4. Selecting the Right BMP

4.1 Introduction

Selecting the most appropriate BMPs for a development is an art as well as a science, if done correctly. This Chapter provides the link between stormwater regulatory requirements and physical site constraints, as well as issues of cost and community acceptance.

For several reasons, there is no one BMP that is best for every site. First, different BMPs are better suited for different aspects of stormwater treatment and control (sediment removal, nutrient removal, and volume control). One particular BMP might not provide all of the required treatment goals of the regulations that apply to a site. Additionally, each site has unique features, such as slope, soils, size, and development density that encourage the use of some types of BMPs and eliminate the use of other types of BMPs. Issues of cost and community acceptance are also vital to consider in the BMP selection process.

Whether or not a structural BMP is needed will be determined by the applicable regulatory requirements for the site, which are covered in Chapter 2. For an exact determination of the applicable regulations at a site, please check with local planning and zoning authorities, as well as using the interactive mapping feature on the DWQ Stormwater Web page at http://portal.ncdenr.org/web/wq/ws/su/maps.

4.2. General BMP Selection Guidance

Prior to selecting a structural BMP, a designer should first consider if it is possible to reduce the impervious surfaces on the site. Reducing impervious surfaces can minimize or eliminate the need for structural BMPs. Strategies for reducing impervious surfaces are discussed in Section 4.3.

If structural BMPs will be required, the following process is recommended for selecting the appropriate one to use:

- First, determine the treatment capability (TSS removal, nutrient removal and peak flow control) that is required of the BMP based on the applicable regulatory requirements for the site (see Chapter 2).
- Second, determine which BMPs will meet the treatment capability requirements (Section 4.4) and create a "short list."
- Third, see which of the "short listed" BMPs will be appropriate for the physical site characteristics (Section 4.5).
- Fourth, consider other factors such as construction cost, maintenance effort, community acceptance and wildlife habitat (Section 4.5).

When a site has a lot of physical constraints and the regulatory requirements are stringent, it can be especially challenging to find a BMP that will fit the bill. In this case, it may be necessary to modify the BMP design for the site characteristics (see individual

BMP chapters) or to provide a combination of BMPs that are suitable for the site in series to provide the required level of stormwater treatment.

Getting even further into the art of good BMP design requires blending the BMP into the natural environment to make it an aesthetic enhancement rather than a thing to hide (especially in areas with considerable pedestrian traffic such as residential, commercial, and office locations). This often requires collaboration between various professions such as civil engineers and landscape architects.

When siting BMPs within a site, they should conform to the natural features of the landscape such as drainage swales, terraces, and depressions. Many of the more "natural" BMPs can readily achieve these goals, such as filter strips, grassed swales, and restored riparian buffers. Other natural-looking BMPs such as bioretention and stormwater wetlands can be blended right into natural areas of site designs, or even create new, small sized natural areas within normally barren portions of the site, such as parking lots, walking areas, and outdoor plazas.

DWQ recommends reintroducing runoff from impervious surfaces into the natural environment as close to the surfaces as possible. Ideally, impervious surfaces should be hydrologically divided so that runoff is delivered in smaller volumes that can be accommodated by smaller, less expensive and less obtrusive BMPs. In general, DWQ recommends against constructing large "end-of-pipe" facilities because of their high cost, maintenance requirements, consumption of land, and disruption of the landscape.

4.3. Reducing Impervious Surfaces

Most stormwater rules provide an option to meet certain low-density development criteria and then typically no engineered stormwater controls will be required. Keeping the percent impervious surface low when possible is the preferred method of stormwater control. In addition, reducing the percentage of impervious cover in a high-density development will reduce the size of BMPs that are needed.

Some of the options for reducing impervious surfaces are listed below. The local planning jurisdiction will usually determine the flexibility that exists to try them.

- Reducing road widths
- Reducing minimum parking requirements
- Minimizing use of curb and gutter
- Cluster or open-space developments
- Traditional neighborhood developments
- Mixed-use developments

Appendix G of the *Neuse River Basin: Model Stormwater Program for Nitrogen Control (*1999) discusses site design techniques to reduce impervious surfaces in greater detail, available at: http://portal.ncdenr.org/web/wq/ws/su/neusensw.

4.4. Comparison of BMP Treatment Capabilities

If the low-density option is not chosen, then one or more structural BMPs will be needed. For structural BMPs, one or more of the following general requirements will apply:

- There will be a pollutant removal requirement (typically 85% for TSS) or a maximum discharge limit (maximum pollutant export rate for TN and possibly also TP) imposed.
- There will be a volume of stormwater that must be captured and treated prior to release (typically first 1 inch or first 1.5 inches of rainfall).
- The post-construction peak stormwater discharge rate must be reduced to no greater than the pre-construction peak stormwater discharge rate (usually for the 1-year, 24-hour storm).

