## *Volume 3, Chapter 2* - BMP Selection

**Users' Guidance:**

If a UDFCD *Section* number in this chapter is **skipped**:
It was adopted as is; please refer to that Section in the **corresponding UDFCD Manual**, Volume, Chapter and *Section.*

If a UDFCD *Section* number in this chapter is **amended or a new COFC *Section* in this Chapter is added**:
It is **listed below**; please refer to it in **this document**.

If a UDFCD *Section* in this chapter is **deleted then** it was **not** adopted by the City of Fort Collins; The deleted UDFCD *Section* number will be **identified as deleted in the text below**.

(1) *Section 1.1* is amended to read as follows:

### 1.1 Physical Site Characteristics

The first step in BMP selection is identification of physical characteristics of a site including topography, soils, contributing drainage area, groundwater, base flows, wetlands, existing drainageways, and development conditions in the tributary watershed (e.g., construction activity). A fundamental concept of Low Impact Development ("LID") is preservation and protection of site features including wetlands, drainageways, soils that are conducive to infiltration, tree canopy, etc., that provide water quality and other benefits. LID stormwater treatment systems are also designed to take advantage of these natural resources. For example, if a portion of a site is known to have soils with high permeability, this area may be well-suited for rain gardens or permeable pavement. Areas of existing wetlands, which would be difficult to develop from a Section 404 permitting perspective, could be considered for polishing of runoff following BMP treatment, providing additional water quality treatment for the site, while at the same time enhancing the existing wetlands with additional water supply in the form of treated runoff. Some physical site characteristics that provide opportunities for BMPs or constrain BMP selection include:

(a) Soils**:** Soils with good permeability, most typically associated with Hydrologic Soil Groups ("HSGs") A and B provide opportunities for infiltration of runoff and are well-suited for infiltration-based BMPs such as rain gardens, permeable pavement systems, sand filter, grass swales, and buffers, often without the need for an underdrain system. Even when soil permeability is low, these types of BMPs may be feasible if soils are amended to increase permeability or if an underdrain system is used. In some cases, however, soils restrict the use of infiltration based BMPs. When soils with moderate to high swell potential are present, infiltration should be avoided to minimize damage to adjacent structures due to water-induced swelling. In some cases, infiltration based designs can still be used if an impermeable liner and underdrain system are included in the design; however, when the risk of damage to adjacent infrastructure is high, infiltration based BMPs may not be appropriate. In all cases, consult with a geotechnical engineer when designing infiltration BMPs near structures. Consultation with a geotechnical engineer is necessary for evaluating the suitability of soils for different BMP types and establishing minimum distances between infiltration BMPs and structures.

(b) Watershed Size: The contributing drainage area is an important consideration both on the site level and at the regional level. On the site level, there is a practical minimum size for certain BMPs, largely related to the ability to drain the WQCV over the required drain time. For example, it is technically possible to size the WQCV for an extended detention basin for a half-acre site; however, designing a functional outlet to release the WQCV over a 40-hour drain time is practically impossible due to the very small orifices that would be required. For this size watershed, a filtering BMP, such as a rain garden, would be more appropriate. At the other end of the spectrum, there must be a limit on the maximum drainage area for a regional facility to assure adequate treatment of rainfall events that may produce runoff from only a portion of the area draining to the BMP. If the overall drainage area is too large, events that produce runoff from only a portion of the contributing area will pass through the BMP outlet (sized for the full drainage area) without adequate residence time in the BMP. As a practical limit, the maximum drainage area contributing to a water quality facility should be no larger than one square mile. For treatment facilities serving tributary areas that are larger than one (1) acre in size, an extended water quality detention basin is the preferred and recommended water quality treatment device.

(c) Groundwater: Shallow groundwater on a site presents challenges for BMPs that rely on infiltration and for BMPs that are intended to be dry between storm events. Shallow groundwater may limit the ability to infiltrate runoff or result in unwanted groundwater storage in areas intended for storage of the WQCV (e.g., porous sub-base of a permeable pavement system or in the bottom of an otherwise dry facility such as an extended detention basin). Conversely, for some types of BMPs such as wetland channels or constructed wetland basins, groundwater can be beneficial by providing saturation of the root zone and/or a source of baseflow. Groundwater quality protection is an issue that should be considered for infiltration-based BMPs. Infiltration BMPs may not be appropriate for land uses that involve storage or use of materials that have the potential to contaminate groundwater underlying a site (i.e., "hot spot" runoff from fueling stations, materials storage areas, etc.). If groundwater or soil contamination exists on a site and it will not be remediated or removed as a part of construction, separation from the groundwater must be provided. As an example, it may be necessary to use a durable liner to prevent infiltration into contaminated areas.

(d) Base Flows: Base flows are necessary for the success of some BMPs such as constructed wetlands ponds, retention ponds and wetland channels. Without base flows, these BMPs will become dry and unable to support wetland vegetation. For these BMPs, a hydrologic budget should be evaluated. Generally, water rights are also required for these types of BMPs in Colorado. Constructed wetland ponds are allowed provided adequate documentation is submitted to establish the presence of a sufficient and sustained flow of water to support the proposed vegetation in the planned constructed wetlands. Hydrologic documentation must be supplied to the City during the initial planning phase. The City must also receive adequate documentation to establish that the responsible party has secured the required water rights to sustain the proposed constructed wetlands ponds. The City is the final determining authority regarding whether the amount of water flow is deemed sufficient to support the wetlands. For some BMPs such as sand filters, base flows are not desirable since they may lead to bio-fouling and failure. If base flows are present, care should be taken to treat the runoff with an appropriate type of BMP that can better handle such conditions.

