Stormwater Prevention and Control

Stormwater
Fact Sheet
No. 4

This fact sheet is No. 4 of a eight-part series focused on stormwater runoff problems and control strategies. The series covers:

1) Stormwater Impacts
2) Human Health Impacts
3) How Citizens Can Help
4) Prevention and Control
5) Control for Development
6) Rules and Regulations
7) "How to" for Local Officials
8) Municipal Prevention

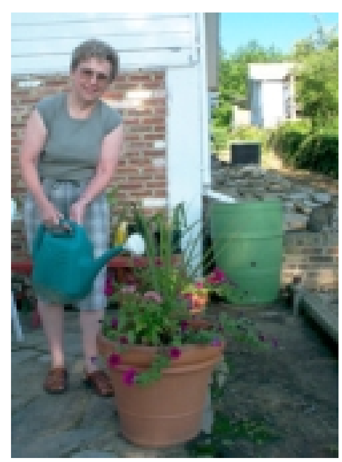
This series was supported by a generous grant from the Z. Smith Reynolds Foundation to RiverLink, Inc.

Principles of Stormwater Management

Previous fact sheets explained the problems, impacts, public health concerns, and some solutions for the problems associated with stormwater runoff. This fact sheet further describes prevention and control practices that should be utilized to address problems created by uncontrolled stormwater runoff.

Traditional Approach
Draining runoff into a pipe as quickly as possible to prevent ponding is the traditional approach to stormwater management. The traditional approach does not attempt to prevent or control stormwater pollution. As a result, the traditional approach often results in downstream flooding and water quality problems.

Current Integrated Systems Approach
The current trend is toward a more comprehensive "systems approach" to managing stormwater runoff. An integrated system of preventive and control practices is used to accomplish stormwater management goals. The first principle is to minimize the generation of runoff and pollutants through a variety of techniques. The second principle is to manage runoff and its pollutants to minimize its impacts on humans and the environment in a cost effective manner. This approach stresses optimum site planning and the use of more natural drainage systems, rather than traditional curb, gutter and piped systems. This "soft approach" can often reduce the cost of stormwater management on development sites.



Stormwater management at the residential level can provide many benefits such as landscape features through rain gardens or extra water from your rain barrel. Photos from http://www.cwp.org.

STORMWATER MANAGEMENT PRACTICES

Preventive Measures

Preventive measures include nonstructural practices that help prevent the generation of runoff and the contamination of runoff by pollutants. Preventive measures are considered the “first line of defense” in an integrated stormwater management system. These measures are usually very cost effective compared to traditional structural control measures, which can have significant capital, operation, and maintenance costs. Many of these measures involve changing the behavior of individuals who are contributing to stormwater pollution. Examples of preventive measures include:

• Land Use Planning and Management Techniques

All growth should be planned and managed to minimize the quantity and quality impacts of runoff. Sensitive areas such as floodplains, wetlands, water supply watersheds, high quality water, and trout waters, deserve special planning and protection measures. Specific management techniques include establishing greenways along waterways, limiting the amount of impervious surfaces, requiring building setbacks and vegetative buffers along streams, discharging downspouts from roof gutters into vegetated areas, and eliminating curbs and gutters, thus allowing runoff to flow off the street or parking area in a sheet flow.

Community design has a major effect on stormwater volumes and quality, as well as treatment methods and costs. The total area of impervious surfaces in a community is one of the most common reasons for the increase of stormwater pollution. Many of the impacts of urbanization on the habitat and water quality of streams are related to the fundamental change in the hydrologic cycle caused by the increase of impervious coverage throughout the landscape. Also important is the degree of connection between impervious surfaces and the storm drainage system; surfaces that drain directly to vegetated areas produce less runoff and help reduce the flow of stormwater. Runoff measured from suburban developments has been shown to be 1.5 to 4 times greater than that from rural areas, although low-density development may produce less runoff than do some intensive agricultural land uses. Moreover, construction of low-density developments disturbs the soil over larger land areas, accelerating transport of sediment and associated pollutants into water bodies. Stripping the protective vegetation cover from construction sites accelerates soil erosion to a rate up to 40,000 times higher than before the soil was disturbed.

• On-Lot Treatment

The term “on-lot treatment” refers to a series of practices, such as rain barrels or rain gardens, that are designed to treat runoff from individual residential lots. The primary purpose of most on-lot practices is to manage rooftop runoff and, to a lesser extent, driveway and sidewalk runoff. Rooftop runoff, and particularly residential rooftop runoff, generally has low pollutant concentrations compared with other urban sources. The primary strategy for managing runoff from rooftops is to disconnect the rooftop from ground-level impervious surfaces, reducing the total effect of impervious cover in a watershed.

