Stormwater Best Management Practice

Riparian/Forested Buffer

Minimum Measure: Post Construction Stormwater Management in New Development and Redevelopment
Subcategory: Innovative Practices for Site Plans

Description

A riparian or forested buffer is an area along a shoreline, wetland or stream where localities restrict or prohibit development. Its primary function is to physically protect and separate a stream, lake or wetland from future development, disturbance or encroachment. With proper design, a buffer can provide stormwater management benefits, provide room to mitigate natural flooding, and assist in sustaining the integrity of stream ecosystems and habitats. As conservation areas, buffers are part aquatic ecosystem and part urban forest.

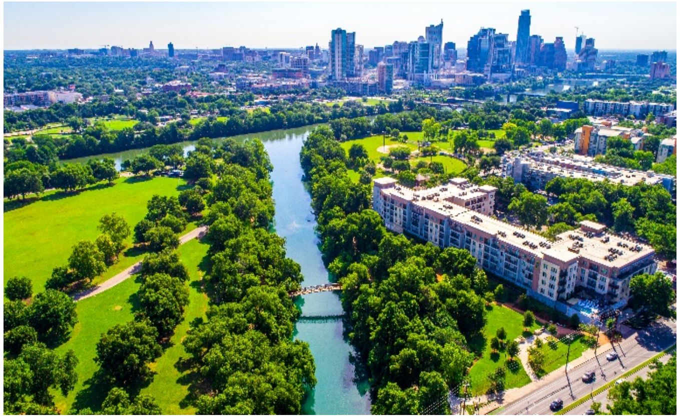
There are three types of buffers:

- *Water pollution hazard setbacks*—areas separating potential pollution hazards from waterways. Such buffer setbacks reduce the potential for pollution.
- *Vegetated buffers*—natural areas that divide land uses or provide landscape relief.
- *Engineered buffers*—areas with specific designs to treat stormwater before it enters streams, lakes or wetlands.

Buffers can be effective stormwater controls while also providing a range of other environmental and public benefits. In addition to reducing stormwater, improving water quality and helping to mitigate flooding risks, they can preserve habitat, provide recreational opportunities and increase surrounding property values.

Applicability

Buffers are applicable to new development and redevelopment areas. For new development areas, planners can incorporate buffers through the designation of specific preservation areas. These areas can be managed through long-term easements or by community associations. For existing developed areas, an easement to the property of adjoining landowners may be necessary. A local ordinance, such as Kansas City's stream setback ordinance (Brown et al., 2009), can help set specific criteria for buffers to achieve stormwater management or other community goals.



Riparian forested buffers can reduce pollution in stormwater from urban landscapes.

In many regions of the country, managing buffers in a forested condition can enhance their benefits. This is because buffers mimic the functioning of natural forested riparian zones. In most settings, buffers can remove surface and subsurface pollutants through interception and treatment of stormwater and shallow groundwater. Shoreline and stream buffers in flat or gently sloping areas are particularly effective at removing sediment, nutrients and bacteria, as they mimic natural floodplain processes.

Note that federal regulations (see 40 CFR 450.21[a][6]) also dictate that National Pollutant Discharge Elimination System permits for active construction sites disturbing 1 or more acres must require operators to provide and maintain "natural buffers" around any waters of the United States. The specific requirements for these buffers depend on the permitting authority.

Siting and Design Considerations

Buffer establishment considerations vary widely depending on restoration goals, local design standards and site conditions including soil type, land use and topography. Design engineers should consult local permitting authorities at the start of the project to ensure they follow local design standards and obtain any required permits. Depending on the site or the presence of jurisdictional wetlands or flood zone designations, the site may require several permits. Examples include:

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- State or municipal permits.
- U.S. Army Corps of Engineers Nationwide Permit 27, "Aquatic Habitat Restoration, Enhancement, and Establishment Activities."
- U.S. Army Corps of Engineers Section 404 Permit, "Dredge and Fill."

A common and effective approach to buffer design or preservation is the three-zone buffer system, consisting of inner, middle and outer zones (Brown et al., 2009; Hawes & Smith, 2005; Schultz et al., 2013). Function, width, vegetative target and allowable uses distinguish the zones, with the type and number of uses increasing with distance from the waterbody. The design of each zone should encourage sheet flow and avoid concentrated channel flow.

- The inner zone protects physical and ecological integrity by providing bank stabilization, and habitat and flood protection. It is generally the narrowest zone, often around 25 feet, and encompasses wetlands and other critical habitats. Its allowable uses are very restricted and may include minimal utility infrastructure and footpaths.
- The middle zone provides distance between upland development and the inner zone. It is typically 50 to 100 feet depending on stream order, slope, width of the 100-year floodplain or presence of jurisdictional wetlands. The vegetative target for this zone is mature riparian vegetation, which in most cases consists of riparian forest. Usage is restricted to limited recreational activities, stormwater controls and bike paths.
- The outer zone is the first zone to encounter stormwater discharge from upland development. It prevents encroachment while slowing and filtering stormwater discharge, similar to a vegetated filter strip. The outer zone's width is variable, though guidance manuals often recommend a minimum of around 25 feet. While a natural forest is preferable, turf-grass or ornamental vegetation is also appropriate. Any vegetation should not receive regular fertilization. The outer zone's uses are unrestricted; they can include lawn, garden, compost, yard wastes and most stormwater controls.

