Chapter 4 Selecting and Locating the Most Effective Stormwater Best Management Practice System

4.1 Choosing Stormwater Management Best Practices (BMPs)

This chapter outlines a general process for selecting appropriate BMPs at a development site. Guidelines are presented for choosing which BMPs can meet the retention and treatment volume targets for design storms and which BMPs are most feasible when various site constraints are present.

This chapter represents guidelines, not rules, to determine the most appropriate BMP for a site. It is important to note that certain BMP design modifications or specific site characteristics may allow for a particular BMP to become better suited at a particular location. Several of these design modifications are noted in the following tables and are described in more detail in the individual BMP specifications (see Chapter 3).

The following questions organize a framework for decision making:

- **Regulatory Criteria**

  Can the BMP meet all stormwater sizing criteria at the site or are a combination of BMPs needed?

- **Land Use Factors**

  Which practices are best suited for the proposed land use at this site?

- **Physical Feasibility Factors**

  Are there any physical constraints at the project site that may restrict or preclude the use of a particular BMP?

- **Community and Environmental Factors**

  Do the remaining BMPs have any important community or environmental benefits or drawbacks that might influence the selection process?

- **Location and Permitting Considerations**

  What environmental features must be avoided or considered when locating the BMP system at a site to fully comply with District and federal regulations?

4.2 Regulatory Compliance

Table 4.1 summarizes the capability of each BMP to meet the stormwater management sizing criteria outlined in Chapter 2. Designers can use Table 4.1 to screen BMP options to determine whether a particular BMP can meet the SWRv storage, peak discharge (Qp_2, Qp_{15}, and Q_f), and pollutant removal requirements. Finding that a particular BMP cannot meet a requirement does not necessarily mean that it should be eliminated from consideration. This screening process can reduce BMP options to a manageable number and determine whether a single BMP or a group of BMPs will be needed to meet stormwater sizing criteria at the site.

The following are key considerations for compliance:

- **Stormwater Retention Volume (SWRv) Storage.** A single BMP may not be capable of meeting the SWRv requirement. This column can assist in identifying supplemental practices.
- **Quantity Control (Qp_2, Qp_{15}, or Q_f).** These columns show whether a BMP can typically meet the peak discharge requirements.
- **Pollutant Removal.** This column examines the capability of each BMP option to remove total suspended solids (TSS) from stormwater runoff.

Note: Table 4.1 should be used as a guide for how practices typically perform. Individual designs may be sized or designed with greater or lesser capabilities than are indicated in the table.

Table 4.1 BMP Selection Based on Regulatory Criteria

Code	BMP	SWRv Storage	Qp_2/Qp_{15} Control	Q_f Control	TSS Removal
G-1	Extensive Green Roof	●	⦿	☒	N/A
G-2	Intensive Green Roof		⦿		
R-1	Rainwater Harvesting	⦿	⦿	☒	N/A
D-1	Simple Disconnection to a Pervious Area	⦿	☒	☒	NO
D-2	Simple Disconnection to a Conservation Area				
D-3	Simple Disconnection to a Soil Compost Amended Filter Path				
P-1	Porous Asphalt	●	⦿	☒	N/A or Yes*
P-2	Pervious Concrete				
P-3	Permeable Pavers				
B-1	Traditional Bioretention	●	⦿	☒	N/A or Yes*
B-2	Streetscape Bioretention		⦿		
B-3	Expanded Tree Pits		⦿		
B-4	Stormwater Planters		⦿		
B-5	Residential Rain Gardens		⦿		
F-1	Surface Sand Filter	☒	☒	☒	Yes
F-2	1-Chamber Underground Sand Filter				
F-3	3-Chamber Underground Sand Filter				

Code	BMP	SWRv Storage	Qp_2/Qp_{15} Control	Q_f Control	TSS Removal
F-4	Perimeter Sand Filter				
I-1	Infiltration Trench	●	⦿	☒	N/A
I-2	Infiltration Basin				
O-1	Grass Channels	⦿	☒	☒	No
O-2	Dry Swale	●			Yes
O-3	Wet Swale	☒			Yes
P-1	Micropool Extended Detention Pond	☒	●	●	Yes
P-2	Wet Pond				
P-3	Wet Extended Detention Pond				
W-1	Shallow Wetland	☒	●	●	Yes
W-2	Extended Detention Shallow Wetland				
S-1	Underground Detention	☒	●	●	No
S-2	Dry Extended Detention Pond				
PP-1	Proprietary Practice	☒	☒	☒	Yes
TP-1	Tree Preservation	⦿	☒	☒	No
TP-2	Tree Planting				

● = Yes; ⦿ = Partial; ☒ = Minor or No Benefit
* Depends upon design type.

