjoining forest, and the adjoining forest contains less than 20 percent cover of invasive exotic species. In this case, supplemental planting must ensure a density of 400 seedlings per acre.
- All plant materials used must be native to the mid-Atlantic region and must be installed in areas suitable for their growth. Lists of native species of shrubs, grasses, and wildflowers are published in the US Fish and Wildlife Service, 2009, Native Plants for Wildlife Habitat and Conservation Landscaping: Chesapeake Bay Watershed. There are several websites that may be consulted to select the most appropriate plantings for the District;
  - http://www.wildflower.org/collections/collection.php?collection=DC
  - http://www.nps.gov/plants/pubs/nativesMD/pdf/MD-CoastalPlain.pdf
  - http://www.nps.gov/plants/pubs/nativesMD/pdf/MD-Piedmont.pdf
- Plants can be irrigated until established.

N.4 Stormwater Management Plans and Natural Cover

Sites using preservation of existing areas for the natural cover designation shall include on their Stormwater Management Plan (SWMP) a tree and vegetation survey, identification of location, and extent of preservation areas. Depending on the extent of the preservation area DDOE may require the SWMP include a more detailed schedule for retained trees noting tree species, tree size, tree canopy, tree condition, and tree location.

The SWMP will include the identification of material and equipment staging areas and parking areas. Material and equipment staging areas and parking areas must be sufficiently offset for preservation areas to ensure no adverse impacts.

For areas maintained as meadow in good condition, the SWMP shall document either the preservation of existing conditions or the creation of meadow conditions. A plan submission claiming meadow preservation will note the existing meadow boundaries and include a field survey of the richness and diversity of existing plant species and the existing soil conditions. A plan submission claiming meadow creation will note the proposed meadow boundaries, the planting and/or seeding species methods, and provide a soil amendments plan as specified in Appendix J.

N.5 Construction Requirements for Natural Cover Designation

The preservation of lands designated as natural cover, such as undisturbed portions of yards, community open space, and any other areas designated on a site's SWMP as preserved natural cover, must be shown outside the limits of disturbance on the site's Soil Erosion and Sediment Control Plan. These areas must be clearly demarcated with signage prior to commencement of construction on the site on the site and with fencing during construction.

The creation of lands designated as natural cover as part of a public right-of-way (PROW) project and on sites where soils were not protected from compaction during construction the soils must be conditioned prior to planting with soil compost amendments as prescribed in Appendix J.

For maximum survivability, planting of trees, shrubs, and herbaceous vegetation for the creation of natural cover should occur only during the fall and early spring (September–November and March–May). The work should be done only under the supervision of someone qualified and skilled in landscape installation (see Section 3.14 Tree Planting and Preservation for details on qualifications). Proper maintenance of the materials after installation will be key in ensuring plants survival. Prior to inspection, all trees and shrubs planted must be alive and in good health, and native grass and wildflower seeds must have been sown at adequate densities and at the right time of year for each species.

Once a natural cover designation has been assigned to a portion of regulated development site, that area will need to be recorded in the declaration of covenants, documented at the site prior to construction activities, protected during construction activities, and permanently protected/maintained for the life of the regulated site.

Root pruning and fertilizing are examples of preconstruction activities. These measures aim to increase the wellbeing of trees and prepare them for higher stress. Prior to beginning construction, temporary devices such as fences or sediment controls are installed and remain throughout the construction phase. Some devices, like retaining walls and root aeration systems may remain permanently. For example, if part of a root system is collapsed by a built road, permanent aeration may be necessary for the tree to remain healthy.

N.6 Maintenance Requirements for Natural Cover Designation

All areas that will be considered natural cover for stormwater purposes must have documentation that prescribes that the area will remain in a natural, vegetated state. Appropriate documentation includes subdivision covenants and restrictions; deeded operation and maintenance agreements and plans; parcels of common ownership with maintenance plans; third-party protective easements within PROW or p maintenance plans; or other documentation approved by DDOE. Natural cover designation must be identified in the site's declaration of covenants.

While the goal is to have natural cover areas remain undisturbed, some activities may be prescribed in the appropriate documentation, as approved by DDOE, such as forest management, control of invasive species, replanting and revegetation, passive recreation (e.g., trails), limited bush hogging to maintain desired vegetative community, etc.

N.7 Compacted Cover Designation

The compacted cover designation can apply to all site areas that are disturbed and/or graded for eventual use as managed turf or landscaping. Examples of compacted cover include lawns; portions of residential yards that are graded or disturbed and maintained as turf, including yard areas; residential utility connections; and PROW. Landscaping areas intended to be maintained as vegetation other than turf within residential, commercial, industrial, and institutional settings are also considered compacted cover if regular maintenance practices are employed.

Appendix O Geotechnical Information Requirements for Underground BMPs

O.1 General Notes Pertinent to All Geotechnical Testing

A geotechnical report is required for all underground stormwater best management practices (BMPs), including infiltration-based practices, filtering systems, and storage practices, as well as stormwater ponds and wetlands. The following must be taken into account when producing this report.

- Testing is to be conducted by a qualified professional. This professional shall either be a registered professional engineer, soils scientist, or geologist and must be licensed in the District of Columbia.
- Soil boring or test pit information is to be obtained from at least one location on the site. However, the location, number, and depth of borings or test pits shall be determined by a qualified professional, and be sufficient to accurately characterize the site soil conditions.
- Depth to the ground water table and estimated depth to the seasonally high ground water table must be included in the boring logs/geotechnical report.
- Laboratory testing must include grain size analysis. Additional tests such as liquid limit and plastic limit tests, consolidation tests, shear tests and permeability tests may be necessary based on the discretion of the qualified professional.
- The geotechnical report must include soil descriptions from each boring or test pit, and the laboratory test results for grain size. Based upon the proposed development, the geotechnical report may also include evaluation of settlement, bearing capacity and slope stability of the proposed structures.
- All soil profile descriptions should provide enough detail to identify the boundary and elevations of any problem (boundary/restrictions) conditions such as fills and seepage zones, type and depth of rock, etc.

In addition to the testing requirements described above, infiltration tests must be performed for all BMPs in which infiltration will be relied upon, including permeable pavement systems, bioretention, infiltration, and dry swales. Specific requirements for infiltration testing are discussed below.

O.2 Initial Feasibility Assessment

The feasibility assessment is conducted to determine whether full-scale infiltration testing is necessary, screen unsuitable sites, and reduce testing costs. However, a designer or landowner may opt to skip the initial feasibility assessment at his or her discretion, and begin with soil borings.

The initial feasibility assessment typically involves existing data, such as the following:

- On-site septic percolation testing, which can establish initial rate, water table, and/or depth to bedrock;
- Previous geotechnical reports prepared for the site or adjacent properties.; or
- Natural Resources Conservation Service (NRCS) Soil Mapping.

If the results of initial feasibility assessment show that a suitable infiltration rate (typically greater than 0.5 inches per hour) is possible or probable, then test pits must be dug or soil borings drilled to verify the infiltration rate.

O.3 Test Pit/Boring Requirements for Infiltration Tests

a. Excavate a test pit or drill a standard soil boring to a depth of 2 feet below the proposed facility bottom.

b. Determine depth to groundwater table (if within 2 feet of proposed bottom), and the estimated seasonally high groundwater table.

c. Determine Unified Soil Classification (USC) System textures at the proposed bottom and 4 feet below the bottom of the BMP.

d. Determine depth to bedrock (if within 2 feet of proposed bottom).

e. The soil description must include all soil horizons. If any of the soil horizons below the proposed bottom of the infiltration practice appear to be a confining layer, additional infiltration tests must be performed on this layer (or layers), following the procedure described below.

f. The location of the test pits or borings shall correspond to the BMP locations; test pit/soil boring stakes are to be left in the field for inspection purposes and shall be clearly labeled as such.

At least 1 test pit must be dug or encased soil boring drilled for each proposed infiltration-based BMP. For larger practices, additional test pits or soil borings are required for infiltration testing, as described in Table O.1 below.

Table O.1 Number of Infiltration Tests Required per BMP

Area of Practice (ft^2)	Minimum Number of Test Pits/Soil Borings
< 1,000	1
1,000–1,999	2
2,000–9,999	3
≥ 10,000	Add 1 test pit/soil boring for each additional 5,000 ft^2 of BMP.

When more than one test pit or boring is necessary for a single BMP, the pit or boring locations must be equally spaced throughout the proposed area of the practice, as directed by the qualified professional. The reported infiltration rate for a BMP shall be the median or geometric mean of the observed results from the soil boring/test pit locations.

O.4 Infiltration Testing Requirements

The following tests are acceptable for use in determining soil infiltration rates. The geotechnical report shall include a detailed description of the test method and published source references:

- Well Permeameter Method (USBR 7300-89)
- Tube Permeameter Method (ASTM D 2434);
- Double-Ring Infiltrometer (ASTM D 3385);
- Other constant head permeability tests that utilize in-situ conditions and are accompanied by a recognized published source reference.

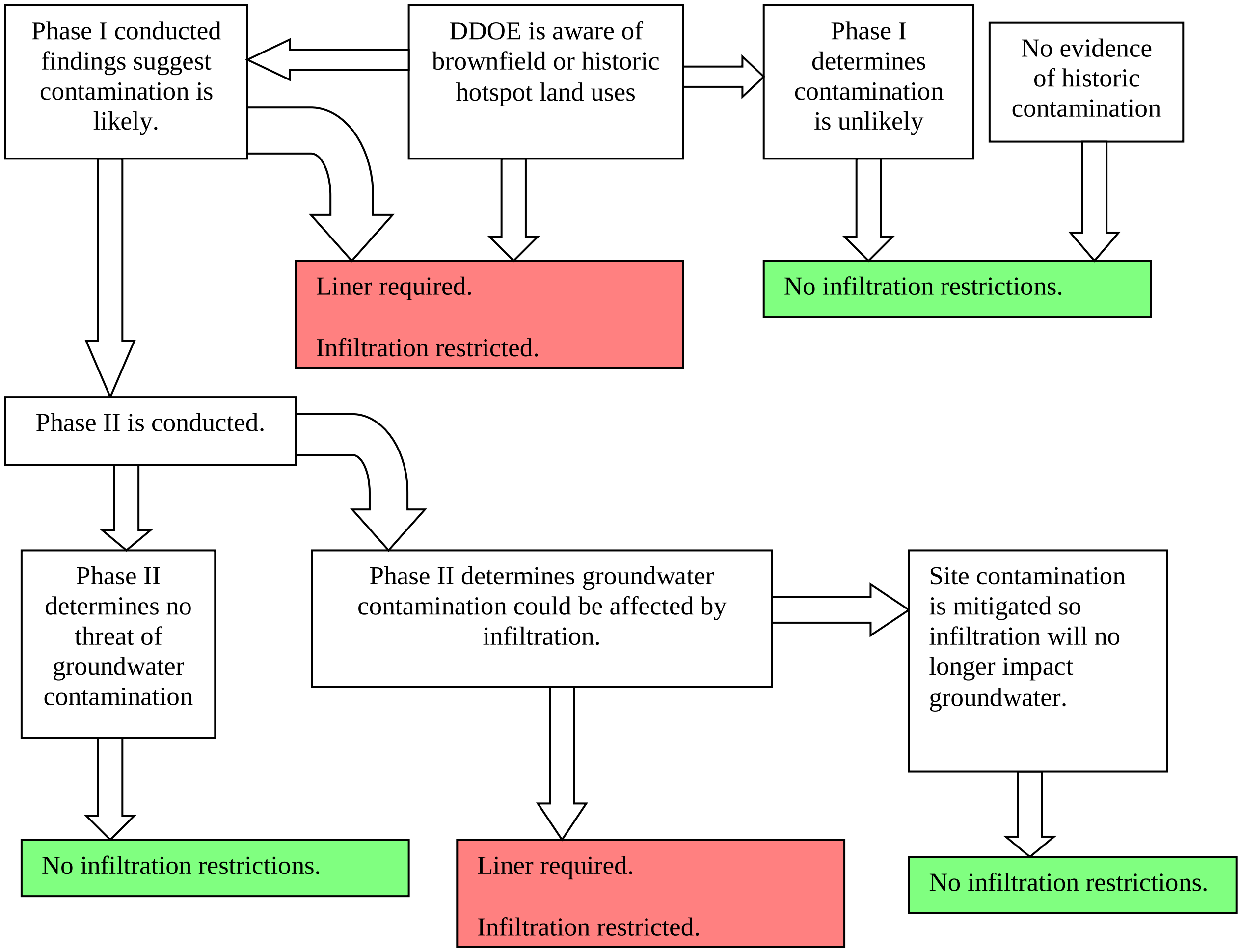
An infiltration test does not require ground water quality protection approval if

- the test is conducted to a depth of fifteen feet or less below the ground surface, and
- a Professional Engineer licensed in the District of Columbia certifies the infiltration rate and that the test was carried out in compliance with this guidance and accepted professional standards.