There are some limitations to the use of on-lot practices, including:

- Each practice requires some maintenance, as well as responsibility on the part of the homeowner, including some maintenance
- Some of these practices are less practical on small lots (<1/8 lots).

• **Pollution Prevention Techniques -** There are many ways to prevent the generation of pollutants or their entry into stormwater. Everyone can practice preventive maintenance to reduce leaks, breakdowns, spills and accidents that could result in contaminated runoff. Materials stored outside, such as road salt or coal piles, should be covered to prevent exposure to rainfall or runoff. Facilities that handle hazardous chemicals should develop effective spill control plans and response programs. Local governments should establish collection and disposal programs for household hazardous wastes and used oil to prevent their entry into storm drains. Sanitary sewers should be maintained to prevent leaks and overflows into urban streams. (A complete list of preventative techniques for households is available in Fact Sheet #3, and for developers in Fact Sheet #5).

• **Public Education and Involvement Programs –** Educating employees and the public about stormwater problems, best management practices (BMPs) and the individual's role in minimizing runoff and protecting water quality is a very cost effective preventive BMP. Changing citizen behavior and practices is key to a successful program. Citizens need to learn environmentally sound lawn care practices and how to properly dispose of used oil, yard wastes, pesticides and other chemicals. Stenciling storm drains warns citizens that dumping into storm drains can pollute local waterways.

• **Erosion and Sedimentation Control Programs -** Sediment is the number one polluter in the French Broad River Basin and is a major pollutant in stormwater runoff. Local erosion control programs may be the most effective means of preventing the contamination of stormwater runoff and protecting bodies of water in developing areas.

• **Illicit Connection or Discharge Elimination Programs –** Illicit connections such as sanitary sewer interconnections, floor drains, washing machines, and other inappropriate discharges of non-stormwater, represent another significant source of pollutants entering storm sewers. Local officials should develop programs to identify and eliminate these connections.

An illicit discharge occurs when something other than the normal contents of stormwater is allowed to enter a storm drainage system. The causes can be intentional, such as someone deliberately dumping chemicals, domestic waste or trash into a storm drainage inlet. Individuals and businesses who make a physical connection to a storm sewer to dump industrial process waste, laundry water or domestic waste are also causing an illicit discharge. Illicit discharges can be unintentional as well, such as leaving chemicals, lawn clippings, or pet waste in an area where stormwater may carry away the polluting material. Local officials should develop programs to identify and eliminate these illicit connections and discharges.

Control Measures

Control measures are structural practices that control the volume and pollutant concentration of stormwater. They utilize the processes of detention/retention, settling, percolation, evaporation, evapotranspiration, filtration, absorption and biological uptake to reduce flows and remove pollutants. Stormwater runoff is a significant source of water pollution in urbanizing areas. To address this problem, the State of North Carolina and some local governments have adopted programs that require or encourage the use of best management practices (BMPs) to treat stormwater runoff.

Research administered by North Carolina State University and other groups such as the Center for Watershed Protection have demonstrated that specific technologies (aka BMPs) can be very effective in removing certain pollutants including sediment, some nutrients and heavy metals. If properly designed, constructed and maintained, these BMPs will not only protect water quality, but can reduce peak stormwater flows and can be an attractive landscaping feature of a development. Following is a brief discussion of commonly used technologies and limitations in the mountain region of North Carolina. Most of the following are from the Center for Watershed Protection's stormwater website at (http://www.stormwatercenter.net/)

Grass Filter Strips

Grassed filter strips (aka vegetated filter strips, filter strips, or grassed filters) are vegetated areas that are intended to treat sheet flow from adjacent impervious areas. Filter strips function by slowing runoff velocities and filtering out sediment and other pollutants, and providing some infiltration into underlying soils. Filter strips were originally used as an agricultural treatment practice, and have more recently evolved into an urban practice. With proper design and maintenance, filter strips can provide relatively high pollutant removal. One challenge associated with filter strips, however, is that it is difficult to maintain sheet flow. Consequently, urban filter strips are often "short circuited" by concentrated flows, which results in little or no treatment of stormwater runoff.

