Riparian Buffer Design and Maintenance Manual

Greenville County, SC

Land Development Division

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Introduction

Greenville County requires waterbody buffer areas for the protection of the County's natural resources. Buffer areas (or buffers) are an important part of protecting and restoring water quality and healthy ecosystems and are defined as the area within a certain distance of the bank of a stream, river, wetland, pond, lake, or other waterbody in which activities and structures are restricted. The buffer is critical for the protection of water quality in the waterbody because it protects the waterbody from the negative effects of development, agriculture, and/or other human uses.

Buffers in Greenville County

Buffers around streams, wetlands, ponds, and other waterbodies have been required and/or encouraged by Greenville County for many years and are comprised of various sizes, conditions, and uses depending on existing vegetation and management practices. Recent research, studies, and examples from around the Country have made the benefits of buffers more clear and the County has responded with an increased emphasis on this practice.

Figure 1: Wide Stream Buffer Providing Shade

Buffers typically function best when allowed to remain in their natural state without human interference. Therefore, efforts to protect existing buffers are one of the best ways to protect the natural benefits and contribute to sustainably healthy watersheds.

Buffers can take many forms, and even healthy buffers may look very different from one location to another. This manual describes the ways to evaluate the health and benefits of a buffer, improve and/or protect its functions, and maintain a high level of function sustainably. The impacts of a buffer reach far up into watersheds, infiltrating and filtering runoff that flows through the buffer to the stream, slowing and calming floodwaters, protecting stream banks from erosion during major storm events, and providing habitat for wildlife species that venture away from the banks of the waterbody. Protection of the County's waterbodies is a crucial aspect of providing a high quality of life and economic stability for the County's residents, businesses, and visitors.

Purpose of this Manual

This manual was written to maximize the benefits of waterbody buffers, both natural and revegetated. It will do so by educating designers, property owners, and those who live on property adjacent to waterbodies on stream buffer characteristics, benefits, maintenance, and restoration. The education is intended to translate into action, helping protect and restore buffers around the County.

This manual will also be used as a compilation of best practices and requirements regarding buffers. The County has adopted regulations through Ordinances, the Stormwater Management Design Manual (including a Specification and Detail for the Permanent Water Quality Stream Buffer BMP, WQ-11), and Land Development Division Policies that are best understood as a single, continuous approach to buffer management and restoration. This manual contains references to each and will be updated as any of these sources change.

The term "buffer" may have different meanings and connotations to different people, so this manual is intended to provide a common definition and understanding. There are also many views of the role of people in protecting and restoring animal habitat, floodplains, and water quality. There is certainly confusion among County residents, and the public at large, about the water quality impacts of pollution caused by development and the mitigation that buffers can provide. This manual is intended to serve as a resource for understanding and caring for buffers to maximize their benefit to the waterbody, wildlife, and the property owner and/or resident.

Riparian Buffer Benefits and Characteristics

The wide array of benefits provided by buffers cannot be achieved if forests and vegetation are removed from alongside streams, rivers, and other bodies of water. Ideally, the buffer will consist of undisturbed natural vegetation; however, there are instances where a buffer may need to be further developed to achieve water quality goals. It is important to periodically check on the vegetation to ensure the buffer is healthy; qualities such as bare ground, dead or dying plants, lack of species diversity, and the presence of upland plants are all indicators that the health of the buffer is suffering.

Figure 2: Example of Healthy Buffer

Benefits of Buffers

A healthy riparian buffer will successfully filter out pollutants, stabilize the bank, shade the waterbody, and provide habitat for wildlife from microscopic to migratory. Depending on location within a watershed, type of waterbody, slope of the land to the water's edge, water velocity, water depth, and upstream water quality, each of these benefits can be extremely important for overall waterbody health. Additionally, protecting water quality and ecosystems at any point on a waterbody helps provide all of those same benefits to that waterbody downstream.

Natural and Healthy Buffers

Natural buffers occur when there is no human interference such as the removal of plants and trees or the introduction of invasive species. Typically, natural riparian buffers in South Carolina are forested with a variety of tree, shrub, and groundcover plant species present. These plants, in addition to sufficient decaying plant matter, create a full ecosystem capable of supporting a diverse array of animal life. Many studies, particularly those in and around streams, have found that the presence of certain bugs and other seemingly insignificant species can be an indicator of overall health of an ecosystem. Generally, if these small creatures are not present, larger species will also not find the necessary food, shelter, and/or other crucial conditions to thrive. While different conditions are required for each species, the most obvious condition needed for many larger species is available land. Even in urban settings, a sufficiently sized buffer, like the ones required in Greenville County, can support mammals like squirrels, raccoons, rabbits, foxes, and even deer. A buffer denuded of vegetation, or where clearing has occurred too close to the streambank, will not provide adequate cover or food sources for many of these mammals. Because of the interconnections of food chains, the presence of much smaller species will also affect the likelihood of larger species utilizing the area. For many smaller species, elements like water quality, presence of a range of plant types, uncompacted soils, and undisturbed natural processes (leaving fallen trees and limbs, undisturbed floodplain) are critical for creating a complete food chain and ecosystem.

During development, or when considering changes to a buffer in a previously-developed area, it is important to keep as much of the natural buffer as possible. Because the presence of development usually means compacted soils and the presence of impervious surfaces, an upper zone of smaller vegetation including grass and shrubs is extremely helpful in protecting the buffer from runoff. Leaf litter is one of the most effective mechanisms for improving water quality in the runoff before it reaches the stream, but this litter can be washed away if too much runoff is directed toward the buffer. If the leaf litter is removed, it leaves bare soil exposed, exacerbating the issue by creating conditions for erosion, which in turn makes it more difficult for plants to establish roots to hold the soil (and leaf litter) in place.

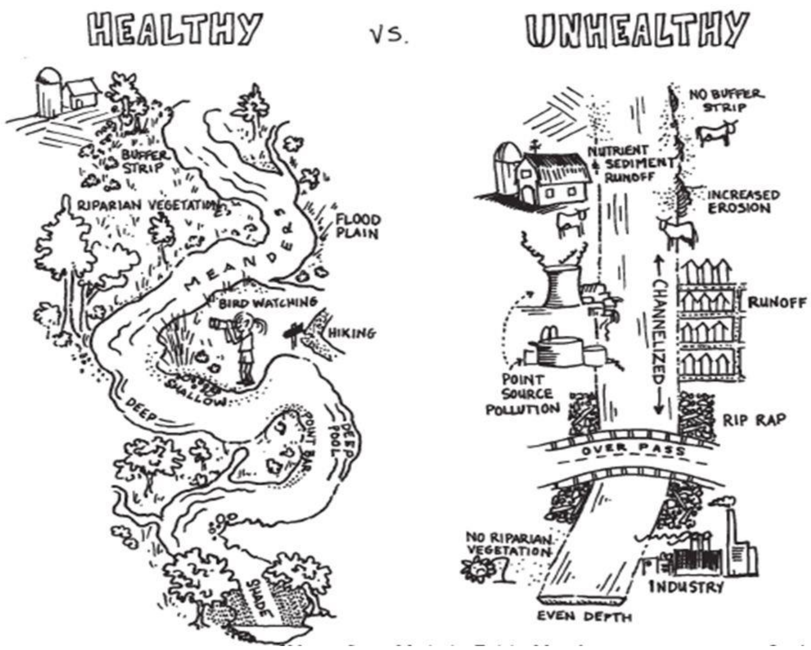

Figure 3: Schematic of Healthy vs. Unhealthy Riparian Buffers

Mechanisms for Water Quality Improvement

Riparian buffers are essential for protection of water quality. Vegetative buffers provide erosion protection by holding soil in place and preventing it from washing into waterways during storm events. The various types of vegetation ranging from grass to shrubs to trees help to slow down runoff to allow it to more easily infiltrate the soil as well as to allow nutrients to be captured by the plants.

Erosion and Sedimentation

Soil that makes its way into waterways can be detrimental to the ecosystem because it causes increased turbidity and transports pollutants. The increase in suspended soil particles is life-threatening for some species of fish whose gills are unable to handle such conditions. Increased turbidity also has a negative effect on fish eggs by preventing proper development. Over time, sediment deposits on the river bottom can cover important organisms that ordinarily grow in the benthic sediment. While turbidity has many negative effects on marine animals, it also effects recreation. Higher turbidity means that the water is murkier, so it makes activities like fishing more difficult.

Healthy buffers are highly capable of preventing erosion. Forested areas with dense canopies and thick groundcover stop raindrops from impacting the ground and dislodging soil particles. Plant roots also help hold soil in place when runoff travels over the ground. These stabilization functions minimize the generation of sediment in the buffer area and reduce the pollution entering the waterbody.