Note: If the infiltration testing procedure reveals smells or visual indications of soil or groundwater contamination then the boring or test hole must be filled in accordance with wellhead protection best practices, unless laboratory analysis determines groundwater or soil is not contaminated, as defined in the District of Columbia Brownfield Revitalization Act of 2000, as amended (D.C. Official Code §§ 8-631 et seq).

O.5 Infiltration Restrictions

If a Phase I Environmental Site Assessment determines that site contamination is likely, or if DDOE is aware of the presence of a brownfield or historic hotspot uses, such as current or previously existing leaking underground storage tanks (LUSTs), gas stations, or asphalt plants, an impermeable liner must be used for BMPs, and infiltration is restricted. If a Phase II Environmental Site Assessment is performed, and a qualified professional determines that the use of infiltration-based practices will not increase the likelihood of groundwater contamination, infiltration is not restricted. If there is no evidence of a history of contamination, impermeable liners are not required, and infiltration is not restricted.



Phase I conducted findings suggest contamination is likely.
DDOE is aware of brownfield or historic hotspot land uses
Phase I determines contamination is unlikely
No evidence of historic contamination
Liner required.
Infiltration restricted.
No infiltration restrictions.
Phase II is conducted.
Phase II determines no threat of groundwater contamination
Phase II determines groundwater contamination could be affected by infiltration.
Site contamination is mitigated so infiltration will no longer impact groundwater.
No infiltration restrictions.
Liner required.
Infiltration restricted.
No infiltration restrictions.

Appendix P Stormwater Hotspots

P.1 Stormwater Hotspots

Stormwater hotspots are defined as commercial, industrial, institutional, municipal, or transport-related operations that produce higher levels of stormwater pollutants, and/or present a higher potential risk for spills, leaks or illicit discharges. The following operations are classified as stormwater hotspots operations in the District of Columbia:

H-1 Vehicle Maintenance and Repair

H-2 Vehicle Fueling

H-3 Vehicle Washing

H-4 Vehicle Storage

H-5 Loading and Unloading

H-6 Outdoor or Bulk Material Storage

If any of the above operations are expected to occur on the proposed site for which a Stormwater Management Plan (SWMP) is required, the Stormwater Hotspot Cover Sheet must be completed. Further, if a Construction General Permit Stormwater Pollution Prevention Plan ($SWPPP_{CGP}$) was not required or the $SWPPP_{CGP}$ does not cover operational pollution prevention practices, then the *Stormwater Hotspot Checklist* must be submitted with the SWMP.

This appendix contains the following information:

- Stormwater Hotspot Cover Sheet
- Stormwater Hotspot Checklist
- Hotspot operation pollution prevention profile sheets for operations H-1 through H-6

P.2 Stormwater Hotspot Cover Sheet

GOVERNMENT OF THE DISTRICT OF COLUMBIA
District Department of the Environment
1200 First Street NE, Fifth Floor, Washington DC 20002

DISTRICT DEPARTMENT OF THE ENVIRONMENT green forward

Stormwater Hotspot Cover Sheet

Project Name: ______________________________

Applicant Name: ______________________________

Date: ______________

Please indicate the appropriate hotspot operations for your project (check all that apply). If none apply check N/A.

Hotspot Operations:

___ Vehicle Maintenance and Repair (H-1)

___ Vehicle Fueling (H-2)

___ Vehicle Washing (H-3)

___ Vehicle Storage (H-4)

___ Loading and Unloading (H-5)

___ Outdoor or Bulk Material Storage (H-6)

___ N/A

If "N/A" is checked, please include this sheet only with plan submittal.

Otherwise, please indicate which of the following items are being included with the submittal of the Stormwater management Plan (SWMP). ***Note: If a SWPPP$_{CGP}$ has not been completed or the SWPPP$_{CGP}$ does not cover operational pollution prevention practices, then the Stormwater Hotspot Checklist must be completed for the SWMPsubmittal to be considered complete.***

___ A completed Construction General Permit Stormwater Pollution Prevention Plan (SWPPP$_{CGP}$)

___ A completed ***Stormwater Hotspot Checklist***

P.3 Stormwater Hotspot Checklist

Stormwater Hotspot Checklist

Instructions: *Complete the following site information:*

	Requirement	***Description***
Site Description	List the type of facility and facility address	
Site Operations	Describe the operations to be conducted on-site.	
Receiving Waters	Name(s) of the receiving water(s). If drains to a municipal storm sewer system, include ultimate receiving waters.	
Site Materials	Significant materials to be stored on site (specify indoor or outdoor storage)	
Stormwater Management Practices	List the stormwater management practices being used to treat runoff from the site. Where appropriate, include description of design modifications appropriate for treatment of hotspot runoff (i.e., bioretention area with impermeable liner and underdrain)	
Spill Prevention and Response	Describe methods to prevent spills along with clean-up and notification procedures.	
Employee Education Program	Description of employee orientation and education program.	

Instructions: *Fill in the appropriate page number(s) from the site plans where the following site elements are clearly indicated.*

Site elements	**Site Plan Sheet Number(s)**	**Check if N/A**	**Approved (for official use only)**
Material loading and access areas			
Material storage and handling areas			
Cleaning and maintenance areas			
Vehicle or machinery storage areas			
Vehicle or machinery maintenance/service areas			
Treatment or disposal areas for significant materials			
Hazardous waste storage areas			
Areas of outdoor manufacturing			
Stormwater management calculations			
Drainage area outline for each stormwater inlet or structure			
Stormwater management practices			
Stormwater management maintenance inspection agreements			
Spill Prevention and Response Kits			
Facility inspection agreements for inspections of areas where potential spills of significant materials or industrial activities can impact stormwater			

For official use only:		
Date of Submission: _______________ ***Date Received:*** _______________	***Reviewed by:*** _________________ ***Reviewed on:*** _________________	***Plan Accepted:*** ***Y / N***

Instructions: *Complete this table only if operation H-1 was checked on Page Q.2.*

H-1 Vehicle Maintenance and Repair Operations			
Description of Operation			
Requirement	**Description of pollution prevention mechanism or BMP to be implemented**	**Site Plan Sheet Number(s)**	**Approved (for official use only)**
Provide locations for recycling collection of used antifreeze, oil, grease, oil filters, cleaning solutions, solvents, batteries, hydraulic and transmission fluids			
Cover all vehicle and equipment repair areas with a permanent roof of canopy.			
Connect outdoor vehicle storage areas to a separate stormwater collection system with an oil/grit separator or sand filter.			
Designate a specific location for outdoor maintenance activities that is designed to prevent stormwater pollution (paved, away from storm drains, and with stormwater containment measures)			
Stencil or mark storm drain inlets with "No Dumping, Drains to ______" message			

For official use only:		
Date of Submission: ______________ ***Date Received:*** ______________	***Reviewed by:*** ________________ ***Reviewed on:*** ________________	***Plan Accepted: Y / N***

Instructions: *Complete this table only if operation H-2 was checked on Page Q.2.*

H-2 Vehicle Fueling			
Description of Operation			
Requirement	**Description of pollution prevention mechanism or BMP to be implemented**	**Site Plan Sheet Number(s)**	**Approved (for official use only)**
Cover fueling stations with a canopy or roof to prevent direct contact with rainfall			
Design fueling pads to prevent the run-on of stormwater and pretreat any runoff with an oil/grit separator or a sand filter			
Locate storm drain inlets away from the immediate vicinity of the fueling area			
Stencil or mark storm drain inlets with "No Dumping, Drains to ______" message			
Pave fueling stations with concrete rather than asphalt			

For official use only:		
Date of Submission: ______________ ***Date Received:*** ______________	***Reviewed by:*** ________________ ***Reviewed on:*** ________________	***Plan Accepted: Y / N***

Instructions: *Complete this table only if operation H-3 was checked on Page F.2.*

H-3 Vehicle Washing			
Description of Operation			
Requirement	**Description of pollution prevention mechanism or BMP to be implemented**	**Site Plan Sheet Number(s)**	**Approved (for official use only)**
Include flow-restricted hose nozzles that automatically turn off when left unattended.			
a containment system for washing vehicles such that wash water does not flow into storm drain system.			
orm drain inlets with "No Dumping, Drains to ______" signs to deter disposal of wash water in the storm drain system			
Design facilities with designated areas for indoor vehicle washing where no other activities are performed (e.g., fluid changes or repair services)			

For official use only:		
Date of Submission: ______________ ***Date Received:*** ______________	***Reviewed by:*** ________________ ***Reviewed on:*** ________________	***Plan Accepted: Y / N***

Instructions: *Complete this table only if operation H-4 was checked on Page Q.2.*

H-4 Vehicle Storage			
Description of Operation			
Requirement	**Description of pollution prevention mechanism or BMP to be implemented**	**Site Plan Sheet Number(s)**	**Approved (for official use only)**
Label storm drain inlets with "No Dumping, Drains to ______" message			
All stormwater runoff from the fleet storage area must receive pretreatment via an oil/grit separator or sand filter.			
Untreated stormwater from the fleet storage area may not be discharged off site.			
Connect outdoor vehicle storage areas to a separate stormwater collection system with an oil/grit separator or sand filter.			

For official use only:		
Date of Submission: ______________ ***Date Received: ______________***	***Reviewed by: ________________*** ***Reviewed on: ________________***	***Plan Accepted: Y / N***

Instructions: *Complete this table only if operation H-5 was checked on Page Q.2.*

H-5 Loading and Unloading			
Description of Operation			
Requirement	**Description of pollution prevention mechanism or BMP to be implemented**	**Site Plan Sheet Number(s)**	**Approved (for official use only)**
Design liquid storage areas with impervious surfaces and secondary containment			
Minimize stormwater run-on by covering storage areas with a permanent canopy or roof			
Slope containment areas to a drain with a positive control (lock, valve, or plug) that leads to the sanitary sewer (if permitted) or to a holding tank			
Provide permanent cover for building materials stored outside			
Direct runoff away from building material storage areas			
Install a high-level alarm on storage tanks to prevent overfilling			

For official use only:		
Date of Submission: ______________ ***Date Received:*** ______________	***Reviewed by:*** ________________ ***Reviewed on:*** ________________	***Plan Accepted: Y / N***

Instructions: *Complete this table only if operation H-6 was checked on Page Q.2.*

H-6 Outdoor or Bulk Material Storage			
Description of Operation	(include methods of storage, usage, treatment, and disposal).		
Requirement	**Description of pollution prevention mechanism or BMP to be implemented**	**Site Plan Sheet Number(s)**	**Approved (for official use only)**
Grade the designated loading/unloading to prevent run-on or pooling of stormwater			
Cover the loading/unloading areas with a permanent canopy or roof			
Install an automatic shutoff valve to interrupt flow in the event of a liquid spill			
Install a high-level alarm on storage tanks to prevent overfilling			
Pave the loading/unloading area with concrete rather than asphalt			
Position roof downspouts to direct stormwater away from loading/unloading areas			

For official use only:		
Date of Submission: ______________ ***Date Received:*** ______________	***Reviewed by:*** ________________ ***Reviewed on:*** ________________	***Plan Accepted: Y / N***

P.4 Hotspot Operation Pollution Prevention Profile Sheets

The following profile sheets include:

H-1 Vehicle Maintenance and Repair

H-2 Vehicle Fueling

H-3 Vehicle Washing

H-4 Vehicle Storage

H-5 Loading and Unloading

H-6 Outdoor or Bulk Material Storage

H-1	**Hotspot Source Area: Vehicles** VEHICLE MAINTENANCE AND REPAIR	

Description

Vehicle maintenance and repair operations can exert a significant impact on water quality by generating toxins such as solvents, waste oil, antifreeze, and other fluids. Often, vehicles that are wrecked or awaiting repair can be a stormwater hotspot if leaking fluids are exposed to stormwater runoff (Figure 1). Vehicle maintenance and repair can generate oil and grease, trace metals, hydrocarbons, and other toxic organic compounds. Table 1 summarizes a series of simple pollution prevention techniques for vehicle maintenance and repair operations that can prevent stormwater contamination. You are encouraged to consult the Resources section of this sheet to get a more comprehensive review of pollution prevention practices for vehicle maintenance and repair operations.