Table 4-1 presents the TSS, N, and P removal efficiencies of the various BMPs discussed in this manual. These removal efficiencies assume that the BMPs are designed in accordance with the design requirements presented in Chapters 8 through 20. The removal efficiencies presented are in accordance with the September 8, 2004 memorandum *Updates to Stormwater BMP Efficiencies* from the North Carolina Department of Environment and Natural Resources (DENR), Division of Water Quality (DWQ) Stormwater Unit (DWQ, 2004).

Fecal coliform reduction is currently regulated as a narrative requirement rather than a quantitative requirement. Effort must be made to reduce fecal coliform levels in SA waters. The current main mechanism for reducing fecal coliform in stormwater BMPs is through exposure to UV light (sunlight), which happens regularly in devices containing areas which become temporarily inundated with stormwater. Fecal coliforms can be deposited and exposed to UV light. Additionally, in Bioretention cells, fecal coliforms can be reduced by filtration, drying events between storms, and sedimentation. Some scientists also believe predation from other microbes can significantly reduce fecal coliform numbers (Hathaway and Hunt, 2008). BMPs are ranked relatively for fecal coliform removal in Table 4-1.

High temperature of BMP discharges is of concern in HQW waters that support trout. The higher temperatures reduce dissolved oxygen, reduce reproductive rates, hinder growth, and increase disease exposure, among other things. Temperatures are typically increased due to ponded water being exposed to sunlight. BMPs are ranked relatively for temperature issues in Table 4-1.

Table 4-1
BMP Ability for Stormwater Quality Control

	Peak Attenuation	TSS Removal Efficiency	TN Removal Efficiency	TP Removal Efficiency	Fecal Removal Ability	Potential to heat stormwater
Bioretention without IWS	Possible	85%	35%	45%	High	Med
Bioretention with IWS *Coastal Plain & Sand Hills*	Possible	85%	60%	60%	High	Med
Bioretention with IWS *Piedmont & Mountains*	Possible	85%	40%	45%	High	Med
Stormwater wetlands	Yes	85%	40%	40%	Med	High
Wet detention basin	Yes	85%	25%	40%	Med	High
Sand filter	Possible	85%	35%	45%	High	Med
Filter strip	Some	40%	30%	35%	Med	Low
Grassed swale	No	0-35%	0-20%	0-20%	Low	Low
Restored riparian buffer	No	60%	30%	35%	Med	Low
Infiltration devices	Yes	85%	30%	35%	High	Low
Dry extended detention basin	Yes	50%	10%	10%	Med	Med
Permeable pavement *Infiltrating system*	Yes	85%	30%	60%	High	Low
Permeable pavement *Detention system*	Yes	70-85%	10%	10%	Med	Med
Rooftop runoff management	Possible	0%	0%	0%	Low	Med

4.5. Comparison of BMP Site Constraints

The basic nature of stormwater BMPs often places them in low-lying areas and next to existing waterways, which can put them at odds with other regulations. The designer must always be aware of other regulations when siting BMPs. A non-exhaustive list of possible environmental regulatory issues is provided below:

- Jurisdictional wetlands
- Stream channels
- 100-year floodplains
- Stream buffers
- Forest conservation areas
- Critical areas
- Endangered species

BMPs should also be sited in a manner that avoids the following types of infrastructure:

- Utilities
- Roads
- Structures
- Septic drain fields
- Wells

A BMP will not work unless it is sited appropriately. It is very important to visit the site and obtain information about the size of the drainage area, soils and slopes as well as depth to groundwater table and bedrock.

The various site considerations for siting BMPs is presented in Table 4-2 below. Each of these considerations is discussed below.

The **size of drainage area** is a primary consideration in selecting a BMP. Some BMPs will only work with drainage area that is sufficient to provide a permanent pool of water. Other BMPs, such as bioretention areas and sand filters, are specifically designed to handle smaller flows and could easily become overwhelmed if sited at the outlet of a large drainage area.

The **space required** for a BMP is another important consideration, particularly if the site does not have a lot of space to accommodate a BMP. It is important to note, however, that some of the BMPs that require a small space are relatively expensive (i.e., sand filter) or do not have high treatment capabilities (i.e., grassed swale).

The **head required** (elevation difference) will also affect the BMP selected. In areas of low relief excavations are often required for basins, which can be expensive. In addition, some devices require several feet of hydraulic head, which may not be available in low relief areas.

Steep slopes will affect the BMP selection process. Larger BMPs, such as wet detention basins and extended detention wetlands, may not fit well on a site where there is not a relatively flat area to site them or result in an impractically large embankment height. Also, steep slopes may create excessive water velocities for some systems (e.g.: filter strips, swales, restored riparian buffer). When an entire site has steep slopes, it may be best to provide a number of smaller BMPs that can fit into the existing contours of the site.

A **shallow water table** can limit some types of BMP systems. For example, bioretention areas require a minimum depth to groundwater of two feet; otherwise, the bioretention area will actually function as a stormwater wetland.