Pollutant Filtering

Not only does sediment-laden runoff cause an increase in turbidity, but it also can carry contaminants such as phosphorous that are harmful in high concentrations. Plants require phosphorous to create energy from sunlight, but in an aquatic environment, an excess of phosphorus can cause eutrophication. Eutrophication occurs when a water body becomes overloaded by nutrients; this excess of nutrients causes an overgrowth of plants called algae blooms, which in turn depletes oxygen and causes fish kills. Buffers are important for holding back the soil that is carrying such nutrients to prevent them from entering waterways and causing dead zones where aquatic life cannot survive.

Like a grassed vegetated filter strip, a forested riparian buffer filters runoff that flows across it toward the stream. As runoff travels through a buffer, it is slowed by the leaf litter, stems of plants, and fallen branches. The reduction in velocity causes sediment, and other pollutants with it, to settle to the ground and remain trapped in the buffer area before reaching the stream. Some of the runoff is even infiltrated into the uncompacted soil. This usually becomes shallow groundwater that slowly seeps into the stream for days after the rain event, sustaining the stream's baseflow. The infiltration also helps reduce downstream flooding by attenuating and reducing the peak flow entering the stream. Further description of the mechanics of pollutant filtering is provided in the Modeling section below.

Figure 4: Buffer on Steep Slope (left) and Gentle Slope (Right)

Biological Uptake and Denitrification

Another large contributor to eutrophication is nitrogen. A diverse mix of vegetation including trees, shrubs, and grass will be beneficial to the ecosystem by removing nitrogen before the runoff enters the waterbody. Nitrate is a form of nitrogen that is highly soluble and able to move into ground water very easily. Fortunately, plants with long roots that are able to reach sub-surface waters can take up a significant quantity of nitrate. Plants perform a process called denitrification in which they convert nitrate to nitrogen gas and then release that gas into the atmosphere. Trees are extremely important during the winter months when other plants may go dormant because they continue the denitrification process throughout the seasons.

Thermal Protection

In addition to treating runoff before it enters streams, buffers are also necessary for the quality of water already in the stream. One of the ways buffers enhance water quality is by providing shade that keeps the water cool. Heat from the sun's direct rays has a negative effect on aquatic ecosystems and, when combined with high levels of pollutants, can exacerbate pollution issues. Due to shade from buffers, the maximum water temperature in a stream may be reduced by as much as 10- to 20-degrees Fahrenheit in the summer. In order for a buffer to provide shade, it must have tall, mature trees as well as a dense understory. Smaller streams should be entirely shaded if proper buffers exist on both sides. The wider the river, the less of its width can be shaded, but the shade provided on the edges of even large rivers is still valuable.

Buffer Zones

A typical riparian buffer consists of three zones as seen in Figure 5 below and the County's Water Quality BMP Specification and Detail WQ-11 (Permanent Water Quality Stream Buffers). These zones are not necessarily naturally-occurring but are useful for describing the interface between development and the natural stream. When creating and maintaining a buffer, it is important to recognize these zones, so the proper vegetation management is performed. It is also important to note that the descriptions of the zones are descriptions of what is allowable, not necessarily what is best for protecting water quality. Dense, diverse, and infrequently maintained buffers are best; more frequent maintenance or the planting of more homogenous zones is provided as an aid to a property owner wanting to balance the beneficial uses of their property with protection of water quality.

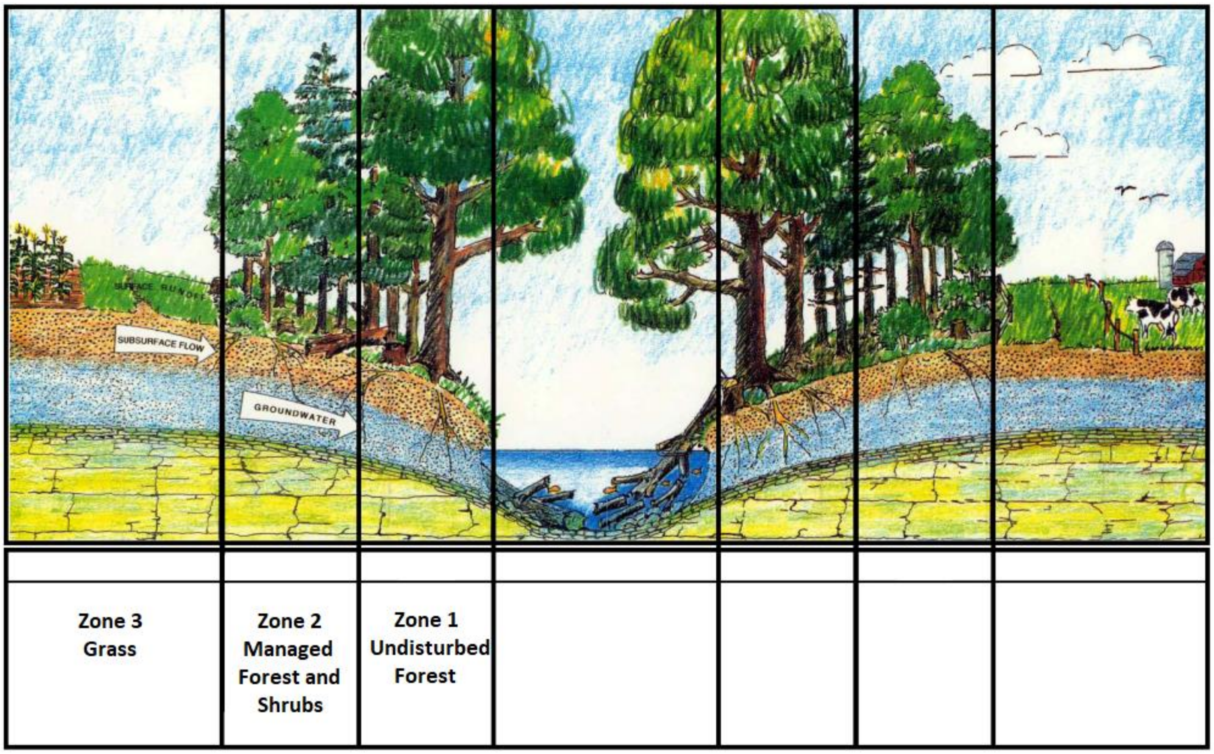

Figure 5: Riparian Buffer Zones

Zone 1

As the zone closest to the waterbody, the trees in Zone 1 should be tolerant of water. It is recommended that Zone 1 consist of trees that prefer wet to moderate moisture contents due to its proximity to the stream and susceptibility to frequent saturation. Zone 1 is the densest of the three zones, and it should be left untouched in order to thrive. Ideally Zone 1 will mimic a natural forest that contains dense vegetation and undisturbed soils.

The trees in Zone 1 provide shade that helps to regulate the temperature of the waterbody. The cooler temperatures in the water allow for macroinvertebrates to thrive and therefore provide food for larger aquatic animals. Zone 1 typically has the steepest slopes (except in some cases with wide floodplains). The maximum amount of vegetation is desirable for stabilizing steep slopes as well as preventing erosion from high stream flows.

Zone 2

Zone 2 is located in the middle of the buffer, and it should mostly consist of smaller trees and shrubs that are managed. This means that they will be maintained, pruned, and removed as necessary to allow for new growth and therefore new nutrient uptake. In a natural buffer, there would not likely be a visible distinction between Zones 1 and 2. The zones are primarily meant to inform the amount of maintenance that can be performed while still maintaining a healthy buffer. In most cases, dense vegetation like Zone 1 is preferable from a water quality perspective.

Deciduous trees are useful in Zone 2 because they produce leaf litter that encourages bacterial processes through the production of carbon leachate. These processes remove nitrogen and sequester nutrients that would otherwise be washed into the waterbody.

Zone 3

This zone is furthest from the waterbody and can consist of grasses and shrubs. The main purposes of this zone are to slow down the water and filter out sediment and nutrients in runoff. Maintenance should be performed periodically to ensure sediment deposits are removed from the grass in order for it to function properly. Like with Zone 2, more vegetation, and a greater diversity of species is encouraged. The use of Zones is not meant to suggest that removing trees and shrubs to install turf in Zone 3 will enhance water quality, as it likely would not.

Creating an Effective Riparian Buffer

While it is highly preferable to leave a vegetated riparian buffer in place anywhere they exist, not all areas of the County have existing functional buffers. Agriculture, development, and illegal clearing have left many stream and pond banks stripped of woody vegetation. In some cases, there is not even grass or other groundcover and the potential for erosion and watershed degradation is high.