Figure 1: Junkyard and Potential Source of Stormwater Pollution

Application

Pollution prevention practices should be applied to any facility that maintains or repairs vehicles in a subwatershed. Examples include car dealerships, body shops, service stations, quick lubes, school bus depots, trucking companies, and fleet maintenance operations at larger industrial, institutional, municipal or transport-related operations. Repair facilities are often clustered together, and are a major priority for subwatershed pollution prevention.

Table 1: Pollution Prevention Practices for Vehicle Maintenance and Repair Activities
▪ Avoid hosing down work or fueling areas
▪ Clean all spills immediately using dry cleaning techniques
▪ Collect used antifreeze, oil, grease, oil filters, cleaning solutions, solvents, batteries, hydraulic and transmission fluids and recycle with appropriate agencies
▪ Conduct all vehicle and equipment repairs indoors or under a cover (if done outdoors)
▪ Connect outdoor vehicle storage areas to a separate stormwater collection system with an oil/grit separator that discharges to a dead holding tank, the sanitary sewer or a stormwater treatment practice
▪ Designate a specific location for outdoor maintenance activities that is designed to prevent stormwater pollution (paved, away from storm drains, and with stormwater containment measures)
▪ Inspect the condition of all vehicles and equipment stored outdoors frequently
▪ Use a tarp, ground cloth, or drip pans beneath vehicles or equipment being repaired outdoors to capture all spills and drips
▪ Seal service bay concrete floors with an impervious material so cleanup can be done without using solvents. Do not wash service bays to outdoor storm drains
▪ Store cracked batteries in a covered secondary containment area until they can be disposed of properly
▪ Wash parts in a self-contained solvent sink rather than outdoors

Primary Training Targets
Owners, fleet operation managers, service managers, maintenance supervisors, mechanics and other employees are key targets for training.

Feasibility
Pollution prevention techniques for vehicle repair facilities broadly apply to all regions and climates. These techniques generally rely on changes to basic operating procedures, after an initial inspection of facility operations. The inspection relies on a standard operations checklist that can be completed in a few hours.

Implementation Considerations
Employee training is essential to successfully implement vehicle repair pollution prevention practices. The connection between the storm drain system and local streams should be emphasized so that employees understand why any fluids need to be properly disposed of. It is also important to understand the demographics of the work force; in some communities, it may require a multilingual education program.

Cost - Employee training is generally inexpensive, since training can be done using posters, pamphlets, or videos. Structural practices can vary based on what equipment is required. For instance, solvent sinks to clean parts can cost from $1,500 to $15,000, while spray cabinets may cost more than $50,000. In addition, proper recycling/disposal of used or spilled fluids usually requires outside contractors that may increase costs.

Resources
Stormwater Management Manual for Western Washington: Volume IV -- Source Control BMPs.
http://www.ecy.wa.gov/biblio/9914.html

California Stormwater Quality Association. 2003 California Stormwater BMP Handbook: Industrial and Commercial.
http://www.cabmphandbooks.com/

Coordinating Committee For Automotive Repair (CCAR) Source: US EPA CCAR-*Green*Link®, the National Automotive Environmental Compliance Assistance Center CCAR-*Green*Link® Virtual Shop
http://www.ccar-greenlink.org/

Auto Body Shops Pollution Prevention Guide. Peaks to Prairies Pollution Prevention Information Center.
http://peakstoprairies.org/p2bande/autobody/abguide/index.cfm

Massachusetts Office of Technical Assistance (OTA). Crash Course for Compliance and Pollution Prevention Toolbox
http://www.mass.gov/eea/grants-and-tech-assistance/education-and-training/education-and-outreach/ota-publications/guidance-docs/crash-course.html

Model Urban Runoff Program: A How-To Guide for Developing Urban Runoff Programs for Small Municipalities.
http://www.swrcb.ca.gov/water_issues/programs/stormwater/murp.shtml

US EPA. Facility Regulatory Tour: Vehicle Maintenance.https://www.fedcenter.gov/assistance/facilitytour/vehicle/

City of Santa Cruz. Best Management Practices for Vehicle Service Facilities (in English and Spanish).
http://www.cityofsantacruz.com/Modules/ShowDocument.aspx?documentid=5989

City of Los Angeles Bilingual Poster of BMPs for Auto Repair Industry
http://www.lastormwater.org/wp-content/files_mf/bmp_auto_poster_8.5x14.pdf

H-2	Hotspot Source Area: Vehicles	
	VEHICLE FUELING	

Description

Spills at vehicle fueling operations have the potential to directly contribute oil, grease, and gasoline to stormwater, and can be a significant source of lead, copper and zinc, and petroleum hydrocarbons. Delivery of pollutants to the storm drain can be sharply reduced by well-designed fueling areas and improved operational procedures. The risk of spills depends on whether the fueling area is covered and has secondary containment. The type, condition, and exposure of the fueling surface can also be important. Table 1 describes common pollution prevention practices for fueling operations.

Application

These practices can be applied to any facility that dispenses fuel. Examples include retail gas stations, bus depots, marinas, and fleet maintenance operations (Figure 1). In addition, these practices also apply to temporary above-ground fueling areas for construction and earthmoving equipment. Many fueling areas are usually present in urban subwatersheds, and they tend to be clustered along commercial and highway corridors. These hotspots are often a priority for subwatershed source control.

Figure 1: Covered Retail Gas Operation Without Containment for Potential

Table 1: Pollution Prevention Practices For Fueling Operation Areas
▪ Maintain an updated spill prevention and response plan on premises of all fueling facilities (see Profile Sheet H-7) ▪ Cover fueling stations with a canopy or roof to prevent direct contact with rainfall ▪ Design fueling pads for large mobile equipment to prevent the run-on of stormwater and collect any runoff in a dead-end sump ▪ Retrofit underground storage tanks with spill containment and overfill prevention systems ▪ Keep suitable cleanup materials on the premises to promptly clean up spills ▪ Install slotted inlets along the perimeter of the "downhill" side of fueling stations to collect fluids and connect the drain to a waste tank or stormwater treatment practice. The collection system should have a shutoff valve to contain a large fuel spill event ▪ Locate storm drain inlets away from the immediate vicinity of the fueling area ▪ Clean fuel-dispensing areas with dry cleanup methods. Never wash down areas before dry cleanup has been done. Ensure that wash water is collected and disposed of in the sanitary sewer system or approved stormwater treatment practice ▪ Pave fueling stations with concrete rather than asphalt ▪ Protect above ground fuel tanks using a containment berm with an impervious floor of Portland cement. The containment berm should have enough capacity to contain 110 percent of the total tank volume ▪ Use fuel-dispensing nozzles with automatic shutoffs, if allowed ▪ Consider installing a perimeter sand filter to capture and treat any runoff produced by the station

Primary Training Targets
Training efforts should be targeted to owners, operators, attendants, and petroleum wholesalers.

Feasibility
Vehicle fueling pollution prevention practices apply to all geographic and climatic regions. The practices are relatively low-cost, except for structural measures that are installed during new construction or station remodeling.

Implementation Considerations
Fueling Area Covers - Fueling areas can be covered by installing an overhanging roof or canopy. Covers prevent exposure to rainfall and are a desirable amenity for retail fueling station customers. The area of the fueling cover should exceed the area where fuel is dispensed. All downspouts draining the cover or roof should be routed to prevent discharge across the fueling area. If large equipment makes it difficult to install covers or roofs, fueling islands should be designed to prevent stormwater run-on through grading, and any runoff from the fueling area should be directed to a dead-end sump.

Surfaces - Fuel dispensing areas should be paved with concrete; the use of asphalt should be avoided, unless the surface is sealed with an impervious sealant. Concrete pads used in fuel dispensing areas should extend to the full length that the hose and nozzle assembly can be pulled, plus an additional foot.

Grading - Fuel dispensing areas should be graded with a slope that prevents ponding, and separated from the rest of the site by berms, dikes or other grade breaks that prevent run-on of urban runoff. The recommended grade for fuel dispensing areas is 2–4 percent (CSWQTF, 1997).

Cost - Costs to implement pollution prevention practices at fueling stations will vary, with many of the costs coming upfront during the design of a new fueling facility. Once a facility has implemented the, ongoing maintenance costs should be low.

Resources
Best Management Practice Guide – Retail Gasoline Outlets. Prepared by Retail Gasoline Outlet Work Group. http://www.waterboards.ca.gov/rwqcb4/water_issues/programs/stormwater/municipal/los_angeles_ms4/tentative/rgo%20bmp%20guide_03-97_.pdf

Stormwater Management Manual for Western Washington: Volume IV -- Source Control BMPs. http://www.ecy.wa.gov/biblio/9914.html

California Stormwater Quality Association. 2003 California Stormwater BMP Handbook: New Development and Redevelopment. http://www.cabmphandbooks.com/

City of Los Angeles, CA Best Management Practices for Gas Stations http://www.lacitysan.org/watershed_protection/pdfs/gasstation.pdf

City of Dana Point Tips for the Automotive Industry http://www.danapoint.org/Modules/ShowDocument.aspx?documentid=3309

*Alachua County, FL Best Management Practices for Controlling Runoff from Gas Stations*http://www.alachuacounty.us/Depts/EPD/Documents/WaterResources/Gas%20Stations.pdf

California Stormwater Regional Control Board Retail Gasoline Outlets: New Development Design Standards For Mitigation Of Stormwater Impacts
http://www.waterboards.ca.gov/rwqcb4/water_issues/programs/stormwater/municipal/los_angeles_ms4/tentative/rgopaper.pdf

http://www.waterboards.ca.gov/rwqcb4/water_issues/programs/stormwater/municipal/los_angeles_ms4/tentative/rgopapersupplement_12-01_.pdf

Canadian Petroleum Products Institute Best Management Practices Stormwater Runoff from Petroleum Facilities
http://canadianfuels.ca/userfiles/file/CPPI%20-%20BMP%20Stormwater%20runoff%20-%20March-04.pdf

City of Monterey (CA). Posters of Gas Station BMPs.

Pinole County, CA Typical Stormwater Violations Observed in Auto Facilities and Recommended Best Management Practices (BMPs)
http://www.ci.pinole.ca.us/publicworks/downloads/AutoStormwater.pdf

H-3	Hotspot Source Area: Vehicles
	VEHICLE WASHING

Description
Vehicle washing pollution prevention practices apply to many commercial, industrial, institutional, municipal and transport-related operations. Vehicle wash water may contain sediments, phosphorus, metals, oil and grease, and other pollutants that can degrade water quality. When vehicles are washed on impervious surfaces such as parking lots or industrial areas, dirty wash water can contaminate stormwater that ends up in streams.

Application
Improved washing practices can be used at any facility that routinely washes vehicles. Examples include commercial car washes, bus depots, car dealerships, rental car companies, trucking companies, and fleet operations. In addition, washing dump trucks and other construction equipment can be a problem. Washing operations tend to be unevenly distributed within urban subwatersheds. Vehicle washing also occurs in neighborhoods, and techniques to keep wash water out of the storm drain system are discussed in the car washing profile sheet (N-11). Table 1 reviews some of the pollution prevention techniques available for hotspot vehicle washing operations.

Primary Training Targets
Owners, fleet managers, and employees of operations that include car washes are the primary training target.

Feasibility
Vehicle washing practices can be applied to all regions and climates. Vehicle washing tends to occur more frequently in summer months and in drier regions of the country. Sound vehicle washing practices are not always used at many sites because operators are reluctant to change traditional cleaning methods. In addition, the cost of specialized equipment to manage high volumes of wash water can be too expensive for small businesses.

