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Urban Water Quality Management

Residential Stormwater: Put It in Its Place

Decreasing Runoff and Increasing Stormwater Infiltration

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Introduction

Humans and plants depend on an adequate supply of clean water for a number of reasons, from producing-food to sustaining life. The average Virginia resident uses 826 gallons of fresh water daily (Virginia Department of Environmental Quality [VADEQ] 2008). In the Commonwealth alone, there are more than one million households that depend on well water, withdrawing more than 50 billion gallons annually (Virginia Department of Health 2008). For groundwater replenishment, we depend largely on recharge (water moving from the surface to groundwater) from infiltration of precipitation through permeable surfaces in the environment — an important part of the natural water cycle (VADEQ 2010).

However, due to urbanization, forested areas and grasslands are increasingly converted to commercial, residential, or industrial uses. This conversion creates a significant increase in impermeable surfaces such as concrete, asphalt, building roofs, and even compacted vegetated sites (U.S. Environmental Protection Agency [EPA] 2003).

Impermeable surfaces decrease infiltration and groundwater recharge. They also generate increases in stormwater runoff, defined as any precipitation from a rain or snow event that flows off of impervious surfaces. This runoff often enters surface waters, such as creeks and rivers, without treatment and frequently contains sediment, oils, debris, nutrients, chemicals, and bacteria (EPA 2003; Paul and Meyer 2001). It is also typically warmer than the existing stream water and may flow faster, causing stream bank erosion. These multiple impacts degrade water quality, alter the aquatic habitat, and affect aquatic organisms that depend on clean water (Meyer, Paul, and Taulbee 2005).

Finally, due to the interconnected nature of watersheds, the impaired water travels downstream into the next watershed area. **The combined effects of development are increased stormwater runoff into surface waters and decreased infiltration for groundwater recharge.**

The responsibility for stormwater management is often handled on a large scale and can be fragmented between state, local, and municipal government (Roy et al. 2008). While the focus is typically on large developments and the storm sewers systems, small areas can also contribute significant volumes of stormwater during rain events. By making changes at the residential lot level, much greater infiltration over the watershed area can be attained. Each homeowner can significantly reduce the stormwater load that leaves his or her property, thereby improving surface water quality and helping to recharge groundwater reserves.

Just How Much Runoff Does My House Create?

Making a few simple assumptions, we are able to easily calculate the number of gallons that fall in a single rainfall event or over the course of a year. The assumptions we are making are that all precipitation that falls on an impermeable surface (roof, driveway, or walkway) will run off and that all runoff is leaving the site. These assumptions will allow an understanding of how much runoff water a single-family residential site can produce.

Average annual precipitation for Virginia residential lots is 42.7 inches (Hayden and Michaels 2000). If the roof area of the house is 1,600 square feet and the area of the driveway and all sidewalks totals 750 square feet (this includes a 12-foot by 50-foot driveway and 50 feet of 3-foot-wide walkways around the house), it would total 2,350 square feet of impervious surface.

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A single, half-inch rain generates 732 gallons of runoff from this site, which could fill nearly 15 average bathtubs. Over the course of a year, this impervious area contributes 62,552 gallons of runoff into the local watershed, which is enough to fill seven tractor-trailer tankers with water. Reducing even a small percentage of this runoff by encouraging infiltration will significantly decrease the amount of stormwater leaving this residential site, increase groundwater recharge, and ultimately improve water quality throughout the entire watershed.

Practices to Minimize Runoff or Improve Infiltration

Stormwater on residential sites can be dealt with in a number of ways. The following techniques, which can be integrated into new construction and existing residential settings, help to manage stormwater:

- Increasing permeability.
- Directing water to more permeable areas.
- Detaining water to allow infiltration.
- Intercepting and holding rainwater.
- Utilizing water on-site as it is needed.

Permeable Pavement

Permeable pavement incorporates the use of permeable asphalt or concrete, plastic grid systems, or pavers to form a durable and attractive surface that water can infiltrate (figure 1). These applications are designed to allow water infiltration and produce almost no runoff. In fact, permeable pavement areas can be receiving areas (sinks) for runoff from other areas of the home; by directing water to these areas, significant amounts of runoff can be captured. These permeable surfaces can be incorporated into existing driveways and walkways or can be installed in new applications. As water flows through the pavement, it is then filtered by the sub-base gravel and soil under the pavement and infiltrates into the ground.

