

Goal

The primary goal of urban water quality systems is to design the best management practices (BMP) that retain runoff at the site and allow water to penetrate into the ground where the pollutants can be attached to soil particles and degraded in the rhizosphere, or root zone, of existing vegetation. Techniques outlined here provide a brief overview of how the systems can be designed and adapted to different circumstances relevant to an urban environment.

BMP Objectives

A BMP, or combinations of BMPs, are designed to meet multiple stormwater and water-quality objectives, including treatment of rainfall at the site, allowing water to infiltrate into the ground, and navigating excess water through vegetative cover to stormwater drainage systems. Selection of a BMP should be based on various factors, including meeting stormwater design standards, appropriateness to surrounding landscape, and ability to control the targeted pollutants.

Eight urban water-quality BMPs presented here address many stormwater objectives. For example, they reduce volume and increase duration of runoff that leaves the practice and enters the sewer system, lower peak runoff flowrate, improve water quality by filtering through ground and vegetative systems, as well as address the associated biological and chemical processes.

These BMPs take advantage of natural processes of cleaning and filtering runoff by using the components of the hydrologic cycle. In an urban environment, these BMPs can contribute to conserving CO₂ emissions and reducing a city’s carbon footprint, as well as add special aesthetics and recreational value.

Water Balance

Urban water quality BMPs use multiple hydrologic and hydraulic processes that address different hydrologic components. The general water balance equation at the BMP site can be written as $P = Q + E + I + R + \Delta S$ with hydrologic components of precipitation, P, rainfall interception, Q, evapotranspiration or ET, E, soil infiltration,

I, surface runoff or conveyance, R, and soil detention and storage, S.

Table 1 presents a qualitative ranking of BMPs based on use of hydrologic components. The usage of hydrologic processes of a BMP installation is dependent on individual features of the application site. High usage means the process is integral to the BMP’s functionality, while low usage identifies marginal reliance of the BMP on the process.

Table 1. Use of hydrologic components by BMPs. The rankings are for qualitative purpose only, and may differ for individual BMP installations.

| | Precipitation | Interception | Evapotranspiration | Infiltration | Conveyance/Runoff | Storage/Detention |
|-------------------------------------|---------------|--------------|--------------------|--------------|-------------------|-------------------|
| Swale/Bioswale | ● | ○ | ○ | ● | ● | ● |
| Vegetated Waterway | ● | ○ | ○ | ● | ● | ○ |
| Vegetated Filter Strip | ● | ○ | ○ | ○ | | ● |
| Riparian Buffer | ● | ● | ● | ● | ○ | ● |
| Wetland | ● | ○ | ● | ● | | ● |
| Rain Gardens/ Bioretention Cells | ● | ○ | ● | ● | | ● |
| Vegetated Roofs | ● | ○ | ● | ● | | ● |
| Permeable Pavement | ● | | | ● | | ● |

● high usage; ● medium usage; ○ low usage.

Swale/Bioswale

Swales and bioswales (figure 1) are water conveyance structures that are wet, at least seasonally, and often have an abundance of vegetation. The “bio” indicates there is a beneficial water quality component due to the presence of vegetation. With a little planning and proper plant selection, a bioswale can play an important role in effective water quality enhancement.



Figure 1. *Native grass bioswale.*



Figure 2. *Vegetated waterway.*

Vegetated Waterway

Vegetated waterways (figure 2) are systems that will provide infiltration, filtration, and slow water velocities to reduce erosion. These water conveyance systems are normally lined with grass and expected to be dry much of the time. Proper plant selection will enhance infiltration and filtration. The combination of periods of long dry weather and brief inundation make selecting vegetation a challenge; however, native species, grasses in particular, are normally adapted to such extremes.

Vegetated Filter Strip

Generally, a vegetated filter strip (VFS) (figure 3) is a broad, gently sloping area with dense vegetation that is used for tertiary treatment of water. A VFS is intended to provide physical filtration of particulates such as sediment or precipitates. The goal is to spread incoming water into sheet flow to allow for increased infiltration and filtration. There is an added benefit of little to no water leaving the system with small storms.