Improved vehicle washing practices are relatively simple to implement and are very effective at preventing stormwater contamination. Training is essential to get owners and employees to adopt these practices, and should be designed to overcome cultural and social barriers to improved washing practices.

Table 1: Pollution Prevention Practices for Vehicle Washing
▪ Wash vehicles at indoor car washes that recycle, treat or convey wash water to the sanitary sewer system ▪ Use biodegradable, phosphate-free, water-based soaps ▪ Use flow-restricted hose nozzles that automatically turn off when left unattended ▪ Wash vehicles on a permeable surface or a washpad that has a containment system ▪ Prohibit discharge of wash water into the storm drain system or ground by using temporary berms, storm drain covers, drain plugs or other containment system ▪ Label storm drains with "No Dumping" signs to deter disposal of wash water in the storm drain system ▪ Pressure and steam clean off site to avoid runoff with high pollutant concentrations ▪ Obtain permission from sewage treatment facilities to discharge to the sanitary sewer

Implementation Considerations
The ideal practice is to wash all vehicles at commercial car washes or indoor facilities that are specially designed for washing operations. Table 2 offers some tips for indoor car wash sites. When washing operations are conducted outside, a designated wash area should have the following characteristics:

- Paved with an impervious surface, such as Portland cement concrete
- Bermed to contain wash water
- Sloped so that wash water is collected and discharged to the sanitary sewer system, holding tank or dead-end sump
- Operated by trained workers to confine washing operations to the designated wash area

Table 2: Tips for Indoor Car Wash Sites *(Adapted from U.S. EPA, 2003)*
▪ Facilities should have designated areas for indoor vehicle washing where no other activities are performed (e.g., fluid changes or repair services)
▪ Indoor vehicle wash areas should have floor drains that receive only vehicle washing wastewater (not floor washdown or spill removal wash waters) and be connected to a holding tank with a gravity discharge pipe, to a sump that pumps to a holding tank, or to an oil/grit separator that discharges to a municipal sanitary sewer
▪ The floor of indoor vehicle wash bays should be completely bermed to collect wash water
▪ Aromatic and chlorinated hydrocarbon solvents should be eliminated from vehicle-washing operations
▪ Vehicle-washing operations should use vehicle rinse water to create new wash water through the use of recycling systems that filter and remove grit.

Outdoor vehicle washing facilities should use pressurized hoses without detergents to remove most dirt and grime. If detergents are used, they should be phosphate-free to reduce nutrient loading. If acids, bases, metal brighteners, or degreasing agents are used, wash water should be discharged to a treatment facility, sanitary sewer, or a sump. In addition, waters from the pressure washing of engines and vehicle undercarriages must be disposed of using the same options.

Discharge to pervious areas may be an option for washing operations that generate small amounts of relatively clean wash water (water only - no soaps, no steam cleaning). The clean wash water should be directed as sheet flow across a vegetated area to infiltrate or evaporate before it enters the storm drain system. This option should be exercised with caution, especially in environmentally sensitive areas or protected groundwater recharge areas.

The best way to avoid stormwater contamination during washing operations is to drain the wash water to the sanitary sewer system. Operations that produce high volumes of wash water should consider installing systems that connect to the sewer. Other options for large and small operations include containment units to capture the wash water prior to transport away for proper disposal (Figure 1). If vehicles must be washed on an impervious surface, a storm drain filter should be used to capture solid contaminants.

Cost - The cost of using vehicle-washing practices can vary greatly and depends on the size of the operation (Table 3). The cost of constructing a commercial grade system connected to the sanitary sewer can exceed $100,000. Disposal fees and frequency of washing can also influence the cost. Training costs can be minimized by using

Figure 1: Containment System Preventing Wash Water from Entering the Storm Drain

educational materials available from local governments, professional associations or EPA's National Compliance Assistance Centers (http://www.assistancecenters.net/). Temporary, portable containment systems can be shared by several companies that cannot afford specialized equipment independently.

Table 3: Sample Equipment Costs for Vehicle Washing Practices

Item	Cost
Bubble Buster	$2,000–$2,500*
Catch basin insert	$65*
Containment mat	$480–$5,840**
Storm drain cover (24-in. drain)	$120 **
Water dike/ berm (20 ft)	$100.00 **
Pump	$75–$3,000**
Wastewater storage container	$50–$1,000+**
*Source: *U.S. EPA, 1992 **Robinson, 2003*	

Resources

EPA FedSite Facility Regulatory Tour: http://www.fedcenter.gov/assistance/facilitytour/vehicle/washing/

Alachua County BMP for Outdoor Car Washing. http://www.alachuacounty.us/Depts/EPD/WaterResources/StormwaterPollutionAndSolutions/Reducing%20Stormwater%20Pollution%20Documents/Carwash%20BMP.pdf

Kitsap County Sound Car Wash Program. http://www.kitsapgov.com/sswm/carwash.htm.

Robinson, C., Proprietor, "Latimat" portable wastewater containment system. Personal Communication June 2, 2003. http://www.latimat.com

Washington Department of Ecology. 1995. Vehicle and Equipment Wash Water Discharges: Best Management Practices Manual. Olympia, Washington. http://www.ecy.wa.gov/pubs/95056.pdf

U.S. Environmental Protection Agency. Pollution Prevention/Good Housekeeping for Municipal Operations. http://cfpub2.epa.gov/npdes/stormwater/menuofbmps/poll_18.cfm

U.S. EPA. 1992. Storm Water Management for Industrial Activities: Developing Pollution Prevention Plans and Best Management Practices. US EPA Office of Wastewater Management. Washington, D.C. EPA 832-R-92-006.

California Stormwater Quality Association. 2003 California Stormwater BMP Handbook: Industrial and Commercial. http://www.cabmphandbooks.com/

<table>
<tr><td rowspan="2">H-4</td><td>Hotspot Source Area: Vehicles</td><td rowspan="2"></td></tr>
<tr><td>VEHICLE STORAGE</td></tr>
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Description
Parking lots and vehicle storage areas can introduce sediment, metals, oil and grease, and trash into stormwater runoff. Simple pavement sweeping, litter control, and stormwater treatment practices can minimize pollutant export from these hotspots. Table 1 provides a list of simple pollution prevention practices intended to prevent or reduce the discharge of pollutants from parking and vehicle storage areas.

Application
Pollution prevention practices can be used at larger parking lots located within a subwatershed. Examples include regional malls, stadium lots, big box retail, airport parking, car dealerships, rental car companies, trucking companies, and fleet operations (Figure 1). The largest, most heavily used parking lots with vehicles in the poorest condition (e.g., older cars or wrecked vehicles) should be targeted first.

This practice is also closely related to parking lot maintenance source controls, which are discussed in greater detail in profile sheet H-11.

Primary Training Targets
Owners, fleet operation managers, and property managers that maintain parking lots are key training targets.

Figure 1: Retail Parking Lot

Table 1: Pollution Prevention Practices for Parking Lot and Vehicle Storage Areas
Parking Lots ▪ Post signs to control litter and prevent patrons from changing automobile fluids in the parking lot (e.g., changing oil, adding transmission fluid, etc.) ▪ Pick up litter daily and provide trash receptacles to discourage littering ▪ Stencil or mark storm drain inlets with "No Dumping, Drains to _______" message ▪ Direct runoff to bioretention areas, vegetated swales, or sand filters ▪ Design landscape islands in parking areas to function as bioretention areas ▪ Disconnect rooftop drains that discharge to paved surfaces ▪ Use permeable pavement options for spillover parking (Profile sheet OS-11 in Manual 3) ▪ Inspect catch basins twice a year and remove accumulated sediments, as needed ▪ Vacuum or sweep large parking lots on a monthly basis, or more frequently ▪ Install parking lot retrofits such as bioretention, swales, infiltration trenches, and stormwater filters (Profile sheets OS-7 through OS-10 in Manual 3) *Vehicle Storage Areas* ▪ Do not store wrecked vehicles on lots unless runoff containment and treatment are provided ▪ Use drip pans or other spill containment measures for vehicles that will be parked for extended periods of time ▪ Use absorbent material to clean up automotive fluids from parking lots

Feasibility
Sweeping can be employed for parking lots that empty out on a regular basis. Mechanical sweepers can be used to remove small quantities of solids. Vacuum sweepers should be used on larger parking lot storage areas, since they are superior in picking up deposited pollutants (see Manual 9). Constraints for sweeping large parking lots include high annual costs, difficulty in controlling parking, and the inability of current sweeper technology to remove oil and grease. Proper disposal of swept materials might also represent a limitation.

Implementation Considerations
The design of parking lots and vehicle storage areas can greatly influence the ability to treat stormwater runoff. Many parking areas are landscaped with small vegetative areas between parking rows for aesthetic reasons or to create a visual pattern for traffic flow. These landscaped areas can be modified to provide stormwater treatment in the form of bioretention (Figure 2).

Figure 2: Parking Lot Island Turned Bioretention

Catch basin cleanouts are also an important practice in parking areas. Catch basins within the parking lot should be inspected at least twice a year and cleaned as necessary. Cleanouts can be done manually or by vacuum truck. The cleanout method selected depends on the number and size of the inlets present (see Manual 9).

Most communities have contractors that can be hired to clean out catch basins and vacuum sweep lots. Mechanical sweeping services are available, although the cost to purchase a new sweeper can exceed $200,000. Employee training regarding spill prevention for parking areas is generally low-cost and requires limited staff time.

Resources
California Stormwater Quality Association. 2003 California Stormwater BMP Handbook: Industrial and Commercial
http://www.cabmphandbooks.com/

Stormwater Management Manual for Western Washington: Volume IV -- Source Control BMPs. WA Dept. of Ecology
http://www.ecy.wa.gov/biblio/9914.html

H-5	Hotspot Source Area: Outdoor Materials	
	LOADING AND UNLOADING	

Description
Outdoor loading and unloading normally takes place on docks or terminals at many commercial, industrial, institutional, and municipal operations. Materials spilled or leaked during this process can either be carried away in stormwater runoff or washed off when the area is cleaned. As a result, many different pollutants can be introduced into the storm drain system, including sediment, nutrients, trash, organic material, trace metals, and an assortment of other pollutants. A number of simple and effective pollution prevention practices can be used at loading/unloading areas to prevent runoff contamination, as shown in Table 1.

Application
While nearly every commercial, industrial, institutional, municipal and transport-related site has a location where materials or products are shipped or received, the risk of stormwater pollution is greatest for operations that transfer high volumes of material or liquids, or unload potentially hazardous materials. Some notable examples to look for in a subwatershed include distribution centers, grocery stores, building supply outlets, lawn and garden centers, petroleum wholesalers, warehouses, landfills, ports, solid waste facilities, and maintenance depots (Figure 1). Attention should also be paid to industrial operations that process bulk materials and any operations regulated under industrial stormwater NPDES permits.

Primary Training Targets
Owners, site managers, facility engineers, supervisors, and employees of operations with loading/unloading facilities are the primary training target.

Table 1: Pollution Prevention Practices for Loading and Unloading Areas
▪ Avoid loading/unloading materials in the rain ▪ Close adjacent storm drains during loading/unloading operations ▪ Surround the loading/unloading area with berms or grading to prevent run-on or pooling of stormwater. If possible, cover the area with a canopy or roof ▪ Ensure that a trained employee is always present to handle and cleanup spills ▪ Inspect the integrity of all containers before loading/unloading ▪ Inspect equipment such as valves, pumps, flanges, and connections regularly for leaks, and repair as needed ▪ Install an automatic shutoff valve to interrupt flow in the event of a catastrophic liquid spill ▪ Install a high-level alarm on storage tanks to prevent overfilling ▪ Pave the loading/unloading area with concrete rather than asphalt ▪ Place drip pans or other temporary containment devices at locations where leaks or spills may occur, and always use pans when making and breaking connections ▪ Position roof downspouts to direct stormwater away from loading/unloading areas and into bioretention areas ▪ Prepare and implement an Emergency Spill Cleanup Plan for the facility (see Profile Sheet H-7) ▪ Sweep loading/unloading area surfaces frequently to remove material that could otherwise be washed off by stormwater ▪ Train all employees, especially fork lift operators, on basic pollution prevention practices and post signs ▪ Use seals, overhangs, or door skirts on docks and terminals to prevent contact with rainwater

Feasibility
Loading/unloading pollution prevention practices can be applied in all geographic and climatic regions, and work most effectively at preventing sediment, nutrients, toxic materials, and oil from coming into contact with stormwater runoff or runon. Few impediments exist to using this practice, except for the cost to retrofit existing loading and unloading areas with covers or secondary containment.