When Buffer Creation is Needed

Even when designed and constructed according to regulations, development often leads to increased runoff, erosion, and the introduction of nutrients such as nitrogen and phosphorous from fertilizers. While natural buffers are well equipped to handle normal rainfall events, the decrease in the size of the buffer as well as the decrease in permeability due to buildings and roads increases the runoff to waterways. Because of the increase in volume, velocity, and/or pollutant load, it is important that smaller vegetation is planted on the outer zone of buffers even for conserved buffer areas. The additional vegetation will help to slow down the runoff and increase infiltration into the soil for uptake of nutrients by the plants. Reduced runoff velocity will also help protect the leaf litter and other organic matter that can effectively filter the runoff.

If the area around a waterbody is not well vegetated and providing water quality benefits of a healthy buffer, it may be revegetated to achieve those benefits. In some cases, area adjacent to a waterbody may need to be replanted to restore the buffer when development occurs on the property. Compare the two depictions of a stream buffer's effect on the stream health in Figure 6 below – if the riparian area looks more like the one on the right, then creating a stream buffer is warranted.

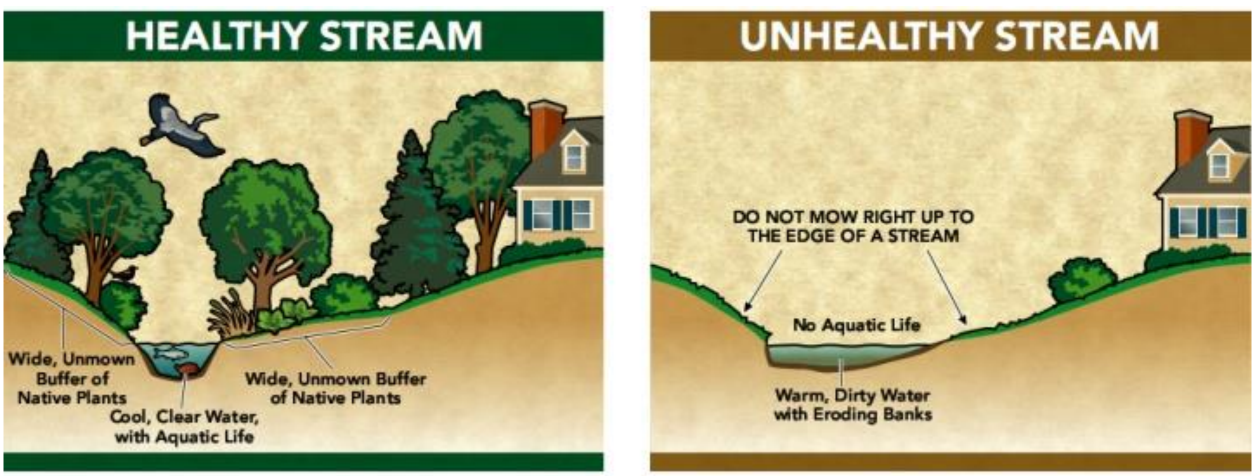

Figure 6: Comparison of Healthy Stream and Unhealthy Stream

In addition to this publication, developers should consult Greenville County's Technical Specification WQ-11: Permanent Water Quality Stream Buffer when planning a development on a property with waterfront. The Specification covers the design, protection, and maintenance considerations when using a buffer to meet water quality requirements as set forth in Chapter 9 of the Stormwater Management Design Manual.

Revegetation Plan

A buffer revegetation plan is a plan that specifies type, quantity, and placement of vegetation to create a healthy buffer as well as the long-term maintenance plan for caring for the buffer. There are three causes for making revegetation plans:

1. An illegal buffer encroachment has occurred without first obtaining an authorized encroachment
2. Revegetation of a stream or wetland buffer is required as a part of an authorized encroachment
3. A property owner is conducting a voluntary buffer restoration

A Buffer Revegetation Plan shall contain two components: a buffer revegetation site plan and a site preparation plan. Appendix A provides details on how revegetation and site preparation plans should be prepared.

Generally, it is important to use native plants and to avoid invasive species that will hinder the diversity of the buffer. Because plant species diversity promotes full ecosystem diversity, the planting plan must be thorough to maximize watershed benefits. Additionally, a site plan must be stamped and signed by a licensed landscape architect registered in the state of South Carolina.

Figure 7: Buffer Revegetation Plan in Early Stages of Implementation

Maintenance

For established or newly-established buffers, maintenance is crucial for continued benefit to the waterbody. The buffer should be periodically checked to ensure the plants are healthy. A typical natural forest should have a mix of canopy trees, subcanopy trees/large shrubs, and smaller shrubs/saplings. Zone 2 should be pruned and thinned at a rate that will not compromise the effectiveness of the buffer while allowing for new growth to take place. Before removal takes place, a professional arborist, forester, or other knowledgeable person should evaluate the vegetation to ensure removal will not harm the effectiveness of the buffer.

Dead and Dying Vegetation

Dead and dying vegetation is a natural element of undisturbed forests. Generally, allowing nature's processes to work undisturbed is best in a buffer. Dead and decaying plant matter provides habitat and food for animals and nutrients and carbon for other plants. Woody plants that fall into the stream after dying are particularly useful to healthy aquatic ecosystems, providing many benefits. Stream in urbanized watersheds tend to be in need of this type of structure as higher flows and velocity of streamflow wash much of the dead wood downstream. The only situation where one should consider removal of dead and decaying plant matter on the ground is if it is increasing erosion or otherwise threatening the stability of the bank.

"Snags" are created when a tree dies without falling over. Snags provide vital habitat for many creatures including several species of birds. Snags are often difficult to find in urbanized or suburbanized environments because they are typically removed quickly after being noticed to prevent injury or property damage when they eventually fall. If a snag exists in a buffer area, and would not pose a threat to life or property, it should be left standing until natural decay processes break it down.

Definitions (adapted from Virginia DCR Buffer Manual)
Noxious species – vegetation that is physically harmful or destructive to living vegetation, especially to native species.
Alien species – non-native species, differing in nature so as to be incompatible with native species.
Invasive – tending to spread uncontrollably, overwhelming other species; a native species may qualify as an invasive.
Non-native – introduced from another country or region.

Invasive and Noxious Species

In keeping with the premise that a buffer should mimic an undisturbed, natural forest to the extent practical, most non-harmful species of vegetation should remain. However, the targeted removal of some species will be beneficial. A plant is considered invasive if it tends to take over an area and dominate in a way that reduces the overall ecosystem health. Invasive plants may be either native or non-native, and it is possible that a single species may be invasive in one setting and non-invasive in another setting.

Any species that is overwhelming large portions of a buffer should be removed, as a buffer with a single plant species is not able to provide the ecosystem benefits of a diverse buffer. Invasive and noxious species are often non-native, but they don't have to be – native species that are overwhelming a buffer should also be managed. Conversely, non-native species are not necessarily in need of removal if they are not overtaking other plants or otherwise damaging the buffer.