Disconnecting Downspouts From Drains

Often downspouts from home gutters connect into underground pipes that run directly into stormwater drains. Simply unhooking your downspouts from the storm drain system can significantly reduce the amount of runoff from your site. When possible, it is best to redirect these downspouts away from the house and toward grassy areas or other areas with high permeability, allowing water infiltration (figure 2).

Permeable Interlocking Concrete Pavers (PICP)

Concrete Grid Pavers (CGP) “Turfstone”

Porous Concrete (PC)

Porous Asphalt (PA)

Plastic Turf Reinforcing Grids (PTRG)

Figure 1. Examples of permeable pavement applications.

Source: N.C. State University.

Rain Harvesting (Bulk or Rain Barrels)

Capturing rainwater for reuse can significantly reduce runoff, and it also provides an alternative source of water for irrigation and other household uses. Collection can be in smaller containers, such as a rain barrel (figure 3), or on a larger scale, capturing thousands of gallons of rainwater in large storage tanks. These tanks can be above-ground or below, and are often equipped with a pump to enable the homeowner to water the home's turf, landscape, and garden areas. Watering a lawn and landscape this way allows water to be applied as needed, utilizing stored rainwater in a controlled fashion, boosting infiltration.

Green Roof Applications

Green roofs, much like permeable pavement, convert an impermeable or nonporous surface into one that can accept and retain precipitation, reducing runoff from the site (figure 4). When rain falls on a green roof, it is held by the substrate (growing media) and then utilized by the plants as needed. During peak growing times, green roofs can retain up to 75 percent of the precipitation that falls on them; 20 to 40 percent is retained during the winter. The website www.greenroofs.org estimates that "a grass roof with a 4 to 20 cm (1.6 to 7.9 inches) layer of growing medium can hold 10 to 15 cm (3.9 to 5.9 inches) of water."

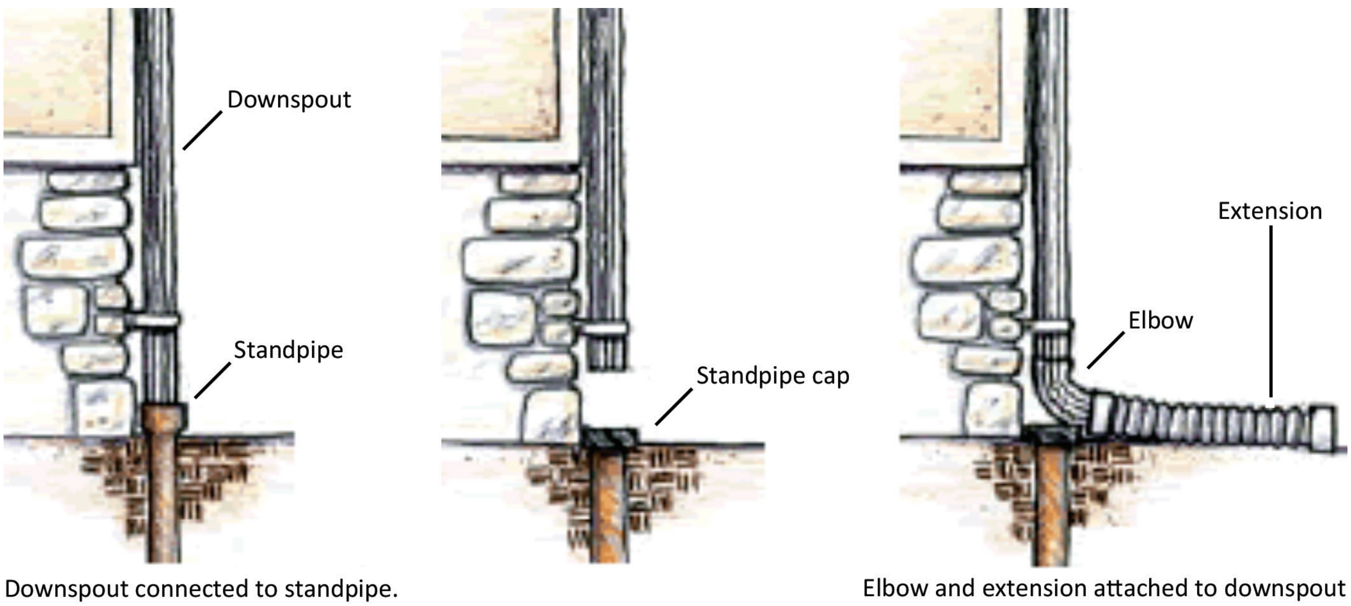

Figure 2. Disconnecting a downspout from underground pipes leading to storm sewers.

