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Best Management Practice Fact Sheet 11:
Wet Swale

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This fact sheet is one of a 15-part series on urban *stormwater management* practices.

Please refer to definitions in the glossary at the end of this fact sheet.
Glossary terms are *italicized* on first mention in the text. For a comprehensive list, see Virginia Cooperative Extension (VCE) publication 426-119, "Urban Stormwater: Terms and Definitions."

What Is a Wet Swale?

A *wet swale* (WS) is an engineered, *best management practice* (BMP) arranged in a straight line that is designed to reduce *stormwater* pollution. A WS consists of a shallow, gently sloping channel with broad, vegetated, side slopes and slow flows (see figure 1). Wet swales typically stay wet because the bottom of the swale is below the *water table*. This is done to encourage the growth of *wetland* vegetation, providing water quality treatment similar to a natural wetland. This *stormwater treatment practice* also functions as part of the *stormwater conveyance system*. Wet swales have a relatively low capital cost; however, maintenance can be intensive and expensive when compared to other BMPs.

Figure 1. Typical wet swale *Source: VA-DCR 2011*

Where Can Wet Swales Be Used?

Wet swales can be used as an alternative to curbs, gutters, and storm drainage pipes. Because they allow biological activity to occur, they are considered to be a green treatment practice. Wet swales are typically restricted to *coastal plain* installations, because they require flat or gently sloped terrain and a high water table. Driveways and culverts crossing a WS may reduce its pollutant removal performance, so these should be limited or controlled if a WS is used. Sandy soils should be avoided or modified to decrease their *permeability*, as the treatment process requires standing water to work.

How Do Wet Swales Work?

Wet swales provide *peak runoff* or water quantity control by storing and slowing runoff. They are designed to provide a minimum of 24 hours of *residence time* as the water flows through them. As the water is temporarily stored, small amounts of *infiltration* may occur (see figure 2).

When runoff slows, it allows water quality treatment to occur. Treatment is accomplished by *settling* (slower flows allow *sediment* to drop out) and by *biological uptake* and *microbial decomposition*. Through these processes, wet swales provide a modest amount of water quality treatment for *nutrients* and sediment.

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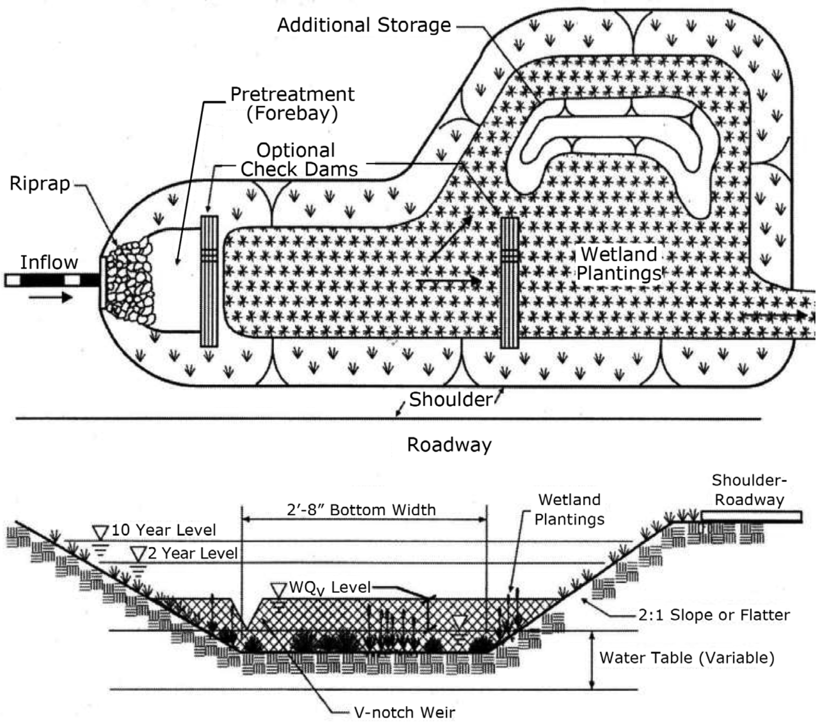

Figure 2. Typical wet swale design details; (top) plan view, (bottom) profile view.
Source: VA-DCR 2011.