4.3 Land Use Factors

Designers can use Table 4.2 to evaluate BMPs that are best suited to a particular land use, including highly urbanized areas.

The following are key considerations for land use factors:

- **Residential.** This column identifies the best treatment options in medium to high density residential developments.
- **Commercial Development.** This column identifies practices that are suitable for new commercial development.
- **Roads and Highways.** This column identifies the best practices to treat runoff from major roadway and highway systems.
- **Hotspot Land Uses.** This column examines the capability of BMPs to treat runoff from designated hotspots. BMPs that receive hotspot runoff may have design restrictions, as noted.

Table 4.2 BMP Selection Based on Land Use Screening Factors

Code	BMP	Residential	Commercial	Roads and Highways	Hotspots
G-1	Extensive Green Roof	⦿	●	☒	☒
G-2	Intensive Green Roof				
R-1	Rainwater Harvesting	●	●	☒	☒
D-1	Simple Disconnection to a Pervious Area	●	●	⦿	☒
D-2	Simple Disconnection to a Conservation Area				
D-3	Simple Disconnection to a Soil Compost Amended Filter Path				
P-1	Porous Asphalt	⦿	●	①	☒
P-2	Pervious Concrete				
P-3	Permeable Pavers				
B-1	Traditional Bioretention	●	●	⦿	②
B-2	Streetscape Bioretention		●	●	
B-3	Expanded Tree Pits		●	●	
B-4	Stormwater Planters		●	☒	
B-5	Residential Rain Gardens		☒	☒	
F-1	Surface Sand Filter	☒	●	●	●
F-2	1-Chamber Underground Sand Filter			⦿	
F-3	3-Chamber Underground Sand Filter			⦿	
F-4	Perimeter Sand Filter			⦿	
I-1	Infiltration Trench	⦿	●	⦿	☒
I-2	Infiltration Basin				
O-1	Grass Channel	●	●	●	②
O-2	Dry Swale				
O-3	Wet Swale				
P-1	Micropool Extended Detention Pond	●	⦿	⦿	③
P-2	Wet Pond				
P-3	Wet Extended Detention Pond				
W-1	Shallow Wetland	●	●	⦿	③
W-2	Extended Detention Shallow Wetland				
S-1	Underground Detention	☒	●	●	☒
S-2	Dry Pond	●	●	⦿	
PP-1	Proprietary Practice	●	●	●	●
TP-1	Tree Preservation	●	●	●	●
TP-2	Tree Planting				

● = Yes; ⦿ = Maybe; ☒ = No

①- Recommended for low volume roads or parking lanes

②-Yes, only if designed with an impermeable liner

③-May require pond liner to reduce the risk of GW contamination

4.4 Physical Feasibility Factors

Typically, the designer narrows the BMP selection list based on regulatory goals and land use constraints before considering physical feasibility factors. Table 4.3 identifies the typical physical conditions needed for each type of BMP. Designers can use Table 4.3 to screen BMP options to determine whether the soils, water table, drainage area, slope, or head conditions present at a particular development site might limit the use of a BMP. These factors are intended as guidelines rather than requirements.

The following are key considerations for physical feasibility:

- **Underlying Soils.** The designer should use NRCS hydrologic soils maps to generally identify expected soils and their locations at the site. More detailed geotechnical tests are required during BMP design to evaluate infiltration feasibility and related design parameters. Once the infiltration rate at a site has been measured, use this column and Table 4.4 to identify recommended design criteria for proposed BMPs that have an infiltration option.
- **Distance to Water Table.** Measure the depth of the groundwater and estimate the depth of the seasonally high water table (see Appendix O). Use this column as an aid to determine recommended BMP sizing.
- **Contributing Drainage Area.** Delineate the contributing drainage area to the proposed BMP, and use this column as an aid to determine the appropriate sizing factor. If the drainage area present at a site is slightly greater than the maximum allowable drainage area for a practice, some leeway is permitted. Likewise, the minimum drainage areas indicated for ponds and wetlands should not be considered inflexible limits, and may be increased or decreased depending on water availability (baseflow or groundwater) or the mechanisms employed to prevent clogging or ensure an impermeable pond bottom.
- **Practice Surface Slope.** Evaluate the site topography. Determine the potential for cut and fill operations. Use this column as an aid to evaluate BMP surface slope restrictions. Specifically, the slope restrictions refer to how flat the area where the practice is installed must be.
- **Head.** To evaluate BMP options, determine the elevation of the discharge point, and use this column as an aid to estimate the elevation difference needed from the inflow to the outflow to allow for gravity operation.

