Steep Slopes

Green Infrastructure: Opportunities for Pittsburgh Fact Sheet Series

The roofs, roads, and parking lots in our urban areas prevent rainfall from soaking into the ground, overwhelming sewers and leading to flooding and polluted rivers. Green infrastructure helps solve flooding and prevent water pollution by using soil, vegetation, and natural processes to restore natural drainage patterns in our communities. Green infrastructure can also clean our air, revitalize our neighborhoods, create jobs, save our communities money, and provide other lasting community benefits.

The Challenge

Soil erosion and landslides are concerns whenever construction occurs on or near slopes, but become even more of a concern when slopes are saturated with water. The Pittsburgh area has a dramatic landscape dominated by steep hills and valleys. Since many green infrastructure practices enhance infiltration of water into the soil, care must be taken when designing green infrastructure for the Pittsburgh area.

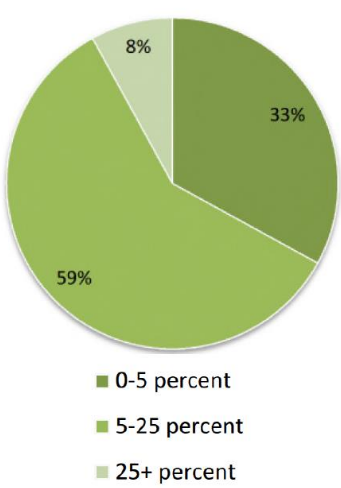
Fortunately, development is restricted on steep slopes, so this challenge is not as daunting as the landscape might suggest. Most ordinances state that a slope greater than 25 percent should be left undisturbed, while roads are typically built with slopes of less than 5 percent. Many strategies are available to manage stormwater at its source for slopes of up to 25 percent.

Opportunities

Green Infrastructure practices appropriate for steep slopes include slope protection, tree planting, use of diversion berms, and use of check dams within bioretention practices.

- Protecting natural slopes reduces erosion and enhances infiltration.
- Planting trees and other vegetation on a disturbed slope stabilizes soil and absorbs water.
- Diversion berms are constructed across slopes to reduce erosion caused by rapidly flowing water and to promote plant growth.
- Check dams can be incorporated into bioretention practices on slopes to encourage infiltration and reduce erosion.

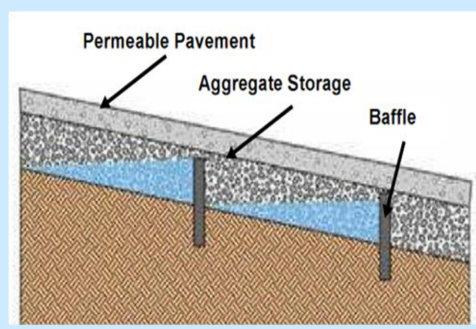
Slope Ranges in the Pittsburgh Area
Source: Tetra Tech, 2013



Green Infrastructure Practices that Work on Steep Slopes

This diversion berm is constructed across a steep slope (max. 25% slope) to slow stormwater.
Source: Pennsylvania SW BMP Manual - BMP 6.4.10

The rock check dams placed along this grassy swale help slow stormwater and prevent erosion in the swale (max. 6% slope).
Source: Pennsylvania SW BMP Manual - BMP 6.4.8

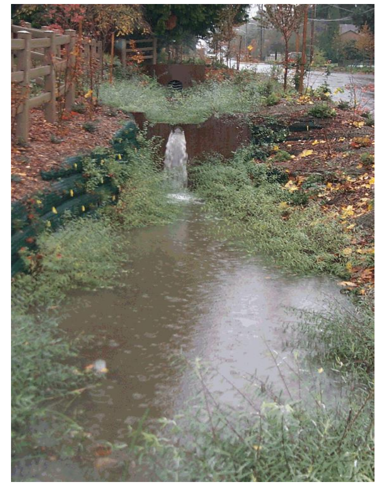


When permeable pavement is installed on a slope (max. 5% slope), baffles can be constructed beneath the pavement to increase water storage and promote infiltration.
Source: Adapted from http://perviouspavement.org/design/hydrologicaldesign.html

Case Studies

110th Street Cascade, built 2002, Seattle, WA

In Seattle, a series of cascading bioretention cells was installed on a sloped (6% grade), residential road to reduce the flow rate and volume of stormwater and to help reduce sediment and pollutant loads from a 2-acre drainage area. The design uses concrete walls, vegetation, and rock to slow down and infiltrate the water.



Cascading bioretention cells in Seattle help treat and infiltrate stormwater from roads.
Source: Seattle Public Utilities; www.seattle.gov

Results

- Monitoring results showed that the system was able to completely absorb 186 (79 percent) of the 235 precipitation events recorded from 2004 to 2006.
- In very dry conditions, storms with rainfall depths of up to 1 inch were completely absorbed by the system.
- Sediment, a pollutant harmful to aquatic life, was reduced by approximately 86 percent.
- Pollutant reductions occurred for sediment, lead and motor oil, nitrogen, phosphorus, copper, and zinc.

Source: Horner, R. R. and Chapman, C. (September 2007). NW 110th Street Natural Drainage System Performance Monitoring. Civil and Environmental Engineering, University of Washington.

Permeable Pavement Road, built 2006, Auckland, New Zealand

A 2,100 square foot permeable pavement test site was constructed on an active roadway with a slope of 6-7.4% and underlying existing clay soils. Flow monitoring was conducted to assess the effectiveness of the site in reducing stormwater volume and peak flow rate. The peak flow rate of a storm is the maximum measured volume of water that moves past a point in a given amount of time.

This monitoring site in Auckland, New Zealand tested the effectiveness of permeable pavement on slopes.
Source: Fassman and Blackbourn, 2010

Results

- Monitoring results showed that the stormwater volume and peak flow rate passing through the permeable pavement was reduced.
- The permeable pavement was able to slow the flow of stormwater so that it resembled the flow from a natural area.
- The permeable pavement was able to effectively handle stormwater from frequent storms and large storms even on steep slopes.
- Typical of sites in the Pittsburgh area, the Auckland project site was challenged with a moderate slope, soil allowing little infiltration, and frequent rainfall.

Source: Fassman, E. A., and Blackbourn, S. June 2010. Urban Runoff Mitigation by a Permeable Pavement System over Impermeable Soils. *Journal of Hydrologic Engineering, ASCE.* 15:475-485.

A variety of green infrastructure designs are suitable for handling stormwater on moderate to steep slopes including berms, swales, permeable pavement, and cascading bioretention cells.