Limitations

- Wet swales are impractical in steep areas, because maintaining a constant water surface elevation or pool becomes too difficult.
- Wet swales are impractical in extremely flat areas, because the lack of gradient may cause excessive ponding and prevent positive drainage.
- Vegetation must be periodically trimmed to keep woody vegetation in check.
- A WS can erode during peak rainfall when water volume and velocity are high.
- Standing water in wet swales may foster mosquitoes, so vector control is recommended.
- Contributing drainage areas should be 5 acres or less to avoid flooding the WS, depending upon the permeability of the upstream drainage area.
- *Resuspension* of sediment can occur during peak storm events.
- Performance is reduced as driveway or road crossings are added to a WS.
- Standing water causes water temperature to rise, which reduces oxygen in the water and negatively impacts nutrient removal.
- Due to the increased potential for *groundwater contamination* from infiltration of oils, metals, and other pollutants, a WS should be used rarely in industrial and commercial areas.

Maintenance

Routine Maintenance (annual)

- Monitor sediment levels. Excess sediment can fill in the WS, harm vegetation, and reduce WS performance.
- Monitor and replace vegetation as needed.
- Inspect WS on a regular basis for erosion and sediment buildup at the inlet and the outlet. Repair as needed.
- Remove trash and debris, particularly from *control structures*.

Nonroutine Maintenance (as needed)

- Remove excess accumulated sediment.
- Control undesirable *invasive species*.

Performance

Wet swales are effective at removing multiple pollutants from incoming water flow. A typical WS is expected to reduce total phosphorus (TP) by 20 percent and total nitrogen (TN) by 25 percent. In a more advanced design, an additional swale is placed offline (at a right angle to the flow direction) and vegetated with wetland plantings similar to a constructed wetland (see VCE publication 426-132, "Best Management Practice Fact Sheet 13: Constructed Wetlands"). The additional vegetation and offline cells provide a longer residence time. Advanced WS designs can reduce TP by 40 percent and TN by 35 percent (VA-DCR 2011).

Expected Cost

Wet swales are considered a moderately priced stormwater treatment practice in terms of construction costs when compared to other alternatives. The construction cost of a wet swale sufficient to treat 2 acres is estimated to be $47,000. The value of land is not included in this analysis. Note that wet swales tend to have high operation and maintenance costs that offset the savings from lower construction costs over time.

Additional Information

The Virginia departments of Conservation and Recreation (VA-DCR) and Environmental Quality (VA-DEQ) are the two state agencies that address nonpoint source pollution. The VA-DCR oversees agricultural conservation; VA-DEQ regulates stormwater through the Virginia Stormwater Management Program.

Additional information on best management practices can be found at the Virginia Stormwater BMP Clearinghouse website at https://www.swbmp.vwrrc.vt.edu/ (Permanent link: https://perma.cc/WC5L-KCZ8). The BMP Clearinghouse is jointly administered by the VA-DEQ and the Virginia Water Resources Research Center.

Online Resources

Connecticut Stormwater Quality Manual – http://ct.gov/dep/cwp/view.asp?a=2721&q=325704

Minnesota Sustainable Housing Initiative – www.mnshi.umn.edu/kb/scale/biofiltration.html (Permanent link: https://perma.cc/HP9Q-ZLT3)

New York Department of Environmental Conservation – www.dec.ny.gov/lands/59310.html (Permanent link: https://perma.cc/TT45-2GME)

University of Florida Build Green – http://buildgreen.ufl.edu/Fact_sheet_Bioswales_Vegetated_Swales.pdf

U.S. Department of Transportation, Federal Highway Administration – https://www.environment.fhwa.dot.gov/Env_topics/water/ultraurban_bmp_rpt/5mcs2.aspx. (Permanent link: https://perma.cc/EH7V-4GF7)

Companion Virginia Cooperative Extension Publications

Daniels, W., G. Evanylo, L. Fox, K. Haering, S. Hodges, R. Maguire, D. Sample, et al. 2011. *Urban Nutrient Management Handbook.* Edited by J. M. Goatley. VCE Publication 430-350.

