# Chapter 2

Minimum Control
Requirements
and
Methods

## 2.0 District of Columbia Stormwater Management Performance Requirements

This chapter presents a unified approach for sizing stormwater best management practices (BMPs) in the District to meet pollutant removal goals, reduce peak discharges, and pass extreme floods. Table 2.1 presents a summary of the sizing criteria used to achieve the stormwater management performance requirements for a major land disturbing activity. Table 2.2 presents a summary of the sizing criteria used in complying with the stormwater management performance requirements for a major substantial improvement activity. This chapter describes the five sizing criteria in detail and provides guidance on how to properly compute and manage the required volumes. This chapter also presents an overview of acceptable BMP options that can be used to comply with the sizing criteria. Appendix A on compliance calculations provides a line-by-line review of the accompanying calculator spreadsheets.

**Table 2.1 Sizing criteria for major land disturbing activity stormwater management performance requirements**

| Sizing Criteria | Description of Stormwater Sizing Criteria |
|---|---|
| **Stormwater Retention Volume** (SWRv) (gal.) | $SWRv = [P \times [(Rv_I \times \%I) + (Rv_C \times \%C) + (Rv_N \times \%N)] \times SA] \times 7.48/12$<br><br>Where:<br>SWRv = volume, in gallons, required to be retained onsite<br>P = $90^{th}$ percentile rainfall event for the District (1.2")<br>$Rv_I$ = 0.95 (runoff coefficient for impervious cover)<br>$Rv_C$ = 0.25 (runoff coefficient for compacted cover)<br>$Rv_N$ = 0.00 (runoff coefficient for natural cover)<br>%I = percent of site in impervious cover (decimal)<br>%C = percent of site in compacted cover (decimal)<br>%N = percent of site in natural cover (decimal)<br>SA = surface area in square feet<br>7.48 = conversion factor, converting cubic feet to gallons<br>12 = conversion factor, converting inches to feet |

**Table 2.1 (Continued) Sizing criteria for major land disturbing activity stormwater management performance requirements**

| | |
|---|---|
| **2 Year Storm Control** ($Qp_2$) | The peak discharge rate from the 2- year storm event controlled to the pre-development peak discharge rate. |
| **15 Year Storm Control** ($Qp_{15}$) | The peak discharge rate from the 15-year storm event controlled to the pre-project peak discharge rate. |
| **Extreme Flood Requirements ($Q_f$)** | The peak discharge rate from the 100-year storm event controlled to the pre-project peak discharge rate if the site:<br>1) Increases the size of a Special Flood Hazard Area (SFHA) as delineated on the effective Flood Insurance Rate Maps (FIRM) or<br>2) Meets the following two conditions:<br>(a) Does not discharge to the sewer system and<br>(b) Has a post-development peak discharge rate for a one hundred-year frequency storm event that will cause flooding to a building. |

**Table 2.2 Sizing criteria for major substantial improvement activity stormwater management performance requirements**

| Sizing Criteria | Description of Stormwater Sizing Criteria |
|---|---|
| **Stormwater Retention Volume** (SWRv) (gal.) | $SWRv = [P \times [(Rv_I \times \%I) + (Rv_C \times \%C) + (Rv_N \times \%N)] \times SA] \times 7.48/12$<br><br>Where:<br>SWRv = volume, in gallons, required to be retained onsite<br>P = $80^{th}$ percentile rainfall event for the District (0.8")<br>$Rv_I$ = 0.95 (runoff coefficient for impervious cover)<br>$Rv_C$ = 0.25 (runoff coefficient for compacted cover)<br>$Rv_N$ = 0.00 (runoff coefficient for natural cover)<br>%I = percent of site in impervious cover (decimal)<br>%C = percent of site in compacted cover (decimal)<br>%N = percent of site in natural cover (decimal)<br>SA = surface area in square feet |

**Table 2.2 Sizing criteria for major substantial improvement activity stormwater management performance requirements**

| Sizing Criteria | Description of Stormwater Sizing Criteria |
|---|---|
| | 7.48 = conversion factor, converting cubic feet to gallons<br>12 = conversion factor, converting inches to feet |