(e) Watershed Development Activities (or otherwise erosive conditions): When development in the watershed is phased or when erosive conditions such as steep slopes, sparse vegetation, and sandy soils exist in the watershed, a treatment train approach may be appropriate. BMPs that utilize filtration should follow other measures to collect sediment loads (e.g., a forebay). For phased developments, these measures must be in place until the watershed is completely stabilized. When naturally erosive conditions exist in the watershed, these measures should be permanent. The designer should consider existing, interim and future conditions to select the most appropriate BMPs.

(2) *Section 1.9* is amended to read as follows:

## 1.9 Integration with Flood Control

In addition to water quality, most projects will require detention for flood control, whether on-site, or in a sub-regional or regional facility. In many cases, it is efficient to combine facilities since the land requirements for a combined facility are lower than those for two separate facilities. Wherever possible, it is recommended WQCV facilities be incorporated into flood control detention facilities
The City requires the following approach be followed, as applicable:

(a) Water Quality: The full WQCV is to be provided according to the design procedures documented in this Manual for water quality facilities.

(b) Minor Storm: The full WQCV, plus the full minor storm detention volume, is to be provided for facilities designed for flows associated with minor storm events.

(c) 100-Year Storm: The full WQCV plus the full 100-year storm event volume must be provided for volumes obtained using the FAA Method or any hydrograph routing methods including SWMM for facilities designed for flows associated with 100-year storm events. When the analysis is done using hydrograph routing methods, each level of control needs to be accounted for and the resultant 100-year flood control volume in addition to the full WQCV should be used in final design.

Finally, designers should also be aware that water quality BMPs, especially those that promote infiltration, could result in volume reductions for flood storage. These volume reductions are most pronounced for frequently occurring events, but even in the major event, some reduction in detention storage volume can be achieved if volume-reduction BMPs are widely used on a site. Additional discussion on volume reduction benefits, including a methodology for quantifying their effects on detention storage volumes, is provided in Volume 3, Chapter 3 of this Manual, "Calculating the WQCV and Volume Reduction".

### 1.9.1 Sedimentation BMPs

Combination outlets are relatively straightforward for most BMPs in this Manual. For BMPs that utilize sedimentation (e.g. EDBs, constructed wetland ponds, and retention ponds) see BMP Fact Sheet T-12. This Fact Sheet shows examples and details for combined quality and quantity outlet structures.

### 1.9.2 Infiltration/Filtration BMPs

For other types of BMPs (e.g. rain gardens, sand filters, permeable pavement systems, and other BMPs utilizing processes other than sedimentation), design of a combination outlet structure generally consists of multiple orifices to provide controlled release of WQCV as well as the minor and major storm event. Incorporation of full spectrum detention into these structures requires reservoir routing. The *UD-Detention* worksheet available at www.udfcd.org can be used for this design. When incorporating flood control into permeable pavement systems, the design can be simplified when a near 0% slope on the pavement surface can be achieved. The flatter the pavement the fewer structures required. This includes lateral barriers as well as outlet controls since each pavement cell typically requires its own outlet structure. When incorporating flood control into a rain garden, the flood control volume can be placed on top of or downstream of the rain garden. Locating the flood control volume downstream can reduce the total depth of the rain garden, which will result in a more attractive BMP, and also benefit the vegetation in the flood control area because inundation and associated sedimentation will be less frequent, limited to events exceeding the WQCV.

(3) *Section 1.10* is amended to read as follows:

**1.10 Land Use, Compatibility with Surroundings, and Safety**

Stormwater quality areas can add interest and diversity to a site, serving a multitude of purposes in addition to providing water quality functions. Gardens, plazas, rooftops, and even parking lots can become amenities and provide visual interest while performing stormwater quality functions and reinforcing urban design goals for the neighborhood and community. The integration of BMPs and associated landforms, walls, landscape, and materials can reflect the standards and patterns of a neighborhood and help to create lively, safe, and pedestrian-oriented districts. The quality and appearance of stormwater quality facilities should reflect the surrounding land use type, the immediate context, and the proximity of the site to important civic spaces. Aesthetics will be a more critical factor in highly visible urban commercial and office areas than at a heavy industrial site. The standard of design and construction should maintain and enhance property values without compromising function. Public access to BMPs should be considered from a safety perspective. The highest priority of the City is to protect public health, safety, and welfare of the citizens of Fort Collins. Stormwater quality facilities must be designed and maintained in a manner that does not pose health or safety hazards to the public. As an example, steeply sloped and/or walled ponds should be avoided. Where this is not possible, emergency egress, lighting and other safety considerations should be incorporated. Facilities should be designed to reduce the likelihood and extent of shallow standing water that can result in mosquito breeding, which can be a nuisance and a public health concern (e.g., West Nile virus). The potential for nuisances, odors and prolonged soggy conditions should be evaluated for BMPs, especially in areas with high pedestrian traffic or visibility.