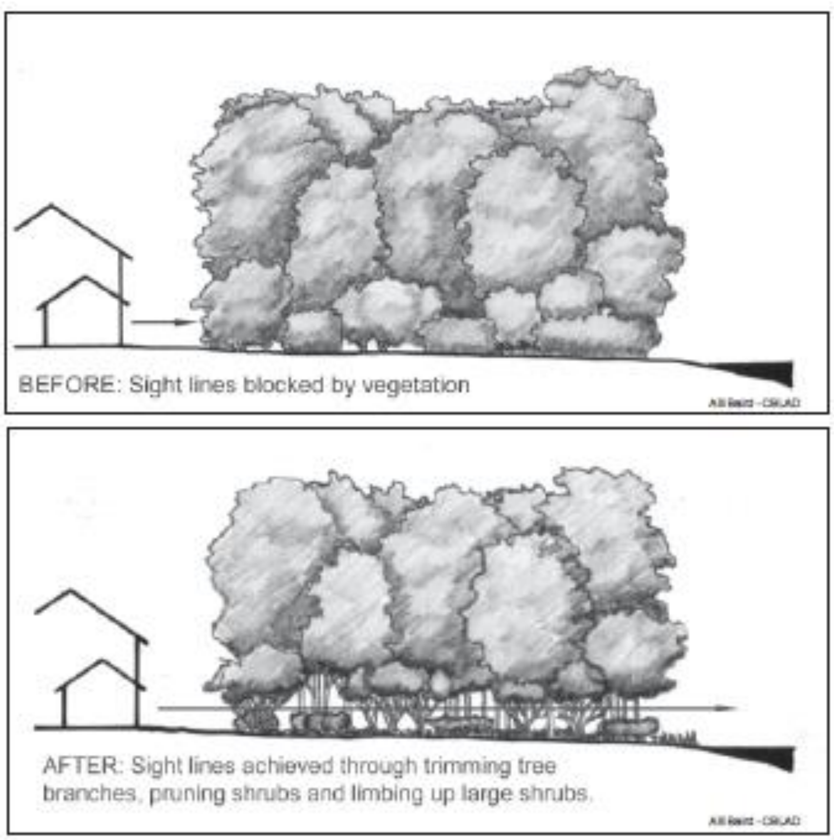

Figure 8: Pruning for Sight Lines

Pruning and Site Lines

Pruning is considered the most desirable solution to enhance site lines. Removal of trees or other vegetation to improve sight lines should be the last resort. If removal is necessary, dead, dying, or diseased vegetation should be given priority for removal. Another option to be considered is planting new vegetation if old vegetation needs to be removed. The functional integrity of the buffer needs to be maintained, and this can be achieved by creating a filtered view of the water body instead of removing everything in sight. Figure 8 demonstrates how sight lines can be achieved by simply pruning vegetation instead of removing it completely. Raising the crown, or "limbing up" a tree is a type of pruning where branches between the ground and the bottom of the tree crown are removed. Limbing up trees for sight lines should never result in the removal of more than one-third of the vegetation and the tree should always maintain at least two-thirds live crown compared to total tree height.

Thinning

Thinning is a term typically applied in silvicultural settings and is generally not a recommended management technique for buffer management. It may be appropriate for areas that have not been maintained or that were once clearcut. Buffers that were clearcut and have a thick stand of trees that are the same age and are too close together would likely benefit from thinning, as long as the thinning is performed as part of a holistic Revegetation Plan that includes other management and planting practices. If thinning is utilized, care should be taken to achieve the goal of fuller forest vegetation, not the promotion of a single tree species for cultivation.

Allowable Activities and Modifications

Buffers provide significant ecological benefits to waterbodies, but they can also be used to provide recreational benefits to property owners. Depending on the size of the stream, location on a property, length of the buffer, and many other factors, an owner may want to utilize this space for some form of property improvement including recreation, beautification, or sight lines.

Activities Allowed in the Buffer

By Ordinance, some activities are not allowed in a waterbody buffer. These activities generally include anything that would require or cause disturbance of the land, removal of vegetation, or diminish the beneficial functions of the buffer in some way. However, there are activities that are allowable and encouraged in each zone of the buffer area. Please note that while these activities are allowed, they may not inhibit the ability of the buffer to meet the Design Requirements as listed in the Greenville County Technical Specification WQ-11 Permanent Water Quality Stream Buffer Section 1.5.

Modifications Allowed in the Buffer

Stream Crossings

Stream crossings should be kept as compatible with the existing stream condition and surroundings as possible. The crossing should take place where there is little disruption of the bank. Ideally the crossing would take place on a well-defined stream channel where the channel width is minimal and stream gradient is flat. If the crossing is located in an area where it will be infrequently used, stepping stones may provide the least disruptive and most effective solution.

Individual Access Paths

These guidelines allow the removal of vegetation to create an access path to the water for the desire to view, fish, swim or boat. For the purpose of this

Figure 9: Example of Stepping Stone Stream Crossing

document an access path means a reasonably narrow pathway through the buffer to provide access to the water for pedestrian use. Bike paths or bridle paths are considered “passive recreation facilities” and are defined under that section. Landowners can either create a path by constant trampling or by planning a path to be constructed in such a way as to limit the likelihood of erosion. Erosion is likely if the path follows the contours straight toward the water, so the path should meander to some degree to prevent it becoming a channel. Existing open areas should be used, and the path should wind around any large vegetation. Pruning of trees and shrubs should be the preferred method of clearing an access path through the buffer. Preferably, pedestrian paths should be kept to a 2-foot wide single lane. To minimize the effects of erosion on the sides of paths, native vegetation or additional mulch, should be used to cover exposed soil.

If a significant amount of leaf litter (2” – 4”) is present and can be left in place, no other material may be necessary. If frequent use is expected some additional material, like mulch, gravel, stepping stones or other permeable material, should be used. Three to four inches of mulch would be the first choice of material, since it is very permeable and does not compact into a hard surface.

Paths on slopes of 2% or greater should be located so as to take advantage of the terrain rather than running perpendicular to the slope. A sloping path cutting straight through the buffer towards the stream bank is more likely to concentrate the overland flow.

Community Access Paths

Private access paths through subdivision buffers or multi-family complexes that are owned and maintained by a homeowners’ association would likely be used more frequently than individual access paths, so greater thought must be given to the location and materials used. Slopes, topography, soils, and frequency of use should be taken into consideration to ensure a long-lasting and safe access path. A thick layer of leaf litter or mulch may be sufficient to prevent erosion along a pedestrian path in a small subdivision, however a path that will be frequently used, is located on unstable soils, or has steep slope (greater than 2%) may require packed gravel or other pervious materials to prevent erosion.

Passive Recreational Facilities

Many public parks, recreational facilities, private businesses, and homeowner associations are located in land adjacent to riparian features. The regulations restrict recreational uses within the 100-foot wide buffer to passive recreation facilities, including trails, boardwalks and paths.

Passive recreation is considered non-motorized activities such as walking, bike riding, picnicking, hiking, sun bathing, and bird watching. Passive recreation includes motorized devices required by physically impaired individuals to access and enjoy any passive recreation facilities. It does not include obtrusive activities that have significant adverse impacts to natural, cultural, open space, or agricultural values, and it does not include sports facilities such as baseball, football, or soccer fields.

Passive recreation includes…	Passive recreation does not include…
Hiking	Organized sports facilities and ball fields
Biking	The use of motorized vehicles, such as golf carts, motorcycles, motor boats or all-terrain vehicles (ATVs)
Picnicking	Structures such as pools, decks, or gazebos
Wildlife viewing	Boat ramps, docks, piers, or marinas
Public boardwalk or trail use	Any activity that contributes to erosion, causes significant vegetation loss, or involves the installation of excessive amounts of impervious surfaces
Fishing	

Paths and trails for passive recreation are exempt from the development criteria the Land Development Division has established for Community Amenity areas but they should be designed to minimize the disturbance to the vegetation, groundcover, and the soils within the buffer to maintain water quality and to protect streambanks. Proper design and placement of paths is necessary to meet the needs of the user while maintaining the integrity of the riparian buffer. Placement of the trail or path is important to assure that it is located in the least sensitive areas. The frequency of use and type of user should dictate the size of the path. Clearing should be minimized as much as possible and pruning should be kept to only that necessary to maintain safe usage. Sizing guidelines for various types of uses are presented below in Table 1.

When the path does enter into the buffer to reach the stream or lake shoreline it should be located so as to minimize impact on the buffer. Soils, slopes, drainage and vegetation will determine the best location for the portions of a path that are located within the buffer. When a trail must be placed within the buffer, the area 75 to 100 feet inland from the water's edge would be the best location for the majority of the trail. The area from the water's edge to 25 feet inland should see only minimal use with occasional access to water. Paths should be kept as short as is feasible within this portion of the buffer to give a direct access to the water.

Figure 10: Walking Trail

A hiking trail is a natural area that is not intensively used may only require a natural surface, while a path in an urban park, or a well-used community recreational path may need some type of harder surfacing than native soil, leaf litter or mulch. Ideally, the path should have the least impervious surfacing that will withstand the proposed level of use. If a paving material is needed to protect exposed soil, use mulch, gravel, stepping stones or other permeable material. Paths with heavy pedestrian use or multi-use trails that may also accommodate bicycles or other uses may need more structural paving. ADA requirements may also indicate a harder surface for the path, such as a compacted granular stone, which is less obtrusive than porous asphalt. Again, the path should have the least impervious surfacing that will withstand the proposed level of use.

Table 1: Trail Width Guidelines

Type of Trail	Vertical Clearance	Trail Width	Horizontal clearance beyond trail width
Hiking	8-feet	2-feet for single lane 5-feet for double lane	2-feet
Biking	8-feet	4-feet for single lane 8-feet for double lane	1-feet for trees/rocks 3-feet for limbs/brush
Mountain Biking	8-feet	2-feet for single lane 5-feet for double lane	1 – 2-feet for single lane 2-feet for double lane
Equestrian	10-feet	5-feet	1-feet for trees/rocks 3-feet for limbs/logs
Multiple use	10-feet 8-feet if no equestrian	8-feet 10-feet if heavy use	2-feet

Trails should follow the contours of the land rather than run perpendicular to the slope. A sloping path cutting straight through the buffer towards the stream bank or lake shoreline is more likely to concentrate storm runoff and develop problems. Access to the lake shoreline may include crossing marshes or other sensitive wetlands. Identification of these sensitive areas should be part of any analysis and avoided. If sensitive shoreline is the only choice for access, boardwalks, overlooks or other structural solutions must provide appropriate protection for the sensitive areas. Any access provided in a wetland or marsh area requires a permit from the Army Corp of Engineers.