Riparian Buffer

A riparian buffer (figure 4) is similar in form and function to a VFS. In most cases, a substantial woody vegetation presence provides added stream bank stability. The goal is spreading flow to increase infiltration and filtration. Municipalities with riparian buffer ordinances have the benefit of the buffer and use of the space for other best management practices. This allows retrofitting to be done with little or no disturbance to adjacent landowners. Some see increased habitat and fauna presence as a benefit.



Figure 3. *Vegetated filter strip at the edge of field.*



Figure 4. *Riparian buffer in Kansas City (reproduced from greentopeka.org).*

Wetlands

As the name suggests, a wetland (figure 5) is wet most of the year and sustains aquatic plants and animals. Wetlands provide physical filtering, particulate settling, and generally small amounts of infiltration. Because it takes a long time for water to move through the wetland, small particulates settle out, carrying pollutants with them. The vegetation takes up settled nutrients and provides an extremely active root zone where other compounds may be transformed into less harmful substances.



Figure 5. *Wetland (credit greentopeka.org).*



Figure 6. *Bioretention cells on Jackson Street in Topeka.*

Rain Gardens/Bioretention Cells

Rain gardens (figure 6) are normally thought of as small structures in residential areas, while bioretention cells are larger and used in commercial applications. Though the terminology is different, these systems function in the same way. The goal is to increase infiltration and reduce the erosive force of runoff. To date, there are no simple and solid designs for bioretention cells because of varying environmental factors and limited research. In many cases the saying “something is better than nothing” applies, which opens up opportunities for installation. For example, bioretention cells planted with native vegetation can replace the raised islands in parking lots to reduce runoff and irrigation.

Vegetated Roofs

Vegetated roofs (figure 7), often called green roofs, are designed to partially or completely cover the roofs of buildings with vegetation and a growing medium, planted over a waterproofing material. They help to absorb and retain rainfall that normally falls directly on an impervious surface area and release it slowly over a period of several hours. Vegetated roofs provide water quality improvements by reducing the volume and peak flow of effluent water entering the sewer system. Since 2015, the bleachers of Kansas State University Memorial stadium have been covered with vegetative material.



Figure 7. *Green roof at Kansas State University Memorial Stadium.*

Permeable Pavement

Permeable pavement (figure 8) provides voids in the paved surface for stormwater to infiltrate and reduce runoff. In addition, suspended solids are trapped in the pavement structure. To preserve permeability for infiltration, regular vacuuming is required. Otherwise, pore void can be filled with sediment and begin to function more like impervious surfaces. More research is needed to develop better porous structures and reduce the cost of installation and maintenance.



Figure 8. *Permeable pavement (credit www.epa.gov).*

Pollutant Treatment

Urban water-quality BMPs are designed to mitigate various pollutants in stormwater runoff. All BMPs are effective for removal of total suspended solids through mechanisms of infiltration, filtration, and settling. To reduce nutrients, the processes of adsorption, biological filtering (wetlands), and biodegradation tend to be efficient. For fecal coliform bacteria, constructed wetlands, swales, filter strips, and waterways have a high likelihood of success.

Runoff from roads and highways contains elements of copper, lead, nickel, and zinc that can be retained by structural urban BMPs. Oil and grease are the other pollutants from industrial, commercial areas, and roadways that are retained by filter strips, waterways, bioretention cells, and swales.

References and Additional Information

Stormwater Best Management Practice maintenance – MF2814: www.bookstore.ksre.ksu.edu/pubs/MF2814.pdf

Glossary of water terms – MF2730: www.bookstore.ksre.ksu.edu/pubs/MF2730.pdf

BMP Manual for Kansas City region (APWA/MARC): <http://www.marc.org/Environment/Water-Resources/Local-Government-Resources/Stormwater-Best-Management-Practices>

Stormwater research at Oklahoma State University: <http://lid.okstate.edu/>

Stormwater research at North Carolina State University: <https://stormwater.bae.ncsu.edu/>

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