Table 4.3 BMP Selection Based on Physical Feasibility Screening Factors

Code	BMP List	Underlying Soils	Distance to Water Table (ft)	Contributing Drainage Area (ac)	Practice Surface Slope (%)	Head (ft)
G-1	Extensive Green Roof	N/A	N/A	green roof surface area + 25%	1–2[a]	N/A
G-2	Intensive Green Roof					
R-1	Rainwater Harvesting	N/A	N/A	no limit	N/A	N/A
D-1	Simple Disconnection to a Pervious Area	all soils	N/A	< 1,000 ft^2 per rooftop downspout[b]	< 5	N/A
D-2	Simple disconnection to a conservation area				< 6	
D-3	Simple Disconnection to a Soil Compost Amended Filter Path				< 5	
P-1	Porous Asphalt	all soils (i < 0.5 in./hr may require underdrains)	2	2–5 × practice surface area	< 5	2–4
P-2	Pervious Concrete					
P-3	Permeable Pavers					
B-1	Traditional Bioretention	all soils (i < 0.5 in./hr may require underdrains)	2	< 2.5	< 1	4–5
B-2	Streetscape Bioretention			< 1		
B-3	Expanded Tree Pits			< 1		
B-4	Stormwater Planters			< 1		
B-5	Residential Rain Gardens			< 1		
F-1	Surface Sand Filter	all soils	2	< 5	N/A	5
F-2	1-Chamber Underground Sand Filter			< 10,000 ft^2		5–10
F-3	3-Chamber Underground Sand Filter			< 2		5–10
F-4	Perimeter Sand Filter			< 2		2–3
I-1	Infiltration Trench	i > 0.5 in/hr is preferred	2	< 2	< 1	2
I-2	Infiltration Basin			< 5		
O-1	Grass Channel	all soils	2	< 2.5	< 4	1
O-2	Dry Swale	all soils (i < 0.5 in./hr may require underdrains)	2			3–5
O-3	Wet Swale	i < 0.5 in./hr	intersect WT			1
P-1	Micropool Extended Detention Pond	soils i > 0.5 in./hr may require pond liner	N/A	10–25	< 1	6–8
P-2	Wet Pond		N/A	10–25		6–8
P-3	Wet Extended Detention Pond		N/A	10–25		6–8
W-1	Shallow Wetland	soils i > 0.5 in./hr may require pond liner	N/A	> 25[e]	< 1	2–4
W-2	Extended Detention Shallow Wetland		N/A			
S-1	Underground Detention	all soils	no restrictions	no restrictions	< 1	> 5
S-2	Dry Extended Detention Pond		2	> 10[d]	< 1	6–8

Code	BMP List	Underlying Soils	Distance to Water Table (ft)	Contributing Drainage Area (ac)	Practice Surface Slope (%)	Head (ft)
PP-1	Proprietary Practice	All soils	2	design dependent	N/A	2–5
TP-1	Tree Preservation	All soils	N/A	N/A	N/A	N/A
TP-2	Tree Planting		N/A	N/A		

Notes: i= infiltration rate or permeability, WT= water table, N/A= not applicable
a Green roof slope can be up to 25% if baffles are used to ensure detention of the design storm
b For impervious areas other than rooftop, the longest contributing impervious area flow path cannot exceed 75 feet.
c The required head for bioretention areas can be reduced in small applications or when an upturned or elevated underdrain design is used
d No limit but practical drainage area limitations may exist due to minimum orifice size (e.g., 1-inch diameter with internal orifice)
e CDA can be smaller if the practice intersects the water table

Table 4.4 Selection of Infiltration BMPs Based on Measured Infiltration Rate*

	Measured Infiltration Rate (in./hr)		
	Less than 0.25	**0.25 to 0.5**	**More than 0.5**
Recommended Design Solution	Use Bioretention, Dry Swale, or Permeable Pavement (likely with an underdrain). Do not use Infiltration Trench/Basin.	Use Bioretention, Dry Swale, or Permeable Pavement (likely with an underdrain). It may be beneficial to include an infiltration sump below the underdrain invert. Infiltration Trench/Basin may not be appropriate.	Use Infiltration Trench/Basin, Bioretention, Dry Swale, or Permeable Pavement without an underdrain.

*Designers must use ½ of the measured infiltration rate for design purposes, as indicated in the design equations given in Chapter 3.

