Chapter 4

Selecting
and
Locating
the
Most Effective
Stormwater
Best
Management
Practice
System

4.0 Choosing between Stormwater Management Best Practice (BMP)

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. The method involves a five step screening process for the following factors:

- Stormwater Management Suitability
- Land Use Factors
- Physical Feasibility Factors
- Community and Environmental Factors
- Location and Permitting Considerations

The factors presented in this chapter represent guidelines, not rules, for which BMP may be most appropriate at 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 tables below and are described in more detail in the individual practice specifications (see ***Chapter 3***).

The general step-wise screening process is described below.

STEP 1 Stormwater Management Suitability
Can the BMP meet all stormwater sizing criteria at the site or are a combination of BMPs needed?
In this step, designers can screen BMP options using Matrix No. 1 to determine if a particular BMP can meet the SWRv, Q_{p2}, Q_{p15}, and/or Q_f storage requirements. In addition, the designer can view the pollutant removal potential for select pollutants to determine the best BMP options for water quality improvements. At the end of this step, the designer can screen the BMP options down to a manageable number and determine if a single BMP or a group of BMPs are needed to meet stormwater sizing criteria at the site.

STEP 2 Land Use Factors
Which practices are best suited for the proposed land use at this site?
In this step, the designer can use Matrix No. 2 to screen select practices that are best suited to a particular land use, including highly urbanized areas.

STEP 3 Physical Feasibility Factors
Are there any physical constraints at the project site that may restrict or preclude the use of a particular BMP?
In this step, the designer can screen BMP options using Matrix No. 3 to determine if the soils, water table, drainage area, slope or head conditions present at a particular development site might limit the

use of a BMP.

STEP 4 Community and Environmental Factors

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

In this step, Matrix No. 4 is used to compare the BMP options with regard to maintenance, habitat, community acceptance, cost, safety, space consumption, and other environmental factors.

STEP 5 Location and Permitting Considerations

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

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.

Section 4.1 Stormwater Management Suitability

The first matrix (Table 4.1) examines the capability of each Stormwater Best Management Practice (BMP) option to meet the stormwater management sizing criteria outlined in Chapter 2. Thus, it shows whether a BMP has the:

Ability to Meet the Stormwater Retention Volume (SWRv) and any remaining TSS removal requirements It should be noted that not all practices are capable of meeting the *SWRv* requirement. Thus, if a single BMP cannot meet this requirement, the matrix can help identify supplemental practices that can.

Ability to Provide Additional Quantity Control (Q_{p2}, Q_{p15} and/of Q_f). The matrix shows whether a BMP can typically meet the peak discharge requirement for the site. Again, the finding that a particular BMP cannot meet the requirement does not necessarily mean that it should be eliminated from consideration, but rather, is a reminder that more than one practice may be needed at a site (e.g., a bioretention area and a downstream storage practice).

Pollutant Removal. The matrix 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 is indicated in the table.

Table 4.1. BMP selection based on regulatory goals.

Code	BMP	SWRv Storage	Q_{p2}/Q_{p15} Control	Q_f Control	TSS removal
G-1	Extensive Green Roof	●	☒	☒	L
G-2	Intensive Green Roof		◉		
R-1	Rainwater Harvesting	◉	☒	☒	L
D-1	Simple disconnection to a pervious area	◉	☒	☒	L
D-2	Simple disconnection to a conservation area				
D-3	Simple disconnection to a soil compost amended filter path				
P-1	Porous Asphalt	●	◉	☒	M
P-2	Pervious Concrete				
P-3	Permeable Interlocking Concrete Pavers				
B-1	Traditional bioretention	●	◉	☒	H
B-2	Streetscape bioretention		☒		
B-3	Expanded tree pits		☒		
B-4	Stormwater planters		☒		
B-5	Residential rain gardens		☒		
F-1	Surface SF	☒	☒	☒	H
F-2	1-Chamber Underground SF				H
F-3	3-Chamber Underground SF				H
F-4	Perimeter SF				H
I-1	Infiltration Trench	●	◉	☒	M
I-2	Infiltration Basin				
S-1	Underground Detention	☒	●	●	L
S-2	Dry ED Pond				
P-1	Micropool ED Pond	☒	●	●	H
P-2	Wet Pond				
P-3	Wet ED Pond				
W-1	Shallow Wetland	☒	●	●	H
W-2	ED Shallow Wetland				
O-1	Grass Channels	◉	☒	☒	H
O-2	Dry Swale	●			H
O-3	Wet Swale	☒			H

● = Yes; ◉ = Partial; ☒ = Minor or No Benefit
H = High; M = Medium; L=Low

Section 4.2

Land Use Factors

The second matrix (Table 4.2) allows the designer to make an initial screening of practices most appropriate for a given land use.