Source: Mid-America Regional Council (MARC); www.marc.org/Environment/Water/downspout.htm.

Figure 3. A rain barrel system for rainwater harvesting.

Source: Vision Design Collaborative.

Figure 4. A green roof application. *Source*: Susan Day.

Overall, the EPA estimates that 50 percent of annual precipitation that would otherwise be runoff can be retained via green roof applications (Berghage et al. 2009). This can significantly reduce the stormwater leaving an otherwise impermeable surface. The water that does leave the green roof has been detained, is cooler, and may be cleaner due to substrate filtration, producing cleaner water leaving the site.

There are additional benefits to green roofs, including longer lifespan of roofing materials, sound reduction, and less expensive heating and cooling costs. When retrofitting an existing structure for a green roof application, it is important to follow all building codes to compensate for the additional weight of the media.

Figure 5. An example of urban trees. *Source*: Susan Day.

Urban Forestry Applications

Incorporating trees into residential settings provides a number of benefits for managing stormwater runoff (Nowak and Dwyer 2007). A mature deciduous tree has the potential to intercept 500 to 700 gallons of water per year, mainly via retention on leaves. Additionally, evergreen trees can intercept more than 4,000 gallons per year (Seitz and Escobedo 2008).

The rainfall intercepted by trees is often precipitation that would have fallen on an impermeable surface, contributing to runoff. Surface runoff is reduced when precipitation is held on foliage until it evaporates into the atmosphere. Water also moves through the tree canopy via stem flow (water following twigs, and then branches, then the main trunk to the ground) to permeable areas near the trunk, increasing infiltration.

Other benefits of urban trees include decreased cooling costs, shading, aesthetics, wildlife habitat, and increased real estate value. Tree species vary widely, ranging from deciduous to evergreen trees and are easily integrated into a residential landscape (figure 5).

Rain Garden

Rain gardens are depressions planted with annual and perennial plants that serve to collect rainwater from nearby impervious surfaces, allowing infiltration of water that would otherwise be runoff (figure 6). These areas provide an attractive area to detain a significant volume of rainfall and allow that water to infiltrate slowly into the ground. Often, downspouts can be directed into rain gardens, and these areas are capable of absorbing 30 percent more rainfall compared to the same size turf area.

During the infiltration process, water is filtered by the soil and contaminants are removed. Specific information on rain gardens and plants that are well-suited for our area can be found on the websites of Virginia Cooperative Extension (VCE publication 426-043, http://pubs.ext.vt.edu/426/426-043/426-043.html) and the Virginia Department of Forestry (VDOF publication P00127, www.dof.virginia.gov/mgt/rfb/rain-gardens.htm).

Grass Swales and Berms

Grass swales and berms (also known as bioswales) serve to route water to desired areas or to retain water on the property. These features can be attractively planted and serve to slow water movement and filter out contaminants (figure 7). Swales detain and control water flow and can hold several inches of water. This detained water is filtered and then it infiltrates, as opposed to running off the site. When compared to open ditches, which mainly channel runoff and contribute to erosion, both swales and berms are improved methods of managing stormwater.

Improving Turf Density and Permeability

Improving soil permeability leads to reduced runoff and greater infiltration. The majority of residential homes have a large percentage of ground area in turf.