Implementation Considerations
Loading/unloading pollution prevention practices should be integrated into the overall stormwater pollution prevention plan for a facility. Employee training should focus on proper techniques to transfer materials, using informational signs at loading docks and material handling sites and during routine safety meetings.

Cost - Costs to implement loading/unloading pollution prevention practices consist of one-time construction costs to retrofit new or existing loading areas, but annual maintenance costs are relatively low thereafter. Exceptions include industries that elect to use expensive air pressure or vacuum systems for loading/unloading facilities, which can also be expensive to maintain (U.S. EPA, 1992). Ongoing costs include employee training and periodic monitoring of loading/unloading activities.

Figure 1: Loading/Unloading Area of Warehouse

Resources

California Stormwater Quality Association. 2003 California Stormwater BMP Handbook: Industrial and Commercial. http://www.cabmphandbooks.com/

Stormwater Management Manual for Western Washington: Volume IV -- Source Control BMPs. WA Dept. of Ecology 99-14 http://www.ecy.wa.gov/biblio/9914.html

Ventura County Flood Control District Clean Business Program Fact Sheet

http://www.vcstormwater.org/index.php/clean-business-fact-sheets

Business Best Management Practices Stormwater Bmp #3 - Shipping/Receiving/Loading Docks

City of Los Angeles, CA Reference Guide For Stormwater Best Management Practices http://www.lacitysan.org/watershed_protection/pdfs/bmp_refguide.pdf

H-6	Hotspot Source Area: Outdoor Materials	
	OUTDOOR STORAGE	

Description

Protecting outdoor storage areas is a simple and effective pollution prevention practice for many commercial, industrial, institutional, municipal, and transport-related operations. The underlying concept is to prevent runoff contamination by avoiding contact between outdoor materials and rainfall (or runoff). Unprotected outdoor storage areas can generate a wide range of stormwater pollutants, such as sediment, nutrients, toxic materials, and oil and grease (Figure 1).

Materials can be protected by installing covers, secondary containment, and other structures to prevent accidental release. Outdoor storage areas can be protected on a temporary basis (tarps or plastic sheeting) or permanently through structural containment measures (such as roofs, buildings, or concrete berms). Table 1 summarizes pollution prevention practices available for outdoor storage areas.

Figure 1: Mulch Stored Outdoors at a Garden Center

Application

Many businesses store materials or products outdoors. The risk of stormwater pollution is greatest for operations that store large quantities of liquids or bulk materials at sites that are connected to the storm drain system. Several notable operations include nurseries and garden centers, boat building/repair, auto recyclers/body shops, building supply outlets, landfills, ports, recycling centers, solid waste and composting facilities, highway maintenance depots, and power plants. Attention should also be paid to industrial operations that process bulk materials, which are often regulated under industrial stormwater NPDES permits.

Primary Training Targets

Owners, site managers, facility engineers, supervisors, and employees of operations with loading/unloading facilities are the primary training target.

Feasibility

Outdoor storage protection can be widely applied in all regions and climate zones, and requires routine monitoring by employees. Most operations have used covering as the major practice to handle outdoor storage protection (U.S. EPA, 1999). The strategy is to design and maintain outdoor material storage areas so that they:

- Reduce exposure to stormwater and prevent runon
- Use secondary containment to capture spills
- Can be regularly inspected
- Have an adequate spill response plan and cleanup equipment

Table 1: Pollution Prevention Practices for Protecting Outdoor Storage Areas
• Emphasize employee education regarding storage area maintenance • Keep an up-to-date inventory of materials stored outdoors, and try to minimize them • Store liquids in designated areas on an impervious surface with secondary containment • Inspect outdoor storage containers regularly to ensure that they are in good condition • Minimize stormwater run-on by enclosing storage areas or building a berm around them • Slope containment areas to a drain with a positive control (lock, valve, or plug) that leads to the sanitary sewer (if permitted) or to a holding tank • Schedule regular pumping of holding tanks containing stormwater collected from secondary containment areas

Implementation Considerations

Covers - The use of impermeable covers is an effective pollution prevention practice for non-hazardous materials. Covers can be as simple as plastic sheeting or tarps, or more elaborate roofs and canopies. Site layout, available space, affordability, and compatibility with the covered material all dictate the type of cover needed for a site. In addition, the cover should be compatible with local fire and building codes and OSHA workplace safety standards. Care should be taken to ensure that the cover fully protects the storage site and is firmly anchored into place.

Secondary Containment - Secondary containment is designed to contain possible spills of liquids and prevent stormwater run-on from entering outdoor storage areas. Secondary containment structures vary in design, ranging from berms and drum holding areas to specially designed solvent storage rooms (Figure 2).

Secondary containment can be constructed from a variety of materials, such as concrete curbs, earthen berms, plastic tubs, or fiberglass or metal containers. The type of material used depends on the substance contained and its resistance to weathering. In general, secondary containment areas should be sized to hold 110 percent of the volume of the storage tank or container unless other containment sizing regulations apply (e.g., fire codes).

Figure 2: Secondary Containment of Storage Drums Behind a Car Repair Shop

If secondary containment areas are uncovered, any water that accumulates must be collected in a sanitary sewer, a stormwater treatment system, or a licensed disposal facility. Water quality monitoring may be needed to determine whether the water is contaminated and dictate the method of disposal. If the stormwater is clean, or an on-site stormwater treatment practice is used, a valve should be installed in the containment dike so that excess stormwater can be drained out of the storage area and directed either to the storm drain (if clean) or into the stormwater treatment system (if contaminated). The valve should always be kept closed except when stormwater is drained, so that any spills that occur can be effectively contained. Local sewer authorities may not allow discharges from a large containment area into the sewer system, and permission must be obtained

Table 2: Sample Equipment Costs for Outdoor Storage Protection	
Storage Protection Device	**Cost**
Concrete Slab (6”)	\$3.50 to \$5.00 per ft^2
Containment Pallets	\$50 to \$350 based on size and # of barrels to be stored
Storage buildings	\$6 to \$11 per ft^2
Tarps & Canopies	\$25 to \$500 depending on size of area to cover
Sources: Costs were derived from a review of Ferguson et al., *1997 and numerous websites that handle proprietary spill control or hazardous material control products*	

sanitary sewer system are prohibited, containment should be provided, such as a holding tank that is regularly pumped out.

Employee training on outdoor storage pollution prevention should focus on the activities and site areas with the potential to pollute stormwater and the proper techniques to manage material storage areas to prevent runoff contamination. Training can be conducted through safety meetings and the posting of on-site informational signs. Employees should also know the on-site person who is trained in spill response.

Cost - Many storage protection practices are relatively inexpensive to install (Table 2). Actual costs depend on the size of the storage area and the nature of the pollution prevention practices. Other factors are whether practices are temporary or permanent and the type of materials used for covers and containment. Employee training can be done in connection with other safety training to reduce program costs. Training costs can also be reduced by using existing educational materials from local governments, professional associations or from EPA’s National Compliance Assistance Centers (http://www.assistancecenters.net).

Resources

California Stormwater Quality Association. 2003 California Stormwater BMP Handbook: Industrial and Commercial. http://www.cabmphandbooks.com/

Rouge River National Wet Weather Demonstration Project. Wayne County, MI. http://www.rougeriver.com/proddata/catalog7ad4.html?category=overview#PI-PAPER-01.00

Storm Water Management Fact Sheet: Coverings. USEPA, Office of Water, http://water.epa.gov/scitech/wastetech/upload/2002_06_28_mtb_covs.pdf

EPA Office of Wastewater Management Storm Water Management Fact Sheet: Coverings http://www.epa.gov/owm/mtb/covs.pdf

Ferguson, T., R. Gigac, M. Stoffan, A. Ibrahim, and H. Aldrich. 1997. Rouge River National Wet Weather Demonstration Project. Wayne County, MI.

California Stormwater Quality Association Factsheet: Outdoor Storage of Raw Materials http://www.cabmphandbooks.com/Documents/Municipal/SC-33.pdf

Alameda Countywide Clean Water Program Outdoor Storage of Liquid Materials http://www.cityofalamedaca.org/getdoc.cfm?id=123

Washtenaw County, MI Community Partners for Clean Streams Fact Sheet Series #1: Housekeeping Practices http://www.ewashtenaw.org/government/drain_commissioner/dc_webWaterQuality/dc_cpcs/cpcs-handbook/cpcs-series-1-housekeeping-practices.pd

Appendix Q Pollution Prevention Through Good Housekeeping

Q.1 Pollution Prevention

This appendix is meant to complement Appendix P Stormwater Hotspots and an Erosion and Sediment Control Plan (ESCP), but not reiterate EPA's Construction General Permit requirements. These notes shall appear as stamped notes on Stormwater Management Plans (SWMPs) where land disturbance is greater than 5,000 square feet and less than one acre. These notes shall constitute a minimum Stormwater Pollution Prevention Plan ($SWPPP_{min}$) and provide guidance on good housekeeping practices to prevent potential construction-site pollutants from interacting with stormwater.

Q.2 Stormwater Management Plan (SWMP) Good Housekeeping Stamp Notes

Fuels and Oils. On-site refueling will be conducted in a dedicated location away from access to surface waters. Install containment berms and, or secondary containments around refueling areas and storage tanks. Spills will be cleaned up immediately and contaminated soils disposed of in accordance with all federal and District of Columbia regulations. Petroleum products will be stored in clearly labeled tightly sealed containers. All vehicles on site will be monitored for leaks and receive regular preventive maintenance activities. Any asphalt substances used on site will be applied according to manufacturer's recommendations. Spill kits will be included with all fueling sources and maintenance activities.

Solid Waste. No solid materials shall be discharged to surface water. Solid materials including building materials, garbage and paint debris shall be cleaned up daily and deposited into dumpsters, which will be periodically removed and deposited into a landfill.

Abrasive Blasting. Water blasting, sandblasting, and other forms of abrasive blasting on painted surfaces built prior to 1978 may only be performed if an effective containment system prevents dispersal of paint debris.

Fertilizer. Fertilizers will be applied only in the minimum amounts recommended by the manufacturer, worked into the soil to limit exposure to stormwater, and stored in a covered shed. Partially used bags will be transferred to a sealable bin to avoid spills.

Paint and Other Chemicals. All paint containers and curing compounds will be tightly sealed and stored when not required for use. Excess paint will not be discharges to the storm sewers, but will be properly disposed of according to manufacturer's recommendations. Spray guns will be cleaned on a removable tarp. Chemicals used on site are kept in small quantities and in closed containers undercover and kept out of direct contact with stormwater. As with fuels and oils, any inadvertent spills will be cleaned up immediately and disposed of according federal and District of Columbia regulations.

Concrete. Concrete trucks will not be allowed to wash out or discharge surplus concrete or drum wash on site, except in a specially designated concrete disposal area. Form release oil for decorative stone work will be applied over a pallet covered with an absorbent material to collect excess fluid. The absorbent material will be replaced and disposed of properly when saturated.

Water Testing. When testing and, or cleaning water supply lines, the discharge from the tested pipe will be collected and conveyed to a completed stormwater conveyance system for ultimate discharge into a stormwater best management practice (BMP).

Sanitary Waste. Portable lavatories located on site will be services on a regular basis by a contractor. Portable lavatories will be located in an upland area away from direct contact with surface waters. Any spills occurring during servicing will be cleaned immediately and contaminated soils disposed of in accordance with all federal and District of Columbia regulations.

Appendix R Integrated Pest Management

R.1 Integrated Pest Management

This appendix is in support of the District of Columbia's legislation B19-745, The Anacostia Waterfront Environmental Standards Amendment Act of 2012. This legislation requires regulated projects in the AWDZ governed by this legislation to receive a DDOE approved Integrated Pest Management Plan

Integrated Pest Management (IPM) is an approach that applies biological, cultural, mechanical, and chemical controls to manage pests at acceptable levels. The following are general guidelines to encourage more-considered use of fertilizers, herbicides, and pesticides.