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 Interlocking Concrete 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 SF	☒	●	●	●
F-2	1-Chamber Underground SF			◉	
F-3	3-Chamber Underground SF			◉	
F-4	Perimeter SF			◉	
I-1	Infiltration Trench	◉	●	◉	☒
I-2	Infiltration Basin				
S-1	Underground Detention	☒	●	●	☒
S-2	Dry Pond	●	◉	◉	
P-1	Micropool ED Pond	●	◉	◉	③
P-2	Wet Pond			◉	③
P-3	Wet ED Pond			◉	③
W-1	Shallow Wetland	●	◉	◉	③
W-2	ED Shallow Wetland			◉	③
O-1	Grass Channel	●	●	●	②
O-2	Dry Swale				
O-3	Wet Swale				

● = Yes; ◉ = Maybe; ☒ = No
①- Can be used on low traffic residential roads
②-Yes, only if designed with an impermeable liner
③-May require pond liner to reduce the risk of GW contamination

Section 4.3 Physical Feasibility Factors

At this point, the designer has narrowed the BMP selection list based on regulatory goals and land use constraints. Now, the designer can evaluate the remaining BMP options given the actual physical conditions of a site. The matrix in Table 4.3b identifies the testing protocols needed to confirm physical conditions at the site. The five primary factors are:

Underlying Soils. The key evaluation factors are based on an initial investigation of the NRCS hydrologic soils groups at the site. Note, more detailed geotechnical tests are required to evaluate infiltration feasibility, and related design parameters. Once the infiltration rate at a site has been measured, Table 4.3a can help determine the required design criteria for practices that have an infiltration option.

Table 4.3a. Infiltration design choices based on measured infiltration rate.

Measured Infiltration Rate (inches/hour)			
	Less than 0.25	**0.25 to 0.5**	**More than 0.5**
Recommended Design Solution	Use Bioretention, Dry Swale, or Permeable Pavement with an underdrain. DO NOT use Infiltration Trench/Basin.	Use Bioretention, Dry Swale, or Permeable Pavement with an underdrain, or design with an infiltration sump below the underdrain invert. DO NOT use Infiltration Trench/Basin.	Use Infiltration Trench/Basin, Bioretention, Dry Swale, or Permeable Pavement without an underdrain.

Water Table Depth. This column indicates the minimum depth to the seasonally high water table from the bottom or floor of a BMP.

Contributing Drainage Area. This column indicates the minimum or maximum drainage area that is considered suitable for the practice. 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. This column evaluates the effect of slope on the practice. Specifically, the slope restrictions refer to how flat the area where the practice is installed must be.

Head. This column provides an estimate of the elevation difference needed at a site (from the inflow to the outflow) to allow for gravity operation within the practice.

Table 4.3.b. Physical feasibility screening factors.

Code	BMP List	Underlying Soils	Water Table Depth	Contributing Drainage Area	Practice Surface Slope	Head
G-1	Extensive Green Roof	N/A	N/A	green roof surface area+ 0.25%	1-2%[1]	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	less than 1,000 s.f per rooftop downspout[2]	2 to 5%	N/A
D-2	Simple disconnection to a conservation area	all soils			2 to 6%	
D-3	Simple disconnection to a soil compost amended filter path	all soils			2 to 5%	
P-1	Porous Asphalt	all soils (i < 0.5 in/hr require underdrains)	2 feet	2-5 times practice surface area	less than 3%	2 to 4 feet
P-2	Pervious Concrete					
P-3	Permeable Interlocking Concrete Pavers					
B-1	Traditional bioretention	all soils (i < 0.5 in/hr require underdrains)	2 feet	less than 2.5 acres	0.5 to 1%	4 to 5 ft[3]
B-2	Streetscape bioretention			less than 1 acre		
B-3	Expanded tree pits			less than 1 acre		
B-4	Stormwater planters			less than 1 acre		
B-5	Residential rain gardens			less than 1 acre		
F-1	Surface SF	all soils	2 feet	less than 5 ac	less than 6%	5 ft
F-2	1-Chamber Underground SF			less than 10,000 sq ft		5 to 10ft
F-3	3-Chamber Underground SF			less than 2 ac		5 to 10ft
F-4	Perimeter SF			less than 2 ac		2 to 3 ft
I-1	Infiltration Trench	i > 0.5 in/hr	2 feet	less than 2 ac	less than 6%	2 ft
I-2	Infiltration Basin			less than 5 ac		
S-1	Underground Detention	all soils	no restrictions	no restrictions[4]	0.5 to 1%	>5 ft
S-2	Dry ED Pond		2 feet	greater than 10 ac[4]	0.5 to 1%	6 to 8 ft
P-1	Micropool ED Pond	soils i > 0.5 in/hr may require pond liner	N/A	10 to 25 ac	0.5 to 1%	6 to 8 ft
P-2	Wet Pond		N/A	10 to 25 ac		6 to 8 ft
P-3	Wet ED Pond		N/A	10 to 25 ac		6 to 8 ft

i= infiltration rate or permeability, WT= water table, N/A= not applicable

[1] Green roof slope can be up to 25% if baffles are used to ensure detention of the design storm

[2] For non-rooftop impervious areas, the longest contributing impervious area flow path cannot exceed 75 feet.