## 2.1 Stormwater Retention Volume

Sites that undergo a major activity that qualifies as a regulated event, either a major land disturbing activity or a major substantial improvement activity, shall employ BMPs necessary to achieve the retention of the Stormwater Retention Volume (SWRv) equal to the post-development runoff from the applicable rainfall event, measure for a 24-hour storm with a 72-hour antecedent dry period. For a major land-disturbing activity, the applicable rainfall event is the 90$^{th}$ percentile rainfall event (1.2 inches). For a major substantial improvement activity, the applicable rainfall event is the 80$^{th}$ rainfall event (0.8 inches). The SWRv is calculated as follows:

$$SWRv = [P \times [(Rv_I \times \%I) + (Rv_C \times \%C) + (Rv_N \times \%N)] \times SA] \times 7.48 / 12$$

Where:

SWRv = volume, in gallons, required to be retained onsite.
P = For major land disturbing activity, use 90$^{th}$ percentile rainfall event for the District (1.2") or
For major substantial improvement activity, use 80$^{th}$ percentile rainfall event for the District (0.8")
$Rv_I$ = 0.95 (runoff coefficient for impervious cover)
$Rv_C$ = 0.25 (runoff coefficient for compacted cover)
$Rv_N$ = 0.00 (runoff coefficient for natural cover)
%I = percent of site in impervious cover
%C = percent of site in compacted cover
%N = percent of site in natural cover
SA = surface area in square feet
7.48 = conversion factor, converting cubic feet to gallons
12 = conversion factor, converting inches to feet

The SWRv should be calculated for the entire site and each drainage area.

A site may use off-site retention for up to 50% of its SWRv. Consult Chapter 6 and Appendix C on the use of off-site retention. Each drainage area shall retain a minimum of 50% of its SWRv or provide treatment for that volume to remove 60% of Total Suspended Solids (TSS). A site that opts

to provide treatment for a portion of the SWRv for an individual drainage area shall still be responsible for the SWRv calculated for the entire site, including that drainage area.

Retention in excess of the SWRv for one drainage area may be counted toward meeting the SWRv for another drainage area; however, retention in excess of the 1.7 inch rainfall event shall not be counted toward a SWRv.

Projects claiming "extraordinarily difficult site conditions" and requesting relief from compliance with the minimum on-site retention obligation (50% of the SWRv) will follow the submission and evaluation process in Appendix E. Sites approved for "relief from extraordinarily difficult site conditions" are still responsible for the entire SWRv but will be allowed to use off-site retention to achieve more than 50% of the SWRv.

Major land-disturbing activities in the existing Public Right-of-Way (PROW) must achieve the SWRv to the Maximum Extent Practicable (MEP). The MEP design and review process is detailed in Appendix B.

## 2.2 Quantity Control Requirements ($Qp_2$ and $Qp_{15}$)

To meet quantity control and peak discharge requirements, the District requires the following:

**2-Year Storm Control ($Qp_2$)** Maintain the post-development peak discharge rate for a 24-hour, 2-year frequency storm event at a level that is equal to or less than the storm's pre-development (meadow conditions or better) peak discharge rate. 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).
http://hdsc.nws.noaa.gov/hdsc/pfds/index.html

**15-Year Storm Control ($Qp_{15}$)** Maintain the post-development peak discharge rate for a 24-hour, 15-year frequency storm event at a level that is equal to or less than the storm's pre-project peak discharge rate. 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).
http://hdsc.nws.noaa.gov/hdsc/pfds/index.html.

All stormwater conveyance systems shall be designed using the 15-year design frequency with post-development land uses. In some cases a storm frequency of a longer time interval is required, for

example to protect downstream bridges and culverts designed to a 24-hr, 25-yr frequency storm event. In these cases, the permit review engineer will require all these computations and assumptions be submitted for detailed evaluation. Where the stormwater management facility discharges into a closed conduit system, the release rate of the structure must be designed so as not to adversely affect the downstream hydraulic gradient. See Appendix F for details and guidance on the design of stormwater conveyance systems. See Appendix G for details and guidance on the design of flow control structures. See Chapter 5 for supporting submission documents including the DC Water and Sewer Authority's Discharge Verification form.