R.2 Components of an Integrated Pest Management Plan

1. Identification. Identify the Pest and Understand its Life Cycle. Correctly identify the pest to determine an appropriate control strategy. For assistance with pest identification, contact the Maryland Home & Garden Information Center at Maryland Cooperative Extension.
2. When to take Action. Insects are an integral part of the local ecology and thus their presence alone should not be reason for taking action. First, monitor pest numbers and determine if preventative maintenance measures can be employed to remediate the situation. Take action when alternative preventative methods are no longer feasible and when pest activity threatens the long-term health of the plant.
3. Prevention in Design,
   (a) Choose the right plant for the right location.
   (b) This means assessing species suitability to site soils, moisture, wind, and sun exposure. Well-selected species require less maintenance.
   (c) Select plant species and cultivars resistant to disease.
   (d) Select a diverse plant palate to ensure on-going survival of remaining plant material.
   (e) Inspect delivered plant material prior to installation.
   (f) Material delivered from the nursery may carry pathogens or insects. Inspect all plant material at the nursery and again prior to installation. Reject any material that is diseased.
4. Prevention in Maintenance and Construction. Proper cultural management practices can reduce plant stress and thus decrease their susceptibility to pests. Prior to applying pesticide or herbicides, consider your current landscape management practices. Soils are the foundation for healthy plants. As such, it is important to provide: the proper moisture, fertility, organic matter, and drainage.
   (a) Soil testing. Submit a soil sample to a soil testing laboratory for analysis. The results determine the appropriate soil amendments to be applied.

(b) Fertilizers. Organic fertilizers are derived natural sources such as: cottonseed meal, blood meal, fish emulsion, and manure. Slow-release inorganic fertilizers supply nutrients over the growing season with less nutrient loss than quick-release fertilizers. Fertilizer grade and rate should be selected and applied only as test results indicate. Do not apply fertilizer prior to a heavy rainfall event and do not apply between December and February.

(c) Trees and shrubs. Place mulch underneath the root zone of trees and shrubs to reduce competition with turf and weeds for water and nutrients. Topdress planting beds with compost to improve soil structure, biological activity, and fertility.

(d) Lawn areas. Increased mowing height can reduce weed germination, as less sunlight reaches the soil level. Topdressing with organic matter increases soil moisture and enables turf to withstand drought conditions. Regular monitoring and over-seeding of bare spots prevents weed establishment. After mowing, grass clippings should be left in-place. These above-mentioned strategies will reduce symptoms of disease and weed pressure, thus decreasing herbicide and fertilizer usage.

5. Develop a Treatment Plan. When pest activity exceeds acceptable levels, choose a control method appropriate to observed conditions. This may include biological, cultural, mechanical, and chemical controls.

(a) Biological control. Uses the introduction of a predator. Introduce additional natural predators where existing populations are too few to effectively control pests. Consult with your local Cooperative Extension office.

(b) Cultural control. Use pruning and removal of Prune and remove diseased branches. Sanitize all tools after use. Properly amend soils and irrigate plantings as necessary.

(c) Mechanical control. Conduct weeding by hand, tool, or heat solarization. Remove insect pests by hand or using traps.

(d) Chemical control. Uses non-toxic, non-residual pesticide or herbicide products where necessary.

- Narrow-spectrum contact pesticides target the pest directly and preserve beneficial predator species. Broad-spectrum pesticides also eliminate beneficial predators and thus the natural controls on pest populations. Only certified individuals can apply restricted-use pesticides.
- Insecticidal soap and horticultural oils. Insecticidal soaps are used to penetrate the insect’s outer covering, causing the cells to collapse. Horticultural oils, on the other hand, coat and suffocate the offending insect.
- Application timing is used to maximize effectiveness, apply pesticides at the appropriate life cycle for the pest. Herbicide application also requires consideration for the seasonal growth pattern for the targeted weed.

R.3 Sample Form for an Integrated Pest Management Plan

GOVERNMENT OF THE DISTRICT OF COLUMBIA

DISTRICT DEPARTMENT OF THE ENVIRONMENT

WATERSHED PROTECTION DIVISION

INSPECTION AND ENFORCEMENT BRANCH

Integrated Pest Management Plan

This document/submission will serve as your IPM plan. **It must be printed and distributed to the owner of the property and to any person or company who is given responsibility for on-site pest management, landscaping, or facility maintenance (i.e. homeowners, property managers, maintenance companies).** Per the Stormwater Management Plan that this IPM plan supports, the owner of the property and their agents are legally required to comply with this plan.

Integrated pest management (IPM) is a continuous system of controlling pests (weeds, diseases, insects or others) in which pests are identified, action thresholds are considered, all possible control options are evaluated and selected control(s) are implemented. Control options which include biological, cultural, manual, mechanical and chemical methods are used to prevent or remedy unacceptable pest activity or damage. Choice of control option(s) is based on effectiveness, environmental impact, site characteristics, worker/public health and safety, and economics. IPM takes advantage of all appropriate pest management options.

PROJECT INFORMATION

Project Name

Street Number:

Street Name

Zip Code

Email Address:

Project Developer Information (Name & Title):

Contact

Company

Address

Phone

Fax

JUSTIFICATION FOR IPM PLAN

Ordinance Requirement

Yes No

○ ○ This development is a publically owned, privately developed property within the boundaries of the Anacostia Watershed Development Zone

○ ○ The property requires a Certificate of Occupancy and falls within the regulations of Green Area Ratio.

1

Figure R.1 Sample form for an Integrated Pest Management Plan.

Environmental Criteria Manual requirement
(If site has existing or planned LID stormwater management structures, please refer to the DDOE Stormwater Guidebook for maintenance requirements)

Critical Environmental Features and Buffers (List any that exist - must be shown on the site plan)

Yes	No	
○	○	Streambank
○	○	Wetland
Other		☐

ANTICIPATED LANDSCAPE PESTS and SOLUTIONS
The Maryland Home and Garden Information Center offers regionally appropriate guidelines for preventative landscape maintenance and control of landscape pests. Refer to the following guidelines in the **Maryland Home & Garden Information Center**: http://extension.umd.edu/hgic.

Check all boxes to indicate you have read the guidelines in the Maryland Home & Garden Information Center website.

- ☐ Insects
- ☐ Invasives
- ☐ Lawns
- ☐ Plant Diagnostics
- ☐ Soils
- ☐ Trees & Shrubs
- ☐ Weeds

ADDITIONAL IPM SUBMITTAL REQUIREMENTS – SITES WITH GREEN AREA RATIO OBLIGATION
Where applicable to Green Area Ratio requirements, submit the IPM plan within Green Area Ratio drawings for review by DDOE. Include the following in your submitted plans:

- Seasonal schedule of all landscape management activities for the below categories.
- A paragraph for each category describing: materials, methods, preventative maintenance, and pest management practices as applies to each CATEGORY listed below. To protect our water resources, you are required to start with the least toxic options before using chemical treatment applications.

  CATEGORIES required for submittal in IPM plan:
  - Soil preparation
  - Use of compost
  - Plant replacement
  - Irrigation
  - Weed control
  - Insect/disease control
  - Control of noxious or invasive species

2

FigureR.1 (continued)

MAINTENANCE DOCUMENTATION

The property owner will maintain records of all Service Provider visits and pest control treatments for at least three (3) years. Information regarding pest management activities will be made available to the public at the property owner's administrative office. Requests to be notified of pesticide applications may also be made to this office. All guardians will be informed of their option to receive notification of all pesticide applications at enrollment and once annually.

Maintain the following records for all pesticide, herbicide, and fertilizer application.

- For pesticide and herbicide application:
    - Target pest and description of infestation severity
    - Prevention activities and non-chemical methods applied prior to chemical control
    - Type and quantity of pest/weed control used
    - Location of pesticide or herbicide application
    - Date of treatment application
    - Name and certification number of pesticide applicator
    - Application equipment used
    - Summary of results
- For fertilizer application:
    - Landscape type (lawn, ornamental planting beds, trees, other)
    - Location of fertilizer application within site
    - Soil report from lab with nutrient analysis and application recommendations
    - Fertilizer product description, including: product name, grade
    - Application rate (lb/1000 ft^2)
    - Date of fertilizer application
    - Name of individual applicator and associated landscape business
    - Summary of results

PROGRAM OUTREACH TO PROPERTY OWNER

☐ Developer agrees to inform the owner(s) of the property that they are required to apply less-toxic, non-chemical pest management options as described by the Maryland Home & Garden Information Center. IPM guidelines can be found at http://extension.umd.edu/hgic.

☐ As the person preparing the IPM Plan, I am aware that this IPM plan is required to be filed as an exhibit in the declaration of covenants. If this is a government property where covenants are not filed then this IPM plan must be an element included in the projects SWMP maintenance partnership agreement or memorandum of understanding. These are legal instruments requiring the use of IPM on this site.

By checking all boxes, I certify that I have read the requirements listed here and agree to carry out an Integrated Pest Management strategy for the above-listed property

Signature ____________________________ Date: ___________________________

3

FigureR.1 (continued)

Appendix S Proprietary Practices Approval Process

S.1 Proprietary Practice Consideration Overview

This appendix provides details on the DDOE approval process for the use of a proprietary stormwater best management practice (BMP). If a proposed BMP is not listed in Chapter 3 of the DDOE Stormwater Management Guidebook, or deviates significantly from the specifications listed in this Guidebook, an application with or prior certified approvals sufficient to demonstrate compliance with the stormwater performance standards of the District's stormwater program must be submitted to DDOE. To differentiate between a traditional stormwater BMP, a proprietary practice, or manufactured BMP, the term Manufactured Treatment Device (MTD) will be utilized for the class of practices that require an approval from DDOE.

DDOE recognizes the value of innovative stormwater pollutant removal technologies, especially in the ultra-urban landscape of the District, where available site area is limited and often constrained by utilities and other factors. However, DDOE also acknowledges that the resources required to develop and implement a testing program for the purposes of evaluating the performance of new MTDs are beyond the current capacity of DDOE's Stormwater Management Division. Further, DDOE recognizes that there are other state and potentially national programs being developed to provide for this testing. Therefore, until such time that DDOE develops a MTD performance testing and verification program, DDOE will accept performance testing and compliance with the New Jersey Department of Environmental Protection's (NJDEP) Protocol for Total Suspended Solids Removal as outlined in this Appendix.

S.2 Types of Manufactured Treatment Devices

There are numerous MTDs currently available. The various configurations and stormwater treatment objectives represented by this general category of stormwater BMPs will continue to evolve and expand along with stormwater regulations and land development trends. It is not expected that a standard categorization of MTDs here can accommodate this growing industry. However, in order to best address the current regulations and foreseeable regulatory framework, the following represents the types of MTDs and performance goals that will be considered by DDOE's stormwater program:

- **Hydrodynamic Treatment Devices.** The term "hydrodynamic" has been used to describe a family of MTDs that rely on a wet chamber or manhole to encourage gravity separation or dynamic settling of solids during flow conditions (as opposed to quiescent settling within vaults or chambers sized comparably to wet ponds). In most cases the total area of the wet chamber has been reduced through the application of dynamic settling, or vortex (as borrowed from technology applied to remove coarse solids from combined sewer overflows). The term "hydrodynamic" has therefore been loosely applied to the entire category of practices that are designed to achieve physical settling within a small treatment area, with or without a vortex component. DDOE considers these practices to be applicable as pretreatment devices to be placed in series upstream of a primary (filtering) MTD or a retention or pollutant removal practice included in Chapter 3 of this Guidebook. Pretreatment is typically an essential element of the primary BMP's performance and designed maintenance interval and therefore no additional retention or pollutant removal credit is awarded.