Sample, D., et al. 2011-2012. Best Management Practices Fact Sheet Series 1-15. VCE Publications 426-120 through 426-134.

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Virginia Department of Environmental Quality (VA DEQ). 2011. *VA-DEQ Stormwater Design Specification No. 11: Wet Swale*, Version 1.9. https://www.swbmp.vwrrc.vt.edu/wp-content/uploads/2017/11/BMP-Spec-No-11_WET-SWALE-_v1-9_03012011.pdf..

Glossary of Terms

Anaerobic – Chemical reactions that proceed without the presence of oxygen.

Best management practice – Any treatment practice for urban lands that reduces pollution from stormwater. A BMP can be either a physical structure or a management practice. Agricultural lands use a similar, but different, set of BMPs to mitigate agricultural runoff.

Biological uptake – The process by which plants absorb nutrients for nourishment and growth.

Coastal plains – A physiographic province of Virginia characterized by flat terrain below the fall line (east of I-95) where the water table is usually high.

Control structure – Structure that regulates water discharge from a BMP.

Erosion – A natural process by either physical processes, such as water or wind, or chemical means that moves soil or rock deposits from one source and transports it to another. Excessive erosion is considered an environmental problem and is very difficult to reverse.

Groundwater contamination – The presence of unwanted chemical compounds in groundwater. In the case of infiltrative stormwater treatment, it would normally refer to dissolved compounds, such as nitrates. It could possibly include unwanted bacteria.

Habitat – The environment where organisms, like plants, normally live.

Hydric soils – Soils that form under saturated conditions. When saturated conditions exist, *anaerobic* chemical processes dominate, and unique chemical properties develop. A common characteristic of hydric soils is the presence of a rotten-egg odor, indicating the presence of hydrogen sulfide (H_2S) gas.

Impervious surface – A hard surface that does not allow infiltration of rainfall into it; not pervious.

Infiltration – The process by which water (surface water, rainfall, or runoff) enters the soil.

Invasive species – Nonnative species that can cause adverse economic or ecological impacts to the environment, usually due to the tendency of these introduced species to dominate local *habitats* and replace native ecological communities.

Microbial decomposition – The breakdown of compounds or organic matters into smaller ones with the aid of microorganisms.

Nutrients – The substances required for growth of all biological organisms. When considering water qualities, the nutrients of greatest concern in stormwater are nitrogen and phosphorus, because they are often limiting in downstream waters. Excessive amounts of these substances are pollution and can cause algal blooms and dead zones to occur in downstream waters.

Peak runoff – The highest amount of water flowing off of a surface during a storm event.

Permeability – See *permeable*.

Permeable – A surface that water can easily flow through (porous); allows infiltration into it.

Residence time – The average time it takes water to travel through a treatment system such as a WS. Residence time can also be called detention time.

Resuspension, Resuspend – When sediment that has settled becomes suspended in the water after being disturbed.

Sediment – Soil, rock, or biological material particles formed by weathering, decomposition, and *erosion*. In water environments, sediment is transported across a *watershed* via streams.

Settling – The process by which particles that are heavier than water fall to the bottom using gravity.

Stormwater – Water that originates from *impervious surfaces* during rain events; often associated with urban areas. Also called runoff.

Stormwater conveyance system – Means by which stormwater is transported in urban areas.

Stormwater management – The management of runoff from pre- to post-development, often using stormwater treatment practices and BMPs to manage quality and control release into receiving bodies of water.

Stormwater treatment practice – A type of BMP that is structural and reduces pollution in the water that runs through it.

Watershed – A unit of land that drains to a single "pour point." Boundaries are determined by water flowing from higher elevations to the pour point. A pour point is the point of exit from the watershed or where the water would flow if it were turned on end.

Water table – The depth at which soils are fully saturated with water.

Wetland – Land that has *hydric soil* and wetland vegetation and is periodically saturated with water.

Wet swale – A shallow, gently sloping channel with broad, vegetated side slopes constructed to slow runoff flows. It typically stays wet by intercepting the shallow groundwater table.