## 2.3 Extreme Flood Requirements ($Q_f$)

To meet the extreme flood requirements, a site shall maintain the peak discharge rate from the 100-year storm event controlled to the pre-project peak discharge rate if the site:

1) Increases the size of a Special Flood Hazard Area (SFHA) as delineated on the effective Flood Insurance Rate Maps (FIRM) or
2) Meets the following two conditions:
   (a) Does not discharge to the sewer system and
   (b) Has a post-development peak discharge rate for a one hundred-year frequency storm event that will cause flooding to a building.

The intent of the extreme flood criteria is to (a) prevent flood damage from large storm events, and (b) maintain the boundaries of the 100-year Federal Emergency Management Agency (FEMA) floodplain.

In general, stormwater runoff leaving a development site shall be discharged directly into an adequate natural or man-made receiving channel, pipe or storm sewer system or the applicant shall provide a drainage system satisfactory to the Department to preclude an adverse impact (e.g., soil erosion, sedimentation, flooding, duration of ponding water, inadequate overland relief) on downstream properties and receiving systems. If the applicant chooses to install a drainage system, the system shall be designed in accordance with established, applicable criteria for such systems.

Stormwater runoff leaving a development site where it does not discharge directly to the sewer system shall not aggravate or create a condition where an existing building is flooded from the 100-year storm event. If such a condition exists, on-site detention for the 100-year storm event shall be provided.

In situations where the size of the Special Flood Hazard Area (SFHA) as delineated on the effective Flood Insurance Rate Map (FIRM) by the Federal Emergency Management Agency (FEMA) will be increased based on the increased post-development 100-year discharge, the post-development 100-year peak discharge shall be maintained at a level that is equal to or less than the pre-project 100-year peak discharge.

## 2.4 Minimum Criteria for Determining Extreme Flood Requirements:

In order to determine whether extreme flood requirements are applicable, an applicant shall be conducted in accordance with minimum criteria below.

Downstream Analysis:

1. Consult the Department to initially determine whether or not the downstream analysis needed. Site visit is necessary for the determination. This analysis is used to determine the impact of the 100-year post development discharge on a building.

2. If the analysis is needed, the analysis shall contain supporting computations as justification for the conclusions contained in the analysis. For consistency, the following items are to be included at a minimum:

   (a) Site-specific narrative with a description of the elements of the storm drainage system, overland relief paths and adjoining properties;

   (b) A drainage plan showing outfall location(s) with the contributing drainage areas for each outfall. Digital pictures of the outfall shall be included;

   (c) A profile for each outfall channel and overland relief path;

   (d) Two cross-sections, at a minimum, at each critical location to verify the outfall and overland relief adequacy. Cross-sections shall be based on a 2-foot contour interval and additional spot elevations in the vicinity. The cross-sections shall have the same vertical and horizontal scales and shall identify the top of banks for the channel;

   (e) Description of the outfall channel and permissible velocity. The Manning's roughness coefficient shall be supported by soil classification, cover material, and channel's or flow path's lining. The description of physical characteristics may include the amount of flow meandering, material classification of the flow path and its banks, vegetation, obstruction to flow, variations in cross sections and surface irregularity.

   (f) Detailed hydrologic and hydraulic calculations to obtain the 100-year water surface elevations (WSE). The acceptable methodologies and models are specified within this Guidebook;

   (g) Delineation of the 100-year WSE on the project drainage plan to show the location and approximate extend of the overland relief path and areas that may be affected by

the surface storage for the 100-year storm event. Overlaying arrows, shading or other suitable see-through graphics are suggested for this purpose.

(h) Certification by the DC PE that no buildings will be flooded by the 100-year post-development discharge from the development site.

3. If buildings will be flooded based on the analysis, then the design engineer should perform more precise hydrologic and hydraulic computations. In addition to the on-site 100-year detention, the applicant shall design the outfall drainage system, overland relief swales, and/or surface storage in such a way that no building will be damaged by flooding.