- **Filtering Treatment Devices.** A broad category of MTDs utilize a filter media contained within an engineered structure. In some cases, the filter media itself may be the proprietary product, while others may also include the media container (cartridges, tubes, etc.), and/or the overall structure geometry and hydraulic components as the proprietary product. When necessary, DDOE will determine if the design, sizing, filter media, or other characteristics deviate significantly from the specifications listed in this Guidebook and therefore requires an approval.
- **Retention Devices.** The current category of retention devices is limited to storage chambers, vaults, perforated pipes, and other forms of supplemental storage volume. These devices generally serve to supplement a primary retention practice such as infiltration, bioretention, etc., by providing additional storage within or adjacent to the practice. Alternatively, these devices may also supplement a pollutant removal practice by creating additional runoff storage volume. In either case, the devices are not considered treatment MTDs. Rather, these storage elements allow the primary BMP to capture and retain or treat a larger volume of runoff and are therefore considered part of the primary BMP, and not an additional treatment mechanism. Therefore, no additional pollutant removal is credited.

S.3 Proprietary Practice Approval Process – Background

DDOE has reviewed different testing protocols and state sponsored MTD performance verification programs. In general, the evaluation and approval of MTD performance has traditionally been based on a combination of field monitoring and a rigorous review of the resulting data. While the consensus is that there is no substitute for field monitoring through the seasonal variations in rainfall, pollutant loading, temperature, and other factors to evaluate the performance of a stormwater BMP, there is anecdotal evidence that these studies can take a long time, be very expensive, and in some cases, be inconclusive.

The process and experience in New Jersey was derived from a multi-state testing protocol and reciprocity agreement: The Technology Acceptance Reciprocity Partnership (TARP 2003). TARP refers to a testing protocol that outlines the standard methods and procedures to be employed when testing a stormwater MTD. The concept was based on the belief that if a manufacturer followed the TARP protocol to test the MTD, then the data would be acceptable to all the partner states. The New Jersey Department of Environmental Protection (NJDEP), in partnership with the New Jersey Corporation for Advanced Technology (NJCAT), is a TARP member state that has developed a formal evaluation and acceptance process for MTDs. Unfortunately, the "reciprocity" element of the process did not evolve primarily due to the different partner states having established different treatment objectives and performance goals. The New Jersey program established TSS as the treatment objective, while other states included nutrients or other parameters in addition to TSS.

The MTD performance certification program in New Jersey, implemented by NJDEP and NJCAT, provides a continuous evaluation of the effectiveness of the testing and verification protocol and, in an effort to establish a more reliable and consistent process, are currently transitioning to a prescriptive laboratory testing protocol. The laboratory testing of filter products may be supplemented by optional field testing to demonstrate system longevity and corresponding expected maintenance intervals.

The new protocol, entitled “New Jersey Department of Environmental Protection Process for Approval of Use for Manufactured Treatment Devices January 25, 2013” (NJDEP 2013a), requires that MTD’s obtain Verification through NJCAT. The NJCAT Verification process, entitled “Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology January 25, 2013” (NJCAT 2013), and the NJDEP protocol can be found on NJDEP’s website, http://www.njstormwater.org/treatment.html.

The new protocol includes a formal transition process that recognizes existing MTD certification and allows sufficient time for recertification under the new protocol. In addition, the new NJ protocol remains consistent with the DDOE stormwater program’s treatment objectives (TSS) and performance goals (80 percent reduction). To allow for the use of effective MTDs in the District immediately and include an opportunity to transition to a more reliable and consistent testing protocol, DDOE will accept the existing NJDEP certifications, and implement the same expiration schedule of those existing certifications and accompanying verification/certification renewal as required by NJDEP’s new protocol. DDOE will apply the District’s SWRv treatment requirements (1.2-inch rainfall, or when over-treating, up to 1.7-inch rainfall) to the specific MTD unit sizing formula as verified and certified by NJCAT and NJDEP, respectively.

S.4 MTD Current Approval Status

DDOE will accept MTDs for use in the District that have a current NJDEP verification/certification as conditioned upon those items referenced in Transition for Manufactured Treatment Devices dated July 15, 2011 (NJDEP 2011) as follows:

- All MTDs that have a MTD Laboratory Test Certification for 80 percent TSS removal will be approved for use by DDOE until the NJDEP published certification expiration date (determined in conjunction with NJDEP’s January 25, 2013 adoption of the new testing protocols; NJDEP 2013b);
- All MTD’s that have a MTD Laboratory Test Certification for 50 percent TSS removal will be approved for use by DDOE for pretreatment upstream of MTDs and, on a case by case basis, upstream of applicable practices listed in Chapter 3 until the NJDEP published certification expiration date (determined in conjunction with NJDEP’s January 25, 2013 adoption of the new testing protocols; NJDEP 2013c);
- All MTDs that have a MTD Field Test Certification for 80 percent TSS removal will be approved for use by DDOE until the NJDEP published certification expiration date (determined in conjunction with NJDEP’s January 25, 2013 adoption of the new testing protocols; NJDEP 2013b).

All manufacturers seeking acceptance for use in the District based on certification by NJDEP must submit evidence of NJDEP Verification/Certification (Certification Letter) and documentation representing how the MTD design and sizing is affected by the application of the District's stormwater performance standards as detailed in Chapter 2 and as compared to that of the NJDEP. The application of a specific MTD sizing criteria or model on a given development site must be rated for a Treatment Flow Rate (as defined by the new 2013 protocol) equal to or greater than the Districts Stormwater Retention Volume (SWRv) design storm peak flow rate. Refer to Appendix H for guidance on the computational methodology for computing the District's SWRv design peak flow rate. Developers and consultants may review available products that have been certified by the NJDEP and select the one most appropriate for their site. For most recent MTD approvals consult NJDEP website http://www.njstormwater.org/treatment.html.

S.5 MTD Approval Status Renewal

Prior to the expiration of the NJDEP verification/certification, as noted in SectionS.4, all MTDs that wish to continue to be accepted for water quality treatment in the District shall formally request acceptance by DDOE and submit evidence of approval through NJDEP's 2013 MTD Laboratory Test Certification/Verification process.

S.6 MTD Application Fees

Submission of evidence of verification/certification through NJDEP's MTD Certification Program does not require a review fee. However, any requests for acceptance of an MTD for other treatment parameters, including but not limited to pathogens, metals, oil and grease, or runoff volume may be subject to alternate submittal requirements and a review fee commensurate with the services required for reviewing and approving the MTD.

S.7 References

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The National Environmental Laboratory Accreditation Conference (NELAC) Institute (TNI) Available at: http://www.nelac-institute.org/

New Jersey Corporation for Advanced Technology (NJCAT) Technology Verification Program and Testing Protocols available at: http://www.njcat.org/

NJCAT 2013. Procedure for Obtaining Verification of a Stormwater Manufactured Treatment Device from New Jersey Corporation for Advanced Technology January 25, 2013. Available at: http://www.njstormwater.org/pdf/njcat-mtd-process-1-25-13.pdf

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NJDEP 2013c. Laboratory Protocol to Assess Total Suspended Solids Removal by a Hydrodynamic Sedimentation Manufactured Treatment Device January 25, 2013. Available at: http://www.njstormwater.org/pdf/hds-protocol-1-25-13.pdf

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Appendix T Resources

The following documents provide more detailed information on many aspects of BMP design than is found in this Guidebook. These resources may be useful for those looking to develop greater understanding of individual BMPs or stormwater design in general. Recommendations in these resources may be used to inform BMP designs; however, where conflicts occur between these resources and the Guidebook, the requirements of the Guidebook prevail.

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Appendix U Definitions

Anacostia Waterfront Development Zone (AWDZ) - the following areas of the District of Columbia, as delineated on a map in the DDOE's Stormwater Management Guidebook (Figure 2.1):

(a) Interstate 395 and all rights-of-way of Interstate 395, within the District, except for the portion of Interstate 395 that is north of E Street, S.W., or S.E.;

(b) All land between that portion of Interstate 395 that is south of E Street, S.W., or S.E., and the Anacostia River or Washington Channel;

(c) All land between that portion of Interstate 695, and all rights of way, that are south of E Street, S.W. or S.E., and the Anacostia River;

(d) The portion of Interstate 295 that is north of the Anacostia River, within the District, and all rights-of-way of that portion of Interstate 295;

(e) All land between that portion of Interstate 295 that is north of the Anacostia River and the Anacostia River;

(f) The portions of:

- The Anacostia Freeway that is north or east of the intersection of the Anacostia Freeway and Defense Boulevard and all rights-of-way of that portion of the Anacostia Freeway;
- Kenilworth Avenue that extend to the northeast from the Anacostia Freeway to Eastern Ave; and
- Interstate 295, including its rights-of-way, that is east of the Anacostia River and that extends to the southwest from the Anacostia Freeway to Defense Boulevard.

(g) All land between those portions of the Anacostia Freeway, Kenilworth Avenue, and Interstate 295 described in (f) and the Anacostia River;

(h) All land that is adjacent to the Anacostia River and designated as parks, recreation, and open space on the District of Columbia Generalized Land Use Map, dated January 2002, except for the land that is:

- North of New York Avenue, N.E.;
- East of the Anacostia Freeway, including rights-of-way of the Anacostia Freeway;
- East of the portion of Kenilworth Avenue that extends to the northeast from the Anacostia Freeway to Eastern Avenue;
- East of the portion of Interstate 295, including its rights-of-way, that is east of the Anacostia River and that extends to the southwest from the Anacostia Freeway to Defense Boulevard, but excluding the portion of 295 and its rights-of-way that go to the northwest across the Anacostia River;

- Contiguous to that portion of the Suitland Parkway that is south of Martin Luther King, Jr. Avenue; or
- South of a line drawn along, and as a continuation both east and west of the center line of the portion of Defense Boulevard between Brookley Avenue, S.W., and Mitscher Road, S.W.;

(i) All land, excluding Eastern High School, that is:

- Adjacent to the land described in (h);
- West of the Anacostia River; and
- Designated as a local public facility on the District of Columbia Generalized Land Use Map, dated January 2002;

(j) All land that is:

- South or east of that portion of Potomac Avenue, S.E., between Interstate 295 and 19th Street, S.E.; and
- West or north of the Anacostia River;

(k) The portion of the Anacostia River within the District; and

(l) The Washington Channel.

Anacostia Waterfront Development Zone Site - A site within the Anacostia Waterfront Development Zone (AWDZ) that undergoes a major regulated project that is publicly owned or publicly financed.

Animal confinement area - An area, including a structure, used to stable, kennel, enclose, or otherwise confine animals, not including confinement of a domestic animal on a residential property.

Applicant - A person or their agent who applies for approval pursuant to this chapter.

As-built plan - A set of architectural, engineering, or site drawings, which sometimes include specifications that certify, describe, delineate, or present details of a completed construction project.

Best management practice (BMP) - Structural or non-structural practice that minimizes the impact of stormwater runoff on receiving waterbodies and other environmental resources, especially by reducing runoff volume and the pollutant loads carried in that runoff.

Buffer - An area along a stream, river, or other natural feature that provides protection for that feature.

Building permit - Authorization for construction activity issued by the District of Columbia Department of Consumer and Regulatory Affairs.

Clearing - The removal of trees and brush from the land excluding the ordinary mowing of grass, pruning of trees or other forms of long-term landscape maintenance.

Common plan of development - Multiple, separate, and distinct land-disturbing, substantial improvement, or other construction activities taking place under, or to further, a single, larger plan, although they may be taking place at different times on different schedules.

Compacted cover - An area of land that is functionally permeable, but where permeability is impeded by increased soil bulk density as compared to natural cover, such as through grading, construction, or other activity and will require regular human inputs such as periodic planting, irrigation, mowing, or fertilization. Examples include landscaped planting beds, lawns, or managed turf.

Conservation area – area with a natural cover designation set aside to receive stormwater runoff as part of an impervious surface disconnection practice.

Construction - Activity conducted for the:

(a) Building, renovation, modification, or razing of a structure; or

(b) Movement or shaping of earth, sediment, or a natural or built feature

Control measure - Technique, method, device, or material used to prevent, reduce, or limit discharge.

Critical area stabilization - Stabilization of areas highly susceptible to erosion, including down-slopes and side-slopes, through the use of brick bats, straw, erosion control blanket mats, gabions, vegetation, and other control measures.

Cut - An act by which soil or rock is dug into, quarried, uncovered, removed, displaced, or relocated and the conditions resulting from those actions.

Demolition - The removal of part or all of a building, structure, or built land cover.