Modeling Water Quality Treatment of Forested Buffers

In Greenville County, developers of projects with 1-acre or more disturbed area are required to achieve certain water quality requirements in addition to the buffer requirements established in the ordinance. These requirements are found in Chapter 9 of the Stormwater Management Design Manual.

IDEAL can be used to model forested riparian buffers to aid in achieving the water quality target. IDEAL uses the Vegetated Filter Strip (VFS) BMP object to model buffers. The use input descriptive characteristics into each BMP object. Upland portions of buffers, if grassed, should be modeled separately from the forested portions. While a change in vegetation is a good indicator that a new segment must be added to the model, engineers and designers must also be paying attention to any change in slope, as this could also indicate a need for an additional segment. It is recommended that sections with slopes differing by more than several percent be considered separately.

Trees are important for riparian buffers because the canopies can trap rain water, but their ability to capture pollutants in runoff is not as effective as grass. The leaf litter acts as a barrier between the runoff and the soil and slows the runoff, causing sediment and pollutants to settle. Unfortunately, when runoff velocities get high enough to push the leaf litter, erosion can occur. A new feature in IDEAL simulates this balance to provide an accurate representation of the physical processes.

Slope

One of the most important factors, even more so than vegetation type or density, is the slope of the buffer/filter. The slope is negatively and exponentially related to trapping efficiency – as slope increases marginally, trapping efficiency decreases significantly. It is therefore important to consider how to model a typical riparian buffer area where the slope can be different in Zone 3 than Zone 1. If the slope differs by more than a few percent, it is best to model two sections as separate BMPs.

Vegetation

When modeling a riparian buffer in IDEAL, it is important to realize the difference in vegetation and slope throughout the entire buffer. If there are any drastic changes, the model will be made most accurate by modeling as separate sections as multiple VFSs in series. For example, a typical buffer will consist of multiple zones containing vegetation varying from grass to shrubs to trees. While each of these zones will be modeled as a vegetative filter strip, the physical and grass characteristics will be different, requiring separate VFS objects.

Any grassed section of a buffer is modeled as a traditional vegetated filter strip. Forested sections of a buffer are modeled similarly, but instead of choosing between grass types, the user must choose either “hardwood” forest or “mixed hardwood and pine” forest. The main difference is that the hardwood option does not include pine trees, but the mixed option includes all types of trees. IDEAL uses this input to determine both the type of leaf litter and the density of vegetation expected. While these two categories are broad and do not encompass all potential variation, they represent an approximation commensurate with current research findings and practicality of modeling a natural system. Pine needles act as a stronger barrier than regular leaves because they are able to interlock and therefore can withstand higher velocities. This barrier keeps the ground safer from erosion and is therefore more desirable than a hardwood buffer for water quality and stream bank preservation.

Hardwood Forest

The input of hardwood forest is meant to represent a forest with a large percentage of high canopy trees and very few stems near ground level. Often, floodplains are good representations of this type of forest cover. As shown in Figure 11 below, the ground may have thick cover of leaf litter and even branches and twigs, but there are not many shrubs or young saplings growing.

Mixed Pine and Hardwood Forest

This input will typically indicate a greater variety of tree species and maturity. It also represents more dense coverage of living vegetation, though still having significant leaf litter. From Figure 12 below, it should be clear that the increased density of vegetation will result in better filtering of pollutants in runoff and greater resistance to erosion. Many "hardwood" forests have ample groundcover provided by ferns, grasses, or other similar cover – in those cases, it should be modeled as a mixed pine and hardwood forest to simulate the additional density and groundcover of this selection.

Figure 11: Hardwood Forest Examples

Figure 12: Mixed Pine and Hardwood Forest Examples

Level Spreaders

All of the treatment of runoff that can occur in a riparian buffer area is dependent on the runoff entering the buffer area as sheet flow. When runoff concentrates, it will generally travel through the buffer area in a channel without ever slowing, being filtered, or infiltrating. Therefore, if a buffer area is to be considered a water quality BMP, the designer must ensure runoff entering the practice will be spread into sheet flow using a level spreader. Additionally, high flows must be diverted to a stabilized channel away from the level spreader and buffer. That may mean a pipe or channel is installed through the buffer, but as long as its impact is minimized, it will protect the rest of the buffer. High flows can be detrimental to a buffer because they can remove the layer of leaf litter and other detritus on the ground, leaving bare soil exposed to erosion.

For areas with concentrated flow, or when desiring to use a buffer to meet water quality requirements for a Land Development Permit, level spreaders should be used to create sheet flow into the buffer. A maintenance plan should be put in place for the level spreaders to ensure they function properly for the duration of the development. Greenville County has developed a Specification and Details for WQ-13: Level Spreader. This Specification and Detail should be used to design an effective and robust level spreader that is applicable for the type of development. Some noteworthy items that should be considered when designing a level spreader are as follows:

- Bypass flow method must be provided. High flows will damage a level spreader and should be diverted through a stable conveyance (may be channel or pipe) capable of safely passing all flows greater than the level spreader design flow rate.
- Highly concentrated flows should be dissipated before getting to the level spreader. A level spreader is a device used to supplement water quality BMPs and is not intended to act as an energy dissipator or to convey high flows. In cases where concentrated flow, such as from a pond outfall or drainage system, are conveyed to a level spreader, a separate energy dissipating devise/structure should be designed.
- Level spreader lip should be level.
- Channel should be built with materials that are not easily erodible. For example, concrete or metal can resist erosion much better than soil.
- Level spreader lip should be a minimum of 6 inches above the existing ground.
- Filter fabric with a stone layer on top should be installed from the lip to a minimum of 3 feet downstream to protect from erosion.

In IDEAL, a level spreader is modeled as a “Diffuse Channel.” This conveyance object requires the user to input the width of the level spreader device (perpendicular to flow). It does not simulate, or help design, all the characteristics of level spreader – it is a modeling function used to spread flow over a certain width. A “Diversion” object should be used immediately upstream of the Diffuse Channel to divert high flows. Additionally, if the area of the channel/forebay is significant, it may be modeled as an Infiltration Trench or Bioswale BMP.

Figure 13 demonstrates a basic level spreader that effectively slows down water and creates sheet flow into the buffer. This schematic shows a cross section view of part of the level spreader system. For guidance on the design of other components of the system and alternate construction materials and installations, see Specification and Details for WQ-13: Level Spreader.

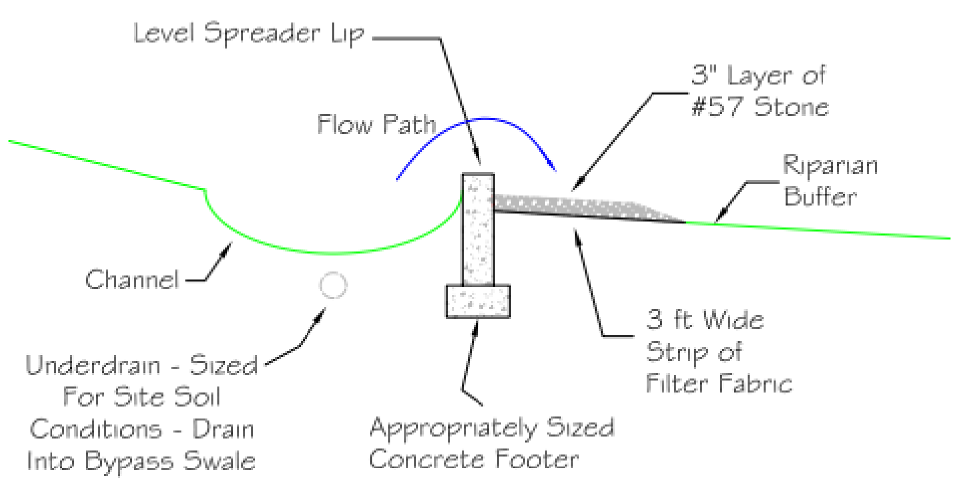

Figure 13: Level Spreader Schematic

Sources

Cover photo – University of Vermont and Student Conservation Association Partnership (LANDS) at Landsuvm.blogspot.com

Figure 1 – University of Vermont at blog.uvm.edu

Figure 2 – Virginia DCR Brochure, "Got Buffer?"