4. If the protection measures for the outfall drainage system or overland relief path are provided, necessary design details shall be shown and supported by calculations and submitted to the Department for review.

Hydrologic and Hydraulic (H&H) Analysis:

1. Consult the Department to initially determine whether or not the H&H analysis is needed. This analysis is used to determine the impact on SFHA by considering the entire watershed.

2. The acceptable methodologies and models for H&H analysis are specified within this Guidebook;

3. Hydrologic and Hydraulic (H&H) investigations may be required to demonstrate that downstream roads, bridges and public utilities are adequately protected from the $Q_f$ storm. These investigations typically extend to the first downstream tributary of equal or greater drainage area or to any downstream dam, highway, or natural point of restricted stream flow.

## 2.5 Additional Stormwater Management Requirements

Any BMP which may receive stormwater runoff from areas which may be potential sources of oil and grease contamination in concentration exceeding 10 milligrams per liter (mg/l) shall include a baffle, skimmer, oil separator, grease trap, or other mechanism which prevents oil and grease from escaping the stormwater discharge facility in concentrations exceeding 10 milligrams per liter (mg/l).

Any BMP which receives stormwater runoff from areas used to confine animals may be required to be connected to a sanitary or combined sewer and to meet pretreatment requirements of the District of Columbia Water and Sewer Authority.

## 2.6 Hydrology Methods

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 criteria appropriate.

- Urban Hydrology for Small Watersheds TR-55 (TR-55)
- Storage-Indication Routing
- HEC-HMS, WinTR-55, TR-20, and SWMM Computer Models
- Rational Method & Modified Rational Method

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.

The use of the Natural Resource Conservation Service storage indication routing method or an equivalent acceptable method may be required to route the design storms through stormwater facilities. See ***Appendix H*** for further details and guidance.

## 2.7 Acceptable Urban BMP Options

This section sets forth thirteen acceptable groups of BMPs that can be used to meet the Stormwater Retention Volume (SWRv), and/or peak flow ($Qp_2$, $Qp_{15}$, $Q_f$) criteria.

The dozens of different BMP designs currently used in the District are assigned into thirteen general categories for stormwater quality control:

| | |
|---|---|
| BMP Group 1 | Green Roofs |
| BMP Group 2 | Rainwater Harvesting |
| BMP Group 3 | Impervious Surface Disconnection |
| BMP Group 4 | Permeable Pavement Systems |
| BMP Group 5 | Bioretention |
| BMP Group 6 | Filtering Systems |
| BMP Group 7 | Infiltration |
| BMP Group 8 | Open Channel Systems |
| BMP Group 9 | Ponds |
| BMP Group 10 | Wetlands |
| BMP Group 11 | Storage Practices |

BMP Group 12 Proprietary Practices
BMP Group 13 Tree Planting and Preservation

Within each BMP group, detailed performance criteria are presented that govern feasibility, conveyance, pretreatment, treatment, landscaping, construction sequence, maintenance, and stormwater retention calculations (see Chapter 3).

Guidance on selecting the most appropriate combination of BMPs is provided in Chapter 4.

**BMP Group 1. Green Roofs**

Green roofs are practices that capture and store rainfall that would otherwise land on an impervious rooftop in an engineered growing media that is designed to support plant growth. A portion of the captured rainfall evaporates or is taken up by plants, which helps reduce runoff volumes, peak runoff rates, and pollutant loads. Design variants include:

G-1 Extensive green roofs have a much shallower growing media layer that typically ranges from 3 to 6 inches thick
G-2 Intensive green roofs have a growing media layer that ranges from 6 inches to 4 feet thick

**BMP Group 2. Rainwater Harvesting**

Rain water harvesting systems intercept, divert, store and release rainfall for future use. Rainwater that falls on a rooftop is collected and conveyed into an above- or below-ground storage tank (also referred to as a cistern or rain tank), where it can be used for non-potable water uses and on-site stormwater disposal/infiltration.