4.5 Community and Environmental Factors

Designers can use Table 4.5 to compare the BMP options with regard to maintenance, habitat, community acceptance, cost, safety, space consumption, and other environmental factors. Table 4.5 employs a comparative index approach to rank the benefits of community and environmental factors as high, medium, or low.

The following are key considerations for community and environmental factors:

- **Maintenance Burden.** This column identifies the relative maintenance effort needed for each BMP option, in terms of the frequency of scheduled maintenance, chronic maintenance problems (such as clogging), and reported failure rates. All BMPs require routine inspection and maintenance (see Appendix L Maintenance Inspection Checklists).

- **Cost.** This column ranks BMPs according to their relative construction cost per cubic foot of stormwater retained, as determined from cost surveys and local experience.
- **Safety Risk.** This column provides a comparative index of the potential safety risks of each BMP option, when designed according to the performance criteria outlined in Chapter 3. The index is included to highlight the need for considerations of liability and public safety in locations, such as residential, public space, schools, and others. A comparatively higher risk BMP may require signage, fencing, or other measures needed to alert the general public or maintenance provider of a potentially harmful situation.
- **Space Required.** This column provides a comparative index of the amount of space each BMP option typically consumes at a site. It may be helpful to consider this factor at an early stage of design because many urban BMPs are constrained by availability of open land.
- **Environmental Factors.** This column assesses the range of environmental factors considered under the Green Area Ratio (GAR) process to identify the broader human and environmental beneficial intersections some BMPs provide. For instance some BMPs contribute to air quality improvements and reduce the urban heat island effect.
- **Habitat Value.** This column evaluates the ability of BMPs to provide wildlife or wetland habitat, assuming that an effort is made to landscape them appropriately. Objective criteria include size, water features, wetland features, and vegetative cover of the BMP and its buffer.
- **Other Factors.** This column indicates other considerations in BMP selection.

Table 4.5 BMP Selection Based on Community and Environmental Factors

Code	BMP List	Maintenance Burden	Cost*	Safety Risk	Space Required	Environmental Benefits	Habitat Value	Other Factors
G-1	Extensive Green Roof	L	H	L	L	H	L	Increases structural loading on building
G-2	Intensive Green Roof	M	H				M	
R-1	Rainwater Harvesting	L	M	L	L	H	L	
D-1	Simple Disconnection to a Pervious Area	L	L	L	M	M	L	
D-2	Simple Disconnection to a Conservation Area							
D-3	Simple Disconnection to a Soil Compost Amended Filter Path							
P-1	Porous Asphalt	H	H	L	L	M	L	
P-2	Pervious Concrete							
P-3	Permeable Pavers							
B-1	Traditional Bioretention	M	L	L	M	H	M	Can be used as landscaping features
B-2	Streetscape Bioretention	H	H		M		M	
B-3	Expanded Tree Pits	M	H		L		M	
B-4	Stormwater Planters	L	M		L		L	
B-5	Residential Rain Gardens	L	L		L		M	
F-1	Surface Sand Filter	M	L	L	M	L	L	Minimize concrete
F-2	1-Chamber Underground Sand Filter	H	M	M	L			Out of sight
F-3	3-Chamber Underground Sand Filter	H	H	M	L			Out of sight
F-4	Perimeter Sand Filter	M	M	L	M			Traffic bearing
I-1	Infiltration Trench	L	M	L	M	L	L	Avoid large stone
I-2	Infiltration Basin							Frequent pooling

Notes: H = High; M = Medium; L=Low
* Cost based on $ per cubic foot of stormwater treated

Code	BMP List	Maintenance Burden	Cost*	Safety Risk	Space Required	Environmental Benefits	Habitat Value	Other Factors
S-1	Underground Detention	M	H	M	L	L	L	Out of sight
S-2	Dry Pond		L		H	M		
P-1	Micropool Extended Detention Pond	M	L	M	H	M	L	Trash/debris
P-2	Wet Pond	H					H	High pond premium
P-3	Wet Extended Detention Pond	H					H	
W-1	Shallow Wetland	M	M	L	H	H	H	
W-2	Extended Detention Shallow Wetland			M				Limit ED depth
O-1	Grass Channel	M	L	L	M	M	L	
O-2	Dry Swale	H	M				L	
O-3	Wet Swale	H	M				M	Possible mosquitoes

Notes: H = High; M = Medium; L=Low
* Cost based on $ per cubic foot of stormwater treated

4.6 Location and Permitting Considerations

In this step, the designer follows an environmental features checklist that asks whether any of the following are present at the site: wetlands, waters of the United States, floodplains, and development infrastructure. Brief guidance is then provided on how to locate BMPs to avoid impacts to sensitive resources. If a BMP must be located within a sensitive environmental area, a brief summary of applicable permit requirements is provided.