Figure 3 – Dominic Cox on Slideplayer.com

Figure 4 – same as cover photo

Figure 5 – Maryland DNR at https://dnr.maryland.gov/forests/Pages/publications/Sink.aspx

Figure 6 – Philadelphia Water Department at phillywatersheds.org

Figure 7 – Potomac Partnership at Potomacpartnership.org

Figure 8 – Virginia DCR Riparian Buffers Modification & Mitigation Guidance Manual, 2006

Figure 9 – Waterville Valley Realty at https://www.wvnh.com/mad-river-stepping-stones/

Figure 10 – Potomac Heritage Trail by Jason Devaney at Rootsrated.com

Figure 11 – Minnesota Audubon Society at http://mn.audubon.org/news/saving-floodplain-forests

Figure 12 - Steven F. Austin University's Pineywoods Ecosystems webpage at http://www3.sfasu.edu/astc/PineywoodsEcosystems/frames_1_Uplands.html and Oakridge Woods property for sale by Fountains Land at https://fountainsland.com/oakridge-woods.html

Figure 13 – Urban Waterways Manual on Level Spreaders by the NC Cooperative Extension at http://chesapeakestormwater.net/wp-content/uploads/downloads/2012/01/LevelSpreaders2006.pdf

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Appendix A – Buffer Revegetation Guidelines

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Preface

Woody vegetation is of significant value for accomplishing water quality protection. The regulations were crafted to protect existing woody vegetation. Scientists consider the multi-tiered buffer (with mature canopy trees, understory trees and shrubs and groundcover) to constitute the ideal buffer that will accomplish the maximum buffer functions. While the entire buffer width (100-feet on the Reedy River and 50-feet elsewhere) is required to accomplish the buffer requirements, scientific studies have noted that, on first, second and third-ordered streams (headwater streams and those less than approximately sixty feet wide), the twenty-five foot zone closest to the stream provide functions critical to the stream health that are in addition to the benefits the remainder provides. The intent of the regulations is to protect existing wooded buffers while allowing certain modifications to the extent that they do not diminish the ability of the buffer to perform its water quality functions. Also, where no vegetation exists in a buffer, or the existing vegetation is insufficient to accomplish the three functions of retarding runoff, preventing erosion and filtering non-point source pollutions, effective vegetation must be established, and woody buffer plantings are encouraged.

Introduction

Not only does the buffer mitigate runoff from the upland but, if forested, it also removes nutrients and pollutants from ground water that originates from areas further away from the surface water. The roots of trees and shrubs and their associated microbes can help remove nitrogen and convert some pesticides and other toxins to harmless substances before they reach ground water and surface waters. Roots and leaf litter also help slow storm water runoff, allowing infiltration into the soil where pollutants may be removed and the ground water recharged.

In order for the buffer to function as intended, it should contain the full complement of vegetation that includes all trophic layers, shade trees, understory trees, shrubs and ground cover, whether the groundcover is vegetation, leaf litter or mulch.

Figure 1: Example of Healthy Riparian Vegetation

When buffers are encroached upon, cleared, disturbed, improperly vegetated or developed, water quality, stream bank stability and wildlife habitat are adversely affected, and revegetating will be required to restore the buffer's important ecological functions. Therefore, should trees and other vegetation be removed for any reason, they must be replaced with material providing an equivalent level of water quality protection.

Figure 2: Example of Poor Riparian Vegetation

These guidelines are intended to apply to revegetation of the areas above the streambank. The "Vegetation Replacement Rates" tables below, are considered to provide an equivalent level of water quality protection. If the streambank has been disturbed or exhibits accelerated erosion or scouring, alternate or additional stabilization utilizing geotextile, soil bioengineering, structural elements, or other techniques may be necessary to prevent further erosion.

Buffer Revegetation

A buffer revegetation plan is a plan that specifies type, quantity, and placement of vegetation to create a healthy buffer as well as the long-term maintenance plan for caring for the buffer. There are three causes for making revegetation plans:

1. An illegal buffer encroachment has occurred without first obtaining an authorized encroachment
2. Revegetation of a stream or wetland buffer is required as a part of an authorized encroachment
3. A property owner is conducting a voluntary buffer restoration

A Buffer Revegetation Plan shall contain two components: a buffer revegetation site plan and a site preparation plan.

Buffer Revegetation Site Plan

A Buffer Revegetation Site Plan shall contain the following items:

- A site plan stamped and signed by a licensed Landscape Architect registered in the state of South Carolina
- Exact locations of affected streams(s) and property boundaries
- The location of the County required stream buffer
- Delineation of the exact location of the buffer encroachment (in square feet)
- Location of all temporary erosion and sediment control BMPs, including but not limited to matting, silt fence, temporary stabilization and construction entrance
- Location of all existing trees six-inch caliper or larger and appropriate tree protection fence
- A list of all plant material to be used and planting methods. Specifically include the types of plants, the number proposed, botanical and common names, whether planting Option A, B or C will be utilized, sizes of plant material, proposed locations, and planting location key.
- Statement guaranteeing all pant materials for two years
- Name and direct contact information of the owner/applicant and the property address
- The following statements shall appear on the plan in bold type:
    - **Following the complete installation of the approved Stream Buffer Revegetation Plan, a final inspection and written approval must be made by Greenville County prior to the issuance of the certificate of occupancy (if applicable).**
    - **Greenville County may inspect the buffer during the two-year guarantee period. It is the responsibility of the property owner to maintain the revegetation site and repair, protect and add additional controls to protect the buffer as necessary. Such controls and additional work shall be at the sole cost of the property owner.**

Site Preparation Plan

The Site Preparation Plan shall be site-specific and shall detail the methods used to implement the following requirements:

- Compacted soils – When a plan proposes to remove impervious surfaces, or when previously impervious areas or compacted soils exist, soils shall be loosened using plowing or subsoil ripping. To avoid compaction of loosened soils, hand planting shall be used when possible.
- Addition of organic matter to soils – Where soils are lacking organic matter, compost or other suitable organic matter shall be incorporated into the soil
- Temporary stabilization – Use short lived annuals or natives that will not hinder establishment of buffer vegetation for initial or temporary stabilization of bare soils.
- Invasive Species Management – Growth of invasive exotics that could hinder the establishments of new vegetation shall be controlled or removed (when applicable). Ongoing management of the site shall prevent regrowth or future establishment of invasive exotics. Areas alongside streams are especially susceptible to colonization of certain invasive species.
- Sod-forming grasses – Existing sod-forming grasses such as fescues or Bermuda shall be controlled or removed (where applicable). These grasses will compete with newly planted native vegetation.

Planting and Site Guidelines

- All plants shall be native to the South Carolina Piedmont Region. South Carolina and Southeastern ecotype plants and seed shall be used when available. Plants should be selected based on appropriate characteristics from the list on page A-9. Additional plants can be found in Appendix D of Life at the

Water's Edge (Huffman et. al., 2004). Plant species not listed may be used subject to approval. Invasive species shall not be used.

- For disturbed areas within the 25-foot buffer and any disturbed areas with slopes 3:2 or greater, soil shall be stabilized with Land Development Division approved matting and blankets or other approved stabilization method until permanent vegetation is established. Only 100% biodegradable material shall be used.
- Planting allowances may be made for existing trees.
- Ordinarily, fertilizers should not be used in the 75-foot buffer area due to the risk of water pollution from fertilizer in stormwater runoff. Incorporation of compost or organic matter should provide sufficient nutrients for adequate plant growth. Fertilizers should only be used in extremely infertile soils, and only after a soil test confirms the need for additional nutrients. Fertilizer should be slow-release, organic fertilizer and should only provide the nutrients deemed necessary by the soil test.
- Plants must be installed manually (no motorized vehicles).

Species Diversity Requirements

- A minimum of six species of trees shall be planed for Buffer Revegetation Plans calling for greater than 20 trees.
- A minimum of three species of shrubs shall be planted for Buffer Revegetation Plans calling for greater than 15 shrubs. A minimum of five species of shrubs shall be planted for Buffer Revegetation Plans calling for greater than 50 shrubs.
- A minimum of four species of grasses and grass-like plants, and a minimum of two species of forbs shall be planted when these plants are used to establish ground cover in areas greater than 1,000 square feet. For areas less than 1,000 square feet there are no minimum species requirements; however, species from the list starting on page A-9 should be used. Appendix D of Life at the Water's Edge can also be used as an optional resource.