If design engineers expect the forested riparian buffer to receive a large amount of stormwater discharge from upland areas, they can incorporate a depression into the outer zone to provide temporary storage and limit overland flow through the buffer. They should design the depression to capture and store stormwater from smaller events and bypass stormwater from larger events. It may be useful to consider elements of bioretention design such as shallow ponding depths, underdrains and drop inlet bypasses. The design should also allow any discharge to sheet flow to downstream practices to limit erosion. Ultimately, the goal of any depression area or other stormwater control within the buffer should be to minimize overland flow to the downstream waterbody by promoting stormwater infiltration.

Limitations

In urban areas especially, paved and hard-packed turf surfaces concentrate stormwater discharge and generate high flow rates. If the stormwater discharges toward a riparian buffer, it can result in channel flow that reduces the buffer's effectiveness and potentially causes erosion of both the buffer and stream banks. Therefore, riparian forested buffers are not suitable "end of pipe" stormwater controls. Design engineers should implement buffers in highly urban areas in conjunction with upstream stormwater controls to reduce the amount and rate of stormwater discharge.

Maintenance Considerations

An effective buffer management plan includes activities associated with vegetation establishment and maintenance, as well as designation and monitoring of allowable and prohibited uses in the buffer zones. Planners should clearly define buffer boundaries and make them visible before, during and after construction so that local governments, contractors and residents can follow the management plan.

Vegetation management activities vary by location and project type. New buffers require establishing and monitoring vegetation to ensure survival. For conservation of existing buffers, removing invasive species or replanting areas with low vegetation survival may be necessary. Generally, engineers should design inner zones to be dynamic and regenerative, similar to natural riparian areas, which should reduce maintenance requirements over time. Outer zones, especially those with the designs and maintenance of lawns, gardens or stormwater controls, require maintenance typical of those uses.

The Green Book for the Buffer, a report for Maryland's Critical Area Commission, provides guidance on preparation and implementation of a buffer management plan.

Effectiveness

Forested riparian buffers are effective at reducing peak flows to downstream waterbodies, reducing stormwater pollutant concentrations through direct filtration, and enhancing in-stream and riparian nutrient processing through increased stream–floodplain connectivity. The effectiveness of each depends on the design of the buffer and the length of installation along the riparian zone. Although quantifying the effectiveness of stream-floodplain connectivity is still an evolving area of research, more data exists to quantify the effectiveness of buffers as direct filtration systems.

Unlike more traditional stormwater treatment practices, design engineers generally size buffers according to the space available and not around any specific treatment volume. Accordingly, buffers' abilities to reduce peak flows, infiltrate stormwater and filter pollutants are more variable, according to pollutant removal studies (see Table 1). Still, proper buffer design can increase pollutant removal from stormwater discharge. Factors that improve effectiveness include:

- Slopes less than 5 percent
- Upgradient overland flow paths less than 150 feet
- Groundwater close to the surface
- Contact times longer than 5 minutes
- Planting during the growing season
- Buffer widths greater than 25 feet
- Presence of organic matter, humus or mulch layer
- Entry stormwater velocity less than 1.5 feet per second
- Trees with deep root systems

Table 1. Pollutant removal rates in buffer zones.

Buffer Vegetation	Buffer Width (Meters)	Total Percent Mass Total Suspended Solids Removal	Total Percent Mass Phosphorus Removal	Total Percent Mass Nitrogen Removal	Total Percent Mass Nitrate as Nitrogen Removal	References
Grass	0–5	—	—	—	48	Jaynes and Isenhart, 2019
Grass	5–10	75–95	55–78	25–80	50–62	Schmitt et. al., 1999 Lee et al., 2000 Lee et al., 2003
Grass	10–20	88–93	72–83	40–52	25	Schmitt et al., 1999 Jaynes and Isenhart, 2019
Grass	20–30	—	—	—	39–84	Jaynes and Isenhart, 2019
Grass/woody	10–20	85–97	72–94	40–91	85	Schmitt et al., 1999 Lee et al., 2000 Lee et al., 2003
Forested	10–20	—	—	—	97	Schoonover et al., 2005

Cost Considerations

The upfront costs of forested riparian buffers include those typical of stormwater controls, including design, permitting, grading, planting and maintenance. However, buffers have some economic benefits that can offset these costs, including higher property values and mitigation of flood impact costs (Brown et al., 2009; Kenney et al., 2012).

For local governments, the costs of instituting a buffer program include extra staff, plan review training, technical assistance, field delineation, construction and ongoing buffer education programs. A community wanting to implement a stream buffer program would likely adopt an ordinance, develop technical criteria, and invest in additional staff resources and training. Buffer programs also often include a training component for plan reviewers and consultants. To explain the new requirements to stakeholders and land developers, communities can develop manuals, workshops, seminars and direct technical assistance. Lastly, buffers require maintenance. Activities should include systematic inspections of the buffer networks before and after construction, as well as increasing resident awareness about buffers.

One way to provide flexibility is to allow buffer averaging. This option allows developers to narrow the buffer width at some points if the average width of the buffer and the overall buffer area meet the minimum criteria. Municipalities can also grant variances for redevelopment projects if the landowner or property owner can demonstrate severe economic hardship or unique circumstances that make compliance with the buffer ordinance difficult.

Additional Information

Additional information on related practices and the Phase II MS4 program can be found at EPA's National Menu of Best Management Practices (BMPs) for Stormwater website

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Disclaimer

This fact sheet is intended to be used for informational purposes only. These examples and references are not intended to be comprehensive and do not preclude the use of other technically sound practices. State or local requirements may apply.