In the last step, a designer assesses the physical and environmental features at the site to determine the optimal location for the selected BMP or group of BMPs (Table 4.5). The checklist below provides a condensed summary on current BMP restrictions as they relate to common site features that may be regulated under District or federal law. These restrictions fall into one of three general categories:

1. Locating a BMP within an area that is expressly *prohibited* by law.
2. Locating a BMP within an area that is *strongly discouraged*, and is only allowed on a case by case basis. District and/or federal permits shall be obtained, and the applicant will need to supply additional documentation to justify locating the BMP within the regulated area.
3. BMPs must be *set back* a fixed distance from the site feature.

This checklist is only intended as a general guide to location and permitting requirements as they relate to siting of stormwater BMPs. Consultation with the appropriate regulatory agency is the best strategy.

Table 4.6 Location and Permitting Considerations

Site Features and Relevant Agencies	Location and Permitting Guidance
Jurisdictional Wetland U.S. Army Corps of Engineers Section 404 Permit	▪ Delineate wetlands prior to locating BMPs. ▪ Use of natural wetlands for stormwater management is *strongly discouraged*. ▪ BMPs are also *restricted* in the 25 to 100 foot required wetland buffer. ▪ Buffers may be utilized as a non-structural filter strip (i.e., accept sheetflow). ▪ Must justify that no practical upland treatment alternatives exist. ▪ Stormwater must be treated prior to discharge into a wetland. ▪ Where practical, excess stormwater flows should be conveyed away from jurisdictional wetlands.
Stream Channel (Waters of the U.S.) U.S. Army Corps of Engineers Section 404 Permit	▪ Delineate stream channels prior to design. ▪ In-stream ponds (should be located near the origin of first order streams) are *strongly discouraged* and require review and permit. ▪ Must justify that no practical upland treatment alternatives exist. ▪ Temporary runoff storage (peak flow management) is preferred over permanent pools. ▪ Implement measures that reduce downstream warming.

Site Features and Relevant Agencies	Location and Permitting Guidance
100 Year Floodplain District of Columbia Homeland Security and Emergency Management Agency District Department of the Environment	▪ Grading and fill for BMP construction is *strongly discouraged* within the 100 year floodplain, as delineated by FEMA Flood Insurance Rate Maps (FIRM). ▪ Floodplain fill may be restricted with respect to impacts on surface elevation (DCMR 20, Chapter 31 Flood Hazard Rules>).
Utilities	▪ Locate existing utilities prior to design. ▪ Note the location of proposed utilities to serve new construction. ▪ Consult with each Utility on their recommended offsets ▪ Consider altering the location or sizing of the BMP to avoid or minimize the utility conflict. Consider an alternate BMP type to avoid conflict. ▪ Use design features to mitigate the impacts of conflicts that may arise by allowing the BMP and the utility to coexist. The BMP design may need to incorporate impervious areas, through geotextiles or compaction, to protect utility crossings. Other a key design feature may need to be moved or added or deleted. ▪ Coordinate with Utilities to allow them to replace or relocate their aging infrastructure during construction. ▪ If utility functionality, longevity and vehicular access to manholes can be assured accept the BMP design and location with the existing utility. Incorporate into the BMP design sufficient soil coverage over the utility or general clearances or other features such as an impermeable linear to assure all entities the conflict is limited to maintenance. ▪ When accepting utility conflict into BMP design, it is understood that 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. If the BMP is located in the public right-of-way the BMP restoration will also conform with 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.
Public Right-of-Way District Department of Transportation	▪ BMP installation in PROW will require a DDOT Public Space Permit. ▪ Consult DDOT for guidance on placement and any setback requirement from local roads.

Site Features and Relevant Agencies	Location and Permitting Guidance
Structures District Department of Transportation District of Columbia Water and Sewer Authority Department of Consumer and Regulatory Affairs	▪ Consult review authority for BMP setbacks from structures. ▪ Recommended setbacks for each BMP group are provided in the performance criteria in Chapter 3.

4.7 References

Galli, John. 1992. Analysis of Urban BMP Performance and Longevity in Prince George's County, Maryland. Prepared for Prince George's County Department of Environmental Resources Watershed Protection Branch. Prepared by Metropolitan Washington Council of Governments, Department of Environmental Programs. Washington DC.