Planting Density Requirements

All trees and shrubs shall be guaranteed for two years and replaced accordingly

A. ¼ acres or less of buffer area disturbed (up to 10,890 square feet or less of buffer area)

For every 400-square-foot unit (20' X 20') or fraction thereof, plant:

- One canopy tree @ 1 ½" caliper or large evergreen @ 6' height
- Two understory trees @ ¾" – 1 ½" caliper or evergreen @ 4' height
    - Or one understory tree and two large shrubs @ 3'-4' height
- Three small shrubs or woody groundcover @ 15" – 18" height
- 100% vegetative cover of all exposed soil (no bare areas larger than one square foot) using native grasses, grass-like plants and forbs
- Organic mulch (shredded or chipped wood or leaf mulch, not including sawdust) shall be applied in a ring around the base of new trees and shrubs to aid in establishment and prevent competition by ground layer plantings

B. Greater than ¼ acre of buffer (more than 10,890 square feet)

The waterside 50% of the buffer (from the waterline inland for the first 50 feet): plant at the same rate as for ¼ acre or less

For every 400 square foot unit (20’ X 20’) or fraction thereof plant:

- One canopy tree @ 1 ½” caliper or large evergreen @ 6’ height
- Two understory trees @ ¾” – 1 ½” caliper or evergreen @ 4’ height
  - Or one understory tree and two large shrubs @ 3’-4’ height
- Three small shrubs or woody groundcover @ 15” – 18” height

And the landward 50% of the buffer (from 50 feet inland to 100 feet inland)

Tree Density Goal:

- Achieve 348 live trees per acre after 2 years (1 tree for every 125-square-feet)
- Initial planting should be greater than 320 trees per acre to allow for some mortality. An initial planting rate of 435 trees per acre (10” on center) would allow for 20% mortality
- Trees may be dormant bare-root stock, but must be at least 2-feet in height after planting
- 40 – 60% of trees shall be understory species
- No greater than 10% of trees shall be pines
- To achieve a natural distribution, trees do not have to be evenly spaced

Shrub Density Goal:

- Achieve 435 live shrubs per acre after 2 years (1 shrub per 100-square-feet)
- Shrub may be containerized or bare root stock
- If bare rooted or small containerized shrubs are used, initial planting should be greater than 435 per acre to allow for failure
- Shrubs should be planted in groups and more densely along the outer edges of the buffer to prevent light penetration and recolonization by invasive species
- 100% cover of all exposed soil using either native grasses, grass-like plants and forbs, or mulch, in accordance with the following guidelines:
  - Native grasses, grass-like plants and forbs
    - When establishing smaller trees, if grasses and forbs are planted in the ground layer, only the shorter growing species should be used in order to limit competition and shading of the trees
    - Mulch should be applied around the bases of the trees to limit competition
  - Mulch
    - Mulch shall be maintained at a minimum of two-inches thick.
    - Mulch must be shredded or chipped wood or leaf mulch. Sawdust shall not be used.
    - When using small, bare-rooted trees and shrubs, competition from grasses and forbs planted around them could hinder growth of trees. Mulching for the initial year after planting suppresses week growth and allows for greater tree growth.
    - Mulch shall not be used in areas within the 25-foot buffer that are subject to flooding. These areas should utilize native grasses, grass-like plants, and forbs to achieve 100% vegetative cover in addition to any required matting and blankets.

C. 1-acre or more of Buffer

- With an evaluation from an arborist, forester or other qualified professional, natural regeneration may be an acceptable method of buffer establishment. However, a forestry management plan must be in place **prior** to any vegetation being removed. A minimum of 35-feet next to the water must be left in forest and protected prior to any vegetation being removed.

Plant List

The following lists are the County recommended plants for riparian buffers. Please refer to Appendix D of Life at the Water's Edge (Huffman et. al., 2004) as an optional resource for additional information.

MEDIUM TO LARGE DECIDUOUS CANOPY TREES

Red maple – Acer rubrum
Silver maple – Acer saccharum
Black birch – Betula lenta
River birch – Betula nigra
Shagbark hickory – Carya ovata-
Mockernut hickory – Carya tomentosa
Hackberry – Celtis occidentalis
Washington hawthorn – Craetagus phaenopyrum
Persimmon – Diospyros virginiana
American Beech – Fagus grandifolia
White ash – Fraxinus americana
Green ash – Fraxinus pennsylvanica
Water locust – Gleditsia aquatica-
Black walnut – Juglans nigra
Tulip poplar – Liriodendron tulipifera
Water tupelo – Nyssa aquatica
Black gum – Nyssa sylvatica
Sourwood – Oxydendron arboreum
Black cherry – Prunis serotina
White oak - Quercus alba
Shingle oak – Quercus imbricata
Laurel oak – Quercus laurifolia
Overcup oak – Quercus lyrata-
Chestnut oak – Quercus prinus
Water oak – Quercus nigra
Pin oak – Quercus palustris
Shumard oak – Quercus shumardii
Willow oak – Quercus phellos
Weeping willow – Salix babylonica

SMALL CANOPY/UNDERSTORY TREES

Red buckeye – Aesculus pavia
Smooth alder – Alnus serrulata
Serviceberry – Amelanchier canadensis
Devil's walkingstick – Aralia spinosa
Pawpaw – Asimia triloba
American hornbeam – Carpinus caroliniana
Sugar hackberry – Celtis laevigata
Redbud, Judas tree – Cercis canadensis
Fringetree – Chionanthus virginicus
Dogwood – Cornus florida
Cockspur hawthorn – Crataegus crus-galli
Green hawthorn – Crataegus viridis
Parsley hawthorne – Crataegus marshalli
Two-winged Silverbell – Halesia diptera
American holly – Ilex opaca
Possumhaw – Ilex deciduas
Spicebush – Lindera benzoin
Sweetbay Magnolia – Magnolia virginiana
Eastern hophornbeam – Ostrya virginiana
Sourwood – Oxydendron arboreum
Elderberry – Sambucus candensis
Sassafras – Sassafras albidum
Sparkleberry – Vaccinium arboreum
Nannyberry – Viburnum lentago

EVERGREEN TREES

American holly – Ilex opaca
Eastern red cedar – Juniperus virginiana
Southern magnolia – Magnolia grandiflora
Eastern white pine – Pinus strobus
Loblolly pine – Pinus taeda
Virginia pine – Pinus virginiana
Darlington oak – Quercus laurifolia Darlingtonia
Live oak – Quercus virginiana

EVERGREEN SHRUBS

Inkberry holly – Ilex glabra
Common juniper – Juniperus communis
Shore juniper – Juniperus conferta
Southern wax myrtle – Myrica cerifera
Bayberry – Myrica pennsylvanica
Swamp azalea – Rhododendrona viscosum
Farkleberry – Vaccinium arboreum

LARGE SHURBS

Alder – Alnus serrulata
False indigo – Amorpha fruiticosa
Red chokeberry – Aronia arbutifolia
American beautyberry –Calicarpa americana
Eastern sweetshrub – Calycanthus floridus
Buttonbush – Cephalanthus occidentalis
Silky dogwood – Cornus amonum
Greystem dogwood – Cornus racemose
Red twig dogwood – Cornus stolonifera
Witch hazel – Hammamelis virginiana
Wild hydrangea – Hydrangea arborescens
Oakleaf hydrangea – hydrangea quercifolia
Winterberry holly – Ilex verticilata
Yaupon holly – Ilex vomitoria
Virginia sweetspire – Itea virginica
Fetterbush/ Sweetbells – Leucothoe racemose
Fetterbush – Lyonia lucida
Male-berry – Lyonia ligustrina
Southern wax myrtle – Myrica cerifera
Bayberry – Myrica pennsylvanica
Common ninebark – Physocarpus opulifolius
Choke cherry – Prunus virigniana
Swamp azalea – Rhododendrona viscosum
Smooth sumac – Rhus glabra
Allegheny blackberry – Rubus allegheniensis
Pussy willow – Salix discolor
Silky willow – Salix sericea
Elderberry – Sambucus Canadensis
American snowbell – Styrax americanus
Highbush blueberry – Vaccinium corybosum
Arrowwood viburnum – Viburnum dentatum
Swamphaw Viburnum – Viburnum nudum
Blackhaw viburnum – Viburnum prunifolium

SMALL SHRUBS

Obovate serviceberry – Amelanchier obovalis
Black chokecherry – Aronia melanocarpa
Sweet pepperbush – Clethra alnifolia
Sweet fern – Comptonia peregrina
Strawberry bush – Euonymus americanus
Fothergilla – Fothergilla gardenii
Black huckleberry – Gaylussacia baccata
Dangleberry – Gaylussacia frondosa
Wild hydrangea – Hydrangea arborescens
Oakleaf hydrangea – Hydrangea quercifolia
Mountain laurel – Kalmia latifolia
Staggerbush – Lyonia mariana
Shrubby cinquefoil – Potentilla fruitcosa
Bankers willow – Salix cottettii
White meadowsweet – Spiraea alba
Meadowsweet – Spiraea latifolia
Steeplebush – Spiraea tomentosa
Common snowberry – Symphocarpos albus
Coralberry – Symphocarpos orbiculatus
Lowbush blueberry – Vaccinium angustifolium
Maple-leaved viburnum – Vaccinium acerifolium