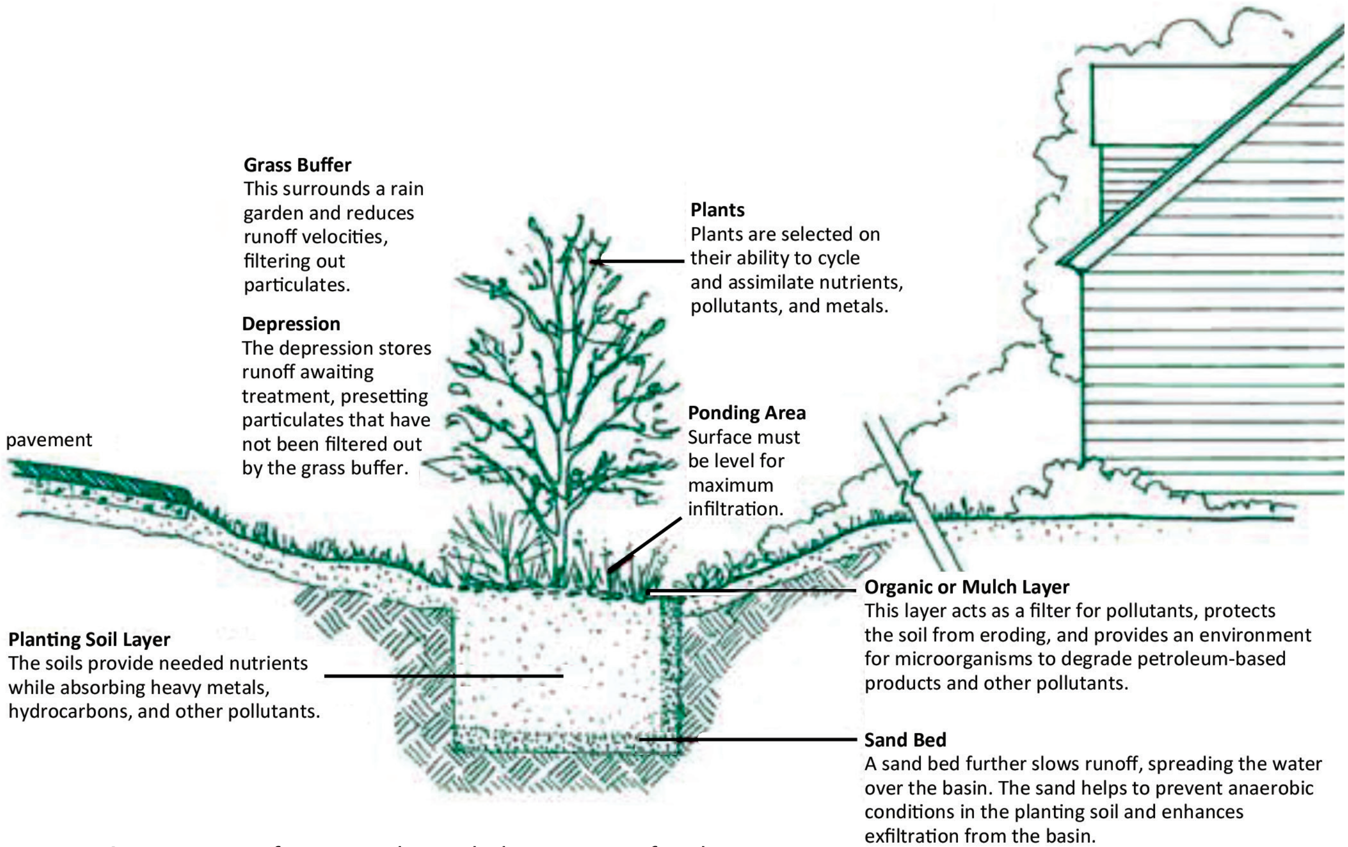

Figure 6. Cross-section of a rain garden with descriptions of each component.

Source: Rain Gardens Technical Guide. www.dof.virginia.gov/mgt/resources/pub-Rain-Garden-Tech-Guide_2008-05.pdf.

Figure 7. An example of a grass swale in a residential application.

Source: Kara Bonsack, University of Connecticut.

Turfgrass is very effective at filtering out sediment and increasing infiltration, but two issues affect the ability of turf to perform these functions. First, high traffic on turf areas can increase compaction, making infiltration slow and allowing for more runoff. Second, when turf is not managed properly, it can become thin and sediment erosion can occur. In order to reduce compaction and keep turf density high, annual core aeration of the turf areas is recommended. Furthermore, following a fertilization program such as suggested by "Lawn Fertilization in Virginia," VCE publication 430-011, can promote healthy turf that will allow maximum infiltration of precipitation.

Mulched Areas

The application of organic mulches generates a number of benefits for both plants and soils in mulched areas. Mulch contributes to soil moisture retention, provides organic matter, and moderates the root-zone temperature (Relf 2009). In addition to these benefits, mulches also significantly reduce compaction and erosion and improve the infiltration of water as they increase the organic-matter content of soils. By incorporating well-designed mulch beds around landscape areas and trees and as border areas, water that falls on the area or arrives via stem flow from plants in the mulch areas has more opportunity to infiltrate the soil.

Summary

Land development activities convert highly permeable surfaces into impermeable ones. This conversion often causes an increase in stormwater runoff and a decrease in both surface water quality and infiltration to groundwater. On residential lots, these negative effects can often be minimized by incorporating some of the techniques described in this publication. By making small changes at the local level, water quality in the watershed can be greatly improved.

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