Grass Swales

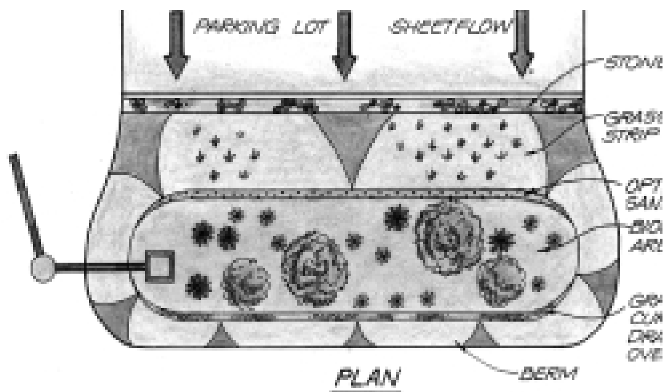
The term "swale" (aka grassed channel, dry swale, wet swale, or biofilter) refers to a series of vegetated, open channel practices that are designed specifically to treat and attenuate stormwater runoff for a specified water quality volume. As stormwater runoff flows through the channels, it is treated through filtering by the vegetation in the channel, filtering through a subsoil matrix, and/or infiltration into the underlying soils. There are many design variations of the grassed swale, including the grassed channel, dry swale and wet swale. The specific design features and treatment methods differ in each design, but all are improvements on the traditional drainage ditch. Each swale design incorporates modified geometry and other features to convey and treat stormwater runoff.

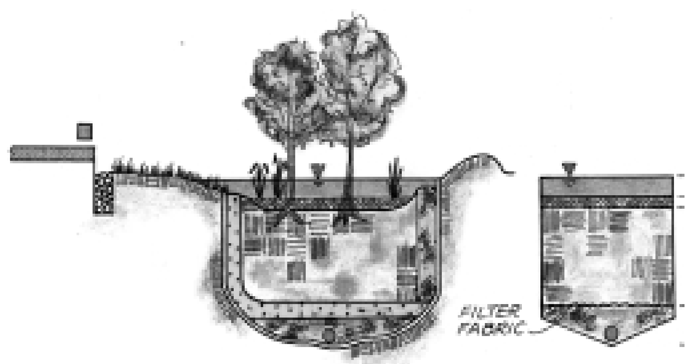
Constructing grass channels is a good treatment practice for watersheds that have cold water streams. Swales do not pond water for a long period of time, and often induce infiltration. As a result, standing water will not typically be subjected to warming by the sun.

Grassed channels have some limitations:

- Individual grass channels cannot treat a very large drainage area.
- Grass channels do not appear to be effective at reducing bacteria levels in stormwater runoff.
- Wet swales may become a nuisance due to mosquito breeding.
- If designed improperly (e.g., proper slope is not achieved), grassed channels will have very little pollutant removal.
- A thick vegetative cover is needed for proper function.

Detention/Retention Practices - Detention/ Retention practices use the processes of detention and retention to reduce peak discharge rates and pollutant loadings. Examples of these construction include dry detention basins, wet retention ponds, and artificial wetlands. Studies have shown these practices are effective in reducing flow rates and many stormwater pollutants. Their longevity can be 20 years or more, representing a major advantage over other BMPs such as infiltration devices.





Wet Detention Ponds

Wet ponds (aka stormwater ponds, retention ponds, or wet extended detention ponds) are constructed basins that have a permanent pool of water through out the year (or at least throughout the wet season). These are other effective ways to treat stormwater and reduce the peak flow of flood events. Studies have shown that poor operation and maintenance are the leading causes of pond failure. Poor maintenance may also create nuisance odors, insects, algae blooms and unsightly areas. Detention ponds can fail for several reasons, including improper design and location, poor vegetation management, inlets and outlets clogged by sediment or trash and debris, reduced storage capacity due to sediment accumulation, failed side slopes or dam, and inadequate access for maintenance.

Stormwater Wetlands

Stormwater wetlands (aka constructed wetlands) are constructions similar to wet ponds (see Wet Ponds in this fact sheet) that incorporate wetland plants in a shallow pool. As stormwater runoff flows through the wetland, pollutant removal is achieved by settling and biological uptake within the pool. Wetlands are among the most effective stormwater practices in terms of pollutant removal, and also offer the advantage of adding aesthetic value to a property.

Wetlands pose a moderate risk to cold water systems because of their potential for stream warming. When water remains in the permanent pool, it is heated by the sun. Trees may be a useful feature in cooling the wetland. Check with your local landscape architect or soil and water agency to identify strategies for addressing the warming aspect of this BMP.

Rain Gardens:A rain garden like the one pictured to the right is a bioretention area that helps manage stormwater discharges. This BMP is not only useful in managing non-point source pollution, but it also can provide an attractive landscape feature for a home site.

A backyard rain garden is an inexpensive way to improve water quality and enhance the beauty of your yard or business. Rain gardens should be placed between stormwater runoff sources (roofs, driveways, parking lots) and runoff destinations (storm drains, streets, streams).