NATIVE GRASSES

Big Bluestem – Andropogon gerardi
Broomsedge – Andropogon virginicus
Indian woodoats – Chasmanthium latifolium
Coastal panic grass – Panicum amarum
Switch grass – Panicum virgatum
Little bluestem – Schizachyrium scoparium
Indian grass – Sorghastrum nutans
Eastern gama grass – Tripsacum dactyloides

HERBACEOUS PLANTS

Black-eyed Susan – Rudbeckia fulgida
Cardinal Flower – Lobelia cardinalis
Coralbells – Heuchera Americana
Creeping Phlox – Phlox stolonifera
Crested Iris – Iris cristata
Foamflower – Tiarella cordifolia
Goldenrod – Solidago Canadensis
Great Blue Lobelia – Lobelia siphilitica
Green and Gold – Crysogonum virginianum
Ironweed – Vernonia noveboracensis
Jack-in-the-Pulpit – Arisaema triphyllum
Joe-Pye Weed – Eupatorium purpureum
Mayapple – Podophyllum peltatum
Mistflower – Eupatorium coelestinum
Mouse-ear Coreopsis – Coreopsis auriculata
Pink Turtlehead – Chelone lyonii
Purple Coneflower – Echinacea purpurea
Small Solomon's Seal – Polygonatum biflorum
Swamp Milkweed – Asclepias incarnate
Sweet Flag – Acorus americanus
Tall Gayfeather – Liatris scarios
Three-toothed Cinquefoil – Potentilla tridentata
Tickseed – Coreopsis grandiflora
Wild Columbine – Aquilegia Canadensis
Woodland Phlox – Phlox divaricata

SHADE TOLERANT PLANTS

Trees

Red maple
Sugar maple
Serviceberry, Shadbush
Pawpaw
Yellow birch
Hornbeam
American beech
White ash
Sweetbay magnolia
Hop hornbeam
Canada hemlock

Small Trees & Shrubs

Dogwood
Redbud
Fringetree
Sweet pepperbrush
Gray dogwood
American hazelnut
Witchhazel
Inkberry
Mountain laurel
Spicebush
Staghorn sumac
Elderberry
Highbush blueberry
Witherod
Southern arrowwood
Highbush cranberry
Virginia sweetspire

PART SUN (semi-shade intolerant)

Trees

Silver maple
Sweet birch
Bitternut hickory
Shagbark hickory
Tulip poplar
Easter white pine
Sycamore
White oak
Chestnut oak
Willow oak
Northern red oak
Slippery elm

Small Trees & Shrubs

Red chokeberry
Black chokeberry
Black huckleberry
Winterberry
Swamp azalea
Meadowsweet
Nannyberry
Smooth alder
Pinxterbloom azalea

FULL SUN (shade intolerant)

Trees

Persimmon
Black ash
Red ash
Honey-locust
Kentucky coffee-tree
Black walnut
Sweet gum
Black gum
Eastern cottonwood
Black cherry
Pin oak
Black willow
Sassafras

Small Trees & Shrubs

Groundsel bush
Buttonbush
Silky dogwood
Red-osier dogwood
Bayberry
Wax myrtle
Ninebark
Rosebay rhododendron
Blackhaw viburnum

FLOOD TOLERANT

Trees

Red maple
Shadbush
Yellow birch
Black ash
Red ash
Sweetbay magnolia
Eastern cottonwood
Willow oak
Black willow
Slippery elm

Small Trees & Shrubs

Small alder
Red chokeberry
Black chokeberry
Groundsel bush
Buttonbush
Silky Dogwood
Red-osier dogwood
Inkberry
Winterberry
Bayberry
Ninebark
Rosebay rhododendron
Swamp azalea
Swamp rose
Meadowsweet
Highbush blueberry
Witherod
Southern arrowwood
Northern arrowwood
Highbush cranberry

SEMI-FLOOD TOLERANT (good for wet sites)

Trees

Atlantic white cedar
Allegheny serviceberry
Bald cypress
Black gum
Bitternut hickory
Elderberry
Grey birch
Green ash
Hackberry
Persimmon
White ash
Honey-locust
Kentucky coffee-tree
Black walnut
Tulip popular
Black gum
Sycamore
Northern red oak
River birch

Shrubs

Serviceberry
Fringe tree
American hazelnut
Black huckleberry
Grey dogwood
Spicebush
Witchhazel
Mountain laurel
Staghorn sumac
Nannyberry viburnum
Blackhaw viburnum

SALT TOLERANT SPECIES

Shrubs

Bearberry
Red chokeberry
Black chokeberry
Buttonbush
Sweet pepperbush
Inkberry
Spicebush
Southern wax myrtle
Bayberry
Staghorn sumac
Rugosa rose
Arrowwood viburnum
Blackhaw viburnnum
Highbush blueberry

Invasive Plant List

This list includes some exotic plants that cause serious problems in the natural areas of South Carolina by extensively invading native plant communities and displacing native species.

Tree-of-heaven – Ailanthus altissima (P. Mill.) Swingle
Mimosa – Albizia julibrissin Durazz.
Giant reed – Arundo donax L.
Paper mulberry – Broussonetia papyrifera (L.) L'Her. ex. Venti
Nodding thistle – Carduns nutens app. leiophyllus (Petrovic) Stojanov S Stef
Oriental bittersweet – Celastrus orbiculatus Thunb.
Bull thistle – Cirsium vulgau (Saui) Ten.
Sweet autumn virgrobower – Clematis terriflora DC
Showy rattle box – Crotalaria spectabilis Roth
Scotch broom – Cytisus scoparius
Queen Anne's Lace – Daucus carota L.
Chinese yam – Dioscorea oppositfolia L.
Thorny olive – Elaeagnus pungens Thunb.
Autumn-olive – Elaeagnus umbellate Thunb.
Weeping lovegrass – Eragrostis curvula (Schrad.) Ness
Tall fescue – Festuca arundinacea Schreb.
Fig buttercup – Ficaria verna
Chinese Parasol Tree – Firmlana simplex (L.) W. Wight
English ivy – Hedera helix L.
Cogongrass – Imperata cylindrica
Shrubby lespedeza – Lespedeza bicolor Turcz.
Sericea lespedeza – Lespedeza cuneate (Dum.-Cours.) G. Don
Japanese privet – Ligustrum japonicion Thunb.
Chinese privet – Ligustrum sinense Lour.
Japanese honeysuckle – Lonicera japonica Thunb.
Japanese climbing fern – Lygodium japonicum (Thunb. ex Murr.) Sw.
Chinaberry – Melia azedarach
Chinese Silvergrass – Miscanthus sirensis Andersson
Nepalese browntop – Microstegium vimineum (Trin.) A. Camus
White mulberry – Morus alba L.
Marsh dayflower – Murdannia keisak (Hassk.) Hand.-Maz.
Nandina – Nandina domestica Thunb.
Crested floating heart – Nymphoides cristata (Rexb.) O. Ktze.
Dallisgrass – Paspalum dilatatum Poir.
Bahiagrass – Paspalum notatum Fluegg'e
Vaseygrass – Paspalum urvillei Steud.
Torpedograss – Panicum repens L.
White poplar – Populus alba L.
Princesstree – Paulownia tomentosa (Thunb.) Sieb. & Zucc. ex Steud.
Golden bamboo – Phyllostachys aurea Carr. ex A.&C. Riviere
Japanese knotweed – Polygonum cuspidatum Siebold & Zucc.

Kudzu – Pueraria montana var. lobata (Lour.) Merr.
Callery pear – Pyrus calleryana Decre
Multiflora rose – Rosa multiflora Thunb. ex Murr.
Rattle box – Sesbania punicea (Cav.) Benth
Tropical soda apple – Solanum viarum Dunal
Johnsongrass – Sorghum halepense
Big periwinkle – Vinca major L.
Common periwinkle – Vinca minor L.

Sources

Figure 1 – Alexauken Creek, NJ by Bill Wolfe at http://www.wolfenotes.com/2009/10/get-the-cows-out-of-the-stream/

Figure 2 – Juanita Creek, Washington at https://www.researchgate.net/figure/Modestly-incised-urban-channel-with-likely-lowering-of-the-water-table-beneath-the_fig5_226149021

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