A **shallow depth to bedrock** can greatly limit BMP options. Shallow bedrock can restrict the use of infiltration systems, prevent the excavation of basins, and limit the hydraulic functions of certain BMPs. The BMP options in this scenario may be limited to filter strips, restored riparian buffers and rooftop runoff management.

High sediment input can limit the longevity of certain BMPs, especially sand filters, bioretention, infiltration systems, stormwater wetlands, and permeable pavement. These BMPs should not be placed in locations where high sediment loads are expected upstream in the future (typically from future development). Alternatively, high sediment loads that might adversely affect BMPs can be overcome by providing filter strips and sediment basins in upgradient areas.

Poorly drained soils are another BMP siting consideration. For example, poorly drained soils may exclude the use of any system relying on infiltration, such as bioretention areas without an underdrain (However, this problem can be corrected with the use of an underdrain.) Poorly drained soils may be very well suited, however, for BMPs that retain water, such as a wet detention basin or a stormwater wetland.

Table 4-2
Possible Siting Constraints for BMPs

BMP	Size of Drainage Area	Space Required	Head Required	Works with Steep Slopes?	Works with Shallow Water Table?	Works with Shallow Depth to Bedrock?	Works with High Sediment Input?	Works with Poorly Drained Soils?
Bioretention without IWS	S	High	Med	Y	N	N	N	Y
Bioretention with IWS	S	High	Med	Y	N	N	N	N
Stormwater wetlands	S-L	High	Med	N	Y	N	Y	Y
Wet detention basin	M-L	High	High	N	Y	N	Y	Y
Sand filter	S	Low	Med	Y	N	N	N	Y
Filter strip	S	Med	Low	N	Y	Y	N	Y
Grassed swale	S	Low	Med	Y	Y	N	N	Y
Restored riparian buffer	S-M	Med	Low	N	Y	Y	N	Y
Infiltration devices	S-M	High	Low	N	N	N	N	N
Dry extended detention basin	S-L	Med	High	N	N	N	Y	Y
Permeable pavement system	S-M	N/A	Low	N	N	N	N	Y
Rooftop runoff management	S	Variable	Low	Y	Y	Y	Y	Y

4.6. Comparison of BMP Costs and Community Acceptance

Construction costs and operation and maintenance efforts for each of the BMPs are listed in Table 4-3. However, it is important to note that some of the lowest cost or lowest maintenance level BMPs also have some of the lowest treatment capabilities. Using low-cost BMPs could result in a need for additional BMPs to achieve the requirements, thereby increasing costs and maintenance requirements. In addition, several of the lowest cost BMPs may be difficult to integrate into the natural features of a site or may be the least desirable from an aesthetic or safety point of view. Often, a slightly more expensive or maintenance intensive BMP may be a better choice for overall site design.

Sometimes community and environmental factors seem like the least important, but they can actually have a big impact on the public perception and acceptance of a site development. For instance, a prospective homeowner may think twice before buying a lot or home bordering a large, fenced-in dry extended detention basin with a large corrugated metal riser pipe and occasional mosquito outbreaks after storms. However, if the BMP were designed as a bioretention device or stormwater wetland served as an aesthetic amenity on the site, possibly with birds, frogs, and fish. Table 4-3 provides information on each BMP's safety concerns, community acceptance, and wildlife habitat.

Table 4-3

Cost, Community and Environmental Issues for BMPs

	Construction Cost	Maintenance Level	Safety Concerns	Community Acceptance	Wildlife Habitat
Bioretention	Med-High	Med-High	N	Med-High	Med
Stormwater wetlands	Med	Med	Y	Med	High
Wet detention basin	Med	Med	Y	Med	Med
Sand filter	High	High	N	Med	Low
Filter strip	Low	Low	N	High	Med
Grassed swale	Low	Low	N	High	Low
Restored riparian buffer	Med	Low	N	High	Med-High
Infiltration devices	Med-High	Med	N	Med-High	Low
Dry extended detention basin	Low	Low-Med	Y	Med	Low
Permeable pavement system	Med-High	High	N	Med	N/A
Rooftop runoff management	Med	Med	N	High	Low

September 28, 2007 Changes:

1. 4.5: Deleted a reference to "pocket wetland". Pocket wetlands are not addressed in the 2007 manual.
2. 4.5: Deleted the list of BMPs with minimum drainage areas. It was inaccurate.
3. Table 4-1: Corrected the bioretention TN removal efficiency from 40% to 35%.

June 2009 Changes:

1. Updated information about fecal coliforms per newest research.
2. Updated pollutant removal credits for Bioretention with IWS (Table 4-1).
3. Updated siting constraints for Bioretention with IWS (Table 4-2).

November 2012 Changes:

1. Updated pollutant removal credits for Filter Strips and Permeable Pavement (Table 4-1).
2. Miscellaneous updates in Table 4-1.
3. Web links have been updated.