**BMP Group 3. Impervious Surface Disconnection**

This strategy involves managing runoff close to its source by intercepting, infiltrating, filtering, treating or reusing it as it moves from the impervious surface to the drainage system. Simple disconnection variants include:

D-1 Simple disconnection to a pervious Compacted Cover area
D-2 Simple disconnection to a conserved Natural Cover area
D-3 Simple disconnection to a soil compost amended filter path

Disconnection can also be employed as part of infiltration, bioretention, and rainwater harvesting systems.

**BMP Group 4. Permeable Pavement Systems**

Permeable pavement is an alternative paving surface that captures and temporarily stores the design volume by filtering runoff through voids in the pavement surface into an underlying stone reservoir. Filtered runoff may be collected and returned to the conveyance system, or allowed to partially infiltrate into the soil. Design variants include:

P-1 porous asphalt (PA)
P-2 pervious concrete (PC)
P-3 permeable interlocking concrete pavers (PICP) or concrete grid pavers (CGP)
P-4 plastic grid pavers

**BMP Group 5. Bioretention**

Bioretention facilities are practices that capture and store stormwater runoff and pass it through a filter bed of engineered soil media comprised of sand, soil and organic matter. Filtered runoff may be collected and returned to the conveyance system, or allowed to infiltrate into the soil. Design variants include:

B-1 traditional bioretention
B-2 streetscape bioretention
B-3 engineered tree pits
B-4 stormwater planters
B-5 residential rain gardens

**BMP Group 6. Filtering Systems**

Filtering systems are practices that capture and temporarily store the design volume and pass it through a filter bed of sand, organic matter, soil or other filtering media. Filtered runoff may be collected and returned to the conveyance system. Design variants include:

F-1 non-structural sand filter
F-2 surface sand filter
F-3 three-chamber underground sand filter
F-4 perimeter sand filter
F-5 proprietary filters

**BMP Group 7. Infiltration Practices**

Infiltration practices capture and store the design volume before allowing it to infiltrate into the soil over a two day period. Design variants include:

I-1 infiltration trench
I-2 infiltration basin

**BMP Group 8. Open Channel Practices**

Open channel practices are vegetated open channels that are designed to capture and treat or convey the design storm volume. Design variants include:

O-1 grass channels
O-2 dry swale
O-3 wet swale

**BMP Group 9. Ponds**

Stormwater ponds are stormwater storage practices that consist of a combination of a permanent pool, micropool, or shallow marsh that promote a good environment for gravitational settling, biological uptake and microbial activity. Design variants include:

P-1 micropool extended detention pond
P-2 wet pond
P-3 wet extended detention (ED) pond

**BMP Group 10. Wetlands**

Stormwater wetlands are practices that create shallow marsh areas to treat urban stormwater which often incorporate small permanent pools and/or extended detention storage. Stormwater wetlands are explicitly designed to provide stormwater detention for larger storms (2-year, 15-year or flood control events) above the Retention Storage Volume (SWRv). Design variants include:

W-1shallow wetland
W-2extended detention (ED) shallow wetland

**BMP Group 11. Storage Practices**

Storage practices are explicitly designed to provide stormwater detention (2-year, 15-year, and/or flood control). Storage practices, alone, are not considered acceptable practices to meet Retention Storage Volume (SWRv), or TSS removal, requirements. Design variants include:

S-1 underground vault
S-2 dry pond
S-3 rooftop storage
S-4 stone storage under permeable pavement or other BMPs

Design guidance and criteria for the practice of rooftop storage is provided in Appendix I.

### BMP Group 12. Proprietary Practices

Proprietary practices are manufactured stormwater BMPs that utilize settling, filtration, absorptive/adsorptive materials, vortex separation, vegetative components, and/or other appropriate technology to manage the impacts of stormwater runoff.

Proprietary practices may establish Retention Volume (SWRv) value, as well as TSS removal value, provided they have been approved by the District through the approval process detailed in Appendix X.

### BMP Group 13. Tree Planting and Preservation

Trees can significantly reduce stormwater runoff by canopy interception and uptake of water from the soil. Trees are well documented in their ability to reduce stormwater runoff, particularly when the tree canopy covers impervious surface, such as in the case of street trees.