Department - The District Department of the Environment or its agent.

Dewatering - Removing water from an area or the environment using an approved technology or method, such as pumping.

Director - The Director of the District Department of the Environment.

District - The District of Columbia.

Drainage area - Area contributing runoff to a single point.

Easement - A right acquired by a person to use another person's land for a special purpose.

Electronic media - Means of communication via electronic equipment, including the internet.

Erosion - The process by which the ground surface, including soil and deposited material, is worn away by the action of wind, water, ice, or gravity.

Excavation - An act by which soil or rock is cut into, dug, quarried, uncovered, removed, displaced or relocated and the conditions resulting from those actions.

Existing retention - Retention on a site, including by each existing best management practice (BMP) and land cover, before retrofit of the site with installation of a new BMP or land cover.

Exposed area - Land that has been disturbed or land over which unstabilized soil or other erodible material is placed.

Grading - Causing disturbance of the earth, including excavating, filling, stockpiling of earth materials, grubbing, root mat or topsoil disturbance, or any combination of them.

Green Area Ratio (GAR) - The ratio of the weighted value of landscape elements to land area, as it relates to an increase in the quantity and quality of environmental performance of the urban landscape as defined in the Zoning regulation (Title 11 DCMR) Chapter 34. Details are provided under a separate and unique DDOE guidance manual.

Impervious cover - A surface area which has been compacted or covered with a layer of material that impedes or prevents the infiltration of water into the ground, examples include conventional streets, parking lots, rooftops, sidewalks, pathways with compacted sub-base, and any concrete, asphalt, or compacted gravel surface and other similar surfaces.

Infiltration - The passage or movement of surface water through the soil profile.

Land cover - Surface of land that is impervious, compacted, or natural.

Land-cover change - Conversion of land cover from one type to another, typically in order to comply with a requirement of this chapter or to earn certification of a Stormwater Retention Credit.

Land-disturbing activity - Movement of earth, land, or sediment and related use of land to support that movement. This includes stripping, grading, grubbing, trenching, excavating, transporting, and filling of land, as well as the use of pervious adjacent land for movement and storage of construction vehicles and materials.

Low impact development (LID) - A land-planning and engineering-design approach to manage stormwater runoff within a development footprint. It emphasizes conservation, the use of on-site natural features, and structural best management practices to store, infiltrate, evapotranspire, retain, and detain rainfall as close to its source as possible with the goal of mimicking the runoff characteristics of natural cover.

Maintenance agreement – See Section 5.4.2 Maintenance Agreement.

Maintenance contract – See “maintenance agreement.”

Maintenance responsibility – See Section 5.4.1 Maintenance Responsibility.

Maintenance plan – Planned scheduled maintenance for the life of the BMP.

Maintenance schedule – See "maintenance plan".

Maintenance standards – Detailed maintenance plan laid out in Exhibit C within Declaration of Covenants.

Major land-disturbing activity - Activity that disturbs, or is part of a common plan of development that disturbs, five thousand square feet (5,000 ft^2) or greater of land area, except that multiple distinct projects that each disturb less than 5,000 ft^2 of land and that are in separate, non-adjacent sites do not constitute a major land-disturbing activity.

Major regulated project - A major land-disturbing activity or a major substantial improvement activity.

Major substantial improvement activity - Substantial improvement activity and associated land-disturbing activity, including such activities that are part of a common plan of development, for which the combined footprint of improved building and land-disturbing activity is 5,000 square feet or greater. A major substantial improvement activity may include a substantial improvement activity that is not associated with land disturbance.

Market value of a structure - Assessed value of the structure for the most recent year, as recorded in the real property assessment database maintained by the District of Columbia's Office of Tax and Revenue.

Natural cover - Land area that is dominated by vegetation and does not require regular human inputs such as irrigation, mowing, or fertilization to persist in a healthy condition. Examples include forest, meadow, or pasture.

Non-structural BMP - A land use, development, or management strategy that minimizes the impact of stormwater runoff, including conservation of natural cover or disconnection of impervious surface.

Off-site retention - Use of a Stormwater Retention Credit or payment of in-lieu fee in order to achieve an Off-Site Retention Volume under these regulations.

Off-Site Retention Volume (Offv) - A portion of a required Stormwater Retention Volume or required Water Quality Treatment Volume that is not retained on site.

On-site retention - Retention of a site's stormwater on that site or via conveyance to a shared best management practice on another site.

On-site stormwater management - Retention, detention, or treatment of stormwater on site or via conveyance to a shared best management practice.

Original Stormwater Retention Credit (SRC) owner – A person who is indicated as the proposed SRC owner in an application to the Department for the certification of an SRC. The proposed SRC owner becomes the original SRC owner upon the Department's certification of the SRC.

Owner - The person who owns real estate or other property, or that person's agent.

Peak discharge - The maximum rate of flow of water at a given point and time resulting from a storm event.

Person - A legal entity, including an individual, partnership, firm, association, joint venture, public or private corporation, trust, estate, commission, board, public or private institution, cooperative, the Government of the District of Columbia and its agencies, and the federal government and its agencies.

Pervious Area – area with a compacted cover designation set aside to receive stormwater runoff as part of an impervious surface disconnection practice.

Post-development - Describing conditions that may be reasonably expected to exist after completion of land development activity on a site.

Practice - A system, device, material, technique, process, or procedure that is used to control, reduce, or eliminate an impact from stormwater; except where the context indicates its more typical use as a term describing a custom, application, or usual way of doing something.

Preconstruction meeting - The mandatory meeting occurring prior to any construction, including the owner, the designer, the installer, and the DDOE inspector. This meeting must contain an on-site component to evaluate the SWMP against existing site conditions. This should include, at a minimum, a visual examination of land cover types, the tree preservation plan, boundaries of the contributing drainage area(s), the existing inlet elevation(s) to ensure they conform to original design.

Predevelopment - Describing conditions of meadow land and its relationship to stormwater before human disturbance of the land.

Preproject - Describing conditions, including land covers, on a site that exist at the time that a stormwater management plan is submitted to DDOE.

Publicly owned or publicly financed project - A project:

(a) That is District-owned or District-instrumentality owned;

(b) Where at least fifteen percent (15%) of a project's total cost is District-financed or District-instrumentality financed; or

(c) That includes a gift, lease, or sale from District-owned or District instrumentality-owned property to a private entity.

Public right-of-way (PROW) - The surface, the air space above the surface (including air space immediately adjacent to a private structure located on public space or in a public right-of-way), and the area below the surface of any public street, bridge, tunnel, highway, lane, path, alley, sidewalk, or boulevard.

Public space - All the publicly owned property between the property lines on a street, park, or other public property as such property lines are shown on the records of the District, and includes any roadway, tree space, sidewalk, or parking between such property lines.

Raze - The complete removal of a building or other structure down to the ground.

Responsible person - Construction personnel knowledgeable in the principles and practices of soil erosion and sediment control and certified by a Department-approved soil erosion and sedimentation control training program to assess conditions at the construction site that would impact the effectiveness of a soil-erosion or sediment-control measure on the site.

Retention - Keeping a volume of stormwater runoff on site through infiltration, evapotranspiration, storage for non-potable use, or some combination of these.

Retention capacity - The volume of stormwater that can be retained by a best management practice or land cover.

Retention failure - Failure to retain a volume of stormwater for which there is an obligation to achieve retention, including retention that an applicant promises to achieve in order to receive Department-certified Stormwater Retention Credits (SRCs). Retention failure may result from a failure in construction, operation, or maintenance; a change in stormwater flow; or a fraud, misrepresentation, or error in an underlying premise in an application.

Retrofit - A best management practice or land cover installed in a previously developed area to improve stormwater quality or reduce stormwater quantity relative to current conditions.

Runoff - That portion of precipitation (including snow-melt) which travels over the 1and surface, and also from rooftops, either as sheetflow or as channel flow, in small trickles and streams, into the main water courses.

Sediment - Soil, including soil transported or deposited by human activity or the action of wind, water, ice, or gravity.

Sedimentation - The deposition or transportation of soil or other surface materials from one place to another as a result of an erosion process.

Shared best management practice (S-BMP) - A best management practice (BMP), or combination of BMPs, providing stormwater management for stormwater conveyed from another site or sites.

Site - A tract, lot or parcel of 1and, or a combination of tracts, 1ots, or parcels of land for which development is undertaken as part of a unit, sub-division, or project. The mere divestiture of ownership or control does not remove a property from inclusion in a site.

Site drainage area (SDA) - The area that drains to a point on a site from which stormwater discharges. Throughout this guidance and in accompanying calculator spreadsheets this is referred to as the drainage area(s) within the limits of disturbance. The use of DA to indicate SDA, or a subset of SDA, is common.

Soil - All earth material of whatever origin that overlies bedrock and may include the **decomposed zone of bedrock which can be readily excavated by mechanical equipment.**

Soil Erosion and Sediment Control Plan - A set of drawings, calculations, specifications, details, and supporting documents related to minimizing or eliminating erosion and off-site sedimentation caused by stormwater on a construction site. It includes information on construction, installation, operation, and maintenance.

Soils report - A geotechnical report addressing all soil erosion and sediment control-related soil attributes, including but not limited to site soil drainage and stability.

Storm sewer - A system of pipes or other conduits which carries or stores intercepted surface runoff, street water, and other wash waters, or drainage, but excludes domestic sewage and industrial wastes.

Stormwater - Flow of water that results from runoff, snow melt runoff, and surface runoff and drainage.

Stormwater Fee Discount - The program that will allow District water and sewer ratepayers to apply for a discount of up to fifty-five percent (55 %) of the DDOE Stormwater Fee that appears on their DC Water bill. To be eligible for a discount, ratepayers must have installed Best Management Practices (BMPs) that retain or prevent stormwater runoff. The program rules are defined in Title 21, Water and Sanitary, Chapter 5, Water Quality and Pollution, of the DCMR sections 557 through 563. Details are provided under a separate and unique DDOE guidance manual.

Stormwater management - A system to control stormwater runoff with structural and non-structural best management practices, including: (a) quantitative control of volume and rate of surface runoff and (b) qualitative control to reduce or eliminate pollutants in runoff.

Stormwater Management Guidebook (SWMG) - The current manual published by DDOE containing design criteria, specifications, and equations to be used for planning, design, and construction, operations, and maintenance of a site and each best management practice on the site.

Stormwater Management Plan (SWMP) - A set of drawings, calculations, specifications, details, and supporting documents related to the management of stormwater for a site. A SWMP includes information on construction, installation, operation, and maintenance.

Stormwater Pollution Prevention Plan (SWPPP) - A document that identifies potential sources of stormwater pollution at a construction site, describes practices to reduce pollutants in stormwater discharge from the site, and may identify procedures to achieve compliance.

Stormwater Retention Credit (SRC) - One gallon (1 gal.) of retention capacity for one (1) year, as certified by DDOE. An SRC may also be referred to as a RainReC.

Stormwater Retention Credit ceiling - Maximum retention for which DDOE will certify an SRC, calculated using the SWRv equation with P equal to 1.7 inches.

Stormwater Retention Volume (SWRv) - Volume of stormwater from a site for which the site is required to achieve retention.

Stripping - An activity which removes or significantly disturbs the vegetative surface cover including clearing, grubbing of stumps and rock mat, and top soil removal.

Substantial improvement - A repair, alteration, addition, or improvement of a building or structure, the cost of which equals or exceeds fifty percent (50%) of the market value of the structure before the improvement or repair is started.

Structural best management practice - A practice engineered to minimize the impact of stormwater runoff, including a bioretention, green roof, permeable paving system, system to capture stormwater for non-potable uses, etc.

Supplemental review - A review that DDOE conducts after the review it conducts for a first re-submission of a plan.

Swale - A narrow low-lying stretch of land which gathers or carries surface water runoff.

Total suspended solids (TSS) - The entire amount of organic and inorganic particles dispersed in water. TSS is measured by several methods, which entail measuring the dry weight of sediment from a known volume of a subsample of the original.

Waste material - Construction debris, dredged spoils, solid waste, sewage, garbage, sludge, chemical wastes, biological materials, heat, wrecked or discarded equipment, rock, sand, cellar dirt, and industrial or municipal waste.