A rain garden is a shallow depression in the ground that captures runoff from your driveway or roof and allows it to soak into the ground, rather than running across roads, capturing pollutants, and delivering them to a stream, plants and soil work together to absorb and filter pollutants and return cleaner water through the ground to nearby streams. Rain gardens also reduce flooding by sending the water back underground, rather than into the street and stormwater drains. Besides helping to improve water quality and to reduce flooding, rain garden plants provide habitat for beneficial insects and wildlife!

When designed properly, the rain garden fills with a few inches of water after a storm and the water slowly filters into the ground. Because water is only in the rain garden for a day or two, it does not become a breeding ground for mosquitoes. For more information on how to build a rain garden, see the North Carolina State Cooperative Extension link at www.bae.ncsu.edu/topic/raingarden/stormwater.htm. <u>This information was reprinted with permission of the NC State Cooperative Extension.</u>

Infiltration Devices - Infiltration devices capture and retain a portion of runoff onsite and allow it to infiltrate into the soil; or, in the case of surface basins, evaporate into the air. If properly sited, designed, constructed and maintained regularly, these devices can be very effective in reducing peak discharge rates and stormwater volumes and removing pollutants from the first flush of runoff. Examples of these devices include infiltration trenches, infiltration basins, dry wells, leaching catch basins, porous pavement/blocks and infiltration islands within parking areas.

Porous Pavement

Porous pavement is a permeable pavement surface with an underlying stone reservoir that temporarily stores surface runoff before infiltrating runoff into the subsoil. This porous surface can replace traditional pavement, allowing parking lot runoff to infiltrate directly into the soil and receive water quality treatment. There are several pavement options, including porous asphalt, pervious concrete, and grass pavers. Porous asphalt and pervious concrete appear the same as traditional pavement from the surface, but are manufactured without "fine" materials, and incorporate void spaces to allow infiltration. Grass pavers are concrete interlocking blocks or synthetic fibrous grid systems with open areas designed to allow grass to grow within the void areas.

Porous pavement can help to reduce the increased temperature commonly associated with increased impervious cover. Stormwater runoff ponds on the surface of conventional pavement and is subsequently heated by the sun and hot pavement surface. By rapidly infiltrating rainfall, porous pavement can reduce the time that stormwater is exposed to the sun and heat. However, this BMP could be difficult in certain circumstances. Porous pavement has specific site criteria:

- Soils need to have a permeability between 0.5 and 3.0 inches per hour.
- The bottom of the stone reservoir should be completely flat so that infiltrated runoff will be able to infiltrate through the entire surface.
- Porous pavement should be located on parking areas with at least 2 to 5 feet above the seasonally high groundwater table, and at least 100 feet away from drinking water wells.
- Porous pavement should be located only on low traffic or overflow parking areas which are not sanded or salted during wintertime conditions.

Infiltration Trench

An infiltration trench is a rock-filled trench with no outlet that receives stormwater runoff. Stormwater runoff passes through some combination of pretreatment measures, such as a swale or sediment basin, before entering the trench. Runoff is then stored in the voids of the stones, slowly infiltrated through the bottom and into the soil matrix over a few days. The primary pollutant removal mechanism of this practice is filtering through the soil. Infiltration trenches are an excellent option for preserving the quality of cold water streams because they encourage infiltration of stormwater. Stormwater does not warm as it travels underground to the stream, which reduces the temperature impacts commonly associated with urbanization and stormwater practices. Infiltration is also very helpful in sustaining dry weather stream flows because of the slow release of water.

Conclusion

Each stormwater BMP has different advantages, disadvantages and a set of unique characteristics, making it suitable or unsuitable for use in a particular situation. An effective stormwater management plan will use a number of BMPs in an integrated system to achieve the goals and objectives of reducing the amount of pollution that enters our waterways and of reducing the potential for flooding. As impervious surfaces increase, the amount of water that rushes off these surfaces greatly increases, instead of slowly filtering into the landscape, thus increasing the severity of floods. We should choose best management measures to prevent stormwater runoff because they can be a way to avoid the necessity of using more extensive and expensive control measures.

For more information

- Appropriate Local Government Officials www.seris.info/RiverLink/techinfo.shtml
- Land of Sky Regional Council 251-6622.

- Center for Watershed Protection. www.cwp.org.
- North Carolina Division of Water Quality Stormwater Unit: Manuals and Factsheets
- www.h2o.enr.state.nc.us/su
- North Carolina Division of Water Quality Stormwater Permitting Unit: Stormwater Permitting Unit Home h2o.enr.state.nc.us/su/stormwater.html
- North Carolina Phase II Stormwater www.ncphase2sw.org/
- North Carolina State University www.bae.ncsu.edu/stormwater/
- RiverLink www.seris.info/RiverLink/techinfo.shtml or www.riverlink.org

Written and Edited by Hartwell Carson, Bill Eaker, Phillip Gibson, and Mike Randall