[3] The required head for bioretention areas can be reduced in small applications or when an upturned or elevated underdrain design is used

Table 4.3.b. Physical feasibility screening factors.

Code	BMP List	Underlying Soils	Water Table Depth	Contributing Drainage Area	Practice Surface Slope	Head
[4] No limit but practical drainage area limitations may exist due to minimum orifice size (e.g., 1" diameter with internal orifice)						
W-1	Shallow Wetland	soils i > 0.5 in/hr may require pond liner	N/A	typ. greater than 25 ac[5]	0.5 to 1%	2 to 4 ft
W-2	ED Shallow Wetland		N/A			
O-1	Grass Channel	all soils	2 feet	less than 2.5 ac	less than 4%	1 ft
O-2	Dry Swale	all soils (i < 0.5 in/hr require underdrains)	2 feet			3 to 5 ft
O-3	Wet Swale	i < 0.5 inch/hr	intersect WT			1 ft
i= infiltration rate or permeability, WT= water table, N/A= not applicable [5] CDA can be smaller if the practice intersects the water table						

Section 4.4 Community and Environmental Factors

The fourth step considers community and environmental factors involved in BMP selection. This matrix (Table 4.4) employs a comparative index approach. The table indicates whether a BMP has a high, medium, or low benefit in each of four categories. A fifth category includes miscellaneous factors to consider.

Maintenance Burden. This column assesses the relative maintenance effort needed for a BMP, in terms of three criteria: frequency of scheduled maintenance, chronic maintenance problems (such as clogging) and reported failure rates. It should be noted that all BMPs require routine inspection and maintenance (maintenance checklists for all BMPs can be found in Appendix M).

Cost. The BMPs are ranked according to their relative construction cost per cubic foot of stormwater retained as determined from cost surveys and local experience.

Safety Risk. A comparative index is provided to expresses the potential safety risk of a BMP when designed according to the performance criteria outlined in Chapter 3. The index is included at this stage of the screening process 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 comparative index expresses how much space a BMP typically consumes at a

site. Again, this factor is included in this early screening stage because many 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 reductions in the urban heat island effect.

Habitat Value. BMPs are evaluated on their ability 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 4.4. 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 Interlocking Concrete Pavers							
B-1	Traditional bioretention	M	L	L	M	H	M	Can be used as landscaping features
B-2	Streetscape bioretention	H	H		M	H	M	
B-3	Expanded tree pits	M	H		L	H	M	
B-4	Stormwater planters	L	M		L	H	L	
B-5	Residential rain gardens	L	L		L	H	M	
F-1	Surface SF	M	L	L	M	L	L	Minimize concrete
F-2	1-Chamber Underground SF	H	M	M	L	L		Out of sight
F-3	3-Chamber Underground SF	H	H	M	L	L		Out of sight
F-4	Perimeter SF	M	M	L	M	L		Traffic bearing
I-1	Infiltration Trench	L	M	L	M	L	L	Avoid large stone
I-2	Infiltration Basin				M	L		Frequent pooling
S-1	Underground Detention	M	H	M	L	L	L	Out of sight
S-2	Dry Pond		L		H	M		
H = High; M = Medium; L=Low * Cost based on $ per cubic foot of stormwater treated								
P-1	Micropool ED Pond	M	L	M	H	M	L	Trash/debris

Table 4.4. Community and environmental factors.

Code	Bmp List	Maintenance Burden	Cost*	Safety Risk	Space Required	Environmental Benefits	Habitat Value	Other Factors
P-2	Wet Pond	H			H	M	H	High pond premium
P-3	Wet ED Pond	H			H	M	H	
W-1	Shallow Wetland	M	M	L	H	H	H	
W-2	ED Shallow Wetland	M		M	H	H	H	Limit ED depth
O-1	Grass Channel	M	L	L	M	M	L	
O-2	Dry Swale	H	M	L	M	M	L	
O-3	Wet Swale	H	M	L	M	M	M	Possible mosquitoes

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

Section 4.5 Location and Permitting Considerations

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 local 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. Local 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 *setback* 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 4.5 Location and Permitting Considerations

Site Feature	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.
100 Year Floodplain District of Columbia Homeland Security and Emergency Management Agency District Department of 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>).

Table 4.5 Location and Permitting Considerations

Site Feature	Location And Permitting Guidance
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 ■ Coordinate with Utilities to allow them to replace or relocate their aging infrastructure during construction. ■ BMP and utility conflicts will be a common occurrence in public right of way projects. The standard solution should be BMP acceptance provided sufficient soil coverage over the utility can be assured. ■ When accepting utility conflict into BMP design, it is understood that the BMP will be temporarily impacted during utility maintenance but restored to its original condition.
Public Right of Way District of Columbia Department of Transportation	■ Consult DDOT for any *setback* requirement from local roads. ■ Approval must also be obtained for any stormwater discharges to a District-owned conveyance channel. ■ BMP installation in PROW will require DDOT public space approval.
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 of this manual.